Currency Mispricing and Dealer Balance Sheets*

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Abstract

We find dealer-level evidence that recent regulation on the leverage ratio requirement causes deviations from covered interest parity. Our analysis uses a unique dataset of contract-level currency derivatives with disclosed counterparty identities and a plausibly exogenous variation arising with the introduction of the UK leverage ratio framework. We find that affected dealers, after the regulatory change, charge a premium to clients that synthetically borrow dollars through the foreign exchange market relative to unaffected dealers, even after controlling for changes in clients' demand. Also, some clients increase their trading activity with unaffected dealers with whom they already had a pre-existing relationship.

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

In the wake of the global financial crisis, policy-makers and regulators embarked on a bundle of financial reforms to enhance the ability of the banking sector to absorb capital losses. As part of this package, the Basel Committee on Banking Supervision introduced a minimum requirement on the leverage ratio, defined as high-quality capital over consolidated exposures, to guard against the build-up of excessive leverage in the banking system and reduce the chances of harmful deleveraging in a downturn (BCBS, 2014). Market participants, however, have argued that this regulatory rule may have increased the costs of financial intermediation, especially for balance-sheet-intensive activities, by affecting the size rather than the composition of a bank's balance sheet relative to its capital (e.g., ESRB, 2016a,b). A Reuters article on 5 August 2013, for example, voiced 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."*

This paper studies the link between the leverage ratio rule for dealer banks and the recent violations of the covered interest parity (CIP), a no-arbitrage condition affecting foreign exchange (FX) markets (e.g., Akram, Rime, and Sarno, 2008). These deviations have made the cost of borrowing dollars through the world's largest financial market significantly more expensive than in the US money market, thus commanding a premium for international investors with dollar funding needs. While this mispricing has been associated with banks' balance sheet costs that coincide with tighter leverage constraints at quarter ends (e.g., Du, Tepper, and Verdelhan, 2018) or hedging demand (e.g., Borio, Iqbal, McCauley, McGuire, and Sushko, 2018), the evidence is far from being conclusive as the existing literature relies on aggregate data that prevent a neat empirical identification of the underlying determinants.[1]

[1] This recent literature includes, among many others, Rime, Schrimpf, and Syrstad (2017) who consider

As noted by He and Krishnamurthy (2018), we generally observe only one price in the currency forward market and this only allows us to learn how a shock to capital affects the aggregate supply curve for forwards. Accounting for heterogeneity across dealers and clients is then critically important to construct economically sound models and understand the real implications of the leverage ratio requirement.

Figure 1 about here

As an illustrative example, Figure 1 displays the one-month dollar basis on the euro and yen against the dollar together with the average leverage ratio of major dealer banks operating in London, the global hub for FX trading. The dollar basis denotes the difference between the direct dollar funding rate via the US money market and the synthetic dollar funding rate implied from the FX market. While this chart provides evidence of a strong correlation – the basis widened substantially between 2014 and 2016 while dealers faced tighter leverage constraints – testing any causal relationship between the leverage ratio and the dollar basis remains difficult as both components may be driven by common yet unobserved factors. The most important challenge for the empirical identification is to find an exogenous variation in the leverage ratio requirement of dealer banks as this measure may be correlated with unobserved bank characteristics. Also, the leverage ratio requirement varies little over time and whenever it is revised, it may change for all major banks at the same time. Finally, the cost of synthetic dollar funding may vary because of both changes in supply and demand conditions and we should control for the latter.

To address these challenges, we exploit a quasi-natural experiment associated with the introduction of the UK leverage ratio framework in January 2016. This regulatory shock produces a plausibly exogenous variation to the leverage exposure of major UK dealer banks, thus accounting for potential time-varying omitted variables that could correlate with banks' balance sheet shocks. Hence, we employ the contract-level dollar basis with counterparty

differences in liquidity premia resulting from the underlying money market rates, Arai, Makabe, Okawara, and Nagano (2016) who provide evidence on the role of both monetary policy divergence and regulatory reforms as possible drivers, Andersen, Duffie, and Song (2019) who highlight the role of counterparty risk that gives rise to credit value adjustments, and Bahaj and Reis (2019) who show that central bank swap lines have created a ceiling on CIP deviations.

information, a critical ingredient to sweep out all time-varying counterparty- and currency-specific characteristics in the spirit of Khwaja and Mian (2008). 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 dealer banks with relatively tighter leverage conditions.

Our analysis employs a novel dataset on contract-level currency forwards (outright forwards and forward legs of FX swaps) enriched with counterparty information and contract characteristics and corresponding to 42% of the global daily trading activity (e.g., BIS, 2016). The sample covers six major currency pairs relative to the US dollar, i.e., Australian dollar, British pound, Canadian dollar, euro, Japanese yen, and Swiss franc, and runs between December 2014 and December 2016. We use all transactions between major dealer banks and their clients, where at least one counterparty is a UK legal entity, reported to the DTCC Derivatives Repository under the European Market Infrastructure Regulation (EMIR). To construct the dollar basis, we synchronize the contract-level forward rates with Refinitiv Tick History's second-level quotes on spot exchange rates and overnight index swap rates. Hence, we collapse our contract-level dollar basis into volume-weighted weekly data to identify clients with multiple trading relationships in line with Khwaja and Mian (2008). While our main focus is to examine the impact of the leverage ratio rule on the dollar basis implied from currency forwards, our investigation further differentiates between the leverage ratio and the risk-weighted capital requirements as well as between currency forwards (short-term instruments) and currency basis swaps (long-term instruments). For this exercise, we will employ contract-level currency basis swaps or floating-for-floating currency swaps reported to the DTCC Derivatives Repository and exogenous bank-specific capital requirements from the Bank of England (e.g., Aiyar, Calomiris, Hooley, Korniyenko, and Wieladek, 2014; Forbes, Reinhardt, and Wieladek, 2017).

Our identification strategy relies on a difference-in-differences method that exploits the change in the reporting obligation of the leverage ratio for major UK banks in January 2016.[2] Following a transitional period of twelve months, covered by our sample, affected

[2]This measure was part of the UK leverage ratio framework announced in December 2015 and made mandatory in January 2016, two years ahead of the Basel Committee proposal (Bank of England, 2015b). We thank José Manuel Marqués Sevillano (discussant) from the Banco de España for suggesting this exercise.

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 day of each quarter as prescribed by the EU legislation. This shift from end-of-quarter to a monthly average reduced the ability of affected banks to window-dress their balance sheets at quarter ends and effectively made the leverage ratio more binding. Also, this regulatory change is presumably exogenous as major UK banks had no incentive to adjust their reporting obligation before its actual implementation. In our experiment, UK dealer banks constitute the treatment group whereas the subsidiaries of international banks represent the control group. Our before-after and treatment-control group comparison shows, on average, that affected dealer banks (relative to exempted dealer banks) have charged to their clients in response to the regulatory change an extra premium of 16 basis points per annum. Using a simple back-of-the-envelope calculation based on a 33 day average maturity and a $43.75 million average volume in our sample, we estimate an additional cost of about six thousand dollars per transaction.

Policy-makers have argued that the persistently negative dollar basis could be attributed to the surge in FX hedging imbalances coupled with limits to arbitrage arising from tighter balance sheet constraints imposed on global banks (e.g., Arai, Makabe, Okawara, and Nagano, 2016; Debelle, 2017; Nakaso, 2017). Divergent monetary policy stances, for example, have created an incentive for non-US investors to increase their holdings of dollar-denominated assets, partly hedged for currency risk or funded by raising dollars via FX swaps. At the same time, a steeper supply of dollar funding via FX swaps related to stricter regulation has exerted a widening pressure on the dollar basis quoted by global banks. This narrative seems to suggest the existence of important heterogeneous effects on clients borrowing synthetic dollars (or selling dollars forward) and clients lending synthetic dollars (or buying dollars forward). To unfold these effects, we employ the buy/sell indicator on forward contracts available in our data and run difference-in-differences regressions for both types of clients. We find that affected dealer banks (relative to unaffected ones) demand a higher premium of 22 basis points per annum to clients borrowing synthetic dollars after the regulatory change. When inspecting clients lending synthetic dollars, in contrast, no significant arbitrage violation is recorded. To the best of our knowledge, we are among the first to unveil that the leverage ratio requirement affects different clients differently. This evidence would be otherwise hidden with aggregated data.

We then conduct a variety of additional exercises and robustness tests that confirm our core findings. First, tests based on fictitious regulatory shocks lend support to the parallel trend assumption between treated and untreated dealer banks. Second, we rule out other possible changes in regulation implemented at the same time by using placebo outcome exercises based either on an intra-month dollar basis or currency basis swaps, which should not be affected by the regulatory shock. Third, we examine the role of risk-weighted capital requirements by running panel regressions coupled with exogenous bank-level capital requirements set by the UK regulator. While an increase in the capital requirement predicts a widening of the dollar basis associated with currency basis swaps, we find no statistical relationship with the dollar basis arising from currency forwards. This result is consistent with the fact that long-term contracts tend to have a higher risk weight in the calculation of the regulatory capital ratio (e.g., Du, Tepper, and Verdelhan, 2018). Fourth, as opposed to using the buy/sell indicator, we categorize clients as natural hedgers (i.e., real money investors and non-financial corporate firms) and other investors (i.e., hedge funds, nondealer banks, and central banks) with the former (latter) generally borrowing (lending) synthetic dollars (e.g., Arai, Makabe, Okawara, and Nagano, 2016). We find that only natural hedgers face an additional premium. Fifth, we replace the dollar basis with the relative effective spread on currency forwards (i.e., the percentage difference between the transaction price and the interdealer midquoted price) and find that the leverage ratio requirement has a significant impact only on clients borrowing synthetic dollars. This exercise shows that our results cannot be simply attributed to variation in the effective spread across dealers, i.e., less aggressive dealers for unobserved reasons would eventually charge a significant spread regardless of their clients' trading direction. Finally, we run subsample exercises by maturity and currency pairs and find no significant difference in our results.

An alternative regulatory experiment we consider is the obligation for dealer banks to publicly disclose their leverage ratio starting from January 2015 (e.g., Du, Tepper, and Verdelhan, 2018; Haynes, McPhail, and Zhu, 2019). For this exercise, we first measure the leverage ratio of dealer banks in December 2007 as shareholders' claims to total assets using published accounts (e.g., Bank of England, 2015a), then classify dealer banks with a lower (higher) than the median leverage ratio into the treatment (control) group, and finally perform a difference-in-differences exercise before and after January 2015. Ultimately, we examine whether dealer banks with a low leverage ratio before the policy debate on excessive leverage (e.g., Draghi, 2008; G20 Summits, 2008) have faced a wider negative dollar basis following the date that marked the introduction of the public disclosure requirement (BCBS, 2014). We find a wider negative dollar basis of 14 basis points per annum for treated dealer banks relative to other dealer banks. While we have no buy/sell indicator for this period, we can categorize clients into natural hedgers and other investors and report a significant wider negative basis of 25 basis points per annum for the former group and an insignificant effect for the latter one. This evidence corroborates the findings reported in our core analysis.

The impact of the leverage ratio on the dollar basis can be further amplified by the inability of dealer banks to fully offset positions on similar transactions with different clients in determining the leverage ratio. This netting restriction follows from the fact that a derivative creates an underlying asset exposure and a counterparty credit risk exposure (BCBS, 2014). As a result, the intermediation of currency forwards may effectively expand a bank's balance sheet when potentially offsetting transactions are undertaken with different counterparties. In contrast, these transactions may be netted when conducted against the identical counterparty, thus having a lower impact on the balance-sheet exposure of a dealer bank. This critical consideration guides us to account for dealer-client netting activity in our analysis. To this end, we identify two types of clients during the pre-treatment period of our quasi-experimental exercise, i.e., clients with more (less) capital intensive transactions. The former group includes clients with zero netting against dealers (labeled as directional clients) whereas the latter group comprises clients with non-zero netting against dealers (referred to as non-directional clients). Hence, we rerun our difference-in-differences analysis around January 2016 and find that affected dealer banks (relative to unaffected ones) have charged a significant (insignificant) premium of 54 (6) basis points per annum to directional (non-directional) clients seeking synthetic dollars funding. For clients providing synthetic dollars, no significant evidence is reported.

Tighter leverage constraints may also impact the trading activity of dealer banks. For example, Gropp, Mosk, Ongena, and Wix (2018) empirically find that banks reduce their lending activity in response to higher capital requirements. We extend our analysis to the volume of currency forward as a measure of trading activity and document that treated dealer banks (relative to untreated banks) have reduced (increased) their volume of currency forwards by 25% (23%) against directional (non-directional) clients selling dollars forward. For clients buying dollars forward, we continue to find no significant impact, even after accounting for dealer-client netting. Also, we find evidence that clients with more capital intensive transactions and high exposure to UK banks during the pre-intervention period have increased their trading activity during the post-intervention period with unaffected dealers with whom they already had a pre-existing relationship rather than switching to new dealers. On the extensive margin, moreover, we uncover that affected banks are more likely to stop trading with existing clients that borrow synthetic dollars and reduce their intake of new clients that borrow synthetic dollars.

Literature Review. There exists a voluminous literature on the validity of the CIP condition and our paper speaks to this literature. This condition has worked fairly well for the last few decades (e.g., Frenkel and Levich, 1975; Akram, Rime, and Sarno, 2008). Its validity, however, was severely compromised during the global financial crisis when an unprecedented US dollar funding shortage primarily due to funding liquidity and counterparty risk materialized (e.g., Baba and Packer, 2009; Fong, Valente, and Fung, 2010; Pasquariello, 2014; Buraschi, Menguturk, and Sener, 2015; Ivashina, Scharfstein, and Stein, 2015). Despite a significant improvement in market conditions, recent years have been characterized again by large and systematic arbitrage deviations. Du, Im, and Schreger (2018) measure the CIP deviation between US Treasury bonds and foreign bonds in local currencies and document a secular decline at medium to long maturities but not for short maturities. Du, Tepper, and Verdelhan (2018) document that one-week and one-month CIP deviations are more pronounced at quarter-ends after January 2015 when dealer banks started to publicly disclose their leverage ratio. They interpret this finding as evidence that constrained banks window-dress their leverage ratios that must be reported at the quarterly frequency. Eguren-Martin, Ossandon Busch, and Reinhardt (2018) find evidence that when the cost of obtaining funding through the FX market in a particular foreign currency increases, banks reduce their supply of cross-border credit in that currency. Our evidence is consistent with many of the results reported in these studies. However, we go beyond by identifying the supply at the *dealer level*, exploiting much more variation in the data arising from the regulatory shock associated with the introduction of the UK leverage ratio framework. Also, our analysis controls for changes in client demand and, to the best of our knowledge, this is the first paper to apply this methodology to the exchange rate economics literature.

Our findings are also consistent with the growing literature on intermediary asset pricing (Brunnermeier and Pedersen, 2009; He and Krishnamurthy, 2013; Gabaix and Maggiori, 2015; Adrian, Etula, and Muir, 2014; He, Kelly, and Manela, 2017; Du, Hébert, and Huber, 2019). 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. Gabaix and Maggiori (2015) present a new theory of exchange rate determination that builds on the limited risk-bearing capacity of financial intermediaries. Their model links several stylized facts about exchange rates, including CIP deviations, to the balance sheet of intermediaries. Our results are also related to the literature on limits to arbitrage. 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. More recently, Hazelkorn, Moskowitz, and Vasudevan (2020) report evidence that the bases implied from differences between futures and spot prices are driven by the cost of capital of intermediaries and consistent with uninformed leverage demand.

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 harmed 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 (2020) 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 the CIP condition and the recent regulatory changes. Section 3 provides a detailed description of the data and explains the construction of the contract-level dollar basis. Section 4 exploits the introduction of the UK leverage ratio framework for the dollar basis while Section 5 provides further analysis and refinements of the main results before concluding in Section 6. A separate Internet Appendix provides additional robustness tests and supporting analysis.

2 Background

This section reviews the covered interest parity (CIP) and then summarizes the key aspects of the post-crisis financial regulation, with a particular emphasis on the UK regulatory framework.

2.1 A Review of Covered Interest Rate Parity

The gap between the funding cost in the US cash market and the funding cost implied through the FX market defines the *dollar basis*, which is zero when CIP holds. In contrast, when CIP breaks down, the dollar basis deviates from zero and arbitrage opportunities arise. As an example, suppose that the dollar basis is negative. Then an arbitrageur could earn a profit by simultaneously borrowing in the dollar cash market, selling dollars for foreign currency in the spot market, lending the resulting amount in the foreign cash market, and entering a forward contract to convert the final proceeds in dollars at maturity, thus offsetting the initial short domestic position. This strategy is often implemented via an FX swap contract, which combines a spot with a forward transaction.

The CIP no-arbitrage relationship is routinely summarized as follows

$$1 + r_{\ell,t} = \frac{F_{i\ell,t}}{S_{i,t}}(1 + r_{i\ell,t}),$$

where $S_{i,t}$ denotes the spot exchange rate expressed in units of dollars per foreign currency i, $F_{i\ell,t}$ is the corresponding forward exchange rate with delivery date $t + \ell$, and $r_{\ell,t}$ ($r_{i\ell,t}$) is the (foreign) interest rate at time t with maturity ℓ. While the left-hand side of this equation indicates the gross return from lending in the dollar cash market, the right-hand side is the swap-implied dollar rate obtained from lending in the foreign cash market while *covering* foreign currency risk. When the underlying cash market instruments are equivalent in all respects, except for the currency of denomination, both strategies are equivalent and must deliver an identical payoff. This is the usual textbook-style exposition which abstracts from bid and ask prices, assumes an absence of default, liquidity, counterparty, and settlement risk, and relies on periodic interest rates (e.g., Bekaert and Hodrick, 2012).

Starting from mid-2014, the FX market has experienced a large and persistent negative dollar basis as documented, among many others, by Du, Tepper, and Verdelhan (2018). In this paper, we will empirically show that such a negative basis can be attributed to a steeper supply curve of forwards resulting from tighter leverage ratio constraints. As an illustrative example in the spirit of Prachowny (1970), suppose that a Japanese investor borrows an amount x_i in the local money market, exchanges yen for dollars in the spot market, invests in the US money market, and finally hedges her currency exposure by selling dollars for yen in the forward market. Assume that the supply of yen in the forward market is such that the forward price rises with the quantity of funds transacted x_i, i.e., $dF_i/dx_i > 0$.

The dealer takes the other side of the transaction and his profit π is defined (while removing both subscripts ℓ and t for simplicity) as

$$\pi = x(1 + r_i)\frac{F_i}{S_i} - x(1 + r),$$

with profit maximization implying that

$$\frac{\partial \pi}{\partial x_i} = (1 + r_i)\frac{F_i}{S_i} + (1 + r_i)x_i\frac{dF_i}{dx_i} - (1 + r) = 0. \tag{1}$$

By rearranging Equation (1), we obtain

$$1 + r = (1 + r_i)\left(\frac{F_i}{S_i} + \frac{F_i}{E_s}\right), \tag{2}$$

where $E_s \equiv (dx_i/dF_i)(F_i/x_i)$ denotes the elasticity of supply of forwards. With perfectly elastic supply (i.e., $E_s = \infty$) and Equation (2) reduces to the textbook no-arbitrage condition. When the supply of forwards becomes inelastic (i.e., $E_s \to 0$), instead, the dollar basis turns out to be negative. We now move to outline the key components of the financial regulation designed in the aftermath of the global financial crisis.

2.2 Post-Crisis Financial Regulation

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

As part of this comprehensive bundle of rules, the Basel Committee proposed a non-risk-weighted capital requirement – the leverage ratio – according to which a bank has to hold a minimum level of high-quality loss-absorbing (Tier 1) capital in proportion to its total consolidated assets. The latter include on-balance sheet exposures, derivatives exposures, securities financing transactions exposures, and other off-balance sheet items (e.g., BCBS, 2014).[3] By weighting all exposures equally, the leverage ratio can potentially increase the intermediation costs of those assets that are characterized by a low margin and high volume. This is especially true for FX derivatives which can substantially expand a dealer's balance sheet thus attracting a capital charge under the leverage ratio framework. For the calculation of the leverage ratio, moreover, banks have a limited capability to net out derivatives exposure that offset each other across different counterparties. This happens as derivatives generate an underlying asset exposure and counterparty credit risk exposure (e.g., BCBS, 2014).

The Basel Committee finalized the definition of the leverage ratio in May 2014 (BCBS, 2014) and required banks to disclose publicly their leverage ratio on a quarter-end basis since January 2015, with a mandatory minimum requirement postponed to January 2018. In the UK, however, a binding leverage ratio requirement was announced by the Prudential Regulation Authority in early December 2015 and became mandatory for major UK banks

[3] The leverage ratio differs from the capital ratio, which is defined as capital over risk-weighted assets. The weights depend on both credit and market risk with the latter being measured using a value-at-risk (VaR) based on 10-day holding period returns.

(those with deposits over £50 billion) since January 2016. The UK leverage ratio framework consists of a *minimum leverage ratio requirement* of 3% (three-quarters of which must be met with common equity Tier 1 capital instruments), a *countercyclical buffer*, and an *additional buffer for global systemically important institutions* (Bank of England, 2015c,b). Regarding the reporting requirements, the regulator introduced a transition period of 12 months during which the numerator and denominator of the leverage ratio were calculated using end-of-month figures during the reference quarter. Other regulated banks, i.e., small domestic banks as well as the subsidiaries of foreign banks, remained subject to the path set by the Basel Committee and continued to report their leverage ratio as a point-in-time estimate at quarter-end periods.[4] The key dates are presented in Figure A.1 in the Internet Appendix.

We will make use of the two regulatory events, namely, the introduction of the UK leverage ratio framework in 2016 (core analysis) and the public disclosure of the leverage ratio in 2015 (robustness analysis) to design difference-in-differences regressions. Ultimately, this exercise will help improve our identification, thus offering a supply-side explanation for the existence of a non-zero dollar basis. We now move to the description of the data before turning to our empirical analysis.

3 Data Description

This section first describes the trade repository data on forward contracts and then shows the construction of the contract-level dollar basis that we use in our empirical analysis.

3.1 Trade Repository Data

Over-the-counter (OTC) derivatives markets are regarded as the most opaque financial markets. Understanding the complexity and functioning of these "dark markets" is notoriously difficult as buyers and sellers negotiate the terms of the trade privately (e.g., Duffie, 2012). Not surprisingly, financial regulators have struggled for a long time to gather key information

[4] In the European Union, Basel III was introduced through a legislative package covering prudential rules for banks, building societies, and investment firms, i.e., the Capital Requirements Directive (2013/36/EU) implemented through national law, and the Capital Requirements Regulation (575/2013) directly applicable to firms across the Union.

