Currency Mispricing and Dealer Balance Sheets*

Gino Cenedese **Pasquale Della Corte** **Tianyu Wang**

September 16, 2017

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*The views expressed in this paper are those of the authors, and are not necessarily those of the Bank of England. The authors would like to thank Andrea Buraschi, Andrea Appeddu, Matt Boge, Wenxin Du, Darrell Duffie, Pierre Collin-Dufresne, Catherine Koch, Roman Kozhan, Ulf Lewrick, Bob McCauley, Michael Moore, Matteo Regesta, Riccardo Reis, Dagfinn Rime, Lucio Sarno, Andreas Schrimpf, Suresh Sundaresan, Vladyslav Sushko, Itay Tuchman, Adrien Verdelhan, Gertjan Vlieghe and seminar and conference participants at the 2016 Workshop on the Financial Determinants of Exchange Rates in London, 2017 BIS Symposium: CIP–RIP? in Basel, 2017 Bank of England Research Awayday on the Interaction between Financial Markets, Macroeconomy and Monetary Policy, 2017 Annual Meeting of the European Finance Association, 2017 Asset Pricing Workshop at the University of York, INSEAD, Bank for International Settlements, Bank of England, and Swiss National Bank for their helpful and constructive comments. We gratefully acknowledge financial support from INQUIRE Europe. Pasquale and Tianyu acknowledge the gracious hospitality of the Macro Financial Analysis Division of the Bank of England where part of this research was conducted. All remaining errors are our own. The paper previously circulated under the title "Limits to Arbitrage in the Foreign Exchange Market: Evidence from FX Trade Repository Data". Gino Cenedese is with Bank of England, email: `gino.cenedese@bankofengland.co.uk`. Pasquale Della Corte is with Imperial College London and the Centre for Economic Policy Research (CEPR), email: `p.dellacorte@imperial.ac.uk`. Tianyu Wang is with Imperial College London, email: `t.wang12@imperial.ac.uk`.

Currency Mispricing and Dealer Balance Sheets

Abstract

We use a unique transaction-level dataset on over-the-counter foreign exchange derivatives — forwards, swaps and cross-currency swaps — to study the failure of the covered interest rate parity (CIP) condition. Empirically, an increase in the non-risk based balance sheet constraint of dealer banks, commonly known as leverage ratio, is associated with a wider basis over the next following quarter. We also construct a measure of hedging demand between dealers and clients, and find that hedging demand causes a widening of the basis especially when dealer banks face a deleveraging pressure associate with a higher leverage ratio.

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

JEL Classification: F31, G12, G15.

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

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

1 Introduction

Market participants argue that post-crisis financial regulation has increased the balance sheet costs associated to financial intermediation and reduced dealers' capacity to warehouse risk (e.g., ESRB, 2016). The leverage ratio – a non risk-based constraint related to the size rather than to the composition of a bank's balance sheet – is particularly blamed for introducing an additional burden on the market making activity. A Reuters article on 5 August 2013, for instance, stressed 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."* More recently, Duffie (2017) has pointed out that the leverage regulation is likely to cause distortions to the incentives for banks to intermediate safe assets.

The large and persistent deviations from covered interest rate parity (CIP) observed since mid-2014 in the foreign exchange (FX) market, the largest and most liquid financial market in the world, could be thought as an unexpected collateral effect of the recent regulatory environment (Du, Tepper, and Verdelhan, 2016). The direct evidence, however, on the link between dealer banks' leverage ratio and these arbitrage violations remains scarce and far from being conclusive (e.g., Avdjiev, Koch, Shin, and Du, 2016; Sushko, Borio, McCauley, and McGuire, 2016; Rime, Schrimpf, and Syrstad, 2017). This paper fills a gap in this recent but rapidly growing literature, and directly studies the empirical relation between dealer balance sheet costs and violation from CIP condition.

A bank could respond to tighter requirements in multiple ways. When access to additional source of capital is easily available, a bank could satisfy higher requirements without necessarily reducing its asset exposure. A bank, however, could actively manage its ratio requirements to keep a precautionary buffer that reduces the likelihood and the costs of breaching regulatory constraints. This may happen as raising capital in response to higher requirements is not readily available. In this case, a bank facing more stringent regulatory obligations may reduce its total asset exposure (e.g., de-Ramon, Francis, and Harris, 2016). In line with this second hypothesis, we find strong statistical evidence that a deleveraging process associated with a higher leverage ratio predicts wider CIP deviations during the next following quarter. This happens as an increase in balance sheet costs reduces both trading activity and market liquidity and, in turn, causes non-zero CIP violations. In a similar vein, Adrian, Boyarchenko, and Shachar (2017) find that institutions facing more regulation reduce the volume of their trading activity in the the US corporate bond market.

Our empirical analysis employs supervisory transaction-level data on over-the-counter foreign exchange derivatives – outright forwards, FX swaps and cross-currency swaps – for six major US dollar currency pairs. We use all transactions, where at least one of the counterparties is a legal entity under the jurisdiction of the UK, reported to the Depository Trust & Clearing Corporation Derivatives Repository (DTCC) between December 204 and December 2016. This reporting obligation is mandatory under the European Market Infrastructure Regulation (EMIR). This dataset comprises more than 17 million transactions for which we observe detailed information about counterparty identities and contract characteristics such as price, notional amount, execution date, and maturity date. Overall, we uncover an average daily turnover of more than 800 USD billions which corresponds to roughly 43% of the global daily turnover according to the statistics reported by the 2016 Triennial Central Bank Survey (BIS, 2016).

We also use confidential data on the leverage ratio of ten global banks acting as major FX dealers in London and under the supervision of the Bank of England. The leverage ratio measures the capital of a bank as a percentage of its overall assets, including other commitments such as derivatives exposures and off-balance sheet items (see BCBS, 2014). Unlike the capital ratio, i.e., capital over risk-weighted asset, the leverage ratio does not discriminate between safer or riskier assets.[1] As a result, this new metric makes more expensive for financial institutions to act as intermediaries especially in those markets where both risk and margins are low. The impact of the leverage ratio, moreover, is further amplified by the fact that dealers are not allowed to offset for regulatory reasons on a bilateral basis similar transactions with respect to different counterparties. In the case of derivatives, for instance, the Basel III leverage ratio framework states that derivatives create two types of exposure, one arising from the underlying of the derivative contract, and another

[1] In the UK, the leverage ratio comprises a minimum requirement component, an additional leverage ratio buffer for systemically important banks (G-SIBs), and a countercyclical leverage ratio buffer. In our exercise, all dealer banks are G-SIBs.

one from counterparty credit risk.

In our main exercise, we construct transaction-level CIP deviations by synchronizing our data on forwards (outright forwards and forward legs of FX swaps) with second-level data on spot exchange rates and overnight index swap (OIS) rate from Thomson Reuters Tick History. While forward prices are available at different maturities, OIS rates are only available at fixed maturities between 1-month and 3-month for all currency pairs in our sample. As a result, we only focus on CIP deviations falling within this maturity spectrum but linearly interpolate OIS rates using the closest available tenors for not standard maturities (e.g., 50 days).[2] Using fixed-effects panel regressions, we find that an increase in the leverage ratio is associated with larger CIP deviations during the next following quarter. Note that leverage ratio data are only available at quarter-end, and we retrieve high-frequency data by forward filling. This result squares with the argument that an increase in balance sheet constraints may push down trading activity and market liquidity, thus causing non-zero CIP violations. We corroborate this hypothesis by showing that a) an increase in leverage ratio is empirically linked to a future decline in volume, b) a drop in volume causes larger CIP deviations, and 3) the effect of the volume decline on CIP deviations is more pronounced for the most liquid currency pairs and the most traded maturities as they absorb most of the balance sheet capacity of dealer banks. In addition to using the leverage ratio, we also test the sensitivity of CIP deviations with respect to bank's capital ratio but find no significant empirical evidence.