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 improve profoundly the level of transparency in these markets. As part of this initiative, it was agreed that all OTC derivatives contracts would be reported to trade repositories to grant policy-makers and regulators access to high-quality and high-frequency data.

In the European Union (EU), this commitment was introduced with the European Market Infrastructure Regulation (EMIR), which has made mandatory for EU residents to report the details of any derivative transactions to a trade repository authorized by the European Securities and Markets Authority (ESMA) by the next business day. This reporting obligation covers all asset classes and applies to clearinghouses, financial counterparties, and non-financial counterparties that are legal entities under the EU jurisdiction. While this reporting obligation was introduced in 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 November 2014 that has substantially improved the quality of the data as discussed by Abad, Aldasoro, Aymanns, D'Errico, Rousova, Hoffmann, Langfield, Neychev, and Roukny (2016).

We have been given access to EMIR transactions, where at least one of the counterparties is a UK legal entity, by the Bank of England. Our dataset consists of currency forwards (i.e., outright forwards and forward legs of FX swaps) and currency basis swaps (i.e., floating-for-floating currency swaps) traded between December 2014 and December 2016 on six major currency pairs, i.e., Australian dollar (AUD), Canadian dollar (CAD), Swiss franc (CHF), euro (EUR), British pound (GBP), Japanese yen (JPY) relative to the US dollar (USD). We rely on submissions to DTCC Derivatives Repository, the largest trade depository in terms of market share, as there exists a lack of data harmonization across trade repositories. For each transaction, we observe information about counterparties (i.e., legal identifier and corporate sector) and the contract's characteristics (e.g., price, notional amount, maturity date, execution date, execution time) for more than 100 fields. We uncover an average daily volume of \$867 (\$24) billions for currency forwards (currency basis swaps), which corresponds to more than 42% of the daily trading activity for both sets of instruments (e.g., BIS, 2016), consistent with the fact that London is the world's largest FX trading center. See Figures

A.2 and A.3 in the Internet Appendix for additional details.

We collect raw data from the "trade activity report" and discard duplicates of the same transaction using the unique trade identifier as the EMIR imposes a double-sided reporting regime. In some 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 the 99.9% level.

We then 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 with either dealers or other clients. In line with this characterization, we categorize individual counterparties into dealers and clients and then group their transactions accordingly. We classify as dealers the largest banks by market share according to the 2015 and 2016 Euromoney FX survey. 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 (51) different legal entities for currency forwards (currency basis swaps). Dealers' counterparties are manually split into several sectors, i.e., real money investors (asset managers, pension funds, insurance firms, state institutions, and unclassified funds), hedge funds, non-financial corporates, nondealer banks (commercial banks, prime brokerage firms, and non-bank firms offering trading services), and central banks (including monetary authorities). In our sample, we classify more than 30,000 (400) clients for currency forwards (currency basis swaps), which correspond to more than 98% of the total trading volume. The residual 2% is associated with unclassified clients, namely, individual counterparties for which the legal identifier was either missing/incorrect or associated with an entity difficult to categorize. A breakdown by currency, maturity, and sectors can be visualized in the Internet Appendix A.

3.2 Contract-level Dollar Basis

We measure the dollar basis by synchronizing contract-level currency forwards with mid-quotes on spot exchange rates and overnight index swap (OIS) rates from Refinitiv Tick History at the second level.[5] Depending on the availability of OIS rates, we use all forwards between a one-week and three-month maturity. For non-standard maturity contracts (e.g., a 45-day forward), we rely on linearly interpolated OIS rates using the closest available tenors (e.g., one-month and two-month OIS rates). For AUD, CHF and CAD, we restrict the analysis to maturities between one month and three months as OIS rates are not only available for shorter maturities.

We construct the dollar basis for each contract τ, for nearly 3.5 million observations, as

$$B_{ij\kappa\ell,\tau} = \left[(1 + r_{\ell,\tau}) - (1 + r_{i\ell,\tau})\frac{F_{ij\kappa\ell,\tau}}{S_{i,\tau}}\right], \tag{3}$$

where $B_{ij\kappa\ell,\tau}$ denotes the dollar basis for currency i, dealer j, counterparty κ, and maturity ℓ, $r_{\ell,t}$ ($r_{i\ell,t}$) is the dollar (foreign) interest rate with maturity ℓ, $S_{i,t}$ is the spot exchange rate defined in units of dollars per currency i, and $F_{ij\kappa\ell,\tau}$ is the corresponding forward exchange rate. Only the latter price differs across parties consistent with the view that a non-zero basis is primarily caused by shifts in the supply and/or demand of forwards (Du, Tepper, and Verdelhan, 2018; Borio, Iqbal, McCauley, McGuire, and Sushko, 2018). Finally, we appropriately scale the interest rates (quoted in percentage per annum) and express $B_{ij\kappa\ell,\tau}$ in basis points (bps) per annum.

In our exercise, the forward price can be either a bid or an ask price whereas interest rates and spot exchange rates are mid quotes. We abstract from any bid-ask spread since Du, Tepper, and Verdelhan (2018) have already shown that transaction costs cannot fully explain CIP deviations in the recent period. Our interest, instead, is more on what causes the basis to move rather than measuring whether the basis represents a "free lunch". In particular, as our objective is to link the dollar basis to the leverage ratio constraints of dealer banks, we

[5] The dollar basis is generally computed with unsecured interbank rates (e.g., LIBOR rates based on quotes submitted at 11.00 am London time) coupled with spot and forward exchange rates (e.g., prices recorded by Bloomberg at 6.00 pm London time). The Internet Appendix Table A.1 shows that replacing LIBOR with OIS rates sampled at 11.00 am London time generates a qualitatively similar dollar basis.

will only use throughout our analysis transactions between dealers and clients. In doing so, we can control for unobserved characteristics at the client level in the spirit of Khwaja and Mian (2008) and thus isolate demand and supply factors.

TABLE 1 ABOUT HERE

Table 1 reports the descriptive statistics of the contract-level dollar basis in *bps* per annum. We first construct means, standard deviations, and quartiles for each business day using forward transactions between dealers and clients within the same day, and then average them across the entire sample. We employ maturities between one week and three months in Panel A, between one week and one month in Panel B, and longer than one month in Panel C. Because of data availability, we only display the maturity decomposition for the major currency pairs. The dollar basis is generally negative for all currency pairs and increases, in absolute terms, with the maturity of the forward contracts in line with Du, Tepper, and Verdelhan (2018). In Panel A, for example, the average basis for the USD/JPY is about −46 *bps* per annum. Clients at the 75th percentile pay a basis close to −6 *bps* per annum and clients at the 25th percentiles face a basis below −81 *bps* per annum. This basis, moreover, widens with the maturity since we approximately document an average basis of −40 and −54 *bps* per annum, respectively, in Panel B and Panel C.

We observe a substantial amount of dispersion, as measured by the standard deviation, ranging between 70 and 94 *bps* for USD/CHF and USD/GBP, respectively, when all maturities are pooled together. Since our granular dataset captures heterogeneity both across dealers and clients, it is natural to ask whether this source of variation reflects dispersion that occurs between or within dealers. To shed light on this question, we also calculate the between-dealer and within-dealer dispersion. The within-dealer dispersion is fairly high and ranges between 63 *bps* for the USD/CHF and 90 *bps* for the USD/GBP in Panel A, and it is about 13% higher for short-term maturity dollar basis. Our findings seem consistent with recent literature that documents the existence of large price dispersion in OTC markets, which are characterized by imperfect competition, opacity, heterogeneous clientele, price discrimination, bargaining, and search costs for investors (e.g., Duffie, Gârleanu, and Pedersen, 2005, 2007; Hara, Wang, and Zhou, 2018; Hendershott, Li, Livdan, and Schurhoff, 2020). For FX markets, in particular, Bahaj and Reis (2019) provide theoretical arguments by which a different degree of bargaining power between dealers and traders over the terms of a forward contract can produce bank-specific dollar basis. Hau, Hoffmann, Langfield, and Timmer (2019), moreover, use contract-level forwards on the USD/EUR between dealers and non-financial corporate clients and document a large price dispersion, which they attribute to search frictions and client sophistication.

We also document a sizeable between-dealer dispersion, once we control for any residual within-dealer variation, meaning that dealers can charge different dollar basis to their clients. It ranges between 22 *bps* for the EUR and 33 *bps* for the CAD in Panel A, and its cross-currency average evolves around 32 *bps* in Panel B and 22 *bps* in Panel C. A possible explanation could be that dealer banks face different capital constraints and thus different shadow costs in the spirit of the intermediary asset pricing literature (e.g., He and Krishnamurthy, 2013). In the insurance market, for example, one can observe different transaction prices for the same asset sold by insurers to households. Koijen and Yogo (2015) find that life insurers sold policies at prices below actuarial fair value and that this gap was larger for insurers facing tighter capital constraints. In the FX literature, Bahaj and Reis (2019) show that regulatory requirements affecting dealer banks constitute an additional source of variation for the distribution of dollar basis across dealer banks. Abbassi and Bräuning (2019), moreover, use contract-level forwards on the USD/EUR between German banks and their counterparties and find a large cross-sectional dispersion for forward premia, which they attribute to the banks' shadow cost of capital rather than the type of bank or contract (e.g., small or domestically focused banks, client trades, etc.).[6]

Figure 2 about here

Figure 2 provides a visual inspection of both between-dealer and within-dealer dispersion computed on each business day. We use currency forwards with a maturity between one week and three months and then average across all currency pairs. We plot these quantities (shaded lines) as well as the corresponding five-day centered moving averages (solid lines)

[6]Table A.2 in the Internet Appendix presents within-dealer and between-dealer dispersions after controlling for dealer and client sector fixed effects but results remain qualitatively similar.

that mitigate, for example, day-of-week effects. Both within-dealer and between-dealer dispersion display a fair amount of variation over time, with a peak at the beginning of 2015 and 2016. Overall, the existence of a cross-dealer dispersion means that there is a variation to study in the forward market and this source of information can be used to empirically measure the impact of regulatory restrictions on dealer banks. We can thus complement the existing literature, which typically relies on one forward price and can only learn how shocks to capital impact the aggregate supply curve for forwards, as He and Krishnamurthy (2018) point out.

3.3 Effective Spread on Forwards

We also compute the effective spread for currency forwards using our transaction prices synchronized with mid-quotes from Refinitiv Tick History akin to Hau, Hoffmann, Langfield, and Timmer (2019). Specifically, we construct the effective spread in relative terms, to ease the comparison across currency pairs, for each transaction τ as

$$E_{ij\kappa\ell,\tau} = d_\tau \times \left(\frac{F_{ij\kappa\ell,\tau} - F_{i,\tau}}{F_{i,\tau}} \right) \tag{4}$$

where $F_{ij\kappa\ell,t}$ is the contract-level forward, $F_{i,\tau}$ is the mid-quoted forward, and d_τ is the trade direction indicator associated with $F_{ij\kappa\ell,t}$, i.e., $d_\tau = 1$ when a client buys foreign currency (or equivalently sells US dollars) in the forward market and $d_\tau = -1$ when a client sells the foreign currency (or equivalently buys US dollars) in the forward market. We express the effective spread into *bps*. For this exercise, we linearly interpolate mid-quoted forwards across the closest available tenors for non-standard tenors and rely on the buy/sell indicator available in our dataset for currency forwards between October 2015 and December 2016, for an overall sample of about two million observations.

We present descriptive statistics on the relative effective spread in Table A.3 in the Internet Appendix. Similar to Table 1, we first construct means, standard deviations, and quartiles for each business day using all dealer-to-clients forward transactions within the same day, and then average them across the entire sample. The average spread is generally below one *bps*, increases with the contract maturity, and displays a large dispersion.[7] We also report

[7] If we restrict our sample to currency forwards on the USD/EUR between dealers and corporate clients

the between-dealer and within-dealer dispersion, which are proportionally similar to the ones recorded in Table 1. For example, the average within-dealer dispersion is approximately 10 *bps* while the average within-dealer dispersion is not far from 3 *bps*, thus implying a substantial amount of cross-dealer dispersion, once you account for the residual dealer dispersion. Overall, this exercise suggests that a large amount of dispersion observed in our dataset is a genuine feature of the data rather than an artifact of our matching procedure.[8]

4 Dollar Basis and Leverage Ratio

This section studies the impact of the regulatory leverage ratio on the dollar basis, thus offering a supply-side interpretation for the recent failure of CIP condition. We exploit two plausibly exogenous variations affecting the leverage exposure of major dealer banks within a quasi-natural experimental exercise. The first exogenous variation, which we use in our core analysis, is based on the introduction of the UK leverage ratio framework in January 2016. The second one, which we use as a robustness exercise, employs the public disclosure of the leverage ratio in January 2015. We enhance our identification strategy by absorbing changes in demand conditions at the client and currency level following the path-breaking work of Khwaja and Mian (2008) by including a client-currency-time fixed effect. For its implementation, we collapse our contract-level dollar basis into a weekly volume-weighted dollar basis as this allows us to identify 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 tighter leverage constraint.

4.1 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 in January 2016, which only affected major

and use the effective spread in pips (i.e., the numerator of Equation (4)), the mean is about 5.7 pips (with a standard deviation of 28.6), which is largely comparable to the mean of 6.9 pips (with a standard deviation of 19.4) reported in Hau, Hoffmann, Langfield, and Timmer (2019).

[8] Table A.4 in the Internet Appendix presents the summary statistics on the forward premia computed by synchronizing contract-level forwards with midquoted spot rates from Refinitiv Tick History. Both within-dealer and between-dealer dispersion are proportionally comparable to those reported in Table 1.

UK banks. The subsidiaries of foreign banks (including all other domestic banks) continued to fall under the prescription of the EU legislation. 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 us to identify treatment and control groups of dealer banks. In our sample, four dealer banks (Barclays, HSBC, Royal Bank of Scotland, and Standard Chartered) form our treatment group whereas the subsidiaries of international banks (Citibank, Credit Suisse, Goldman Sachs, JP Morgan, Morgan Stanley, and Nomura) act as a control group. 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 should thus be regarded as largely comparable. This is important as any causal inference would be compromised if our treated banks were systematically different, say in terms of business models or funding strategies, from control banks.[9]

In addition to a minimum requirement of 3% plus additional buffers, the UK framework has also introduced an important change to the reporting obligations. During a transitional period of 12 months running 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. This end-of-month average rule aimed at reducing the ability of regulated banks to window-dress their balance sheet at quarter ends, thus making the leverage ratio rule more effective. As banks had little incentive to adjust their reporting obligations ahead of the implementation date, the change in the reporting obligations can be seen as a plausibly exogenous variation that affected a group of banks while leaving other similar banks unaffected.

In our exercise, the pre-intervention period runs from November 2 to December 18, 2015, whereas the post-intervention period runs between January 11 and February 26, 2016. Both periods are intended to capture two months of observations before and after the regulatory

[9] Other European dealer banks are not included in our control group as they have branches rather than subsidiaries in the UK. As a result, they are not UK legal entities and most of their dealer-to-client transactions are not observed by the UK regulator.

shock while removing the weeks bracketing the year-end to avoid, for example, the G-SIB surcharge, end-of-year volatility and tax-driven window-dressing effects (e.g., Kotidis and van Horen, 2018). Our results remain quantitatively and qualitatively similar if we keep these two weeks of data. For this exercise, we also discard forward contracts with intra-month contractual and maturity dates as these contracts should not affect the balance-sheet exposure of dealer banks at the end of the month. An example would be a short-maturity forward contract agreed on November 13, 2015, and expiring on November 20, 2015. Moreover, to minimize any cross-period contamination, we further eliminate forward contracts traded during the pre-intervention period and affecting the balance sheet exposure of a dealer bank at the end of the month during the post-intervention period. For instance, a two-month forward contract traded on December 15, 2015 (pre-intervention period) would affect the balance sheet of a dealer at the end of January 2016 (post-intervention period). We now turn to illustrate our methods before presenting our empirical evidence.

4.2 Methods and Empirical Evidence

We use difference-in-differences regressions based on the following specification:

$$B_{ij\kappa,t} = \gamma D_{affected} \times D_{post} + \delta' X_{j,t-1} + fe + \varepsilon_{ij\kappa,t}, \quad (5)$$

where $B_{ij\kappa,t}$ is the volume-weighted dollar basis measured in a week t for currency i, dealer j and counterparty κ, $D_{affected}$ is a dummy variable that takes on the value of one for affected dealers and zero for unaffected dealers thus capturing the time-invariant difference in outcomes between the two groups, D_{post} is a dummy variable that selects observations after the regulatory intervention and absorbs the impact of time-varying factors that are group-invariant, and $D_{post} \times D_{affected}$ is the interaction term between time and treatment group dummies. $X_{j,t-1}$ refers to a set of lagged control variables that capture time-varying observed dealer characteristics at the weekly frequency such as counterparty and liquidity risk. We use the first-difference of the 5-year CDS spread and the log volume of currency forwards. The coefficient γ measures the treatment effect, namely, 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) before and after the regulatory change. A negative estimate of γ would suggest that affected dealers (relative to unaffected dealers) charge a premium to clients borrowing dollars through the FX market in response to the regulatory shock. We complement our specifications with both time-invariant (e.g., dealer) and time-variant (e.g., currency $\times$ client $\times$ time) fixed effects (fe). The interaction with time is obtained with a weekly time (calendar date) fixed effect. We estimate the difference-in-differences regressions via least-squares and cluster standard errors at the dealer level.[10]

Table 2 reports the estimates of γ using different specifications with multiple combinations of fixed effects. We find that estimates of γ are always negative and statistically significant, even after controlling for observed dealer characteristics and absorbing changes in demand conditions at the currency and client level. Our findings suggest that, after the introduction of the UK leverage ratio framework, dealer banks subject to the policy shock charged a wider negative dollar basis to their clients relative to unaffected dealer banks.

Table 2 about here

In specifications (1) and (2), for example, we control for the time-invariant dealer and currency fixed effects as well as for time-variant unobserved characteristics at the client level in the spirit of Khwaja and Mian (2008). This is important as individual counterparty fundamentals could drive the widening of the dollar basis irrespective of dealer characteristics and we would be unable to give a supply interpretation to our estimates. Note that separate time fixed effects are spanned by the client $\times$ time fixed effect and are, thus, dropped here. The first specification does not include any dealer-specific variables and reports a negative and highly statistically significant estimate of γ, that is, -18.68 *bps* per annum with a standard error of 5.58. The second one further controls for dealer-specific variables but produces qualitatively similar results: the estimate of γ is about -18.11 *bps* per annum with a standard error of 5.89. To translate these estimates into economic terms, we employ a simple back-of-the-envelope calculation knowing that the average maturity of a forward contract is roughly 33 days while its average volume is about \$43.75 million in our sample. We thus

[10] Our results remain robust if we collapse data into a pre- and post-regulatory period to ensure that the standard errors are not artificially low because of serial correlation (e.g., Bertrand, Duflo, and Mullainathan, 2004). We also run a wild cluster bootstrap exercise with 1000 replications to verify the robustness of our analysis for the number of clusters (e.g., Cameron and Miller, 2014).

find that, on average, a dealer bank affected by the regulatory shock will approximately charge its client an additional cost of $(18.11/10{,}000) \times (33/365) \times 43.75$ million = \$7,164 per transaction relative to unaffected banks.

Specifications (3) and (4) further absorb all time-variant unobserved characteristics at the currency level via currency $\times$ client $\times$ time fixed effects. These would include, for example, heterogeneity in currency liquidity and volatility which are not directly observable. The first of these specifications do not include any dealer-specific control variables and produces a negative and statistically significant γ estimate of about -15.90 *bps* per annum with a standard error of 7.43. The second one further controls for dealer-specific variables but produces a virtually identical estimate. The economic value of γ remains large and translates into a premium of about \$6,260 per transaction between affected and unaffected dealer banks.

To sum up, we show that the supply of dollar funding in the FX market steepened for affected dealer banks while controlling for changes in client demand, after the introduction of the UK leverage ratio framework. We thus provide empirical evidence on the causal relationship between the leverage ratio requirement and deviations from CIP condition. We now move to disentangle the dollar basis by trading direction.

4.3 Dollar Basis and Trading Direction

The negative dollar basis has been associated with an increase in FX hedging imbalances and tighter balance sheet costs for global banks (e.g., Borio, Iqbal, McCauley, McGuire, and Sushko, 2018; Du, Tepper, and Verdelhan, 2018). This narrative begs the question of whether the leverage ratio requirement has a more pronounced effect on clients that synthetically borrow dollars (or equivalently sell US dollars forward) as opposed to clients that synthetically lend US dollars (or buy US dollars forward).

Figure 3 about here

As a preliminary exercise, we inspect the aggregate order imbalances between dealers and clients in the forward market, i.e., the value of buyer-initiated orders minus the value of seller-initiated orders for a given currency pair with the initiator of the transaction being the non-quoting counterparty. We rely on the buy/sell indicator of currency forwards available in our dataset between November 2015 and December 2016. Hence, we sign a transaction negatively (positively) if the initiator of the transaction is selling (buying) dollars in the forward market against dealers such that a negative (positive) order flow indicates net selling (buying) pressure on the US dollar in the forward market by end-user clients. Finally, we aggregate the order imbalance across all currency pairs and client sectors every week and then display the mean values, standardized by the corresponding standard deviation to ease the comparison, in Figure 3. A negative value means that, on average, clients in a given sector sell dollars forward or equivalently fund themselves in dollars in the FX market, and vice versa. When we categorize order flow by client type, we document that real money and non-financial corporate firms sell dollars forward in line with the recent literature. Arai, Makabe, Okawara, and Nagano (2016), for example, report that Japanese insurance companies hedge most of their foreign bond investments while corporations have also increased the issuance of bonds denominated in euro and yen while swapping these proceeds into dollars. Central banks and nondealer banks, on the other hand, buy dollars forward consistent with the anecdotal evidence that some central banks have exploited CIP deviations for "return enhancement" on their FX reserves (e.g., Debelle, 2017) with nondealer banks likely acting on behalf of other investors. The average order flow for hedge funds is approximately zero consistent with the fact that they typically bet on dollar-neutral long-short strategies such as carry, value, and momentum. Overall, our sample confirms the aggregate findings reported by the recent literature.

Table 3 about here

We now move to answer our question by using the buy/sell indicator of currency forwards so that we can categorize each client transaction by its trading direction. In doing so, we can unpack the left-hand side of Equation (5) for client transactions selling and buying dollars forward against dealer banks, respectively. The former demand synthetic dollars whereas the latter supply synthetic dollars. Note that we do not change the sign of the dollar basis depending on the direction of the transaction but rather run separate difference-in-differences regressions for different types of client transactions.