While most of the analysis evolves around short-term (i.e., less than a year maturity) CIP deviations, we also shows that the cross-currency basis swap, analogous to long-term CIP deviations, is directly associated with balance sheet constraints, especially in the form of risk-weighted capital requirements. Using transaction-level regressions, we find that an increase in the capital ratio is associated with a widening of the basis during the next following quarter. This result is consistent with the fact that long-term contracts tend to have higher risk weight in the calculation of the regulatory capital ratio (e.g., Du, Tepper, and Verdelhan, 2016).

The richness of our dataset also allows us to examine actual trading activity by different client sectors such as real money investors, hedge funds, non-financial corporates, non-dealer banks and central banks. We construct a measure of order flow using buy and sell orders that dealers receive from their client sectors and find evidence of clients' heterogeneity across different maturities. We

[2]We also consider deposit rates but results remain qualitatively similar.

document a net demand of US dollars for short-term maturity contracts for all client sector (except hedge funds and central banks), and a net supply (demand) of US dollars for long-term maturity instruments by real money investors and non-dealer banks (hedge funds, non-financial corporates and central banks). Also, we find that an increase in order flow, defined as positive net buying of US dollars against foreign currency, tends to close CIP deviations. One possible interpretation is that, when the CIP deviation is negative, a US arbitrageur, by investing in the higher implied dollar rate in the FX swap market and finding her position in the domestic cash market, would sell foreign currency forward against the dollar, which in turn may put downward pressure on the forward price, closing the CIP deviation. This is consistent with the predictions of the model of Sushko, Borio, McCauley, and McGuire (2016), who argue that CIP deviations are proportional to FX hedging demand by clients and the dealers' balance-sheet costs of FX exposures.

CIP states that money market instruments that are identical in all respects except for their currency of denomination should yield the same rate of return when foreign currency risk is fully hedged. When this simple law of finance breaks down, arbitrage opportunities arise thus altering the functioning of the FX market. While this no-arbitrage condition has worked fairly well in the data for more than three decades (e.g., Frenkel and Levich, 1975; Clinton, 1988; Akram, Rime, and Sarno, 2008), its validity was severely compromised during the financial crisis of 2007–2008 when an unprecedented US dollar funding shortage primarily attributed to funding liquidity and counterparty risk materialized (e.g., Baba and Packer, 2009; Coffey, Hrung, and Sarkar, 2009). Despite market conditions have significantly improved, large arbitrage deviations have recently become a systematic feature of global financial markets. (e.g., Du, Tepper, and Verdelhan, 2016; Sushko, Borio, McCauley, and McGuire, 2016; Rime, Schrimpf, and Syrstad, 2017).[3] While recent papers have investigated the drivers of CIP violations, we are among the first to examine actual trading activity by different market participants and how this is related to CIP deviations and balance sheets costs. Du, Tepper, and Verdelhan (2016) find that credit risk and transaction costs fail to explain fully the existence of persistent CIP deviations, and propose frictions in financial intermediation and their interactions with large international imbalances as potential explanations of these deviations. Similarly, Sushko, Borio, McCauley, and McGuire (2016) identify the increase

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

in FX hedging demand on one side and limits to arbitrage due to higher balance sheet costs on the other side as potential explanations. Rime, Schrimpf, and Syrstad (2017) instead argue that market segmentation and funding liquidity premia may explain such deviations.

We see our paper as complimentary to the literature above. Importantly, however, we are the first to analyze actual trading activity in the FX forward markets and its relation to CIP deviations and balance sheet costs. Our unique dataset allows us to observe up to around 42% of global daily turnover in six major currencies. The dataset also allows us to access the identity of the counterparties and therefore analyze different segments of the market. Importantly, existing literature on FX market microstructure is limited to data from much smaller segments of the market (e.g., trading via the so-called electronic communication networks) that constitute only a tiny fraction of our dataset.[4] The richness of the dataset therefore allows us to measure trading activity with much more precision, observe a much more representative sample, and run the analysis from many different angles (e.g., different market segments by counterparty type), which was not possible in the previous literature. More broadly, our results will help shed light on the potential unintended consequences of financial market regulation.

The remainder of this paper is organized as follows. Section 2 reviews CIP condition and the recent regulatory changes. Section 3 provides a detailed a description of the data and explains the construction of the transaction-level CIP deviations. Section 4 links CIP, trading activity and balance sheet costs whereas Section 4 examines the interaction between demand and supply factors. Section 6 concludes.

2 Background

2.1 Failure of Covered Interest Rate Parity

The covered interest rate parity (CIP) condition is the statement that the real cost of funding on the cash market should be equal to the implied cost of funding in the FX swap market. Equivalently, from the perspective of a US investor, if CIP holds, lending dollars in the domestic cash market should yield the same payoff as converting dollars into foreign currency at the prevailing spot

[4] For example Moore, Schrimpf, and Sushko (2016) calculate that the two most important electronic communication networks that are typically used as data sources in the FX microstructure literature, namely Reuters and EBS, account for only 5% of the average daily turnover in FX forwards and 12% of the average daily turnover for FX swaps as of April 2016.

exchange rate, investing that amount in the foreign cash market, and hedging the FX risk by selling foreign currency for dollars in the forward market. This strategy is often implemented via an FX swap contract, which incorporates both the spot and forward transactions in the same contract. In what follows, we refer to FX swaps and the combination of spot and forward contracts interchangeably.

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

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

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

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

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

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

As outright forwards and FX swaps are short-term instrument, the long-term CIP deviation based on Libor is given by the spread on the cross-currency basis swap. A cross-currency basis swap involves an exchange of cash flows linked to floating interest rates referenced to interbank rates in two different currencies, as well as an exchange of principal in two different currencies at the inception and the maturity of the swap. The cross-currency basis swap spread can be interpreted as the analogous of long-term CIP deviations (Du, Tepper, and Verdelhan, 2016).

2.2 Post-crisis Financial Market Regulation

Since the global financial crisis of 2007–2008, authorities around the world embarked in a significant program of reforms to make the global financial system safer. Among these reforms, the Basel III capital requirement framework plays a pivotal role.[5] The Basel III framework was announced in 2010 and agreed internationally by the Basel Committee on Banking Supervision (BCBS). The international minimum standards are implemented by national authorities, which calibrate the requirements and complement them with regulations at the national level. This framework is structured in several phases, with the first phase started in 2013, and the last one planned for 2019.[6]

Broadly speaking, the reforms aimed at improving the capacity of banks to absorb losses, and therefore guaranteeing that banks can meet their liabilities even after a shock. Bank capital adequacy is typically expressed as a ratio of capital to a bank's assets, or total exposures.[7] Two of the main regulations that constitute the Basel III framework are the leverage ratio requirements and the risk-weighted capital requirements.

The leverage ratio is defined as the ratio of so-called Tier 1 capital (a measure of high-quality loss-absorbing capital) to total exposures.[8] The leverage ratio weights all exposures equally, as opposed to risk-weighted capital ratios that differentiate according to assets' riskiness. Market participants often suggest that the leverage ratio impacts the cost of market-making activity relatively more than

[5] The Basel III framework also introduced liquidity risk management requirements, such as the liquidity coverage ratio (LCR) and net stable funding ratio (NSFR). As Du, Tepper, and Verdelhan (2016) note, CIP arbitrage goes long and short in funding of the same tenor, so its effect on these ratios is neutral.

[6] For details on the Basel III phase-in arrangements, see here.

[7] The starting point for measuring exposures in the leverage ratio is the accounting value of a bank's assets. But for some exposures, including banks' derivative positions and their securities financing transactions, accounting values are an unsuitable measure of risks and are replaced with specific methodologies.

[8] The highest quality of capital is known as common equity Tier 1 (CET1). CET1 is available to absorb losses in the widest range of circumstances. This is possible because only perpetual capital instruments count as CET1 and any dividend payments on these instruments must be fully discretionary. CET1 absorbs losses before any other type of capital. Banks can also count other instruments in their regulatory capital calculations to a limited extent. Additional Tier 1 (AT1) capital includes perpetual subordinated debt instruments, but they must have conversion or write-down features. Contingent convertible or 'CoCo' bonds are the most common type of AT1 instrument. Together, CET1 and AT1 capital makes up Tier 1 capital, which is considered to be the sum of capital instruments that a bank can use to cover losses while it remains a going concern.

other business lines, as market making is characterized by high volume and low margins (CGFS, 2014).

In 2010 the BCBS required banks to disclose publicly their leverage ratio from January 2015, and proposed a minimum ratio of 3% that would become binding for all banks from January 2018. National authorities implement the standards agreed by the BCBS by calibrating and timing the minimum requirements at the national level. In the UK, regulated firms were encouraged to disclose their leverage ratio publicly from 2013. In 2014, the minimum leverage ratio requirement was calibrated to 3%, and supplemented with and additional buffer for systemically important institutions and a countercyclical buffer. Three quarters of the capital must be met with the higher quality Tier 1 capital, called common equity Tier 1 (CET1). The requirements have been binding since January 2016 for major UK-regulated banks, ahead of the Basel III arrangements.

The risk-weighted capital ratio is defined as the ratio of capital to risk-weighted assets (RWAs). The RWAs measure assigns weights to a bank's assets to reflect their relative risk of incurring loss. For example, under Basel I capital rules, risk weights were 1 for corporate lending, 0.5 for household lending and 0 for government lending. Under the new Basel II rules, risk weights depend on the credit and market risk of the portfolio. A measure of market risk used in the Basel framework is the value-at-risk (VaR) based on 10-day holding period returns. The revision of Basel II norms, typically called Basel II.5, introduced also a stressed VaR requirement calibrated over a stress period. The minimum internationally agreed Tier-1 capital requirement is 6% of risk weighted assets (three quarters of this capital must be met with CET1). On top of these minimum requirements that must be met at all times (commonly referred to as 'Pillar 1'), there are typically additional buffers set to all banks to absorb losses under stress. Finally, there are additional requirements that apply to individual banks (commonly referred to as 'Pillar 2').

3 Data Description and Preliminary Analysis

3.1 Trade Repository Data

Description. Over-the-counter (OTC) derivatives markets are generally regarded as the most opaque financial markets. Understanding the complexity and the functioning of these "dark markets" (e.g., Duffie, 2012) is notoriously difficult as buyers and sellers negotiate the terms of the trade privately. As a result, financial regulators struggle to gather key information such as price, volume, maturity, outstanding transactions and counterparty identities. The recent global financial crisis, however, marked an important turning point as G20 leaders put forward in September 2009 a broad reform agenda to profoundly improve the level of transparency in these markets. As part of this initiative, it was agreed that all OTC derivatives contracts should have been reported to trade repositories in order to grant policy-markers and regulators access to high quality and high frequency data.

In the European Union, this commitment was introduced with the European Market Infrastructure Regulation (EMIR). Since February 2014, it is mandatory for counterparties resident in the European Union to report by the following business day the details of any derivative transactions to a trade repository authorized by the European Securities and Markets Authority (ESMA).[9] This reporting obligation covers both over-the-counter and exchange-traded derivatives, comprises all asset classes – credit, commodity, equity, interest rates and foreign exchange (FX) – and applies to clearing houses, financial counterparties and non-financial counterparties that are legal entity under the jurisdiction of the European Union.[10]

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

Within the OTC derivatives market, FX derivatives represent the largest segment in terms of daily transaction volume and the second-largest segment in terms of notional value after interest rate

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

[10]A similar reform in US, for instance, has been implemented trough the Dodd-Frank Wall Street Reform and Consumer Protection Act, or simply the Dodd-Frank Act. As of June 2016, according to the Financial Stability Board (FSB), 19 out of 24 FSB jurisdictions have enforced trade reporting requirements.

derivatives (see BIS, 2016). Our dataset consists of transaction level data on FX forwards (outright forwards and forward legs of FX swaps) and cross currency swaps. While the outright forward is an agreement to exchange two currencies on a future date at a rate agreed on the inception date, the FX swap comprises an initial transaction of two currencies, typically at the spot rate, coupled with the commitment to reverse the transaction on a future date at the forward rate. Despite these contracts might be driven by different motives, no information is available in the EMIR data to discriminate one from the other as only the forward leg is reported for FX swaps.[11] A cross currency swap (or simply currency swap), in contrast, is a derivative between two parties to exchange streams of interest payments in different currencies for an agreed period of time. It also involves the exchange of principal amounts in different currencies at a pre-agreed exchange rate at maturity. Floating-for-floating currency swaps, i.e., the interest rate on both legs are floating rates, are commonly used for major currency pairs and the parties involved are generally financial institutions, either acting on their own or as agents for non-financial corporations. FX forwards are mainly traded up to 1 year maturity whereas the bulk of the activity for currency swaps spans longer maturities, typically between 1 and 20 years.

We have been granted access to this highly granular dataset by Bank of England and we observe all derivatives transactions where at least one of the counterparty is a UK legal entity. We rely on the reports submitted to the DTCC – the largest trade depository in terms of market share – as there exists a lack of data harmonization across trade repositories and any attempts to merge the data remains highly challenging to date. Finally, we focus on the most liquid developed currencies – Australian dollar (AUD), Canadian dollar (CAD), Swiss franc (CHF), euro (EUR), British pound (GBP), Japanese yen (JPY) – relative to the US dollar (USD).

Data Structure and Classification. We collect data from the "trade activity report" which contains for each transaction information about the counterparties (i.e., the Legal Entity Identifier (LEI) and the corporate sector) and the contract's characteristic (e.g., forward price, notional amount, type of delivery, maturity date, execution date, execution venue, execution time, currency cross) for a total of more than 100 fields. We then discard duplicates of the same transaction using the unique trade identifier as the EMIR imposes a double-sided reporting regime and we

[11] FX swaps are generally used by dealers to manage their inventories, by asset managers to invest in foreign money markets without taking FX risk on board, and by central banks to manage their reserves liquidity. In contrast, FX forwards are largely used as hedging instruments by exporters and as currency overlay tools by financial institutions.

observe twice the same transaction when both counterparties are UK legal entities and both of them report to DTCC. In a number of cases, we have removed multiple copies of the same trade due to modifications, corrections and valuation updates. Finally, we drop any transactions with missing key information and remove observations with extreme notional values by winsorizing the data at 99.9% level. After processing and filtering more than a terabyte of data, our final dataset consists of roughly 17.2 million transactions – i.e., 34% (EUR), 21% (GBP), 15% (JPY), 13% (CAD), 11% (AUD), and 6% (CHF) – for FX forwards, and nearly 123,000 transactions – i.e., 36% (EUR), 26% (GBP), 21% (JPY), 13% (AUD), 4% (CHF) and 1% (CAD) – for (floating-for-floating) currency swaps.