We report the results in Table 3 and find that estimates of γ are always negative and statistically significant for clients selling dollars forward, even after controlling for the dealer-specific variables and absorbing changes in demand conditions at the currency and client level. In contrast, we record a slightly positive yet statistically insignificant estimate of γ for clients buying dollars forward. These findings indicate that, after the introduction of the UK leverage ratio framework, dealer banks subject to the policy shock have charged a wider negative dollar basis only to clients seeking dollar funding in the FX market relative to unaffected dealer banks.[11]

Specification (1), for example, employs the dollar basis for clients selling dollars forward as a dependent variable. We add a currency $\times$ client $\times$ time fixed effect that absorbs all time-variant unobserved characteristics at the client and currency level beyond a time-invariant dealer fixed effect. The estimate of γ equals -21.71 *bps* per annum and is highly statistically significant with a standard error of 5.18. In terms of economic value, on average, dealer banks affected by the policy shock (relative to unaffected banks) approximately charge clients selling dollars forward an additional cost of about $(21.71/10{,}000) \times (33.2/365) \times 48.69\,\text{million} =$ \$9,615 per transaction, being the average maturity and volume of forwards close to 33.2 days and 48.69 million, respectively, for this type of client in our sample. Specification (2) further introduces dealer-specific control variables but results remain both statistically and economically equivalent. Specifications (3) use the dollar basis for clients buying dollars forward as the left side variable but produces a statistically insignificant estimate of γ, i.e., 2.70 *bps* per annum with a standard error of 12.59. In economic terms, this is equivalent to an additional cost of $(2.70/10{,}000) \times (32.9/365) \times 38.42\,\text{million} =$ \$935. Controlling for dealer-specific variables in the specification (4) makes no qualitative difference.[12]

FIGURE 4 ABOUT HERE

Figure 4 visually summarizes the impact of the regulatory intervention on the dollar basis for

[11] Table 3 employs fewer observations than Table 2. While the latter table keeps all clients with at least two trading relationships in a given week regardless of the trading direction, the former table only selects clients with at least two buying or selling trading relationships in a given week.

[12] Table A.6 in the Internet Appendix presents an equivalent exercise based on the volume-weighted daily dollar basis. Results remain virtually identical albeit we have a fewer number of clients with multiple trading relationships on a single day.

both clients selling (left chart) and clients buying (right chart) dollars forward. We report the mean difference in dollar basis between the treatment and the control group two months before and after the change in the leverage ratio reporting requirements. We denote the 95% confidence interval with the shaded area. While for clients borrowing synthetic dollars there is a statistically significant decline in the mean difference after the regulatory shock, we observe no change in the mean difference for clients lending synthetic dollars.

Table 4 about here

In addition to using the buy/sell indicator, we also group end-users into natural hedgers (i.e., real money investors and non-financial corporate firms) and others (i.e., hedge funds, nondealer banks, and central banks). Hence, we run separate difference-in-differences regressions for both types of end-users and display the evidence in Table 4. Estimates of γ for natural hedgers are largely comparable, both statistically and economically, with those recorded for clients selling dollars forward in Table 3. For the group of end-users labeled as *others*, we obtain a negative but statistically insignificant estimate of γ. This exercise further confirms the effect of the leverage ratio requirement on the dollar basis for clients demanding dollar funding as opposed to clients providing dollar funding in the FX market.

4.4 Placebo Tests

The difference-in-differences method relies on the assumption that outcomes have equal trends between affected and unaffected dealers in the absence of treatment, i.e., confounders varying across groups are time-invariant and confounders varying across time are group invariant. When the underlying common trend assumption is invalid, the estimate of γ is biased as the trend for the control group is not a valid estimate of the counterfactual trend that we would have observed for the treatment group in the absence of the regulatory change. We test the validity of the underlying assumption of equal trends in two different ways. In our first assessment, we run difference-in-differences regressions using a placebo regulatory date, that is, a fake shock at a different time than the actual regulatory change. In our second assessment, our empirical specification employs a placebo outcome, i.e., a dollar basis implied from contracts that should not be affected by the introduction of the UK leverage framework.

Table 5 about here

Table 5 presents estimates of γ for two placebo dates. Panel A sets April 1, 2016, as a placebo shock and uses the dollar basis for all client transactions, only client transactions selling dollars forwards, and only client transactions buying dollars forwards, respectively, as a dependent variable. Estimates of γ are not only statistically insignificant but are also economically small. For example, for all client transactions, the estimate of γ corresponds to less than 3.4 *bps* per annum. Panel B, moreover, considers October 1, 2015, as a placebo shock and uses the dollar basis for all client transactions, only natural hedgers, and only other end-users, respectively, as dependent variables (recall that the buy/sell indicator is not available before November 2015 in our sample). Results remain both qualitatively and quantitatively similar.

Table 6 about here

Table 6 displays estimates of γ for two placebo outcomes. Panel A keeps the actual regulatory shock on January 1, 2016, but employs the dollar basis from currency forwards with intra-month contractual and maturity dates as a dependent variable. These forwards should not alter the month-end balance-sheet capacity of dealer banks as they do not enter the leverage ratio calculation. We find that estimates of γ are statistically insignificant and economically small regardless of whether we use all client transactions or split them into transactions that buy and sell dollars forward, respectively. For all client transactions, for example, the estimate of γ is about 3.2 *bps* per annum.

In Panel B, we continue to use the actual regulatory shock on January 1, 2016, but employ the dollar basis implied from currency basis swaps as the outcome variable. Currency basis swaps are long-term contracts with a maturity up to 30 years whose spread is quoted on the foreign currency leg against the dollar and can be interpreted as long-term CIP deviations (e.g., Du, Tepper, and Verdelhan, 2018).[13] For this exercise, we use the spread of

[13] "Paying" the basis means borrowing the foreign currency versus lending dollars while "receiving" the basis implies lending the foreign currency versus borrowing in dollars. A negative basis denotes strong demand for dollars as one party is willing to receive a lower interest rate on its foreign currency position.

contract-level currency basis swaps measured at the currency, dealer, and sector level and saturate the difference-in-differences regressions with the dealer and currency-sector-time fixed effects. We are unable in this case to work with weekly observations coupled with client fixed effects as we observe few clients with multiple trading relationships at the weekly frequency. Also, we present results for all transactions as well as for natural hedgers and other end-users, respectively, since the buy/sell indicator is unavailable for currency basis swaps. The estimates of γ are both statistically insignificant and economically small, and this is expected as currency basis swaps affect the balance-sheet capacity of dealer banks both at the month-end and quarter-end periods.

To sum up, we provide empirical evidence using both placebo shocks and placebo outcomes on the validity of the parallel trend assumption. These exercises also serve to mitigate any concerns on alternative regulatory shocks taking place within our sample.

4.5 Risk-weighted Capital Requirements

In addition to a minimum leverage ratio that is independent of any risk assessment, dealer banks are also subject to risk-weighted capital requirements, which have substantially increased since the global financial crisis. The key aspect of the capital requirements is that risk weights depend on both credit and market risk with the latter being measured using a value-at-risk (VaR) based on 10-day holding period returns, typically computed over a window that corresponds to the past calendar year. Since short-term arbitrage opportunities have zero VaR, the risk-weighted capital requirements are more likely to play a role for long-term arbitrage deviations (Du, Tepper, and Verdelhan, 2018). In this section, we complement our previous analysis and investigate the impact of risk-weighted capital measures on both short-term and long-term arbitrage deviations.

While the leverage ratio requirement is applied similarly across major dealer banks, a specific component of the risk-weighted capital requirements is set by the UK regulator differently at the dealer level. Specifically, the UK capital requirements are split into 'Pillar 1' and 'Pillar 2' requirements. The former is common across banks and is meant to capture credit and market risks while the latter is bank-specific and is defined at the discretion of the regulator to capture risks that are not related to Pillar 1. Based on this argument and further empirical analysis, Aiyar, Calomiris, Hooley, Korniyenko, and Wieladek (2014) and Forbes, Reinhardt, and Wieladek (2017) conclude that Pillar 2 requirements should reflect mostly non-balance-sheet risks and therefore should be regarded as exogenous to bank balance-sheet variables. Pillar 1, in contrast, may not be exogenous and likely driven by omitted bank-related variables.

Table 7 about here

We analyze the impact of risk-weighted capital requirements on the dollar basis by running fixed-effects panel regressions between December 2014 and December 2016. In Panel A of Table 7, we focus on the (short-term) dollar basis implied from currency forwards using the following specification:

$$B_{ij\kappa,t} = \beta C_{j,t-1} + \delta' X_{j,t-1} + fe + \varepsilon_{ij\kappa,t} \tag{6}$$

where $B_{ij\kappa,t}$ is the volume-weighted dollar basis on week t for currency i, dealer j, and counterparty κ, $C_{j,t-1}$ is the Pillar 2 component of the risk-weighted capital requirements for dealer j, and $X_{j,t-1}$ refers to bank-specific lagged control variables, namely, the change in the 5-year CDS spread, log volume of currency forwards, bank size (log of a bank's total assets in levels), liquid asset share (holdings of liquid assets scaled by non-equity liabilities), and deposit share (fraction of the bank's balance sheet financed with core deposits).[14] We saturate our specifications with both time-invariant (e.g., dealer) and time-variant (e.g., currency $\times$ client $\times$ time) fixed effects (fe). The interaction with time is obtained with a calendar date (week) fixed effect. We cluster standard errors by dealer and time dimension. The estimates of β, across different specifications, are all statistically insignificant, thus suggesting that the risk-weighted capital requirements have a negligible impact on a short-term dollar basis.

In Panel B, we turn to the (long-term) basis from currency basis swaps using specifications similar to those in Equation (6). Specifically, we replace $B_{ij\kappa,t}$ with $B^{xccy}_{ij\kappa\ell,t}$, i.e., the

[14] The Pillar 2 of the risk-weighted capital requirements, bank size, liquid asset share, and deposit share are collected from the Bank of England. These data are available quarterly and we retrieve higher-frequency observations by forward filling, i.e., we keep the latest available observation fixed until a new one is made available. We present a description of these variables in Panel B of Table A.5 in the Internet Appendix.

contract-level dollar basis from currency basis swaps recorded on day t for currency i, dealer j, counterparty κ, and maturity ℓ. We saturate our specifications with both time-invariant (e.g., dealer, hour, maturity) and time-variant (e.g., currency $\times$ sector $\times$ time) fixed effects (fe). The interaction with time is obtained with a calendar date (day) fixed effect. We cluster standard errors by dealer and time dimension. We find strong evidence that the risk-weighted capital requirements affect the long-term dollar basis being the estimate of β negative and highly statistically significant. Specification (4), for example, uses the Pillar 2 capital requirement, controls for a variety of bank-specific variables, and adds both time-invariant (i.e., hour, maturity, and dealer) and time-variant (i.e., currency-sector-time) fixed effects an produces a highly statistically significant estimate of -5.79. In economic terms, the currency basis swap widens by approximately 18 *bps* per annum when the lagged capital requirements increase by one standard deviation (i.e., $5.79 \times 3.10 \approx 18$). Our results suggest that long-term CIP deviations, differently from the short-term ones, have increased in response to higher risk-weighted capital requirements.[15]

4.6 Robustness Analysis

We now present a battery of robustness exercises that further corroborate our findings. To save space, we summarize the key findings here and then report the detailed results in the Internet Appendix.

4.6.1 Subsample Analysis by Currency and Maturity

In our core analysis, we work with six currency pairs and currency forwards with maturity ranging between one week and three months. Table A.9 in the Internet Appendix investigates the robustness of our findings when working with different combinations of currency pairs and maturities. In Panel A, for example, we split the major currency pairs (i.e., EUR, GBP and JPY relative to USD) from the other ones (i.e., AUD, CAD, and CHF relative to USD) and repeat the difference-in-difference regressions with trading directions. The estimate of γ for major currency pairs is highly statistically significant and virtually identical to the one documented in Table 3. For the remaining currency pairs, the impact of the leverage

[15] Results in Panel A remain qualitatively identical when using the contract-level dollar basis and sector fixed effects. Also, the estimates of δ for both Panel A and Panel B are presented in Tables A.7–A.8 in the Internet Appendix.

ratio on the dollar basis implied from the estimate of γ is marginally more pronounced but comparable with the basket of major currency pairs. In Panel B, we separate short-term maturity currency forwards (between one week and one month) from longer-term ones. The magnitude of the γ estimate is slightly larger (but comparable) for short-term contracts (-25 with a standard error of 9.27) than long-term ones (-23 with a standard error of 6.92). These results suggest that the maturity of currency forwards (and the resulting annualization of the dollar basis) is not artificially driving the magnitude of our estimates. Overall, we confirm the general pattern uncovered in our core analysis. Table A.10 in the Internet Appendix further constructs the dollar basis for standard maturity currency forwards (i.e., one week, one month, two months, and three months) and report qualitatively similar results.

4.6.2 Client Hedging Demand

There could be an alternative explanation to rationalize our findings. UK banks, for example, may have absorbed for any unobserved reason a higher level of client hedging demand than international banks during the pre-treatment period. In the post-treatment period, then, they may have counterbalanced a saturated balance-sheet capacity by requiring a wider basis to their clients. To shed light on this possible concern, we regress for the pre-treatment period only the weekly order imbalance of dealer j and currency i on a dummy variable that equals one for affected dealer banks and zero otherwise. We also add the lagged dealer-specific control variables and a currency $\times$ time fixed effect. We report the estimates in Table A.11 in the Internet Appendix and find no statistically significant difference between affected and unaffected banks. As a result, a heterogeneous hedging demand pressure from clients is not an explanation for our main findings.

4.6.3 Effective Spread on Currency Forwards

The previous sections provide evidence that the leverage ratio requirement affects the dollar basis when clients demand synthetic dollar funding. To corroborate our findings, we also examine the impact of the leverage ratio requirement on the relative effective spread between dealers and clients. If dealers are less aggressive in seeking client orders, say for volatility, liquidity, or other unobserved reasons, we should then expect that dealers charge a spread to clients regardless of their trading directions.

For this exercise, we repeat the difference-in-differences regressions presented in Table 3 but replace the dollar basis with the relative effective spread of contractual forward rates relative to interdealer quotes described in Section 3.3. We report the estimates in Table A.12 and find evidence that the leverage ratio rule affects the effective spread when clients raise dollar funding via the FX market. The estimate of γ is approximately equal to 2.84 and is highly statistically significant, after controlling for the dealer and currency-client-time fixed effects. Moreover, adding dealer-specific control variables does not qualitatively alter our estimate. In contrast, we find no statistically significant relationship between effective spread and leverage ratio requirement for clients trading on the opposite side of the FX market. Table A.13 in the Internet Appendix reports comparable results when using different currency and maturity combinations. These results, taken together, suggest that what we capture in the data is unlikely to be attributed to liquidity effects.

4.6.4 The Public Disclosure of the Leverage Ratio

We also exploit, as an alternative plausibly exogenous shock, the obligation of dealer banks to publicly disclose their point-in-time quarter-end leverage ratio after January 2015 (see, for example, Du, Tepper, and Verdelhan, 2018; Haynes, McPhail, and Zhu, 2019). 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 suggested by regulators. Failing to disclose a leverage ratio in line with these expectations could have increased, for example, the cost of capital for highly leveraged banks as a higher level of financial disclosure reduces information asymmetries (Haynes, McPhail, and Zhu, 2019).

Depending on their ex-ante leverage exposure, banks with a larger shortfall in regulatory capital may have charged a wider dollar basis to their counterparty clients. We construct the leverage ratio of dealer banks as of December 2007, i.e., before the policy debate on excessive leverage in the banking sector (e.g., Draghi, 2008), using shareholders' claims to total assets as provided by the Bank of England (see, for more details, Bank of England, 2015a). We then form a treatment and a comparison group of dealer banks using the cross-sectional median value of this measure, with the former (latter) group including banks with a leverage ratio lying below (above) the median value. Hence, we run difference-in-differences regressions around January 2015 to test the causal impact of the leverage ratio disclosure on the dollar basis. The public disclosure requirement constitutes a shock under the assumption that it was not anticipated by banks.[16]

In our exercise, the pre-intervention period runs from December 1, 2014, (when our sample starts) to December 19, 2014, while the post-intervention period runs from January 12 to March 29, 2015. Both periods are intended to capture a month (quarter) of observations before (after) the regulatory shock while removing two weeks of data bracketing the end of the year. We discard forward contracts with intra-quarter contractual and maturity dates as these contracts do not affect the leverage ratio, calculated as a point-in-time estimate at quarter-end periods. In addition to using contracts relative to all clients, we also categorize end-users by trading directions. Since the buy/sell indicator for forward contracts is not available for this period, we split clients into natural hedgers (i.e., real money investors and non-financial corporate firms) and others (i.e., hedge funds, nondealer banks, and central banks). The former (latter) are likely to demand (provide) synthetic dollar funding via the FX market.

We run difference-in-differences regressions and report the estimates of γ in Panel A of Table A.14 in the Internet Appendix. For the natural hedgers, the estimate of γ is negative and highly statistically significant, i.e., -25 *bps* per annum with a standard error of 9.56. For other end-users, we uncover no statistically significant estimate of γ. In Panel B, moreover, we use a placebo shock by shifting the time window by three months but uncover no statistically significant estimate of γ. This alternative quasi-experimental exercise confirms the role of the leverage ratio requirement as a key driver of the negative dollar basis.

5 Further Analysis and Extensions

This section presents a number of additional exercises that complement and refine the results reported earlier. Firstly, we explore the role of bilateral netting between dealers and clients and investigate whether dealers affected by the UK leverage ratio framework have discriminated their clients on these terms. Secondly, we study whether clients with high

[16] We also rank dealer banks into a treatment and control block using the leverage ratio as of December 2012, i.e., before the proposal made by the Basel Committee on the introduction of a leverage ratio requirement. Results, which we report in Table A.15 in the Internet Appendix, remain qualitatively identical.

exposure to affected dealers were able to switch to unaffected dealers after the regulatory change. Finally, we examine whether affected dealers have stopped trading with existing clients and reduced their intake of new clients after the regulatory shock.

5.1 Netting between Dealers and Clients

A derivative contract generates an exposure originating from the underlying asset and an exposure reflecting the creditworthiness of the counterparty entity. The Basel III leverage ratio framework recognizes both types of exposures and dictates that a dealer is unable to net out long and short positions across underlying exposures unless eligible transactions are undertaken against the same counterparty. When netting is permitted, a bank can consolidate outstanding derivatives positions against a particular counterparty into a single legal obligation. This means that highly offsetting transactions should have a quantitatively smaller impact on the balance-sheet exposure of a dealer through the calculation of the leverage ratio. We are unable to precisely evaluate the amount of netted positions between dealers and clients as part of the relevant information is not directly available to us.[17] We can identify, however, clients that do not net transactions and clients that net transactions during the pre-treatment period and then test whether UK banks have charged them a different dollar basis after January 2016. For simplicity, we refer to clients with zero netting as 'directional clients' and to clients with non-zero netting as 'non-directional clients'. In our sample, roughly 69% of the clients have zero netting against dealer banks during the pre-treatment period.

FIGURE 5 ABOUT HERE

As described in Figure 5, we net between identical counterparties long and short currency forwards on a given currency pair during the pre-treatment period. Since forward contracts up to one-year maturity equally contribute to the potential future exposure and have an identical add-on factor, we offset long and short contracts with the same maturity date

[17] To assess the exposure arising from a derivative, a bank must consider the replacement cost computed via marking to market plus an add-on for potential future exposure. The treatment of these components, moreover, can be affected by the existence of an eligible bilateral or multilateral netting contract as well as any posted cash collateral.

but different inception dates. For example, Client A and Client B have pure directional transactions with Dealer X and, as a result, will have zero netting. Client C, instead, enters on the day t into a forward contract that delivers US dollars in exchange for the foreign currency on the day T, with $T > t$. On the day τ, however, Client C decides to offset his position by trading a forward contract that delivers foreign currency in exchange for dollars on the day T, with $t < \tau < T$. Since both transactions are established against the same dealer X, transactions with Client C can be to some extent netted. For illustration purposes, Figure A.6 plots the client netting ratio (i.e., netted positions divided by the corresponding total volume for each client) averaged within each client sector. We find that hedge funds have the highest netting ratio while corporate firms and central banks have the lowest one. This is consistent with the view that non-financial corporate firms use FX derivatives purely for hedging whereas hedge funds reverse speculative positions to either realize profits or limit losses.

We incorporate the role of netting into our analysis by augmenting the specification presented in Equation (5) as follows

$$
\begin{aligned}
B_{ij\kappa,t} = {} & \gamma_1 D_{affected} \times D_{post} + \gamma_2 D_{affected} \times D_{post} \times D_{zeronet} + \\
& \gamma_3 D_{affected} \times D_{zeronet} + \gamma_4 D_{post} \times D_{zeronet} + \delta' X_{j,t-1} + \alpha_j + \alpha_{i,\kappa,t} + \varepsilon_{ij\kappa,t},
\end{aligned} \tag{7}
$$

where $D_{zeronet}$ is a dummy that equals one when netting between dealer j and client κ is zero during the pre-treatment period (and zero otherwise), α_j is the time-invariant dealer fixed effect, and $\alpha_{i,\kappa,t}$ denotes the currency $\times$ client $\times$ time fixed effect. The coefficient γ_1 measures the dollar basis between affected dealers and non-directional clients whereas the sum of γ_1 and γ_2 quantifies the dollar basis between affected dealers and directional clients.

TABLE 8 ABOUT HERE

Panel A of Table 8 reports the estimates of γ_1 and γ_2. We document a substantial amount of heterogeneity between directional and non-directional clients for synthetic dollar borrowing since the estimate of γ_1 is about -6 *bps* (with a standard error of 5.7) whereas the estimate of γ_2 is close to -48 *bps* (with a standard error of 15). Taken together, these figures suggest that dealer banks affected by the regulatory shock have a charged premium of 54 (6) *bps* per annum to more (less) capital intensive client transactions relative to unaffected dealer banks after January 2016. In other words, borrowing synthetic dollars is significantly more expensive for directional clients than for non-directional clients as the former undertake transactions that erode the regulatory capital of a dealer bank. For synthetic dollar lending, in contrast, we register no statistical evidence of CIP deviations even after considering client netting.