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

We classify the largest banks by overall market share according to the 2015 and 2016 Euromoney FX survey as dealers. Using this criterion, we end up with a list of 17 dealers which comprises (in alphabetic order) Bank of America Merrill Lynch, Barclays, BNP Paribas, Citi, Crédit Agricole, Credit Suisse, Deutsche Bank, Goldman Sachs, HSBC, JP Morgan, Morgan Stanley, Nomura, Royal Bank of Scotland, Société Générale, Standard Chartered, State Street and UBS. This set of dealers is obtained by consolidating up to 106 (51) different legal entities in the FX forward (currency swap) market. The remaining counterparties are treated as clients and manually split into real money investors (i.e., asset managers, pension finds, insurance firms, state institutions and unclassified funds), hedge funds, corporates, non-dealer banks (i.e., commercial banks, small dealers, prime brokerage firms and non-bank firms offering trading services), central banks (including monetary authorities) and unclassified clients (i.e., individual counterparties for which the LEI was either missing/incorrect or associated to an entity difficult to categorize). In our sample, we observe than 60,000 (600) clients, i.e., 31% (24%) categorized as real money investors, 1% (5%) as hedge funds, 8% (11%) as corporates, 5% (35%) as non-dealer banks, less than 1% as central banks, and 52% (25%) as unclassified clients, for the FX forward (currency swap) market.[12]

The next step involves grouping transactions across different counterparties. We find that 39% of the 17.2 million transactions in the FX forward market are among dealers, 56% between dealers and clients (i.e., 17% with real money investors, 6% with hedge funds, 6% with corporates, 22% with non-dealer banks, less than 1% with central banks, and only 5% with unclassified clients), and about 5% among clients. The currency swap market, in contrast, turns out to be more concentrated as 82% of the $123,000$ transactions are among dealers, 16% between dealers and clients (i.e., 1% with real money investors, 1% with hedge funds, less than 1% with corporates, 12% with non-dealer banks, and only 1% with unclassified clients), and about 2% among clients.

The ratio between number of transactions and counterparties shows that hedge funds are on average the most active (with more than $2,800$ transactions per entity) whereas real money investors are the least active (with nearly 160 transactions per entity) in the dealer-to-client segment of the FX forward market. In between, we document approximately $1,100$ transactions per entity for non-dealer banks, 480 for central banks, and 190 for corporates. The dealer-client segment is much less active in the currency swap market as we record on average roughly 58 transactions per entity for non-dealer banks, 43 for hedge funds, 10 for real money, and 7 for corporates. The dealer-to-dealer segments, as one could expect, function on a different scale as we uncover on average nearly $390,000$ ($6,000$) transactions per each dealer in the FX forward (currency swap) market.

In terms of maturity distribution, most of the trades in the FX forward market are short term. Approximately 46% of the transactions have a maturity of no more than a week, 20% between 1-week and 1-month, 24% between 1-month and 3-months, and only 10% longer than 3-months. In the currency swap market, nearly 17% of the transactions have a maturity less than a year, 16% between 1-year and 3-years, 14% between 3-years and 5-years, 24% between 5-years and 10-years, and 29% longer than 10-years.

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

Preliminary Analysis. We use all transactions recorded in our dataset to measure volume in the FX forward and currency swap market (based on UTC execution dates). Since we employ a subset of the EMIR transaction-level data, one might be concerned that our data are not representative of the market trading activity. To shed light on the quality of our data, we compare at the outset of our empirical analysis the aggregates of our data with the summary statistics reported in the 2016 Triennial Central Bank Survey of foreign exchange and OTC derivatives markets (BIS, 2016).

Figure 1 about here

As displayed in Figure 1, for instance, the daily average turnover as of April 2016 from the Triennial Survey is about 366 USD billions for outright forwards and 1.622 USD trillions for FX swaps, for a total amount of $1,988$ USD trillions, for the six developed currencies examined in our analysis vis-à-vis the dollar. In our dataset, we uncover an average daily volume of 844 (867) USD billions for both types of instruments as of April 2016 (full-sample period). The currency 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). Despite the comparison may be subject to errors due to different aggregation criteria, our calculations suggests that we observe up to 42% of the daily trading activity for the most liquid currency pairs. This is not surprising as London is the largest trading center for OTC FX instruments (e.g., BIS, 2016).

Figure 2 about here

We also breakdown the volume by currency, maturity and sector. Figure 2 presents this decomposition for the FX forward market and reveals that a large fraction of the trading activity is dominated by the euro against the dollar, spans contracts up to a week maturity, and is concentrated in the interdealer market. In particular, the breakdown by currency pairs shows that approximately 39% of the total daily volume – or up to 340 USD billions per day – is about EUR against USD, an additional 41% is equally split between GBP and JPY, whereas AUD, CAD and CHF (all relative

USD) cover a residual 20%. When we consider the breakdown by maturity, we find that more than 70% of the daily volume is about contracts with less than a week maturity, and up to 93% covers contracts with less than 3-month maturity. Contracts with maturities longer are less popular and make about 7% of the market. The last pie chart slices the trading volume by sector: 55% of the trading activity takes place in the inter-dealer market, 44% between dealers and clients, and only a tiny amount is intra clients. In the dealer-to-client segment, moreover, we document that more than 27.6% of the daily volume is with respect to non-dealer banks (typically acting on behalf of corporate firms and small financial players), 7.6% is with respect to real money investors, 4.1% with respect to hedge funds, 2% with respect to corporates, and less than 1% relative to central banks. As we explained in the previous section, there are more than 60,000 active counterparties in our dataset but we classify nearly half of them. The unclassified counterparties, however, cover roughly 2% of the overall volume.

FIGURE 3 ABOUT HERE

Figure 3 displays the decomposition of the currency swap market. The breakdown by currency pairs shows that more than 88% of the daily volume is concentrated on EUR, GBP and JPY against USD. In terms of maturities, 36% of the daily volume is about currency swaps with less than a year maturity, approximately 30% about contracts with a maturity between 1 and 5 years, 15% about contracts with a maturity between 5 and 10 years, and 18% about contracts with longer maturities.

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

An example of balance sheet costs is the non-risk-based leverage ratio leverage ratio which requires a bank to hold a minimum amount of capital in proportion to its consolidated assets, including non-balance sheet positions and cash held at the central bank. The impact of the leverage ratio is to some extent further amplified by the fact that dealers' are not allowed to net positions across similar transactions with different counterparties for accounting and capital reasons. Netting is generally permitted as long as the transactions have the same counterparty and settlement date. Although most of the ingredients regarding the leverage ratio requirement have been uniformly implemented across jurisdictions, some key features such as the reporting obligation at quarter-end can vary. Specifically, while banks domiciled in the Euro Area, United Kingdom (until December 2016), Switzerland and Japan report their leverage ratio as a snapshot of their value on the last day of the quarter, banks domiciled in the US and the UK (starting from January 2017) disclose their leverage ratio as an average of their daily values over the quarter.

Quarter-end reporting obligations might introduce window-dressing incentives as banks might temporarily alter their balance sheet exposure by decreasing leverage around quarter-end dates while increasing it on other days. Du, Tepper, and Verdelhan (2016) provide evidence of quarter-end effects on CIP deviations. In particular, violations based on 1-week maturity FX forwards become very pronounced a week before and until the quarter-end dates whereas violations implied from 1-month maturity contracts tend to spike a month before and until the quarter-end dates. This happens as 1-week (1-month) maturity contracts intermediated during the last week (month) of the quarter will appear on the bank's balance sheet and the bank has a clear incentive to reduce their intermediation. In contrast, violations based on 3-month contracts are economically small at quarter end dates as 3-month contracts will always appear on the balance sheet at quarter ends irrespective of their execution date.

FIGURE 4 ABOUT HERE

We overall document a similar pattern using FX forward volume as opposed to prices, thus complementing the findings of Du, Tepper, and Verdelhan (2016). In our exercise, we first sample 1-week, 1-month and 3-month maturity FX forwards, then construct weekly volume data by summing up daily volume intra week in order to minimize the impact of day of week effects, and finally plot the average volume four weeks before and after the quarter-end window defined as the last two calendar weeks bracketing quarter-end dates and graphically marked with a shaded area, in Figure 4. Quarter-end FX forward volume significantly drops for both 1-week (Panel A) and 1-month (Panel B) maturity contracts. Specifically, the decline for 1-week contracts amounts to approximately 18%

and 16%, respectively, in the interdealer and dealer-client sector a week prior and until the quarter-end window. For 1-month contracts, volume deteriorates by more than 40% and 30%, respectively, for the two segments of the market a month prior and until the quarter-end window. Panel C displays the average volume for 3-month maturity contracts. This maturity is generally used by pension funds, insurance firms and mutual funds to hedge currency risk. As a result, one should expect an increase rather than a decline in volume at quarter-end. This is by and large what we uncover. This explains why quarter-end effects in CIP deviations are not very pronounced for this maturity.

To sum up, trading FX forwards cause an expansion of a dealer's balance sheet capacity and the disclosure of the leverage ratio leads to a capital charge for the bank subject to such constraint. As a result, dealers will find optimal to reduce the intermediation of FX forwards for those maturities appearing on the balance sheet at quarter ends.[13]

3.2 Contract-level CIP Deviations

We construct transaction-level CIP deviations by synchronizing transaction prices on FX forwards with second level data on spot exchange rates and overnight index swap (OIS) interest rates from Thomson Reuters Tick History. Depending on the availability of OIS rates, we use all FX forwards between 1-month (30 days) and 3-month (92 days) maturity.[14] For nonstandard maturity contracts (e.g., a 45-day FX forward), we rely on linearly interpolated OIS rates using the closest available tenors (e.g., 1-month and two-month OIS rates), and the resulting sample covers nearly 3.6 million observations. It is worth to mention that our matching exercise only uses mid quotes at the second level from Thomson Reuters Tick History. We ignore any bid-ask spread as the main objectives of our study is to understand why non-zero violations exist, what driving forces shift the supply and demand underlying such violations, and the types of constraints affecting the key participants. While measuring the economic size of CIP deviations is of interest, it remains beyond the scope

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

[14] Note that 1-week OIS rates are not available for all currencies in our sample.

of our paper. Measuring the basis with respect to different market participants is challenging as different interest rates might be involved and intraday day might not be available. Moreover, we have no buying/selling indicator that covers the full sample in order to determine whether the bid or the ask price should be used. Despite these difficulties, we will provide a quantitative assessment of the CIP deviations, net of bid-ask spread, when we move to examine long-term CIP deviations as cross currency swaps are directly quoted in terms of basis and we observe transaction-level data on such quantities.

Table 1 about here

Table 1 presents means and standard deviations (in parenthesis) of 1-month and 3-month deviations from textbook LIBOR-based CIP condition (see, among many others, Bekaert and Hodrick, 2012; Du, Tepper, and Verdelhan, 2016) along with the corresponding deviations from transaction-based CIP conditions, averaged intraday for easy comparison. This exercise can be seen as a simple preliminary check that sheds light on the quality of our mixing and matching exercise. Panel A presents the 1-month CIP deviations in basis points per annum (*bpa*). The left-hand side columns (labeled as LIBOR daily) display the violations based on LIBOR rates and end-of-day spot and forward exchange rates from Bloomberg whereas the right-hand side columns (OIS transaction) contain our transaction-level CIP deviations. The middle columns (OIS daily) produce CIP deviations based on OIS rates from Thomson Reuters Tick History sampled at 11 am London time and end-of-day spot and forward exchange rates from Bloomberg. Despite using different data and sources, CIP deviations remain largely comparable. For instance, the cross-currency average CIP deviation is -34 *bpa* for LIBOR daily, -37 *bpa* for OIS daily, and -32 *bpa* for OIS transaction. Even excluding AUD for which there are statistically insignificant sign differences, the cross-currency average CIP deviation remain qualitatively similar and equal to -43 *bpa* for LIBOR daily, -48 *bpa* for OIS daily, and -39 *bpa* for OIS transaction. Panel B produces the same statistics for 3-month CIP deviations and confirms the findings reported in Panel A as the cross-currency average CIP deviation goes from -25 *bpa* for LIBOR daily to -35 *bpa* for OIS daily and -32 *bpa* for OIS transaction. Moreover, we find no sign difference on the CIP deviations for AUD.

As a further robustness check, we also construct transaction-level CIP deviations using deposit rates (as opposed to OIS rates) from Thomson Reuters Tick History and report descriptive statistics in Table A1 in the Internet Appendix. The violations are slightly lower in absolute terms (see the right-hand side columns labeled Deposit transaction) but highly correlated with the ones based on OIS rates. For instance, the average correlation between OIS and Deposit transaction goes from 0.89 to 0.74 for the 1-month and 3-month CIP deviations, respectively.

Table 2 about here

We also examine spreads on cross-currency basis swaps, i.e., the price at which counterparties are willing to exchange foreign currency floating cash flows against US dollar cash flows. The basis is generally quoted on the foreign currency leg against the US dollar, and 'paying' the basis means borrowing the foreign currency versus lending USD while 'receiving' the basis implies lending the foreign currency versus borrowing in USD. Consider, for instance, a 1-year JPYUSD cross-currency swap with a basis of -50 *bpa*. Here, the borrower of dollars will pay USD LIBOR and receive JPY LIBOR minus 50 *bpa* every three months for one year. A negative basis denotes a strong demand for US dollars as one party is willing to receive a lower interest rates on its foreign currency position. More in general, a non-zero basis goes hand in hand with potential deviations from the CIP condition at the long end of the yield curve as one party can take advantage from the swap beyond any exchange risk involved. In our dataset, we directly observe up to 90 thousands data points on transaction-level cross-currency basis. Table 2 displays basic descriptive statistics of daily 1-year, 5-year, and 10-year cross-currency basis in *bpa* using both quotes from Bloomberg as in Du, Tepper, and Verdelhan (2016) and transaction-level data averaged intraday. The spreads are largely comparable across dataset: the cross-currency average based on Blomberg data ranges between -21 and -24 *bpa*, respectively, for the 1-year and 10-year cross-currency basis, whereas the cross-currency average based on transaction-level data goes from -23 and -26 *bpa*, respectively, for the 1-year and 10-year cross-currency basis.

3.3 Other Data

We also employ other data in our analysis, and report summary statistics in Table 3. In particular, we have obtained end-of-quarter data on leverage and capital ratio for all dealer banks domiciled in the UK and, hence, regulated by the Prudential Regulation Authority at Bank of England. This list includes (in alphabetic order) Bank of America Merrill Lynch, Barclays, Citi, Credit Suisse, Goldman Sachs, HSBC, JP Morgan, Morgan Stanley, Nomura, Royal Bank of Scotland, Standard Chartered and UBS. All the dealer-banks from the Euro Area, instead, are not part of this directory as they have branches in the UK and are regulated by the European Central Bank. As a result, we will only use the subset of dealer-banks for which we have data on leverage and capital ratio in our empirical analysis. The mean leverage ratio is close to 4% with a standard deviation of 1.4% whereas the mean capital ratio is slightly higher than 11% with a standard deviation of 1.8%

TABLE 3 ABOUT HERE

We also collect daily observations on 1-week currency option implied volatility, 5-year Credit Default Swap (CDS) of dealer-banks, and the TED spread (i.e., the difference between the 3-month LIBOR and the 3-month T-bill interest rate). Finally, we also report summary statistics of FX forward volume and currency option volume, both from DTCC. We use the latter as an exogenous instrument later in our empirical analysis.

4 Dealer Balance Sheets and CIP Deviations

FX forward volume, as shown in the previous section, is characterized by a pronounced decline at quarter ends. A possible explanation is that dealer banks reduce their market making activity ahead of their leverage ratio disclosure which takes place at the end of each quarter for regulatory reasons. This window-dressing incentive is further aggravated by the fact that regulation imposes restrictions on the bank's ability to net bilateral positions against one another such that the resulting leverage exposure increases. This result is in line with the evidence reported by Du, Tepper, and Verdelhan (2016), who document that CIP deviations spike at quarter-ends, when banks disclose publicly their leverage ratios. In this section, we directly examine the link among CIP deviations, balance sheet costs and trading activity, while controlling for other factors, by running a battery of fixed-effect panel regressions.