In Panel B of Table 8, we extend the analysis to the log volume of currency forwards by replacing $B_{ij\kappa,t}$ with $ln\ V_{ij\kappa,t}$ in Equation (7). For synthetic dollar funding, we find that major UK banks (relative to international banks) have traded substantially more with non-directional clients and considerably less with directional clients. In particular, the estimates of γ_1 and γ_2, both statistically significant, are about 0.25 and -0.48, respectively, and translate into a 25% volume increase for less capital intensive transactions and a 23% volume contraction for more capital intensive transactions. For synthetic dollar lending, no statistical relationship between volume and regulatory change is recorded. We also offset long and short forward transactions between dealers and clients, regardless of the currency pair, but find qualitatively identical results as shown in the Internet Appendix Table A.16. To sum up, the dollar basis widens and the volume falls for more capital intensive client transactions that synthetically borrow dollars against major UK banks (relative to other banks) during the post-treatment window.[18]

5.2 Substitution Effects and New Relationships

The findings reported in the previous section beg the question of whether directional clients (with more capital intensive transactions and higher costs of synthetic dollar borrowing) were able to migrate from affected to unaffected dealer banks after the introduction of leverage ratio framework. We answer this question by running a set of client-level regressions and ultimately test whether directional clients that were more exposed to dealer banks affected by the new regulation have experienced a decline in their trading volume of currency forwards

[18] For the log volume, we also run specifications without $D_{zeronet}$ and report the estimates in Table A.17 in the Internet Appendix. While estimates of γ are statistically insignificant, the sign suggests that major UK banks (relative to other banks) have traded less (more) with clients borrowing (lending) synthetic dollars. These results, however, confirm that incorporating client netting is critically important.

relative to directional clients that were less exposed. For this exercise, we measure the average exposure of each client κ to affected dealers before the regulatory change using the ratio of client κ's volume with affected dealers relative to client κ's total volume during the pre-intervention period. Hence, we construct a dummy variable $D_{highexp}$ for each client κ that is equal to one if the same client has an above-the-median share of currency forwards intermediated by affected dealers, and zero otherwise. Hence, we run client-level regressions based on the following specification

$$ln\, V_{ij\kappa,t} = \gamma_1 D_{highexp} \times D_{post} + \gamma_2 D_{highexp} \times D_{post} \times D_{zeronet} + \gamma_3 D_{highexp} \times D_{zeronet} + \gamma_4 D_{post} \times D_{zeronet} + \gamma_5 D_{highexp} + \gamma_6 D_{post} + \gamma_7 D_{zeronet} + \delta' X_{j,t-1} + \alpha_j + \widehat{\alpha}_{i,\kappa,t} + \varepsilon_{ij\kappa,t} \tag{8}$$

where γ_1 captures the impact of the regulatory change on the volume of non-directional clients with high exposure and the sum of γ_1 and γ_2 quantifies the impact of the regulatory change on the volume of directional clients with high exposure. Since we examine the trading volume at the client level, we are unable to directly absorb changes in the client-currency demand conditions via a time-varying fixed effect. We instead use the pre-estimate $\widehat{\alpha}_{i,\kappa,t}$ from Equation (7) and then add it to our specification in the spirit of Abowd, Kramarz, and Margolis (1999), Cingano, Manaresi, and Sette (2016), and Kotidis and van Horen (2018).

Table 9 about here

Panel A of Table 9 reports the estimates of γ_1 and γ_2, which are statistically significant but have opposite signs for synthetic dollar borrowing, i.e., $\gamma_1 = 0.122$ and $\gamma_2 = -0.240$, and suggest that directional clients with high exposure have experienced an 11.8% decline in their trading volume of currency forward after the regulatory change at the aggregate level. Recall that the estimates of γ_1 and γ_2 reported in Panel B of Table 8 are substantially larger in absolute terms and imply a 23% fall in the trading volume of currency forwards between directional clients and affected dealers. Taken together, these figures suggest that international banks have received more transactions from directional clients with high exposure to major UK banks after the regulatory shock in January 2016, meaning that directional clients have partly migrated from affected to unaffected dealer banks. We also find that the trading volume of currency forwards has gone up by roughly 12% (given the estimate of γ_1)

for non-directional clients with high exposure. Compared with the corresponding estimate in Panel B of Table 8, we conclude that major UK banks have received more transactions from non-directional clients after January 2016. Finally, for client transaction buying dollars forward, we record no statistical evidence of any substitution effect between major UK banks and international banks.

We further check whether the substitution between affected and unaffected dealers took place by strengthening pre-existing relationships or starting new relationships. Akin to Cingano, Manaresi, and Sette (2016) and Kotidis and van Horen (2018), we construct a dummy variable $NewRelationship_{i\kappa}$ that equals one (and zero otherwise) if a client κ has at least a relationship with a new unaffected dealer after January 2016, i.e., a given client trades during the post-intervention period with an unaffected dealer j that was not among her counterparties during the pre-intervention period. Hence, we run a client-level linear probability model as

$$NewRelationship_{i\kappa} = \gamma_1 D_{highexp} + \gamma_2 D_{highexp} \times D_{zeronet} + \gamma_3 D_{zeronet} + \widehat{\alpha}_{i,\kappa} + \varepsilon_{j\kappa}, \quad (9)$$

where γ_1 measures the probability that high-exposure non-directional clients seek for trading substitution with a new unaffected dealer, the sum of γ_1 and γ_2 indicates whether this occurs for high-exposure directional clients, and $\widehat{\alpha}_{i,\kappa}$ is a pre-estimate currency $\times$ client fixed effect obtained by re-estimating the specification in Equation (7). We report the estimates of γ_1 and γ_2 in Panel B of Table 9 but find no statistically significant evidence that more exposed clients (both directional or non-directional) were more likely to establish a new relationship after January 2016. Our findings suggest that clients with more capital intensive transactions and high exposure to major UK banks during the pre-intervention period have increased their trading activity during the post-intervention period with unaffected dealers with whom they already had a pre-existing relationship rather than switching to new dealers.

5.3 Extensive Margin: Client Exit and Entry

The next question we examine is whether the introduction of the UK leverage framework has affected the extensive margin of dealer banks. In other words, we ask whether major UK banks have either stopped trading with existing clients or reduced the intake of new clients in the spirit of Khwaja and Mian (2008). In our first exercise, we define a binary variable that takes on the value of one a directional client κ trades with a given dealer j during the pre-treatment period but stops trading with the same dealer after the regulatory change. This variable, which we label as $EXIT_{j\kappa}$, is then used as the dependent variable of a regression with client fixed-effects α_κ. Ultimately, we test whether a client trading with different dealers during the pre-treatment period is more likely to exit a trading relationship with affected dealers during the post-treatment period via the following specification:

$$EXIT_{j\kappa} = \beta\, D_{affected} + \alpha_\kappa + \varepsilon_{j\kappa}. \tag{10}$$

We report the estimates of β, the coefficient of interest, in Panel A of Table 10. We find that the exit rate of clients borrowing synthetic dollars against affected dealers is 4.4% higher than unaffected ones. This figure is economically important despite being statistically insignificant, likely due to few available observations. For clients lending synthetic dollars, instead, we uncover a negative and statistically significant coefficient of −0.10. A possible interpretation is that affected banks have substitutes clients borrowing synthetic dollars with clients lending synthetic dollars.

Table 10 about here

We then test the extent to which the ability of UK dealer banks to build trading relationships with new clients during the post-treatment period has been influenced by the regulatory shock. We define a new binary variable that takes the value of one when a client κ trades with a given dealer j during the post-treatment period having no transactions with the same dealer before the regulatory change. We refer to this variable as $ENTRY_{j\kappa}$ and use it as a dependent variable in the following client fixed-effect regression:

$$ENTRY_{j\kappa} = \beta\, D_{affected} + \alpha_\kappa + \varepsilon_{j\kappa}. \tag{11}$$

We report the estimates of β in Panel B of Table 10 and observe a significant impact on the ability of affected dealers to establish trading relationships with new borrowers of synthetic dollars. The estimate of β amounts to −0.05 and is statistically significant at the 5% confidence level. For clients that only buy dollars in the forward market, we find no statistical evidence.

To sum up, we find that major UK banks, compared to international banks, are more likely to stop trading with existing borrowers and reduce the intake of new borrowers after the regulatory shocks. These findings are consistent with the results reported earlier, which quantitatively show the impact of the UK leverage ratio framework on the volume of forward contracts intermediated by affected dealer banks against directional traders.

6 Conclusions

The foreign exchange market – the largest financial market by daily turnover – has recently experienced large and persistent arbitrage deviations from covered interest rate parity, a simple no-arbitrage condition that simultaneously ties together the spot/forward exchange rate markets with the domestic/foreign money markets. While there is some evidence that attributes the existence of a negative dollar basis to dealers' balance sheet costs and hedging demand pressure (e.g., Du, Tepper, and Verdelhan, 2018; Borio, Iqbal, McCauley, McGuire, and Sushko, 2018), the direct relationship between the leverage ratio requirement and the dollar basis at the dealer level has not been tested. This paper fills this important gap in the literature and directly examines the causal relationship between the leverage ratio requirement and the dollar basis. We employ a confidential dataset on contract-level foreign exchange derivatives whose richness in terms of counterparty information is attractive from an identification perspective. Hence, we find that the additional funding cost faced by international investors to borrow synthetic dollars through the foreign exchange market can be attributed to the leverage ratio requirement of dealer banks, and can be thought of as an unintended consequence of the post-crisis financial regulation. We also document a fall in volume for synthetic dollar borrowing, especially for clients that have zero netting against counterparty dealers. These are more capital intensive transactions and would thus require a dealer to pledge an additional amount of regulatory capital. Overall, our findings help shed light on the potential costs of the leverage ratio framework while leaving any assessment of the net welfare effect of the leverage ratio rule for future research. Further research could also try to answer the open question of whether market participants will adapt to the new regulation.

References

Abad, J., I. Aldasoro, C. Aymanns, M. D'Errico, L. F. Rousova, P. Hoffmann, S. Langfield, M. Neychev, and T. Roukny, 2016, "Shedding Light on Dark Markets: First Insights from the New EU-wide OTC Derivatives Dataset," Discussion Paper, European Systemic Risk Board.

Abbassi, P., and F. Bräuning, 2019, "The Pricing of FX Forward Contracts: Micro Evidence from Banks' Dollar Hedging," Working Paper, Federal Reserve Bank of Boston.

Abowd, J., F. Kramarz, and D. Margolis, 1999, "High Wage Workers and High Wage Firms," *Econometrica*, 67, 251–333.

Adrian, T., N. Boyarchenko, and O. Shachar, 2017, "Dealer Balance Sheets and Bond Liquidity Provision," *Journal of Monetary Economics*, 89, 92–109.

Adrian, T., E. Etula, and T. Muir, 2014, "Financial Intermediaries and the Cross-Section of Asset Returns," *Journal of Finance*, 69, 2557–2596.

Aiyar, S., C. W. Calomiris, J. Hooley, Y. Korniyenko, and T. Wieladek, 2014, "The International Transmission of Bank Capital Requirements: Evidence from the UK," *Journal of Financial Economics*, 113, 368–382.

Akram, F., D. Rime, and L. Sarno, 2008, "Arbitrage in the Foreign Exchange Market: Turning on the Microscope," *Journal of International Economics*, 76, 237–253.

Andersen, L., D. Duffie, and Y. Song, 2019, "Funding Value Adjustments," *Journal of Finance*, 74, 145–192.

Arai, F., Y. Makabe, Y. Okawara, and T. Nagano, 2016, "Recent Trends in Cross-Currency Basis," *Bank of Japan Review*, E-7, 1–7.

Baba, N., and F. Packer, 2009, "Interpreting Deviations from Covered Interest Parity During the Financial Market Turmoil of 2007–08," *Journal of Banking and Finance*, 33, 1953–1962.

Bahaj, S., and R. Reis, 2019, "Central Bank Swap Lines: Evidence on the Effects of the Lender of Last Resort," Working Paper, London School of Economics.

Bank of England, 2015a, "Financial Stability Report," Financial Policy Committee.

——— , 2015b, "Implementing a UK Leverage Ratio Framework," Policy Statement PS27/15, Prudential Regulation Authority.

——— , 2015c, "Implementing a UK Leverage Ratio Framework," Consultation Paper CP24/15, Prudential Regulation Authority.

BCBS, 2009, "Strengthening the Resilience of the Banking Sector," Bank for International Settlements.

——— , 2010, "The Group of Governors and Heads of Supervision Reach Broad Agreement on Basel Committee Capital and Liquidity Reform Package," Press Release of 26 July 2010, Bank for International Settlements.

——— , 2014, "Basel III Leverage Ratio Framework and Disclosure Requirements," Technical report, Bank for International Settlements.

Bekaert, G., and R. J. Hodrick, 2012, *International Financial Management*. Pearson Prentice Hall, New Jersey.

Bertrand, M., E. Duflo, and S. Mullainathan, 2004, "How Much Should We Trust Differences-In-Differences Estimates?," *Quarterly Journal of Economics*, 119, 249–275.

Bicu, A., L. Chen, and D. Elliott, 2017, "The Leverage Ratio and Liquidity in the Gilt and Repo Markets," Staff Working Paper 690, Bank of England.

BIS, 2016, *Triennial Central Bank Survey of Foreign Exchange and OTC Derivatives Markets Activity in 2016*. Bank for International Settlements.

Borio, C., M. Iqbal, R. McCauley, P. McGuire, and V. Sushko, 2018, "The Failure of Covered Interest Parity: FX Hedging Demand and Costly Balance Sheets," Working Paper, Bank for International Settlements.

Brunnermeier, M., and L. Pedersen, 2009, "Market Liquidity and Funding Liquidity," *Review of Financial Studies*, 22, 2201–2238.

Buraschi, A., M. Menguturk, and E. Sener, 2015, "The Geography of Funding Markets and Limits to Arbitrage," *Review of Financial Studies*, 28, 1103–1152.

Cameron, C., and D. L. Miller, 2014, "A Practitioner's Guide to Cluster-Robust Inference," *Journal of Human Resources*, 50, 317–372.

Cenedese, G., A. Ranaldo, and M. Vasios, 2020, "OTC Premia," *Journal of Financial Economics*, 136, 86–105.

Cingano, F., F. Manaresi, and E. Sette, 2016, "Does Credit Crunch Investment Down? New Evidence on the Real Effects of the Bank-Lending Channel," *Review of Financial Studies*, 29, 2737–2773.

Debelle, G., 2017, "How I Learned to Stop Worrying and Love the Basis," Dinner Address at the BIS Symposium: CIP–RIP? 22 May 2017, Basel.

Draghi, M., 2008, "Statement by Mario Draghi, Chairman of the Financial Stability Forum," Address to the G7 Ministers and Central Bank Governors, 12 April 2008, Washington D.C.

Du, W., B. Hébert, and A. W. Huber, 2019, "Are Intermediary Constraints Priced?," Working Paper, University of Chicago.

Du, W., J. Im, and J. Schreger, 2018, "The U.S. Treasury Premium," *Journal of International*

Economics, 112, 167–181.

Du, W., A. Tepper, and A. Verdelhan, 2018, "Deviations from Covered Interest Rate Parity," *Journal of Finance*, 73, 915–957.

Duffie, D., 2012, *Dark Markets: Asset Pricing and Information Transmission in Over-the-Counter Markets*. Princeton University Press.

Duffie, D., N. Gârleanu, and L. H. Pedersen, 2005, "Over-the-Counter Markets," *Econometrica*, 73, 1815–1847.

——— , 2007, "Valuation in Over-the-Counter Markets," *Review of Financial Studies*, 20, 1865–1900.

Eguren-Martin, F., M. Ossandon Busch, and D. Reinhardt, 2018, "FX Funding Shocks and Cross-Border Lending: Fragmentation Matters," Staff Working Paper 762, Bank of England.

ESRB, 2016a, "Market Liquidity and Market-Making," Report, European Systemic Risk Board.

——— , 2016b, "Preliminary Investigation into the Potential Impact of a Leverage Ratio Requirement on Market Liquidity," Report, European Systemic Risk Board.

Fong, W. M., G. Valente, and J. K. Fung, 2010, "Covered Interest Arbitrage Profits: The Role of Liquidity and Credit Risk," *Journal of Banking and Finance*, 34, 1098–1107.

Forbes, K., D. Reinhardt, and T. Wieladek, 2017, "The Spillovers, Interactions, and (Un)intended Consequences of Monetary and Regulatory Policies," *Journal of Monetary Economics*, 85, 1–22.

Frenkel, J. A., and R. M. Levich, 1975, "Covered Interest Arbitrage: Unexploited Profits?," *Journal of Political Economy*, 83, 325–338.

G20 Summits, 2008, "Declaration of the Summit on Financial Markets and the World Economy," 15 November 2008, Washington DC.

Gabaix, X., and M. Maggiori, 2015, "International Liquidity and Exchange Rate Dynamics," *Quarterly Journal of Economics*, 130, 1369–1420.

Gromb, D., and D. Vayanos, 2018, "The Dynamics of Financially Constrained Arbitrage," *Journal of Finance*, 73, 1713–1750.

Gropp, R., T. Mosk, S. Ongena, and C. Wix, 2018, "Banks Response to Higher Capital Requirements: Evidence from a Quasi-Natural Experiment," *Review of Financial Studies*, forthcoming.

Hara, M. O., Y. Wang, and X. A. Zhou, 2018, "The Execution Quality of Corporate Bonds," *Journal of Financial Economics*, 130, 308–326.

Hau, H., P. Hoffmann, S. Langfield, and Y. Timmer, 2019, "Discriminatory Pricing of Over-the-Counter FX Derivatives," Working Paper, University of Geneva.

Haynes, R., L. McPhail, and H. Zhu, 2019, "When Leverage Ratio Meets Derivatives: Running Out of Options?," Research Paper, CFTC.

Hazelkorn, T. M., T. J. Moskowitz, and K. Vasudevan, 2020, "Beyond Basis Basics: Leverage Demand and Deviations from the Law of One Price," Working Paper, Yale University.

He, Z., B. Kelly, and A. Manela, 2017, "Intermediary Asset Pricing: New Evidence from Many Asset Classes," *Journal of Financial Economics*, 126, 1–35.

He, Z., and A. Krishnamurthy, 2013, "Intermediary Asset Pricing," *American Economic Review*, 103, 732–770.

——— , 2018, "Intermediary Asset Pricing and the Financial Crisis," *Annual Review of Financial Economics*, 10, 173–197.

Hendershott, T., D. Li, D. Livdan, and N. Schurhoff, 2020, "Relationship Trading in OTC Markets," *Journal of Finance*, 75, 683–734.

Ivashina, V., D. S. Scharfstein, and J. C. Stein, 2015, "Dollar Funding and the Lending Behavior of Global Banks," *Quarterly Journal of Economics*, 130, 1241–1281.

Khwaja, A. I., and A. Mian, 2008, "Tracing the Impact of Bank Liquidity Shocks: Evidence from an Emerging Market," *American Economic Review*, 98, 1413–1442.

Koijen, R. S. J., and M. Yogo, 2015, "The Cost of Financial Frictions for Life Insurers," *American Economic Review*, 105, 445–475.

Kotidis, A., and N. van Horen, 2018, "Repo Market Functioning: The Role of Capital Regulation," Staff Working Paper 746, Bank of England.

Nakaso, H., 2017, "Monetary Policy Divergence and Global Financial Stability: From the Perspective of Demand and Supply of Safe Assets," Speech at a Meeting hosted by the International Bankers Association of Japan.

Pasquariello, P., 2014, "Financial Market Dislocations," *Review of Financial Studies*, 27, 1868–1914.

Prachowny, M. F. J., 1970, "A Note on Interest Parity and the Supply of Arbitrage Funds," *Journal of Political Economy*, 78, 540–545.

Rime, D., A. Schrimpf, and O. Syrstad, 2017, "Segmented Money Markets and Covered Interest Parity Arbitrage," Working Paper, BI Norwegian Business School.

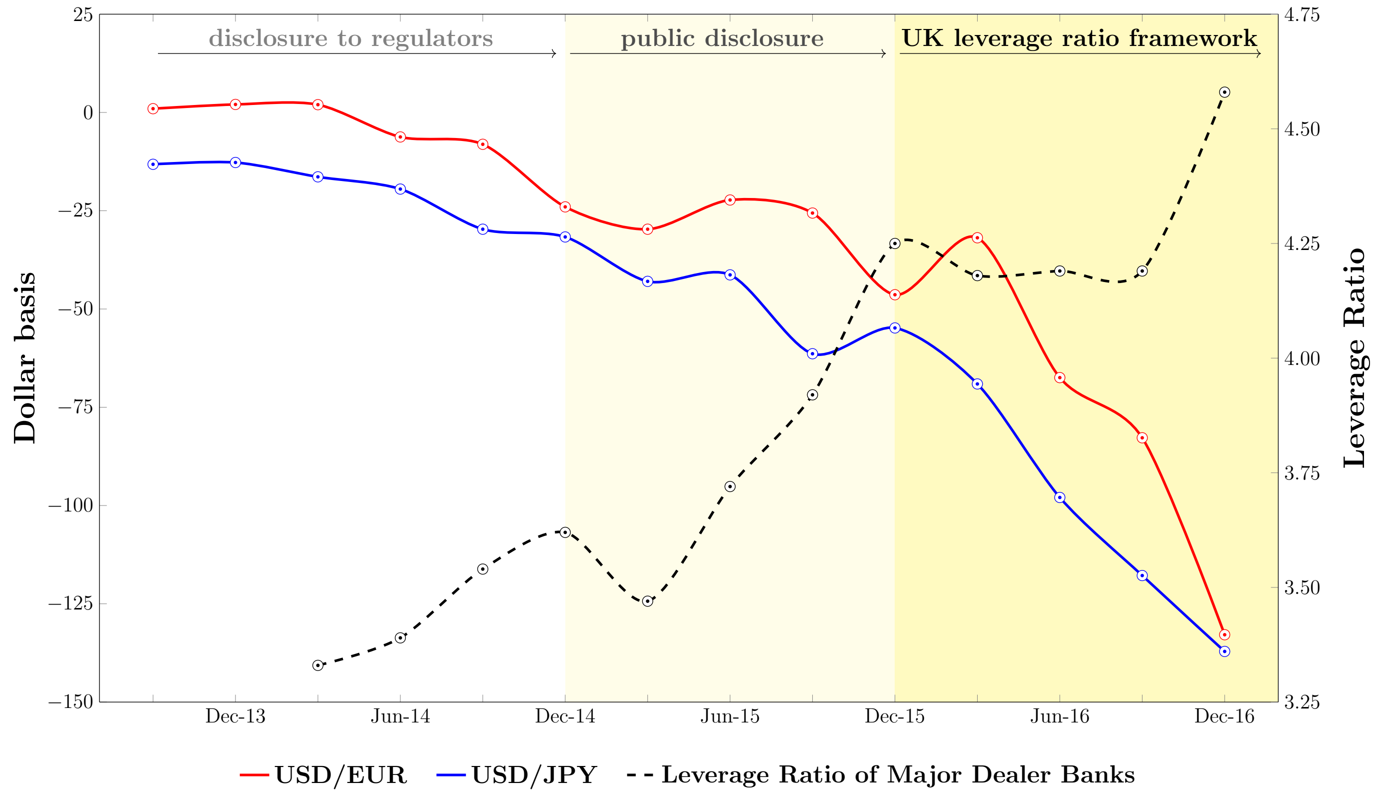

Figure 1. Dollar Basis and Leverage Ratio

This figure displays the one-month 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 dollar basis is expressed in basis points per annum and computed at the end of each quarter (daily average of the last five business days) by combining Libor rates with spot and forward exchange rates from Bloomberg. The leverage ratio is in percentage points and is measured quarterly as high-quality capital over total asset exposure using data from the Bank of England. The public disclosure of the leverage ratio started in January 2015 whereas the UK leverage ratio framework for major UK banks was introduced in January 2016.

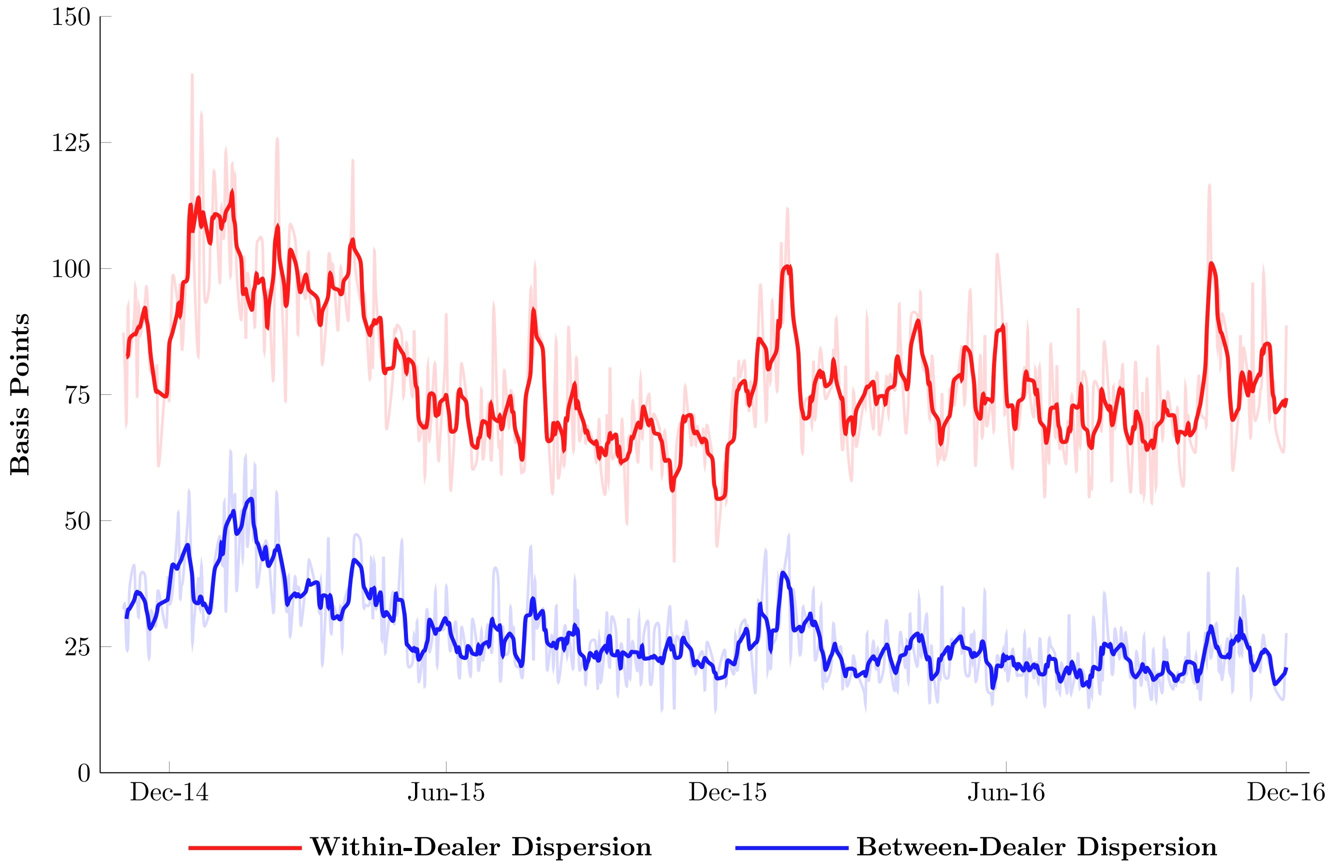

Figure 2. Decomposing the Dispersion of the Dollar Basis

This figure displays the daily within-dealer and between-dealer dispersions (or standard deviations) of the dollar basis. The dispersions are calculated first using the dollar basis measured at the currency, dealer, and client level in basis points per annum and then averaged across all currency pairs. The shaded line denotes the daily standard deviation whereas the solid line is the corresponding five-day centered moving average. The dollar basis is constructed by synchronizing currency forwards between dealers and clients from DTCC Derivatives Repository with spot exchange rates and interest rates from Refinitiv Tick History. The sample runs between December 2014 and December 2016.

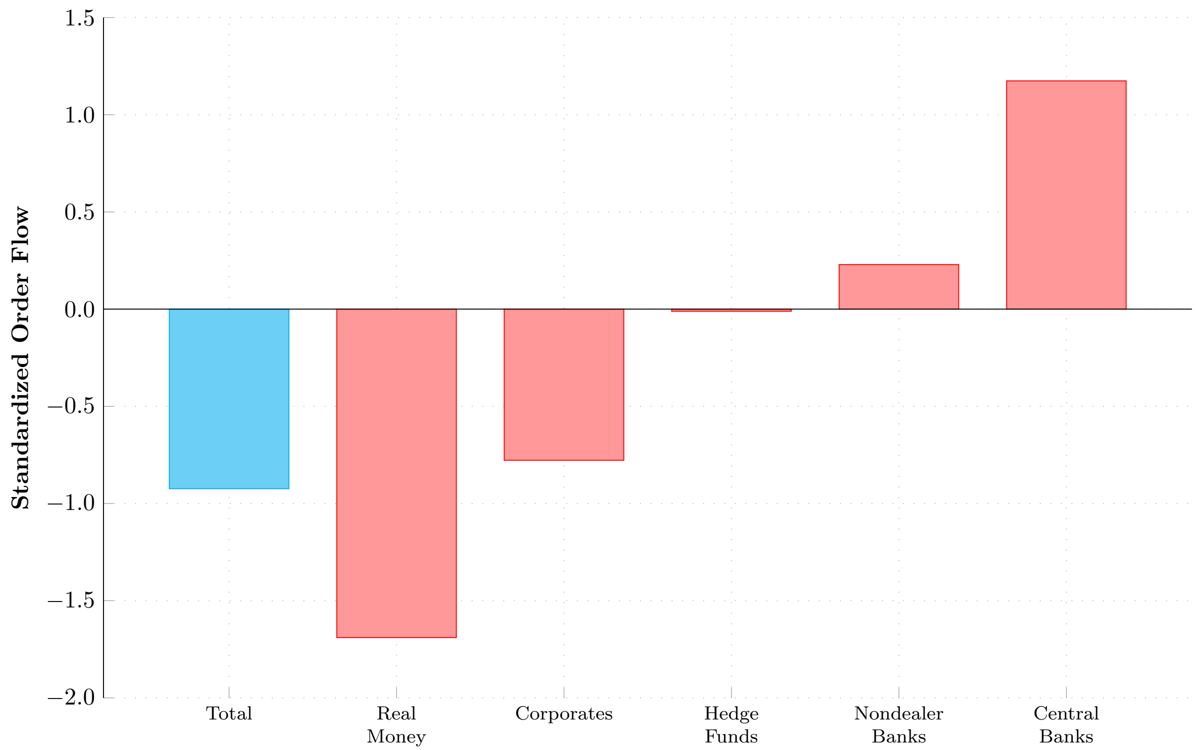

Figure 3. Order Flow Imbalances in the Forward Market

This figure displays the average order flow imbalance between (initiating) clients and dealers in the forward market. The order flow imbalance is the value of buyer-initiated orders minus the value of seller-initiated orders of US dollars against foreign currencies such that a negative (positive) order flow indicates net selling (buying) pressure on the US dollar in the forward market by end-user clients. The order flow is constructed using currency forwards between dealers and clients from the DTCC Derivatives Repository. For each sector (e.g., Real Money), we standardize the average order imbalance by its sample standard deviation for ease of comparison. The sample runs at the weekly frequency from November 2015 to December 2016.

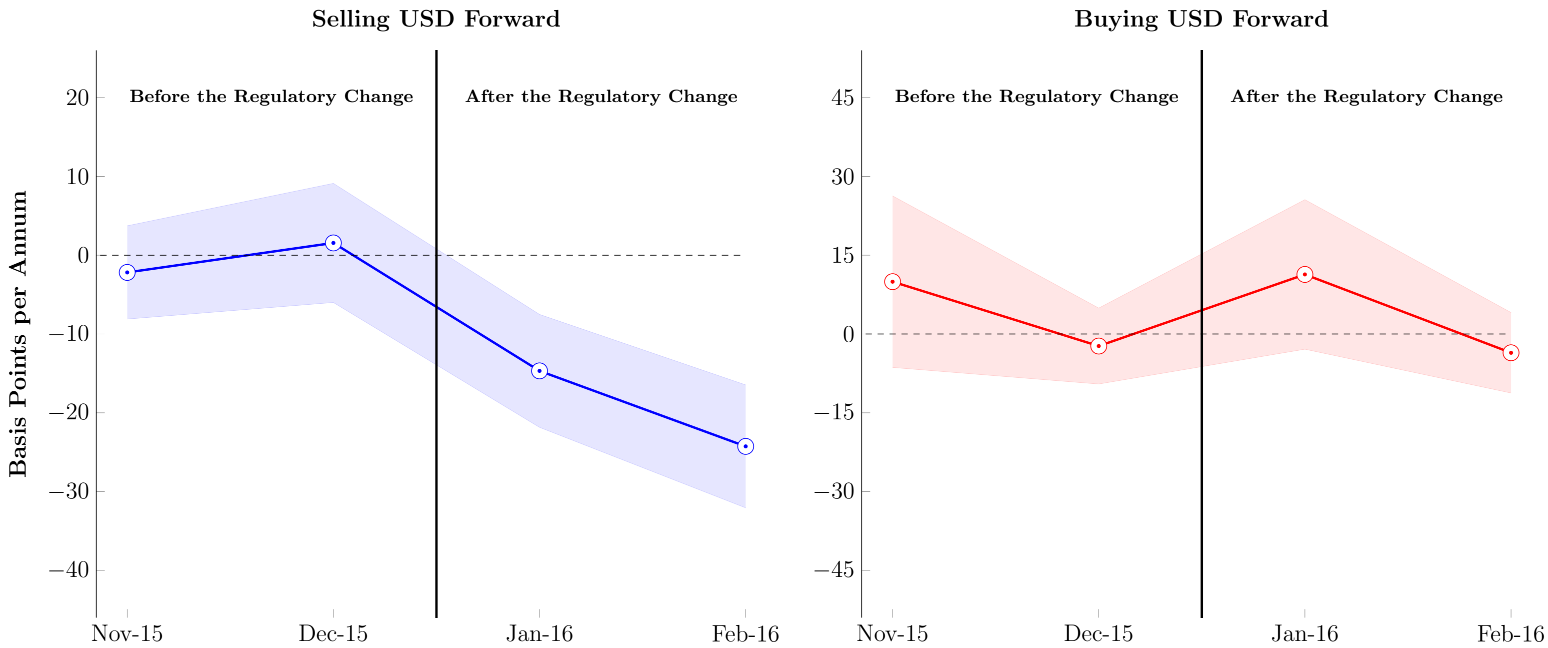

Figure 4. Difference in Dollar Basis between Affected and Unaffected Dealers

This figure displays the average difference in the volume-weighted dollar basis between *affected* and *unaffected* dealer banks two months before and after the introduction of the UK leverage ratio framework on January 1, 2016. The basis is constructed by synchronizing currency forwards between dealers and clients from DTCC Derivatives Repository with spot rates and interest rates from Refinitiv Tick History. Selling (Buying) denotes client transactions that sell (buy) US dollars forward. The basis is expressed in basis points per annum and the shaded area denotes the 95% confidence interval.

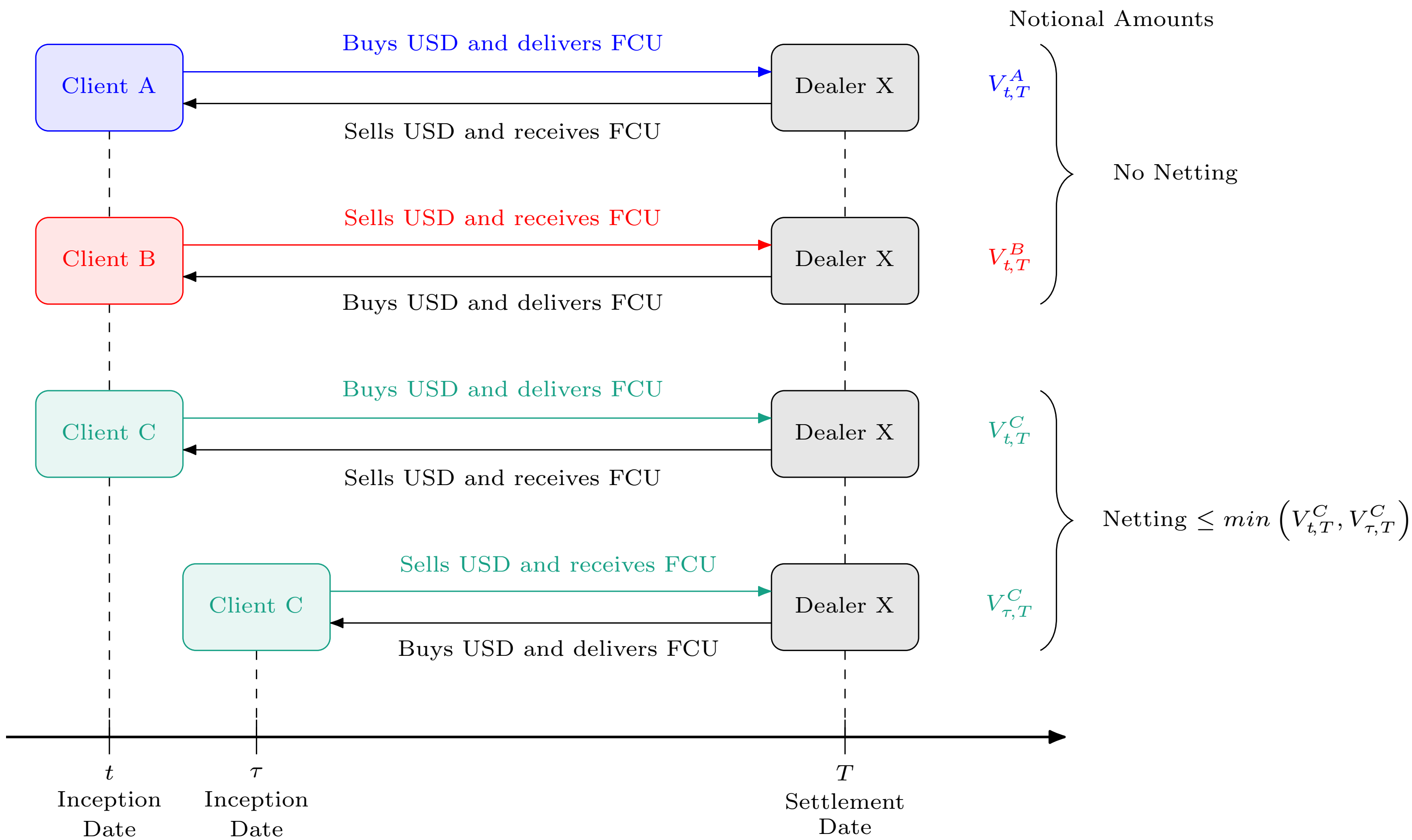

Figure 5. An Illustration of the Netting Rule

This figure provides a simplified illustration of the maximum amount of derivatives exposure that can be netted under the Basel III leverage ratio rule. The notional value on forward contracts that exchange US dollars (USD) for foreign currency (FCU) with the same settlement date (with equal or different inception dates) and identical counterparties determine the maximum notional amount that can be offset.

Table 1. Descriptive Statistics: Dollar Basis

This table presents descriptive statistics of the dollar basis measured at the currency, dealer, and client level in basis points per annum. Panel A employs maturities between one week and three months. Panel B (C) uses maturities between one week and one month (longer than one month). Q_{25}, Q_{50}, and Q_{75} denote the first, second, and third quartile, respectively. All statistics are first calculated daily using the contract-level dollar basis and then averaged across the entire sample. The dollar basis is constructed by synchronizing contract-level currency forwards between dealers and clients from DTCC Derivatives Repository with spot exchange rates and interest rates from Refinitiv Tick History between December 2014 and December 2016.

Panel A: All Maturities

		Standard Deviations					
	Mean	*Overall*	*Between-Dealer*	*Within-Dealer*	Q_{25}	Q_{50}	Q_{75}
AUD	−7.93	86.45	32.42	78.84	−49.14	−3.23	38.25
CAD	−18.42	77.82	32.83	69.21	−49.06	−13.87	19.60
CHF	−68.47	69.53	27.40	62.51	−102.93	−68.44	−29.66
EUR	−29.38	87.91	21.54	84.69	−54.84	−31.03	0.96
GBP	−17.65	94.13	24.62	90.13	−51.52	−18.30	20.13
JPY	−46.03	90.30	24.78	86.22	−81.47	−47.02	−5.91

Panel B: Short Maturities

	Mean	*Overall*	*Between-Dealer*	*Within-Dealer*	Q_{25}	Q_{50}	Q_{75}
EUR	−22.75	102.12	29.46	96.80	−57.70	−22.11	22.78
GBP	−16.82	109.26	34.05	102.60	−62.98	−16.62	37.33
JPY	−39.74	103.23	33.96	96.57	−83.51	−36.56	14.05

Panel C: Longer Maturities

	Mean	*Overall*	*Between-Dealer*	*Within-Dealer*	Q_{25}	Q_{50}	Q_{75}
EUR	−35.33	70.27	20.61	66.58	−53.29	−35.32	−15.29
GBP	−17.68	75.40	22.22	71.33	−43.49	−19.07	8.95
JPY	−54.49	68.45	23.56	63.46	−80.14	−54.57	−27.24

Table 2. Dollar Basis and Leverage Ratio

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 volume-weighted dollar basis from currency forwards measured weekly at the currency, dealer, and client level in basis points per annum. *Affected Dealers* is a dummy that equals one (zero) for major UK banks (subsidiaries of international banks). *Post Regulation* is a dummy that equals one (zero) for a post-treatment (pre-treatment) period of two months after (before) January 1, 2016. The dealer-specific control variables are lagged and include the change in the 5-year CDS spread and the log volume of currency forwards. The fixed effects are denoted by *fe*. Standard errors (in parentheses) are clustered by dealer dimension. The superscripts *, **, and *** indicate statistical significance at 10%, 5%, and 1% respectively. The basis is constructed by synchronizing contract-level currency forwards between dealers and clients from DTCC Derivatives Repository with spot exchange rates and interest rates from Refinitiv Tick History. CDS spreads are from Bloomberg.

	(1)	(2)	(3)	(4)
Affected Dealers × *Post Regulation*	−18.680***	−18.112***	−15.896**	−15.826**
	(5.580)	(5.893)	(7.434)	(7.801)
Δ *Dealer CDS*		−0.679		−0.467
		(0.394)		(0.533)
Dealer Log Volume		−2.472		4.630**
		(3.085)		(2.094)
R^2	0.28	0.29	0.41	0.41
# *Observations*	25,538	25,538	22,293	22,293
Dealer fe	✓	✓	✓	✓
Currency fe	✓	✓		
Client × *Time fe*	✓	✓		
Currency × *Client* × *Time fe*			✓	✓

Table 3. Dollar Basis and Leverage Ratio: Trading Direction

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 volume-weighted dollar basis from currency forwards measured weekly at the currency, dealer, and client level in basis points per annum. Selling (Buying) denotes client transactions that sell (buy) US dollars forward. *Affected Dealers* is a dummy that equals one (zero) for major UK banks (subsidiaries of international banks). *Post Regulation* is a dummy that equals one (zero) for a post-treatment (pre-treatment) period of two months after (before) January 1, 2016. The dealer-specific control variables are lagged and include the change in the 5-year CDS spread and the log volume of currency forwards. The fixed effects are denoted by *fe*. Standard errors (in parentheses) are clustered by dealer dimension. The superscripts *, **, and *** indicate statistical significance at 10%, 5%, and 1% respectively. The basis is constructed by synchronizing contract-level currency forwards between dealers and clients from DTCC Derivatives Repository with spot exchange rates and interest rates from Refinitiv Tick History. CDS spreads are from Bloomberg.

	(1)	(2)	(3)	(4)
	Selling		Buying	
Affected Dealers × *Post Regulation*	−21.706***	−21.751***	2.704	2.434
	(5.183)	(5.347)	(12.585)	(12.255)
Δ *Dealer CDS*		0.274		−0.034
		(0.531)		(0.569)
Dealer Log Volume		−0.826		6.784
		(3.848)		(7.172)
R^2	0.52	0.52	0.49	0.49
# *Observations*	8,842	8,842	8,875	8,875
Dealer fe	✓	✓	✓	✓
Currency × *Client* × *Time fe*	✓	✓	✓	✓

Table 4. Dollar Basis and Leverage Ratio: End-Users

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 volume-weighted dollar basis from currency forwards measured weekly at the currency, dealer, and client level in basis points per annum. Hedgers (Others) refer to real money and non-financial corporates (hedge funds, nondealer banks, and central banks). *Affected Dealers* is a dummy that equals one (zero) for major UK banks (subsidiaries of international banks). *Post Regulation* is a dummy that equals one (zero) for a post-treatment (pre-treatment) period of two months after (before) January 1, 2016. The dealer-specific control variables are lagged and include the change in the 5-year CDS spread and the log volume of currency forwards. The fixed effects are denoted by *fe*. Standard errors (in parentheses) are clustered by dealer dimension. The superscripts *, **, and *** indicate statistical significance at 10%, 5%, and 1% respectively. The basis is constructed by synchronizing contract-level currency forwards between dealers and clients from DTCC Derivatives Repository with spot exchange rates and interest rates from Refinitiv Tick History. CDS spreads are from Bloomberg.