4.1 CIP deviations and Leverage Ratio

We start our analysis by running the following fixed-effect panel regression

$$|CIP_{ij\ell,t+1}| = \alpha + \beta_1 LR_{j,t} + \beta_2 CR_{j,t} + \gamma' Controls_t + \varepsilon_{ij\ell,t}, \tag{3}$$

where $|CIP_{ij\ell,t}|$ denotes the absolute value of all transaction-level CIP deviations recorded on day t for currency i, dealer j, and maturity ℓ; $\alpha = \alpha_i + \alpha_j + \alpha_\ell + \alpha_t$ comprises currency, dealer, maturity and quarter time fixed effects; $LR_{j,t}$ and $CR_{j,t}$ are the leverage and capital ratio, respectively, of dealer j; and $Controls_t$ includes the FX forward volume, currency-related (i.e., exchange rate return, change in the FX forward bid-ask spread, change in FX option implied volatility, and currency risk-reversal), dealer-related (i.e, change in the credit default swap), and global (i.e., change in the TED spread) control variables. Our transaction-level CIP deviations are measured between 1-month and 3-month maturity, and with respect to those dealer banks for which we have data on both leverage and capital ratios. As explained in the data section, these data are available at quarter ends and we retrieve higher-frequency observations by forward filling. Similarly, we measure all control variables weekly and then retrieve higher- frequency data by forward filling. *De facto*, all variables on the right-hand side of our regression are lagged.

Table 4 about here

Table 4 reports the estimates associated with Equation (3) with standard errors (in parentheses) clustered by currency and time dimension (e.g., Petersen, 2009). We find that the slope coefficient β_1 is always positive and highly statistically different from zero, thus suggesting that an increase in the leverage ratio of dealer banks is associated with larger absolute CIP deviations during the next following quarter. In contrast, the capital ratio is never statistically significant and its sign changes from positive to negative when it appears together with the leverage ratio on the right-hand side of the panel specification. Results remain qualitatively similar even after controlling for other factors. In terms of economic interpretation, a standard deviation increase in the leverage ratio is associated with larger CIP deviations, in absolute terms, of 10 *bpa*. An additional increase of roughly 13 *bpa* comes from ΔBAS (change in the FX forward bid-ask spread) which captures the transaction costs for trading FX forwards and could be partly driven by the leverage ratio.[15]

Figure 5 about here

Our findings suggest that the difference between the direct dollar interest rate and the synthetic dollar interest rate obtained by swapping the foreign currency into US dollars increases when dealers face deleveraging pressure. Does this happen across all dealer banks? Since US banks are less reliant than foreign banks on dollar funding, one would expect US banks facing narrower CIP deviations. To answer this question, we run the following fixed effects panel regression

$$|CIP_{ij\ell,t+1}| = \alpha + \delta_{bank} + \gamma' Controls_t + \varepsilon_{ij\ell,t}, \tag{4}$$

where δ_{bank} is a dummy variable that equals one when the counterparty dealer is a US dealer bank, and all other components are the same as in Equation (3). The bar chart in Figure 5 displays the coefficient estimate of δ whereas the error bar denotes the 95% confidence interval based on a standard error clustered by currency and time dimension. The estimate of δ is negative and statistically different from zero, suggesting that US dealers face lower absolute transaction-level CIP deviations that non-US dealers. The difference is on average equal to 17 *pba*.

We also examine whether CIP deviations vary across different clients by running the following fixed effects panel regression

$$|CIP_{ij\ell,t+1}| = \alpha + \sum_{\kappa=1}^{6} \delta_\kappa + \gamma' Controls_t + \varepsilon_{ij\ell,t}, \tag{5}$$

where κ refer to the list of clients, i.e., real money, nondealer banks, hedge funds, central banks, corporates, unclassified, and δ_k is a dummy variable that selects a transaction-level CIP deviation with respect to each of these clients. All other terms are identical to those employed in Equation (3). (everything else stays the same). The bar chart in Figure 5 displays all coefficient estimates of δ including the 95% confidence interval based on clustered standard errors. Real money investors face the largest spread with respect to the interdealer market (16 *pba*), followed by corporate firms

[15] In unreported results, we construct several measures of illiquidity based on the price dispersion of FX forwards, and find a strong predictive relation between leverage ratio and FX forward illiquidity.

(10 *pba*), hedge funds (8 *pba*) and nondealer banks (7 *pba*). Central bank, in contrast, face no difference relative to banks operating in the interdelaer market.

4.2 Trading Volume and Leverage Ratio

The finding of a strong predictive relationship between leverage ratio and CIP deviations begs the question on the mechanism through which this happens. Banks are profit seeking organizations and have an incentive to expand their balance sheet per unit of capital, unless a backstop is at play. The requirement of the leverage ratio was indeed introduced by the regulator in the aftermath of the global financial crisis as a guard against banks' excessive leverage. In response to a higher leverage ratio, one would then expect a bank undertaking a deleveraging process which would lead to a decline in trading activity. For instance, Reuters stated on 5 August 2013 that *"[T]he sudden decision by regulators to focus on bank leverage ratios will hobble the industry's core trading businesses, dramatically slash the liquidity available in the capital markets, and bring about the most sweeping changes to investment banking seen in a generation."*

Table 5 about here

Motivated by these considerations, we complement the findings of the previous section by running the following fixed-effect panel regression

$$V_{ij\ell,t+1} = \alpha + \beta_1 LR_{j,t} + \beta_2 CR_{j,t} + \gamma' Controls_t + \varepsilon_{ij\ell,t}, \tag{6}$$

where $V_{ij\ell,t}$ denotes the FX forward volume in week t for currency i, dealer j, and maturity ℓ; α comprises currency, dealer, maturity and quarter time fixed effects; $LR_{j,t}$ and $CR_{j,t}$ are the leverage and capital ratio, respectively, of dealer j; and $Controls_t$ includes the control variables described above. Table 5 reports the fixed-effect panel regression estimates associated with Equation (6) with standard errors (in parentheses) clustered by currency and time dimension. The slope coefficient β_1 on the leverage ratio is negative and statistically significant, and we find similar results for both interdealer and dealer–client segment. In contrast, the coefficient on the capital ratio is never statistically significant. Most of the coefficients on control variables are not statistically significant either, with the notable exception on the lagged volume and the FX forward bid-ask spread, a common measure of market illiquidity, which is significantly negative. The sign of the coefficient is consistent with the notion that high trading volume is typically associated high liquidity levels. As an additional specification, we replace the leverage and capital ratio with a quarter-end dummy, i.e., a variable that equals one for the last two calendar weeks bracketing quarter-end dates, and find similar, albeit weaker, evidence.

Table 6 about here

We also run subsample panel regressions and report the estimates in Table 6. The negative relationship between leverage ratio and future volume strengthens for the major currency pairs (i.e., EUR, GBP and JPY) as displayed in Panel A, and weakens in Panel B for the less liquid ones (i.e., AUD, CAD and CHF). For example, the coefficient estimate in Panel A for total volume is -0.381 and is significant at 1% level; the corresponding coefficient estimate in Panel B equals -0.149 and is insignificant as the standard error is about 0.105. Intuitively, the most liquid currency pairs occupy most of the balance sheet capacity of bank dealers and, in presence of a leveraging process, they will be affected the most. We also split the sample between short-term ($<$ 3-month in Panel C) and long-term ($\geq$ 3-month in Panel D) FX forward volume. While the negative relationship between leverage ratio and future trading activity remains statistically significant across different maturity, we uncover larger coefficients estimates in Panel C than in Panel D. For example, the coefficient estimate in Panel C for total volume is -0.406 whereas the corresponding coefficient estimate in Panel D equals -0.102. As shown by Figure 2, the bulk of the trading activity is concentrated on FX forwards with less than 3-month maturity and longer-term maturities receive less than 6% of the overall trading activity. As result, when the volume-bearing capacity of dealer banks shrinks, the volume will decline more for the most traded maturity contracts.