	(1)	(2)	(3)	(4)
	Hedgers		Others	
Affected Dealers × *Post Regulation*	−19.740***	−19.363***	−7.331	−8.188
	(4.988)	(4.970)	(5.336)	(5.344)
Δ *Dealer CDS*		−0.977***		0.532**
		(0.256)		(0.241)
Dealer Log Volume		4.666*		3.408
		(2.606)		(2.400)
R^2	0.42	0.42	0.40	0.40
# *Observations*	14,539	14,539	7,754	7,754
Dealer fe	✓	✓	✓	✓
Currency × *Client* × *Time fe*	✓	✓	✓	✓

Table 5. Dollar Basis and Leverage Ratio: Placebo Dates

This table presents difference-in-differences estimates associated with two placebo event dates. The dependent variable is the volume-weighted dollar basis from currency forwards measured weekly at the currency, dealer, and client level in basis points per annum. Selling (Buying) denotes client transactions that sell (buy) US dollars forward. Hedgers (Others) refer to real money and nonfinancial corporate firms (hedge funds, nondealer banks, and central banks). *Affected Dealers* is a dummy that equals one (zero) for major UK banks (subsidiaries of international banks). *Post Placebo Date* is a dummy that equals one (zero) for the pre-treatment (post-treatment) period that covers two months after (before) the placebo date. The dealer-specific control variables are lagged and include the change in the 5-year CDS spread and the log volume of currency forwards. We include dealer, currency, client, and time (calendar date) fixed effects *fe*. Standard errors (in parentheses) are clustered by dealer dimension. The superscripts *, **, and *** indicate statistical significance at 10%, 5%, and 1% respectively. The basis is constructed by synchronizing contract-level currency forwards between dealers and clients from DTCC Derivatives Repository with spot exchange rates and interest rates from Refinitiv Tick History. CDS spreads are from Bloomberg.

Panel A: Placebo Date on April 1, 2016

	All	Selling	Buying
Affected Dealers × *Post Placebo Date*	3.398	5.116	3.378
	(3.189)	(4.334)	(4.876)
R^2	0.50	0.50	0.49
# Observations	19,869	10,295	9,574

Panel B: Placebo Date on October 1, 2015

	All	Hedgers	Others
Affected Dealers × *Post Placebo Date*	5.199	5.797	4.375
	(4.806)	(6.261)	(6.747)
R^2	0.47	0.48	0.46
# Observations	17,377	11,527	5,850
Control Variables	✓	✓	✓
Dealer fe	✓	✓	✓
Currency × *Client* × *Time fe*	✓	✓	✓

Table 6. Dollar Basis and Leverage Ratio: Placebo Outcomes

This table presents difference-in-differences estimates associated with the introduction of the UK leverage ratio framework on January 1, 2016. The dependent variable, in basis points per annum, is the volume-weighted dollar basis from currency forwards (with intra-month contractual and maturity dates) measured weekly at the currency, dealer, and client level in Panel A, and the contract-level dollar basis from currency basis swaps measured at the currency, dealer, and sector level in Panel B. Selling (Buying) denotes client transactions that sell (buy) the dollars forward. Hedgers (Others) refer to real money and non-financial corporate firms (hedge funds, nondealer banks, and central banks). *Affected Dealers* is a dummy that equals one (zero) for major UK (international) banks. *Post Regulation* is a dummy that equals ones (zero) for a post-treatment (pre-treatment) period of two months after (before) January 1, 2016. The dealer-specific control variables are lagged and include the change in the 5-year CDS spread and the log volume of currency forwards or currency basis swaps. The fixed effects are denoted by *fe*. Standard errors (in parentheses) are clustered by dealer dimension. The superscripts *, **, and *** indicate statistical significance at 10%, 5%, and 1% respectively. In Panel A, the basis is constructed by synchronizing forwards between dealers and clients from DTCC Derivatives Repository with spot rates and interest rates from Refinitiv Tick History. In Panel B, the basis is directly available from DTCC Derivatives Repository. CDS spreads are from Bloomberg.

Panel A: Dollar Basis from Currency Forwards

	All	Selling	Buying
Affected Dealers × *Post Regulation*	3.167	6.608	−2.213
	(6.531)	(8.097)	(10.788)
R^2	0.64	0.59	0.67
# Observations	1,023	502	521
Control Variables	✓	✓	✓
Dealer fe	✓	✓	✓
Currency × *Client* × *Time fe*	✓	✓	✓

Panel B: Dollar Basis from Currency Basis Swaps

	All	Hedgers	Others
Affected Dealers × *Post Regulation*	3.467	3.871	2.455
	(3.139)	(6.668)	(3.216)
R^2	0.61	0.93	0.56
# Observations	1,742	164	1,578
Control Variables	✓	✓	✓
Dealer/Maturity/Hour fe	✓	✓	✓
Currency × *Sector* × *Time fe*	✓	✓	✓

Table 7. Dollar Basis and Capital Requirements

This table presents fixed-effects panel regression estimates. The dependent variable, in basis points per annum, is the volume-weighted dollar basis from currency forwards measured weekly at the dealer, currency, and client level in Panel A, and the contract-level dollar basis from currency basis swaps measured at the dealer, currency, and sector level in Panel B. *Capital Requirements* denote bank-specific risk-weighted capital requirements set by the UK regulator. The dealer-specific control variables are lagged and include the change in the 5-year CDS spread, log volume of forwards or currency basis swaps, bank size (log of total assets), liquid asset share (holdings of cash and market loans scaled by non-equity liabilities), and deposit share (fraction of the balance sheet financed with core deposits). The fixed effects are denoted by *fe*. Standard errors (in parentheses) are clustered by time and dealer dimensions. The superscripts *, **, and *** indicate statistical significance at 10%, 5%, and 1%, respectively. The sample runs between December 2014 and December 2016. In Panel A, the basis is constructed by synchronizing forwards between dealers and clients from DTCC Derivatives Repository with spot rates and interest rates from Refinitiv Tick History. In Panel B, the basis is directly available from DTCC Derivatives Repository. CDS spreads are from Bloomberg and other data from the Bank of England.

Panel A: Dollar Basis from Currency Forwards

	(1)	(2)	(3)	(4)
Capital Requirements	0.314	0.298	1.132	0.994
	(0.893)	(1.279)	(1.000)	(1.540)
R^2	0.39	0.39	0.49	0.49
# Observations	749,895	749,895	338,278	338,278
Control Variables		✓		✓
Dealer fe	✓	✓	✓	✓
Currency fe	✓	✓		
Client × Time fe	✓	✓		
Currency × Client × Time fe			✓	✓

Panel B: Dollar Basis from Currency Basis Swaps

	(1)	(2)	(3)	(4)
Capital Requirements	−4.482**	−5.260***	−5.020***	−5.794***
	(1.620)	(1.075)	(1.568)	(1.039)
R^2	0.66	0.68	0.71	0.73
# Observations	7,802	7,802	7,802	7,802
Control Variables		✓		✓
Dealer/Maturity/Hour fe	✓	✓	✓	✓
Currency fe	✓	✓		
Sector × Time fe	✓	✓		
Currency × Sector × Time fe			✓	✓

Table 8. Client Netting and Leverage Ratio

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 volume-weighted dollar basis (log volume) of currency forwards in Panel A (Panel B) measured weekly at the currency, dealer, and client level in basis points per annum (billions of US dollars). Selling (Buying) denotes client transactions that sell (buy) US dollars forward. *Affected Dealers* is a dummy that equals one (zero) for major UK banks (subsidiaries of international banks). *Post Regulation* is a dummy that equals one (zero) for a post-treatment (pre-treatment) period of two months after (before) January 1, 2016. *Zero Netting* is a dummy that equals one (zero) when dealer-client netting (currency specific) during the pre-treatment period is zero (non-zero). The dealer-specific control variables are lagged and include the change in the 5-year CDS spread and the log volume of currency forwards. The fixed effects are denoted by *fe*. Standard errors (in parentheses) are clustered by dealer dimension. The superscripts *, **, and *** indicate statistical significance at 10%, 5%, and 1% respectively. The basis is constructed by synchronizing forwards between dealers and clients from DTCC Derivatives Repository with spot rates and interest rates from Refinitiv Tick History. In Panel B, the basis is directly available from DTCC Derivatives Repository. CDS spreads are from Bloomberg.

Panel A: Dollar Basis

	All	Selling	Buying
Affected Dealers × Post Regulation × Zero Netting	−30.052***	−47.803***	7.166
	(8.704)	(14.999)	(10.552)
Affected Dealers × Post Regulation	−5.717	−5.970	−2.639
	(3.737)	(5.684)	(4.554)
R^2	0.44	0.55	0.52
# Observations	22,293	8,842	8,875

Panel B: Log Volume

	All	Selling	Buying
Affected Dealers × Post Regulation × Zero Netting	−0.143	−0.482***	0.192
	(0.130)	(0.164)	(0.182)
Affected Dealers × Post Regulation	0.126*	0.248**	0.002
	(0.074)	(0.097)	(0.101)
R^2	0.74	0.80	0.77
# Observations	22,293	8,842	8,875
Control Variables and Other Interactions	✓	✓	✓
Dealer fe	✓	✓	✓
Currency × Client × Time fe	✓	✓	✓

Table 9. Substitution Effects and New Relationships

This table presents difference-in-differences estimates associated with the introduction of the UK leverage ratio framework on January 1, 2016. In Panel A, the dependent variable is the log volume of forwards measured weekly at the currency, dealer, and client level in billions of US dollars. In Panel B, the dependent variable is a dummy variable that equals one (and zero otherwise) if a given client has at least a relationship with a new unaffected dealer after January 2016. Selling (Buying) denotes client transactions that sell (buy) US dollars forward. *Post Regulation* is a dummy that equals one (zero) for a post-treatment (pre-treatment) period of two months after (before) January 1, 2016. *High exposure* is a dummy that equals one (zero) if a client's volume to affected dealers relative to her total volume during the pre-treatment period is above (below) the median value. *Zero Netting* is a dummy that equals one (zero) when dealer-client netting during the pre-treatment period is zero (positive). The dealer-specific control variables are lagged and include the change in the 5-year CDS spread and the log volume of currency forwards. The fixed effects are denoted by *fe*. Standard errors (in parentheses) are clustered by client dimension. The superscripts *, **, and *** indicate statistical significance at 10%, 5%, and 1% respectively. Volume is from currency forwards between dealers and clients from DTCC Derivatives Repository. CDS data are from Bloomberg.

Panel A: Substitution Effects

	All	Selling	Buying
Post Regulation × *High Exposure* × *Zero Netting*	−0.080	−0.240**	0.030
	(0.072)	(0.095)	(0.108)
Post Regulation × *High Exposure*	0.051***	0.122***	−0.002
	(0.018)	(0.027)	(0.030)
R^2	0.74	0.79	0.77
# Observations	22,293	8,842	8,875
Dealer fe, Controls, and Other Regressors	✓	✓	✓
Currency × *Client* × *Time (Pre-estimated)*	✓	✓	✓

Panel B: New Relationships

	All	Selling	Buying
High Exposure × *Zero Netting*	−0.004	−0.012	−0.016
	(0.016)	(0.020)	(0.021)
High Exposure	0.006	0.019	0.027
	(0.022)	(0.026)	(0.030)
R^2	0.69	0.72	0.65
# Observations	1,845	1,363	1,392
Other Regressors	✓	✓	✓
Currency × *Client (Pre-estimated)*	✓	✓	✓

Table 10. Client Exit/Entry

This table examines how the introduction of the UK leverage ratio framework on January 1, 2016 has affected the exit and entry rate of directional clients in the forward market. In Panel A, the dependent variable is *Exit*, i.e., a dummy that equals one (and zero otherwise) if a client trades with a given dealer during the pre-treatment period but not during the post-treatment period. In Panel B, the dependent variable is *Entry*, i.e., a dummy that equals one (and zero otherwise) if a client trades with a given dealer during the post-treatment period but not during the pre-treatment period and exits the dealer relationship. The pre-regulatory (post-regulatory) sample covers two months before (after) January 1, 2016. Selling (Buying) denotes clients that sell (buy) US dollars in the forward market against dealer banks. *Affected Dealers* is a dummy that equals one (zero) for major UK banks (subsidiaries of international banks). The fixed effects are denoted by *fe*. Robust standard errors are reported in parentheses. The superscripts *, **, and *** indicate statistical significance at 10%, 5%, and 1% respectively. Transactions on currency forwards between dealers and clients are from DTCC Derivatives Repository.

Panel A: Client Exit	All	Selling	Buying
Affected Dealers	−0.030	0.044	−0.104**
	(0.029)	(0.037)	(0.044)
R^2	0.68	0.71	0.66
# Observations	710	358	352
Panel B: Client Entry			
Affected Dealers	−0.040**	−0.050**	−0.023
	(0.018)	(0.022)	(0.029)
R^2	0.66	0.72	0.60
# Observations	920	480	440
Client fe	✓	✓	✓

Internet Appendix to

“Currency Mispricing and Dealer Balance Sheets”

(not for publication)

Abstract

We present supplementary results not included in the main body of the paper.

A Breakdown by Currency, Maturity, and Sector

Since we employ a subset of the EMIR data, one might be concerned that our data are not representative of the market trading activity. To shed light on the representativeness of our data, we compare the aggregates of our data with the summary statistics reported in the 2016 BIS Triennial Survey (BIS, 2016).

Figures A.2 and A.3 about here

We measure the daily volume of currency forwards and currency basis swaps using all transactions recorded in our dataset, and report the comparison in Figure A.2 and Figure A.3, respectively. As displayed in Figure A.2, the daily average turnover as of April 2016 for the six currency pairs examined in our analysis is about \$366 billions for outright forwards and \$1.622 trillion for FX swaps, for a total amount of \$1,988 trillion, according to the Triennial Survey. In our dataset, we uncover an average daily volume of \$844 (\$867) billions for both types of instruments as of April 2016 (full-sample period). As displayed in Figure A.3, the currency basis swap market is far less liquid as the BIS reports a daily turnover of about 55 USD billions as April 2016. Our dataset comprises an average daily volume of 23 (24) USD billions as of April 2016 (full-sample period). Although the comparison may not be perfect due to different aggregation criteria, our calculations suggest that we observe more than 42% of the daily trading activity for both currency forwards and currency basis swaps. This is consistent with the fact that London is the largest trading center for FX instruments (e.g., BIS, 2016).

Figures A.4 and A.5 about here

We also break down the volume by currency, maturity, and sector. Figure A.4 presents this decomposition for the 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 inter-dealer market. In particular, the breakdown by currency pairs shows that approximately 39% of the total daily volume – or up to \$340 billions per day – is for EUR against USD, an additional 41% is equally split between GBP and JPY, whereas AUD, CAD, and CHF (all relative to USD) cover a residual 20%. When we consider the breakdown by maturity, we find that more than 70% of the daily volume is for contracts with less than a week maturity, and up to 93% covers contracts with less than three-month maturity. Contracts with longer maturities are less popular and make up about 7% of the market. The third pie chart in Figure A.4 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 inter-clients. In the dealer-to-client segment, moreover, we document that more than 27.6% of the daily volume is for nondealer banks (typically acting on behalf of corporate firms and small financial players), 7.6% is for real money investors, 4.1% for hedge funds, 2% for corporates, and less than 1% relative to central banks.

Figure A.5 displays the decomposition of the currency basis 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 basis 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. This market is also highly concentrated as 82% of transactions are among dealers, 16% between dealers and clients, and less than 2% among clients.

B Bank-Level Data

We use data on the quarterly leverage ratio (Tier 1 capital over total exposures) and the capital ratio (Tier 1 capital over risk-weighted assets) of eleven major dealer banks reporting to the Bank of England (i.e., UK COREP dataset). This list includes Barclays, Citi, Credit Suisse, Goldman Sachs, HSBC, JP Morgan, Morgan Stanley, Nomura, Royal Bank of Scotland, and Standard Chartered. Other European dealer banks have branches in the UK and are not part of the UK COREP dataset. As a result, we only use a subset of major dealer banks in our empirical analysis.

We also use bank size measured as the log of a bank's total assets in levels, liquid asset share quantified as 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 sheet financed with core deposits. These data are measured quarterly and are from the Bank of England (BT forms). Finally, we also employ data on five-year CDS spreads of dealer banks from Bloomberg.[19]

[19]We report summary statistics for these variables in Table A.5.

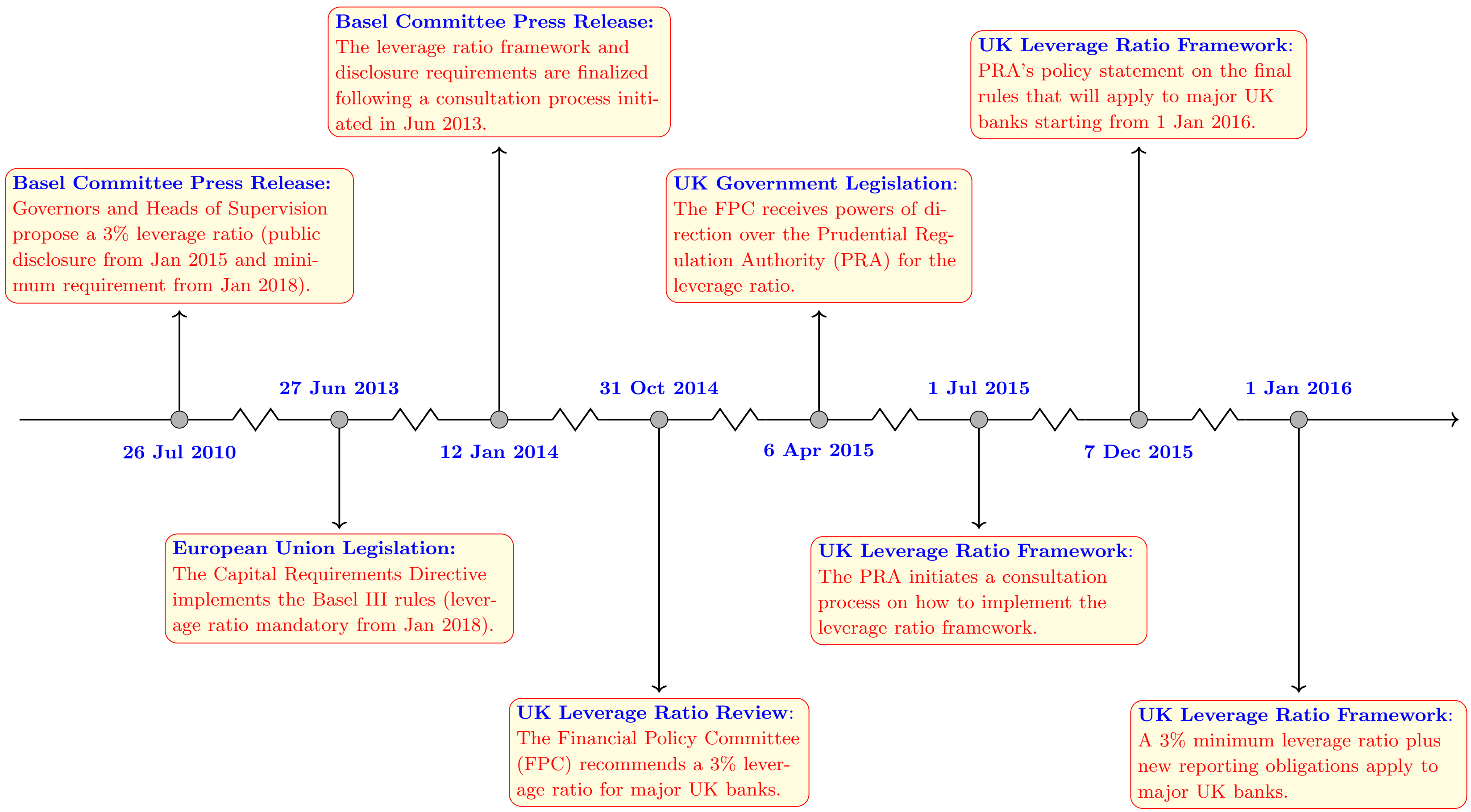

Figure A.1. The Timeline of the Leverage Ratio Requirement

This figure presents the key dates leading to the introduction of the leverage ratio framework in January 2016.

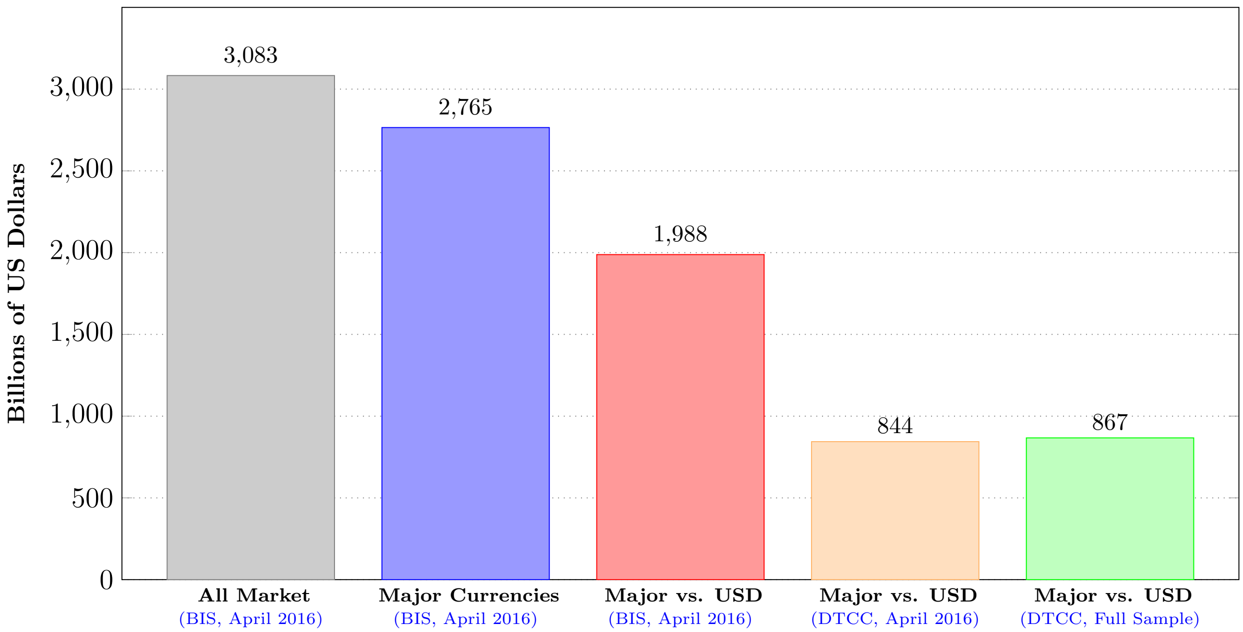

Figure A.2. Currency Forwards: Daily Average Volume

This figure displays the daily average volume on currency forwards based on the 2016 Triennial Central Bank Survey (BIS, 2016) and the contract-level data from the DTCC Derivatives Repository. The latter includes over-the-counter currency forwards (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, Canadian dollar, Swiss franc, euro, British pound, Japanese yen – relative to the US dollar (USD), and runs between December 2014 and December 2016.

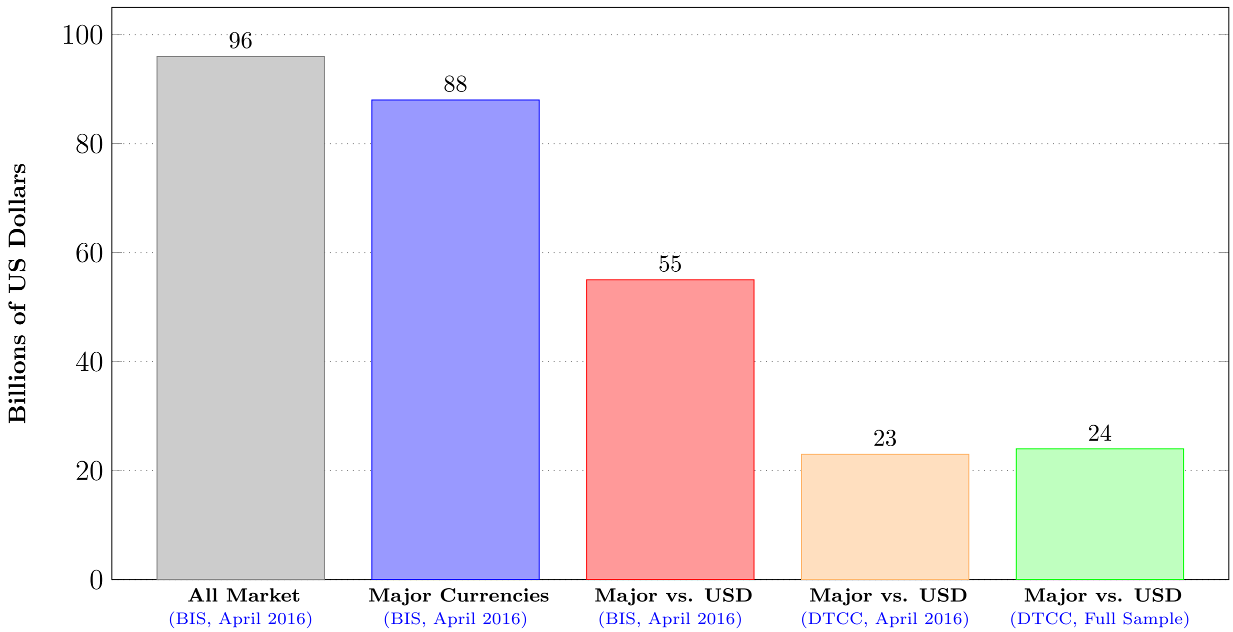

Figure A.3. Currency Basis Swaps: Daily Average Volume

This figure displays the daily average volume on all currency swaps based on the 2016 Triennial Central Bank Survey (BIS, 2016) and the contract-level of currency basis swaps (or floating-for-floating currency swaps) from the DTCC Derivatives Repository. The latter includes over-the-counter transactions undertaken by UK legal entities under the European Market Infrastructure Regulation (EMIR). The sample comprises major currencies – Australian dollar, Canadian dollar, Swiss franc, euro, British pound, and Japanese yen – relative to the US dollar (USD), and runs between December 2014 and December 2016.

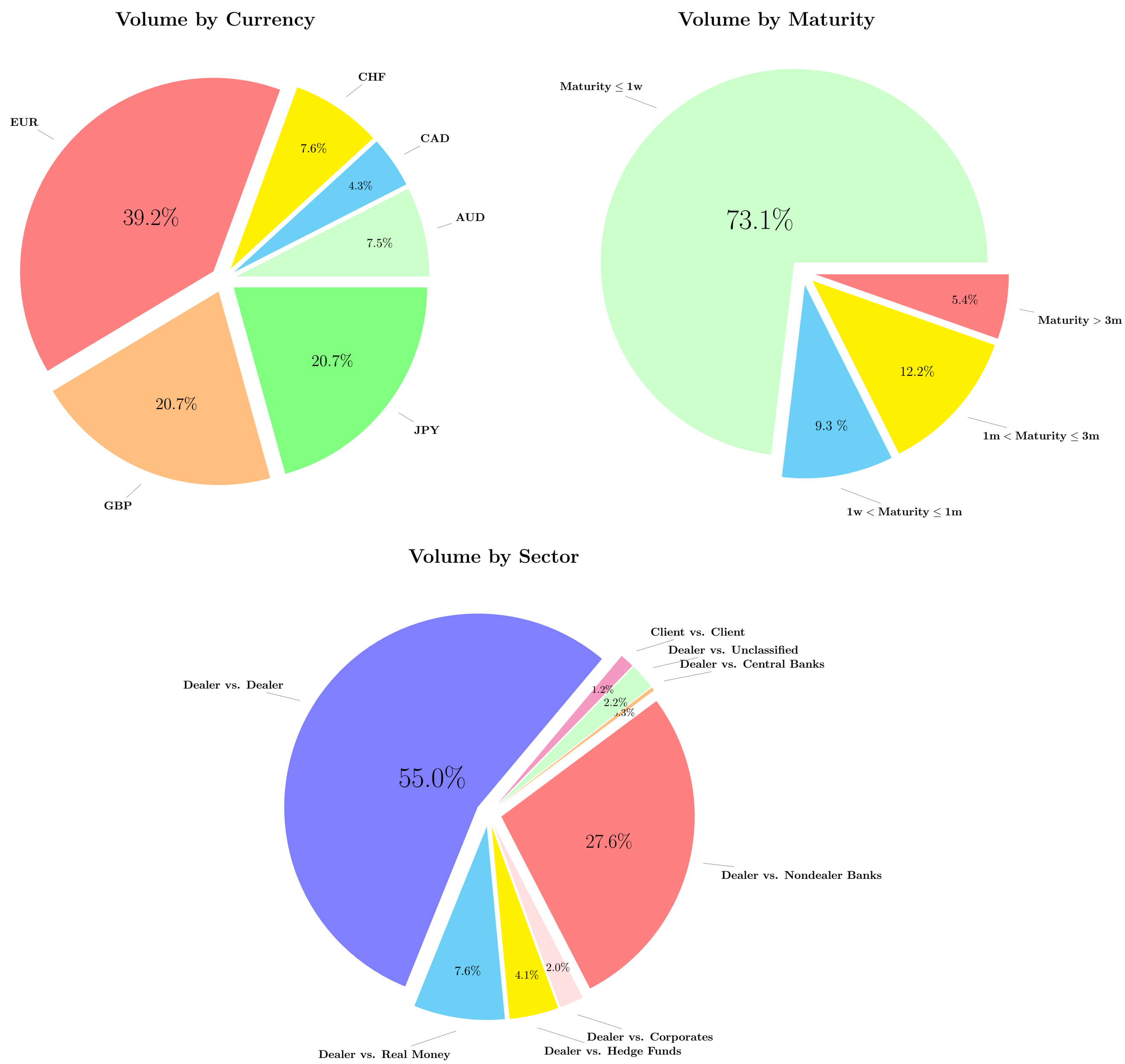

Figure A.4. Currency Forwards: Volume Breakdown

This figure breaks down, by currency, maturity, and sector, the daily average volume of contract-level currency forwards (outright forwards and forward legs of FX swaps) from DTCC Derivatives Repository. The sample runs between December 2014 and December 2016.

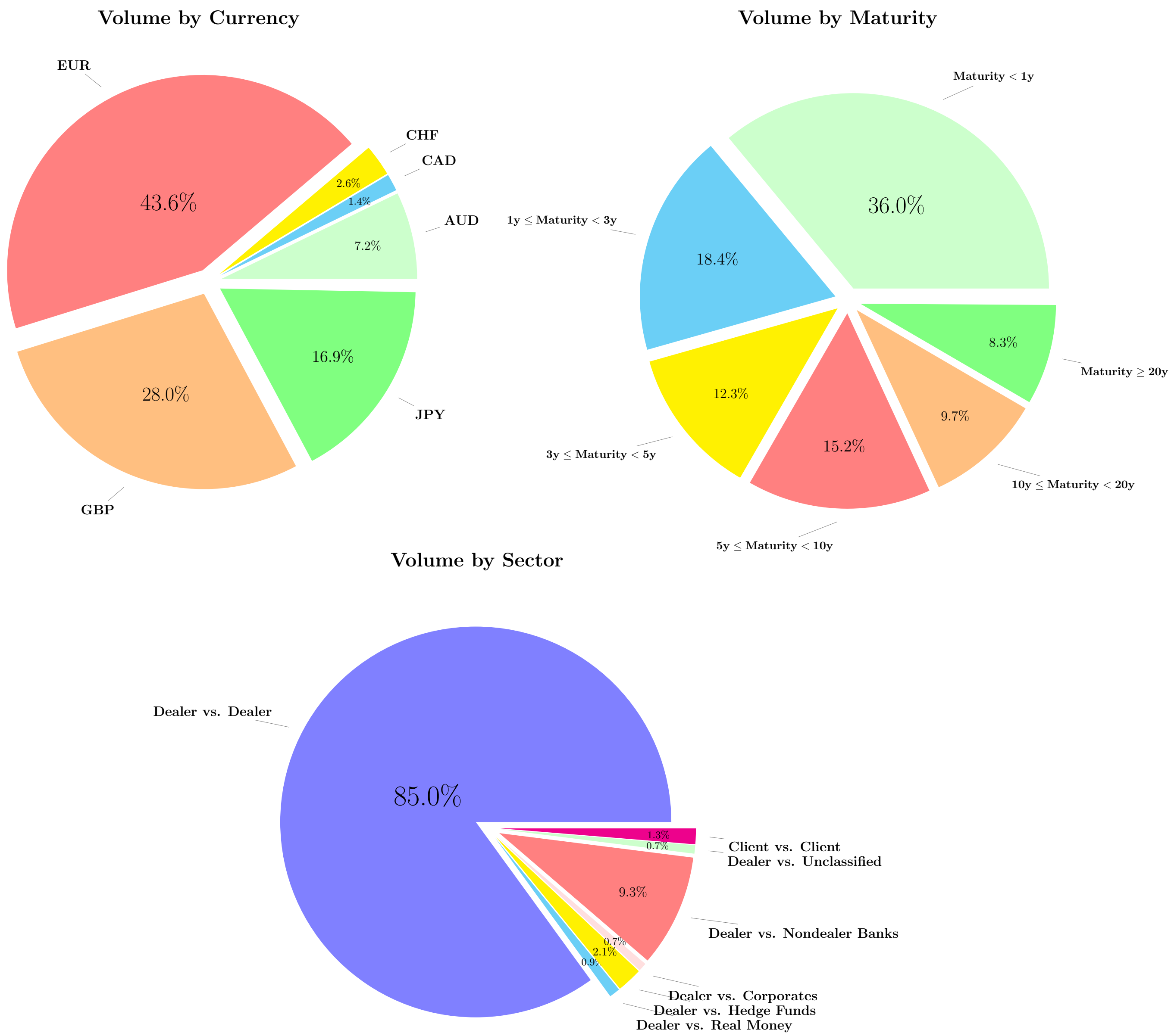

Figure A.5. Currency Basis Swaps: Volume Breakdown

This figure breaks down, by currency, maturity, and sector, the daily average volume of contract-level currency basis swaps from DTCC Derivatives Repository. The sample runs between December 2014 and December 2016.

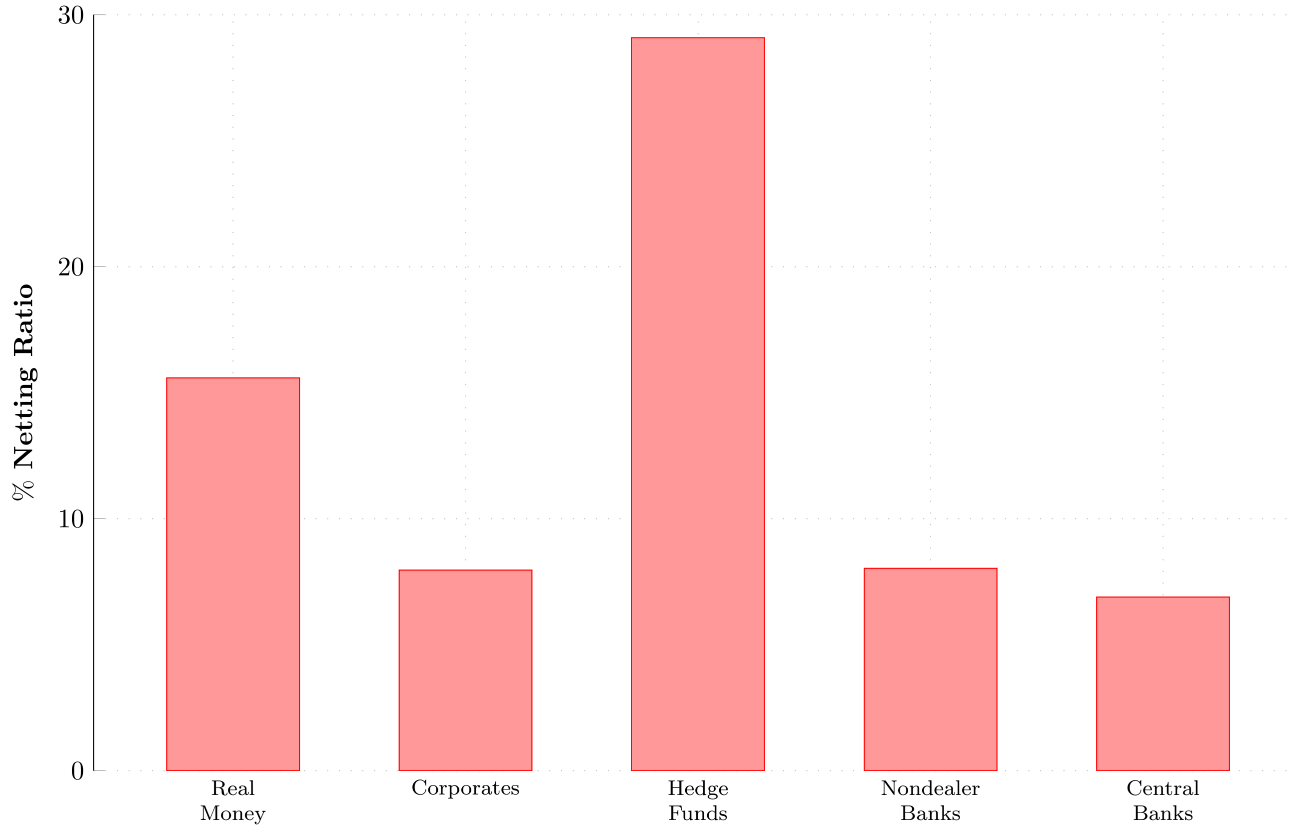

Figure A.6. Netting Ratio in the Forward Market

This figure displays the median value of the (maximum) netting ratio between clients and dealers. For each dealer-client pair, we first aggregate all forward contracts with the same settlement date to determine the maximum notional amount that can be offset, and then scale it by its total volume. Finally, we report the median value of the netting ratio for clients within the same sector. The sample covers the pre-treatment period associated with the difference-in-differences exercise on the introduction of the UK leverage ratio framework on January 1, 2016. The dataset includes currency forwards between dealers and clients from the DTCC Derivatives Repository.

Table A.1. Descriptive Statistics: Dollar Basis

This table presents means and standard deviations (in parentheses) of the daily dollar basis against major currencies. The basis is expressed in basis points per annum and is computed using daily LIBOR rates and London closing spot/forward exchange rates from Bloomberg, and daily OIS rates (sampled at 11.00 am London time) from Refinitiv Tick History and London closing spot/forward exchange rates from Bloomberg. The sample runs between December 2014 and December 2016.

	LIBOR		OIS	
Panel A: One-week Dollar Basis				
EUR	−32.75	(38.72)	−39.23	(48.11)
GBP	−21.77	(28.95)	−21.82	(36.99)
JPY	−49.86	(57.61)	−54.80	(66.47)
Panel B: One-month Dollar Basis				
AUD	10.61	(15.77)	12.97	(16.14)
CAD	−41.76	(13.99)	−15.48	(12.23)
CHF	−51.87	(39.02)	−85.30	(41.46)
EUR	−40.49	(28.74)	−46.92	(33.42)
GBP	−23.17	(22.94)	−24.19	(24.32)
JPY	−58.33	(39.14)	−65.73	(41.05)
Panel C: Three-month Dollar Basis				
AUD	5.89	(6.53)	10.69	(18.04)
CAD	−27.19	(6.24)	−13.13	(9.26)
CHF	−40.91	(18.68)	−80.64	(24.99)
EUR	−29.74	(12.98)	−43.23	(23.36)
GBP	−13.07	(11.59)	−20.36	(16.54)
JPY	−46.94	(17.50)	−64.60	(25.58)

Table A.2. Dollar Basis and Dispersions

This table presents the between-dealer and within-dealer dispersion (or standard deviation) of the dollar basis measured at the currency, dealer, and client level in basis points per annum. Panel A employs maturities between one week and three months. Panel B (C) uses maturities between one week and one month (longer than one month). *Without fe* refers standard deviations without accounting for any fixed effects akin to Table 1. *With Dealer fe* denotes standard deviations after controlling for dealer fixed effects. *With Sector fe* indicate standard deviations after controlling for sector fixed effects. All statistics are first calculated daily using the contract-level dollar basis (before and after accounting for fixed effects) and then averaged across the entire sample. The dollar basis is constructed by synchronizing currency forwards between dealers and clients from DTCC Derivatives Repository with spot exchange rates and interest rates from Refinitiv Tick History between December 2014 and December 2016.

	Without fe		*With Dealer fe*		*With Sector fe*	
	Between-Dealer	*Within-Dealer*	*Between-Dealer*	*Within-Dealer*	*Between-Dealer*	*Within-Dealer*
Panel A: All Maturities						
AUD	32.42	78.84	32.40	78.86	33.54	78.54
CAD	32.83	69.21	32.83	69.25	34.66	68.62
CHF	27.40	62.51	27.37	62.53	28.70	62.20
EUR	21.54	84.69	21.45	84.72	23.09	84.33
GBP	24.62	90.13	24.37	90.22	26.82	89.63
JPY	24.78	86.22	24.73	86.25	26.75	85.71
Panel B: Short Maturities						
EUR	29.46	96.80	29.39	96.82	31.37	96.37
GBP	34.05	102.60	33.79	102.70	36.87	101.87
JPY	33.96	96.57	33.92	96.61	36.43	95.82
Panel C: Longer Maturities						
EUR	20.61	66.58	20.55	66.60	21.76	66.30
GBP	22.22	71.33	22.02	71.39	24.70	70.65
JPY	23.56	63.46	23.59	63.50	25.23	62.95

Table A.3. Descriptive Statistics: Effective Spread

This table presents descriptive statistics of effective spreads measured at the currency, dealer, and client level in basis points. Panel A employs maturities between one week and three months. Panel B (C) uses maturities between one week and one month (longer than one month). Q_{25}, Q_{50}, and Q_{75} denote the first, second, and third quartile, respectively. All statistics are first calculated daily using the contract-level effective spreads and then averaged across the entire sample. The effective spread is constructed by synchronizing currency forwards between dealers and clients from DTCC Derivatives Repository with forward exchange rates from Refinitiv Tick History between November 2015 and December 2016.

		Standard Deviations					
	Mean	*Overall*	*Between-Dealer*	*Within-Dealer*	Q_{25}	Q_{50}	Q_{75}
Panel A: All Maturities							
AUD	0.44	12.71	4.12	11.85	−4.76	0.30	5.20
CAD	0.31	10.98	4.09	9.98	−3.10	0.20	3.91
CHF	0.73	9.57	3.39	8.81	−3.71	0.62	4.82
EUR	0.35	9.16	1.50	9.01	−2.34	0.25	2.85
GBP	0.76	10.71	2.17	10.44	−2.30	0.30	3.51
JPY	0.26	10.60	2.37	10.27	−3.44	0.37	3.93
Panel B: Short Maturities							
EUR	0.30	8.07	1.50	7.90	−2.14	0.24	2.61
GBP	0.51	8.67	1.97	8.39	−2.06	0.21	2.76
JPY	0.29	8.93	2.43	8.52	−2.78	0.35	3.38
Panel C: Longer Maturities							
EUR	0.43	10.15	2.38	9.81	−2.65	0.29	3.21
GBP	1.21	12.48	3.24	11.97	−3.14	0.52	4.73
JPY	0.32	11.99	3.63	11.30	−4.67	0.42	5.01

Table A.4. Descriptive Statistics: Forward Premia

This table presents descriptive statistics of forward premia measured at the currency, dealer, and client level in basis points. Panel A employs maturities between one week and three months. Panel B (C) uses maturities between one week and one month (longer than one month). Q_{25}, Q_{50}, and Q_{75} denote the first, second, and third quartile, respectively. All statistics are first calculated daily using the contract-level effective spreads and then averaged across the entire sample. The effective spread is constructed by synchronizing currency forwards between dealers and clients from DTCC Derivatives Repository with spot exchange rates from Refinitiv Tick History between December 2014 and December 2016.

		Standard Deviations					
	Mean	*Overall*	*Between-Dealer*	*Within-Dealer*	Q_{25}	Q_{50}	Q_{75}
Panel A: All Maturities							
AUD	−156.03	101.97	37.96	93.12	−199.98	−158.19	−112.87
CAD	−13.74	94.50	39.09	84.27	−49.44	−15.32	20.67
CHF	145.38	84.85	33.21	76.41	107.33	148.20	183.28
EUR	74.68	109.98	26.03	106.16	47.14	80.22	104.64
GBP	1.93	114.12	29.09	109.48	−32.92	6.40	39.57
JPY	68.29	111.83	29.89	107.00	31.39	73.59	108.49
Panel B: Short Maturities							
EUR	64.06	131.88	37.49	125.08	23.84	69.46	105.26
GBP	−2.50	137.03	42.06	128.80	−51.88	2.80	49.42
JPY	58.89	130.97	42.31	122.80	10.25	61.36	108.95
Panel C: Longer Maturities							
EUR	83.97	82.40	23.42	78.32	65.14	85.77	103.86
GBP	4.77	86.22	24.78	81.79	−20.57	8.09	32.46
JPY	80.28	79.50	26.80	73.90	54.43	82.21	107.90

Table A.5. Descriptive Statistics: Dollar Basis and Control Variables

Panel A presents the descriptive statistics of the key variable employed for the difference-in-differences regressions reported in Table 2. Panel B displays the descriptive statistics of the key variable employed for the fixed-effects panel regressions in Table 7. The data are sourced from DTCC Derivatives Repository, Refinitiv Tick History, Bloomberg, and the Bank of England.