4.3 CIP Deviations and Trading Volume

Further evidence in support of our findings is reported in Table 7. Our recipe includes $\Delta|CIP_{i\ell,t}|$ (change in the weekly average CIP deviations in absolute value from Bloomberg), $\Delta V_{i\ell,t}$ (percentage change in the weekly FX forward volume), and $\Delta V^{o}_{i\ell,t}$ (percentage change in the weekly FX option volume) as primary ingredients. The latter component acts as an exogenous instrument for the endogenous relation between $\Delta|CIP_{i\ell,t}|$ (the price) and $\Delta V_{i\ell,t}$ (the quantity). While FX option volume is unlikely to be determined endogenously with CIP deviations, we would expect FX option volume and FX forward volume to be correlated as market participants often use options to hedge the tail risk of forward positions or forwards as protection for option positions.

Table 7 about here

In the first stage of the instrument variable exercise (labeled as $2SLS_1$), we regress $\Delta V_{i\ell,t}$ on $\Delta V^o_{i\ell,t}$ plus the usual list of control variables and find that the slope coefficient associated with $\Delta V^o_{i\ell,t}$ is positive and statistically significant in all specifications considered. This suggests that FX option volume is valid instrument for FX forward volume. In the second stage (labeled as $2SLS_2$), we regress $\Delta|CIP_{i\ell,t}|$ on $\widehat{\Delta V_t}$, i.e., the fitted value of the FX forward volume from the previous regression, plus the control variables. The slope coefficient of interest is negative and highly statistically significant and remains so in all specifications considered. This result suggests that a drop in FX forward volume leads to wider CIP deviations, thus confirming and reinforcing the findings presented above.

Table 8 about here

We conclude this section by running fixed-effects panel regressions with instrumental variables. We run a difference-in-difference-in-differences (DDD) exercise where $\Delta|CIP_{i\ell,t}|$ (change in the weekly average CIP deviations in absolute value from Bloomberg) denotes the outcome of interest; C_t (a currency dummy that equals 1 for EUR, GBP and JPY), M_t (a maturity dummy that equals 1 for less than 3-month maturity contracts), and Q_t (a quarter-end dummy that equals 1 for the last two weeks bracketing quarter-end dates) define the control group; and $\Delta V_{i\ell,t}$ (percentage change in the weekly FX forward volume) captures the policy change. The coefficient estimates of interest (or treatment effects) are highlighted in red and reported at the bottom of the table. Standard errors clustered by currency and time dimension are reported in parentheses. We show the estimates for total volume in Panel A, and find statistically significant evidence that a drop in volume leads to larger CIP deviations for the most liquid currency pairs and the most traded maturities, especially at quarter ends when banks are checked for capital adequacy. The coefficient estimate associated with $\Delta V_t \times C_t \times M_t \times Q_t$ is equal to -16.144 and is statistically significant at 5% level. When we experiment across different sectors of the market, we find weaker evidence especially for the interdealer segment. As one might expect, disaggregated volume contains more noise and this could affect the statistical significance of our estimates.

4.4 Long-Term CIP deviations: Cross-Currency Basis Swaps

Most of our analysis focuses on short-term (i.e., less than a year) CIP violations. We now investigate long-term CIP deviations using transaction-level cross-currency basis Du, Tepper, and Verdelhan (e.g., 2016) withing the following fixed-effects panel regressions

$$|CIP^{xccy}_{ij\ell,t+1}| = \alpha + \beta_1 LR_{j,t} + \beta_2 CR_{j,t} + \gamma' Controls_t + \varepsilon_{ij\ell,t}, \tag{7}$$

where $|CIP^{xccy}_{ij\ell,t+1}|$ denotes the absolute value of all transaction-level cross-currency basis recorded on day t for currency i, dealer j, and maturity ℓ; α comprises currency, dealer, maturity and quarter time fixed effects; $LR_{j,t}$ and $CR_{j,t}$ are the leverage and capital ratio, respectively, of dealer j; and $Controls_t$ includes the usual list of control variables.

Table 9 about here

We report our estimates in Table 9 and a positive and statistically significant coefficient estimate for the capital ratio. This implies that an increase in the capital ratio is followed by an increase in the basis, i.e., a widening of CIP deviations. In contrast the coefficient on the leverage ratio is not significant. This result seems consistent with the fact that these cross-currency swaps carry higher risk weight which in turn affect the calculation of the capital ratio (e.g., Du, Tepper, and Verdelhan, 2016).

5 Shocks to Demand or Supply of Dollars?

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

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

5.1 US Money Market Fund Reform

To shed light on the interaction between demand and supply, we consider the US reform of the money market funds and use the implementation date as an adverse supply shock that has increased the price of hedging. On 14 October 2016, the SEC completed the reform of the money market funds, an industry that was about to implode following the debacle of Lehman Brothers. The reform required prime funds, among the largest provider of unsecured banking loans, to introduce a floating net asset value structure and redemption fees in adverse market circumstances, thus making them less attractive. This reform caused a shift in the supply of dollars and nearly 1 trillion of US dollars were rerouted from prime funds into government funds, thus affecting the ability of foreign banks to fund themselves in dollars. European and Japanese banks were particularly exposed to this regulatory change and many of them were forced to use the FX swap market to fund their dollar assets.[16]

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

TABLE 10 ABOUT HERE

We consider a $-/+$ 3 days event window around the implementation date, and assume that the demand for hedging remain constant during this period. Panel B of Table 10 reports the estimates of a difference-in-difference regression where $|CIP_{ij\ell,t}|$, the transaction-level CIP deviations in absolute value, acts as a dependent variable; MMF_t denotes a dummy variable that equals one starting from the implementation date of the reform; and the treatment effect is captured by the slope coefficient on the interaction terms $LR_{j,t} \times MMF_t$ and $CR_{j,t} \times MMF_t$ for the leverage and capital ratio, respectively. The coefficient estimate for $LR_{j,t} \times MMF_t$ is positive and statistically different from zero, even after controlling for other factors (see specification (5) and (6)). In contrast, we find no statistical evidence for the interaction term between the capital ratio and MMF_t (specification (7) and (8)). Our findings suggest that shocks to the supply of dollars drive up the magnitude of the CIP deviations.

5.2 Monetary Policy Shocks

Following Du, Tepper, and Verdelhan (2016), we also analyze the effect of monetary policy changes in conjunction with the leverage ratio on CIP deviations Specifically, we run a fixed-effects panel regression around the monetary policy announcements of the European Central Bank (ECB), and present the estimates in Table 11. The event window starts (ends) at 13:30 (15:30) Central European Time (CET). $\Delta CIP_{j,t}$ denotes the change in the euro-dollar basis. We measure CIP deviations at 13:30 (15:30) as the volume-weighted average of transaction-level CIP deviations between 11:30 and 13:30 (15:30 and 17:30) CET for each dealer. MP_t is the change in the 2-year German zero-yield minus the change in the 2-year US zero-yield between 13:30 and 15:30 CET from Reuters Tick History, and is common across all dealers.

TABLE 11 ABOUT HERE

In the first specification, MP_t is the only driving factor behind CIP deviations. Consistent with the evidence reported in Du, Tepper, and Verdelhan (2016), the coefficient estimate is positive and

the same period.