Panel A: Difference-in-Differences' Sample

	Mean	Sdev	Q_{25}	Q_{50}	Q_{75}
Dollar Basis (Currency Forwards)	−24.03	108.42	−52.52	−19.34	1.23
Dollar Basis (Currency Basis Swaps)	−36.97	30.01	−49.50	−34.00	−13.25
Dealer Log Volume (Currency Forwards)	21.80	1.23	21.29	22.07	22.68
Dealer Log Volume (Currency Basis Swaps)	21.46	1.14	20.80	21.48	22.16
Δ *Dealer CDS*	4.70	13.13	−1.37	2.00	7.08

Panel B: Panel Regressions' Sample

	Mean	Sdev	Q_{25}	Q_{50}	Q_{75}
Dollar Basis (Currency Forwards)	−27.22	139.65	−64.08	−24.40	3.15
Dollar Basis (Currency Basis Swaps)	−36.39	26.80	−47.75	−33.50	−16.00
Dealer Log Volume (Currency Forwards)	23.09	1.14	22.47	23.36	23.96
Dealer Log Volume (Currency Basis Swaps)	21.32	1.04	20.72	21.40	21.97
Capital Requirement	7.07	3.10	5.53	6.54	7.25
Bank Size	25.36	1.92	0.25	25.64	0.75
Liquid Asset Share	0.22	0.16	0.13	0.21	0.28
Deposit Share	0.56	0.14	0.47	0.58	0.65
Δ *Dealer CDS*	0.23	8.83	−3.70	0.29	3.95

Table A.6. Dollar Basis and Leverage Ratio: Daily Frequency

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 volume-weighted dollar basis from currency forwards measured daily at the currency, dealer, and client level in basis points per annum. Selling (Buying) denotes client transactions that sell (buy) US dollars forward. *Affected Dealers* is a dummy that equals one (zero) for major UK banks (subsidiaries of international banks). *Post Regulation* is a dummy that equals one (zero) for a post-treatment (pre-treatment) period of two months after (before) January 1, 2016. The dealer-specific control variables are lagged and include the change in the 5-year CDS spread and the log volume of currency forwards. The fixed effects are denoted by *fe*. Standard errors (in parentheses) are clustered by dealer dimension. The superscripts *, **, and *** indicate statistical significance at 10%, 5%, and 1% respectively. The basis is constructed by synchronizing contract-level currency forwards between dealers and clients from DTCC Derivatives Repository with spot exchange rates and interest rates from Refinitiv Tick History. CDS spreads are from Bloomberg.

	(1)	(2)	(3)	(4)
	Selling		Buying	
Affected Dealers × *Post Regulation*	−21.822***	−22.628***	−0.488	−0.759
	(7.035)	(7.160)	(7.931)	(7.713)
Δ *Dealer CDS*		0.848		0.342
		(0.601)		(0.355)
Dealer Log Volume		0.717		−1.818
		(3.790)		(3.926)
R^2	0.64	0.64	0.66	0.66
# *Observations*	5,844	5,844	5,460	5,460
Dealer fe	✓	✓	✓	✓
Currency × *Client* × *Time fe*	✓	✓	✓	✓

Table A.7. Short-term Dollar Basis and Capital Requirements

This table presents fixed-effects panel regression estimates. The dependent variable is the volume-weighted dollar basis from currency forwards measured weekly at the dealer, currency, and client level in basis points per annum. *Capital Requirements* denote bank-specific risk-weighted capital requirements set by the UK regulator. The dealer-specific control variables are lagged and include the change in the 5-year CDS spread, log volume of forwards or currency swaps, bank size (log of total assets), liquid asset share (holdings of cash and market loans scaled by non-equity liabilities), and deposit share (fraction of the balance sheet financed with core deposits). The fixed effects are denoted by *fe*. Standard errors (in parentheses) are clustered by time and dealer dimensions. The superscripts *, **, and *** indicate statistical significance at 10%, 5%, and 1%, respectively. The sample runs between December 2014 and December 2016. The basis is constructed by synchronizing forwards between dealers and clients from DTCC with spot rates and interest rates from Refinitiv Tick History. CDS spreads are from Bloomberg whereas other bank-level controls are from the Bank of England.

	(1)	(2)	(3)	(4)
Capital Requirements	0.314	0.298	1.132	0.994
	(0.893)	(1.279)	(1.000)	(1.540)
Δ *Dealer CDS*		0.436		0.371
		(0.256)		(0.341)
Dealer Log Volume		−0.232		2.934
		(2.093)		(3.350)
Bank Size		2.697		0.248
		(10.254)		(10.367)
Liquid Asset Share		20.443		33.992
		(35.008)		(37.717)
Deposit Share		2.067		−8.603
		(9.283)		(8.456)
R^2	0.39	0.39	0.49	0.49
# *Observations*	749,895	749,895	338,278	338,278
Dealer fe	✓	✓	✓	✓
Currency fe	✓	✓		
Client × *Time fe*	✓	✓		
Currency × *Client* × *Time fe*			✓	✓

Table A.8. Long-term Dollar Basis and Capital Requirements

This table presents fixed-effects panel regression estimates. The dependent variable is the contract-level dollar basis from currency basis swaps measured at the dealer, currency, and sector level in basis points per annum. *Capital Requirements* denote bank-specific risk-weighted capital requirements set by the UK regulator. The dealer-specific control variables are lagged and include the change in the 5-year CDS spread, log volume of forwards or currency swaps, bank size (log of total assets), liquid asset share (holdings of cash and market loans scaled by non-equity liabilities), and deposit share (fraction of the balance sheet financed with core deposits). The fixed effects are denoted by *fe*. Standard errors (in parentheses) are clustered by time and dealer dimensions. The superscripts *, **, and *** indicate statistical significance at 10%, 5%, and 1%, respectively. The sample runs between December 2014 and December 2016. The basis is directly available from DTCC Derivatives Repository. CDS spreads are from Bloomberg whereas other bank-level controls are from the Bank of England.

	(1)	(2)	(3)	(4)
Capital Requirements	−4.482**	−5.260***	−5.020***	−5.794***
	(1.620)	(1.075)	(1.568)	(1.039)
Δ *Dealer CDS*		−0.060		−0.085
		(0.043)		(0.050)
Dealer Log Volume		0.103		−0.312
		(0.344)		(0.392)
Bank Size		−60.065**		−65.512**
		(23.790)		(23.657)
Liquid Asset Share		0.105		0.115
		(0.527)		(0.508)
Deposit Share		−0.441		−0.634
		(0.452)		(0.441)
R^2	0.66	0.68	0.71	0.73
# Observations	7,802	7,802	7,802	7,802
Dealer/Maturity/Hour fe	✓	✓	✓	✓
Currency fe	✓	✓		
Sector × Time fe	✓	✓		
Currency × Sector × Time fe			✓	✓

Table A.9. Dollar Basis and Leverage Ratio: Subsamples

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 volume-weighted dollar basis from currency forwards measured daily at the currency, dealer, and client level in basis points per annum. Selling (Buying) denotes client transactions that sell (buy) US dollars forward. Panel A splits currency pairs into major (EUR, GBP and JPY) from others (AUD, CAD, and CHF). Panel B categorizes the dollar basis into short-maturity (between one week and one month) and others (longer than one month). *Affected Dealers* is a dummy that equals one (zero) for major UK banks (subsidiaries of international banks). *Post Regulation* is a dummy that equals one (zero) for a post-treatment (pre-treatment) period of two months after (before) January 1, 2016. The dealer-specific control variables are lagged and include the change in the 5-year CDS spread and the log volume of currency forwards. The fixed effects are denoted by *fe*. Standard errors (in parentheses) are clustered by dealer dimension. The superscripts *, **, and *** indicate statistical significance at 10%, 5%, and 1% respectively. The basis is constructed by synchronizing contract-level currency forwards between dealers and clients from DTCC Derivatives Repository with spot exchange rates and interest rates from Refinitiv Tick History. CDS spreads are from Bloomberg.

	Selling		Buying	
Panel A: By Currency Pairs	Major	Others	Major	Others
Affected Dealers × *Post Regulation*	−21.871***	−28.548**	−3.738	1.424
	(5.475)	(12.778)	(10.138)	(31.060)
R^2	0.51	0.61	0.49	0.54
# Observations	7,905	937	7,775	1,100
Panel B: By Maturities	Short	Others	Short	Others
Affected Dealers × *Post Regulation*	−25.328***	−22.978***	2.769	12.698
	(9.273)	(6.917)	(14.628)	(16.962)
R^2	0.52	0.56	0.48	0.55
# Observations	3,401	4,061	3,569	3,958
Control Variables	✓	✓	✓	✓
Dealer fe	✓	✓	✓	✓
Currency × *Client* × *Time fe*	✓	✓	✓	✓

Table A.10. Dollar Basis and Leverage Ratio: Standard Maturities

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 volume-weighted dollar basis from currency forwards measured daily at the currency, dealer, and client level in basis points per annum. Selling (Buying) denotes client transactions that sell (buy) US dollars forward. *Affected Dealers* is a dummy that equals one (zero) for major UK banks (subsidiaries of international banks). *Post Regulation* is a dummy that equals one (zero) for a post-treatment (pre-treatment) period of two months after (before) January 1, 2016. The dealer-specific control variables are lagged and include the change in the 5-year CDS spread and the log volume of currency forwards. The fixed effects are denoted by *fe*. Standard errors (in parentheses) are clustered by dealer dimension. The superscripts *, **, and *** indicate statistical significance at 10%, 5%, and 1% respectively. The basis is constructed by synchronizing contract-level currency forwards with standard maturities (i.e., one week, one month, two months, and three months) between dealers and clients from DTCC Derivatives Repository with spot exchange rates and interest rates from Refinitiv Tick History. CDS spreads are from Bloomberg.

	(1)	(2)	(3)	(4)
	Selling		Buying	
Affected Dealers × *Post Regulation*	−17.374*	−24.205**	−4.289	−4.785
	(9.370)	(10.116)	(12.755)	(13.304)
Δ *Dealer CDS*		−0.779**		1.390***
		(0.350)		(0.412)
Dealer Log Volume		13.299		16.958
		(8.791)		(17.077)
R^2	0.53	0.53	0.53	0.53
# *Observations*	2,256	2,256	1,912	1,912
Dealer fe	Yes	Yes	Yes	Yes
Currency × *Client* × *Time fe*	Yes	Yes	Yes	Yes

Table A.11. Order Flow in the Pre-treatment Period

This table presents fixed-effect panel regressions estimates. The dependent variable is the order flow of currency forwards measured weekly at the currency and dealer level. The sample covers two months before the introduction of the UK leverage ratio framework on January 1, 2016 (the pre-treatment period in our core difference-in-differences exercise). 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-users. *Affected Dealers* is a dummy that equals one (zero) for major UK banks (subsidiaries of international banks). The dealer-specific control variables are lagged and include the change in the 5-year CDS spread and the log volume of currency forwards. The fixed effects are denoted by *fe*. Standard errors clustered by dealer dimension are reported in parentheses. The superscripts *, **, and *** indicate statistical significance at 10%, 5%, and 1% respectively. Order flows are constructed using currency forwards from the Derivatives Repository. All denotes maturities between one week and three months whereas short (longer) maturity refers to contracts between one week and one month (longer than one month).

	(1)	(2)	(3)	(4)	(5)	(6)
	All		Short maturity		Longer maturity	
Affected Dealers	−0.012	−0.033	−0.100	−0.136	0.022	−0.007
	(0.070)	(0.071)	(0.113)	(0.124)	(0.082)	(0.094)
Δ *Dealer CDS*		0.003**		0.012**		−0.003
		(0.001)		(0.006)		(0.002)
Dealer Log Volume		0.017*		0.012		0.042***
		(0.009)		(0.017)		(0.016)
R^2	0.10	0.10	0.25	0.26	0.06	0.08
# Observations	924	924	299	299	619	619
Currency × Time fe	✓	✓	✓	✓	✓	✓

Table A.12. Effective Spread and Leverage Ratio

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 volume-weighted effective spread on currency forwards measured weekly at the dealer, currency, and client level in basis points. Selling (Buying) denotes client transactions that sell (buy) the dollars forward. *Affected Dealers* is a dummy that equals one (zero) for major UK banks (subsidiaries of international banks). *Post Regulation* is a dummy that equals one (zero) for a post-treatment (pre-treatment) period of two months after (before) January 1, 2016. The dealer-specific control variables are lagged and include the change in the 5-year CDS spread and the log volume of currency forwards. The fixed effects are denoted by *fe*. Standard errors (in parentheses) are clustered by dealer dimension. The superscripts *, **, and *** indicate statistical significance at 10%, 5%, and 1% respectively. The effective spread, in relative terms, is constructed by synchronizing currency forwards between dealers and clients from DTCC Derivatives Repository with mid-quoted currency forwards from Refinitiv Tick History. CDS spreads are from Bloomberg.

	(1)	(2)	(3)	(4)
	Selling		Buying	
Affected Dealers × *Post Regulation*	2.839***	2.772***	0.891	0.829
	(0.588)	(0.607)	(0.568)	(0.556)
Δ *Dealer CDS*		0.020		0.007
		(0.022)		(0.024)
Dealer Log Volume		0.225		0.374
		(0.594)		(0.527)
R^2	0.52	0.52	0.53	0.53
# *Observations*	8,464	8,464	8,313	8,313
Control Variables		✓		✓
Dealer fe	✓	✓	✓	✓
Currency × *Client* × *Time fe*	✓	✓	✓	✓

Table A.13. Effective Spread and Leverage Ratio: Subsample

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 volume-weighted effective spread on currency forwards measured weekly at the dealer, currency, and client level in basis points. Selling (Buying) denotes client transactions that sell (buy) US dollars forward. Panel A splits currency pairs into major (EUR, GBP and JPY) from others (AUD, CAD, and CHF). Panel B categorizes the dollar basis into short-maturity (between one week and one month) and others (longer than one month). *Affected Dealers* is a dummy that equals one (zero) for major UK banks (subsidiaries of international banks). *Post Regulation* is a dummy that equals one (zero) for a post-treatment (pre-treatment) period of two months after (before) January 1, 2016. The dealer-specific control variables are lagged and include the change in the 5-year CDS spread and the log volume of currency forwards. The fixed effects are denoted by *fe*. Standard errors (in parentheses) are clustered by dealer dimension. The superscripts *, **, and *** indicate statistical significance at 10%, 5%, and 1% respectively. The effective spread, in relative terms, is constructed by synchronizing currency forwards between dealers and clients from DTCC Derivatives Repository with mid-quoted currency forwards from Refinitiv Tick History. CDS spreads are from Bloomberg.

Panel A: By Currency Pairs

	Selling		Buying	
	Major	Others	Major	Others
Affected Dealers × *Post Regulation*	2.521***	5.512***	0.659	0.473
	(0.584)	(1.958)	(0.605)	(1.648)
R^2	0.51	0.57	0.53	0.53
# Observations	7,523	941	7,308	1,005

Panel B: By Maturities

	Short	Others	Short	Others
Affected Dealers × *Post Regulation*	1.604**	5.374***	−0.575	1.193
	(0.791)	(1.053)	(0.786)	(1.030)
R^2	0.50	0.56	0.57	0.57
# Observations	3,928	3,049	3,823	3,033
Control Variables	✓	✓	✓	✓
Dealer fe	✓	✓	✓	✓
Currency × *Client* × *Time fe*	✓	✓	✓	✓

Table A.14. Dollar Basis and Leverage Ratio: Public Disclosure

This table presents difference-in-differences estimates associated with the public disclosure of the leverage ratio on January 1, 2015 (in Panel A) and a placebo event date on April 1, 2015 (in Panel B). The dependent variable is the volume-weighted dollar basis from currency forwards measured weekly at the currency, dealer, and client level in basis points per annum. Hedgers (Others) refer to real money and non-financial corporates (hedge funds, nondealer banks and central banks). *Affected Dealers* is a dummy that equals one (zero) for dealer banks with a leverage ratio (shareholder claims to total assets) above (below) the median value as of December 2007. *Post Regulation* is a dummy that equals one (zero) for the post-treatment (pre-treatment) period of a quarter (month) after (before) January 1, 2015. We drop two weeks of data bracketing the year-end. *Post Placebo Date* is a dummy that equals one (zero) for the post-treatment (pre-treatment) period of a quarter after (before) April 1, 2015. The dealer-specific control variables are lagged and include the first-difference of the 5-year CDS spread and the log volume of forwards. We include dealer, currency, client, and time (calendar date) fixed effects *fe*. Standard errors (in parentheses) are clustered by dealer dimension. The superscripts *, **, and *** indicate statistical significance at 10%, 5%, and 1% respectively. The basis is constructed by synchronizing currency forwards between dealers and clients from DTCC Derivatives Repository with spot exchange rates and interest rates from Refinitiv Tick History. CDS data are from Bloomberg whereas the leverage ratio is from the Bank of England.

Panel A: Public Disclosure (relative to December 2007)	All	Hedgers	Others
Affected Dealers × *Post Regulation*	−14.157*	−24.910***	6.003
	(7.461)	(9.561)	(12.087)
R^2	0.45	0.45	0.45
# Observations	5,551	3,634	1,917
Panel B: Placebo Date (relative to December 2007)			
Affected Dealers × *Post Placebo Date*	−0.839	0.550	−1.479
	(3.647)	(4.904)	(5.388)
R^2	0.45	0.46	0.44
# Observations	39,907	26,725	13,182
Control Variables	✓	✓	✓
Dealer fe	✓	✓	✓
Currency × *Client* × *Time fe*	✓	✓	✓

Table A.15. Dollar Basis and Leverage Ratio: Public Disclosure

This table presents difference-in-differences estimates associated with the public disclosure of the leverage ratio on January 1, 2015 (in Panel A) and a placebo event date on April 1, 2015 (in Panel B). The dependent variable is the volume-weighted dollar basis from currency forwards measured weekly at the currency, dealer, and client level in basis points per annum. Hedgers (Others) refer to real money and non-financial corporates (hedge funds, nondealer banks and central banks). *Affected Dealers* is a dummy that equals one (zero) for dealer banks with a leverage ratio (shareholder claims to total assets) above (below) the median value as of December 2012. *Post Regulation* is a dummy that equals one (zero) for the post-treatment (pre-treatment) period of a quarter (month) after (before) January 1, 2015. We drop two weeks of data bracketing the year-end. *Post Placebo Date* is a dummy that equals one (zero) for the post-treatment (pre-treatment) period of a quarter after (before) April 1, 2015. The dealer-specific control variables are lagged and include the first-difference of the 5-year CDS spread and the log volume of forwards. We include dealer, currency, client, and time (calendar date) fixed effects *fe*. Standard errors (in parentheses) are clustered by dealer dimension. The superscripts *, **, and *** indicate statistical significance at 10%, 5%, and 1% respectively. The basis is constructed by synchronizing currency forwards between dealers and clients from DTCC Derivatives Repository with spot exchange rates and interest rates from Refinitiv Tick History. CDS data are from Bloomberg whereas the leverage ratio is from the Bank of England.

Panel A: Public Disclosure (relative to December 2012)	All	Hedgers	Others
Affected Dealers × Post Regulation	−16.407**	−27.933***	9.065
	(7.322)	(9.425)	(11.277)
R^2	0.45	0.46	0.45
# Observations	5,551	3,634	1,917
Panel B: Placebo Date (relative to December 2012)			
Affected Dealers × Post Placebo Date	0.166	2.453	−3.098
	(3.440)	(4.355)	(5.548)
R^2	0.45	0.46	0.44
# Observations	39,907	26,725	13,182
Control Variables	✓	✓	✓
Dealer fe	✓	✓	✓
Currency × Client × Time fe	✓	✓	✓

Table A.16. Client Netting and Leverage Ratio: Mixed Currency

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 volume-weighted dollar basis (log volume) of currency forwards in Panel A (Panel B) measured weekly at the currency, dealer, and client level in basis points per annum (billions of US dollars). Selling (Buying) denotes client transactions that sell (buy) US dollars forward. *Affected Dealers* is a dummy that equals one (zero) for major UK banks (subsidiaries of international banks). *Post Regulation* is a dummy that equals one (zero) for a post-treatment (pre-treatment) period of two months after (before) January 1, 2016. *Zero Netting* is a dummy that equals one (zero) when dealer-client netting during the pre-treatment period is zero (non-zero). The dealer-specific control variables are lagged and include the change in the 5-year CDS spread and the log volume of currency forwards. The fixed effects are denoted by *fe*. Standard errors (in parentheses) are clustered by dealer dimension. The superscripts *, **, and *** indicate statistical significance at 10%, 5%, and 1% respectively. The basis is constructed by synchronizing forwards between dealers and clients from DTCC Derivatives Repository with spot rates and interest rates from Refinitiv Tick History. In Panel B, the basis is directly available from DTCC Derivatives Repository. CDS spreads are from Bloomberg.

	All	Selling	Buying
Panel A: Dollar Basis			
Affected Dealers × Post Regulation × Zero Netting	−23.721***	−46.176***	13.421
	(7.823)	(11.931)	(10.963)
Affected Dealers × Post Regulation	−6.221	−5.251	−4.539
	(4.571)	(6.749)	(6.289)
R^2	0.44	0.55	0.52
# Observations	22,293	8,842	8,875
Panel B: Log Volume			
Affected Dealers × Post Regulation × Zero Netting	−0.050	−0.395**	0.218
	(0.141)	(0.178)	(0.208)
Affected Dealers × Post Regulation	0.102	0.204**	0.218
	(0.074)	(0.098)	(0.098)
R^2	0.74	0.80	0.77
# Observations	22,293	8,842	8,875
Control Variables and Other Interactions	✓	✓	✓
Dealer fe	✓	✓	✓
Currency × Client × Time fe	✓	✓	✓

Table A.17. Trading Activity and Leverage Ratio

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 log volume of currency forwards measured weekly at the currency, dealer, and client level in billions of US dollars. Selling (Buying) denotes client transactions that sell (buy) US dollars forward. *Affected Dealers* is a dummy that equals one (zero) for major UK banks (subsidiaries of international banks). *Post Regulation* is a dummy that equals one (zero) for a post-treatment (pre-treatment) period of two months after (before) January 1, 2016. The dealer-specific control variables are lagged and include the change in the 5-year CDS spread and the log volume of currency forwards. The fixed effects are denoted by *fe*. Standard errors (in parentheses) are clustered by dealer dimension. The superscripts *, **, and *** indicate statistical significance at 10%, 5%, and 1% respectively. Volume is from currency forwards between dealers and clients from DTCC Derivatives Repository. CDS data are from Bloomberg.

	All	Selling	Buying
Affected Dealers × *Post Regulation*	0.057	−0.020	0.114
	(0.086)	(0.106)	(0.102)
Δ *Dealer CDS*	0.001	0.004	−0.008**
	(0.003)	(0.003)	(0.003)
Dealer Log Volume	0.207**	0.361**	0.172
	(0.099)	(0.137)	(0.144)
R^2	0.74	0.79	0.78
# *Observations*	22,293	8,842	8,875
Dealer fe	✓	✓	✓
Currency × *Client* × *Time fe*	✓	✓	✓