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

5.3 Order Flows

FX Dealers act as financial intermediaries and facilitate trades by quoting prices at which they are willing to trade with clients. Trades between dealers and customers, however, are not transparent as prices and transaction volumes are only observed by the two transacting counterparties. This trading mechanism implies that customer orders may contain valuable information regarding their motivation for trading, attitude towards risk and investment horizon. The information content of customer orders is typically quantified by constructing the order flow, a measure of the net demand for a particular currency defined as the value of buyer-initiated orders minus the value of seller-initiated orders. We rely for our exercise on the buy/sell indicator for FX forwards available between November 2015 and December 2016.[17] Each transaction is signed positively or negatively depending on whether the initiator of the transaction (the non-quoting counterparty) is buying or selling US dollars such that a positive (negative) order flow indicates net demand (supply) of US dollars in the forward market. We aggregate order flows within each week and report descriptive statistics in Table 12. Order flows are measured in USD billions and recall that a positive (negative) order flow denotes net demand (supply) of US dollars in the forward market.

Table 12 about here

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

We document a net demand of US dollars for short-term maturity FX forwards, and a net supply of US dollars for longer-term maturity instruments. For real money investors, for example, we uncover an average positive order flow of 44.89 USD billions (with a t-stat of 16.80) for contracts up to a week maturity, and an average negative order flow of -5.43 USD billions (with a t-stat of -3.01) for maturities between 1-week and 1-month, which then becomes more pronounced between 1-month and 3-month. Nondealer banks share the same behavior as they exhibit a positive order flow up to 1-month maturity and a negative order flow for longer-maturities. Central banks and, to a lesser extent, hedge funds and corporate firms display an opposite pattern. What does order flow tell us about CIP deviations? Recall that investing in the US money market generates a lower return than investing in the foreign money market while hedging out any FX risk. Hence, an arbitrageur should borrow dollars, buy foreign currency in the spot market, invest in the local money market and simultaneously hedge her currency risk away by buying dollars in the forward market. This means that a positive (negative) order flow can be associated with more arbitrageurs (hedgers) populating the FX forward market. One can then concludes that the long-term behavior of real money investors and nondealer banks is somewhat in line with the net foreign currency hedging demand story mentioned in the literature.

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

We run the following fixed-effect panel regression

$$\Delta CIP_{i\ell,t} = \alpha + \beta_1 OF_{i\ell,t} + \beta_2 LR_t + \beta_3 CR_t$$
$$+ \gamma_1 OF_{i\ell,t} \times LR_t + \gamma_2 OF_{i\ell,t} \times CR_t + Controls_t + \varepsilon_{i\ell,t},$$

where $\Delta CIP_{i\ell,t}$ denotes the weekly change in CIP deviations for currency i and maturity ℓ (between 1-week and 1-year), $alpha$ includes currency, maturity and quarter time fixed effects, $OF_{i\ell,t}$ is the order flow for currency i and maturity ℓ, LR_t (CR_t) is the leverage (capital) ratio average constructed as a volume-weighted average across dealer banks, $\times$ refers to the interaction terms, and $Controls_t$ is the usual list of control variables.

Table 13 about here

We report the estimates in Table 13. In the first two specifications, we find a positive and statistically significant coefficient estimate for order flow which calls for the following interpretation. CIP deviations widen in response to an increase in the hedging demand (i.e., order flow moves south), consistent with the work of Sushko, Borio, McCauley, and McGuire (2016). When we add the leverage ratio and its interaction term with order flow (see specifications (3) and (4)), β_1 becomes negative whereas γ_1, the coefficient on the interaction term, turns out to be positive and statistically significant. Conversely, the capital ratio seem to play no role in this setting, in line with our previous finds. In conclusion, we find that hedging demand causes a widening of the basis especially when dealer banks face deleveraging pressure associate with balance costs.

6 Conclusions

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

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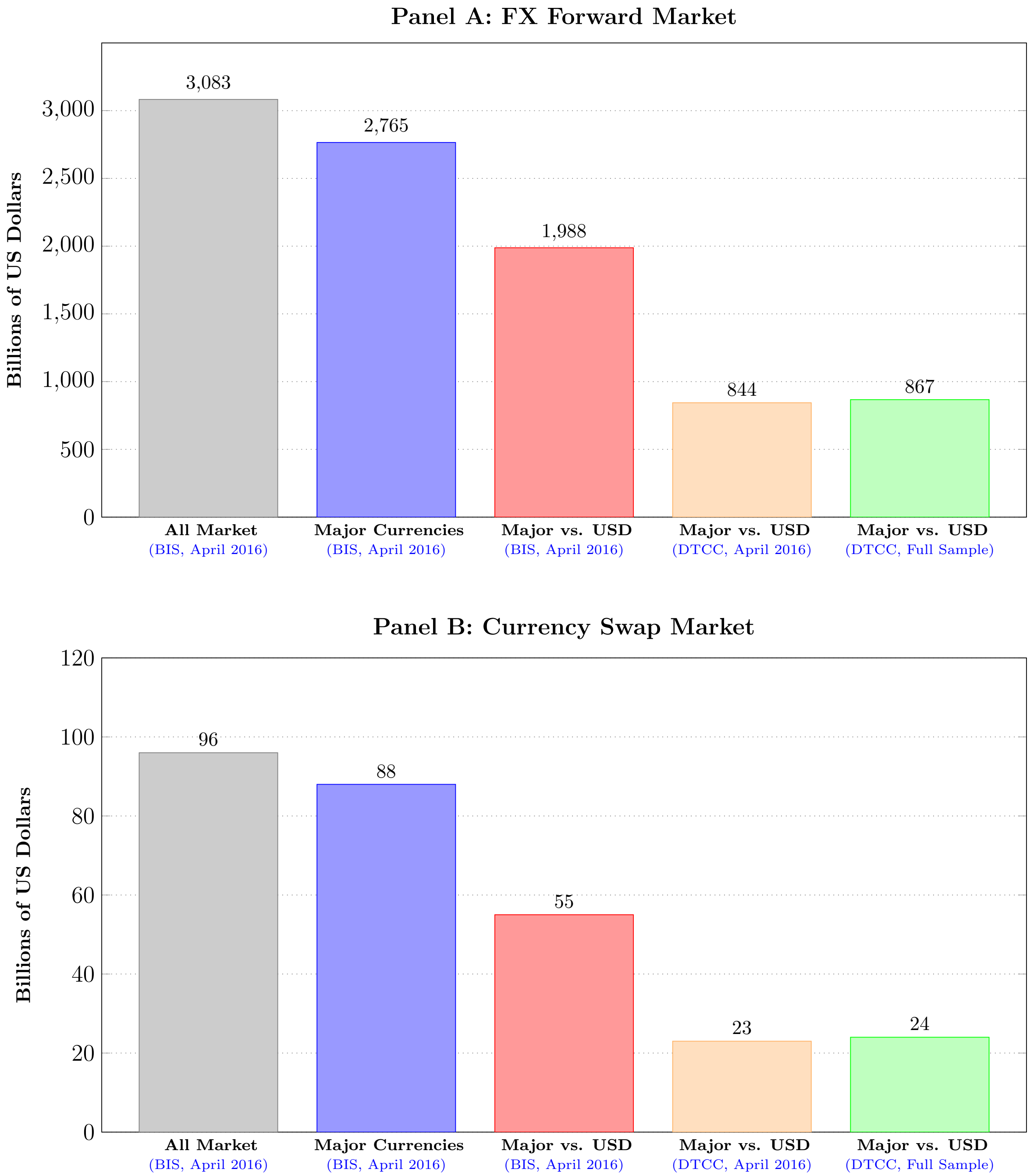

Figure 1: Daily Volume from Trade Repository Data

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

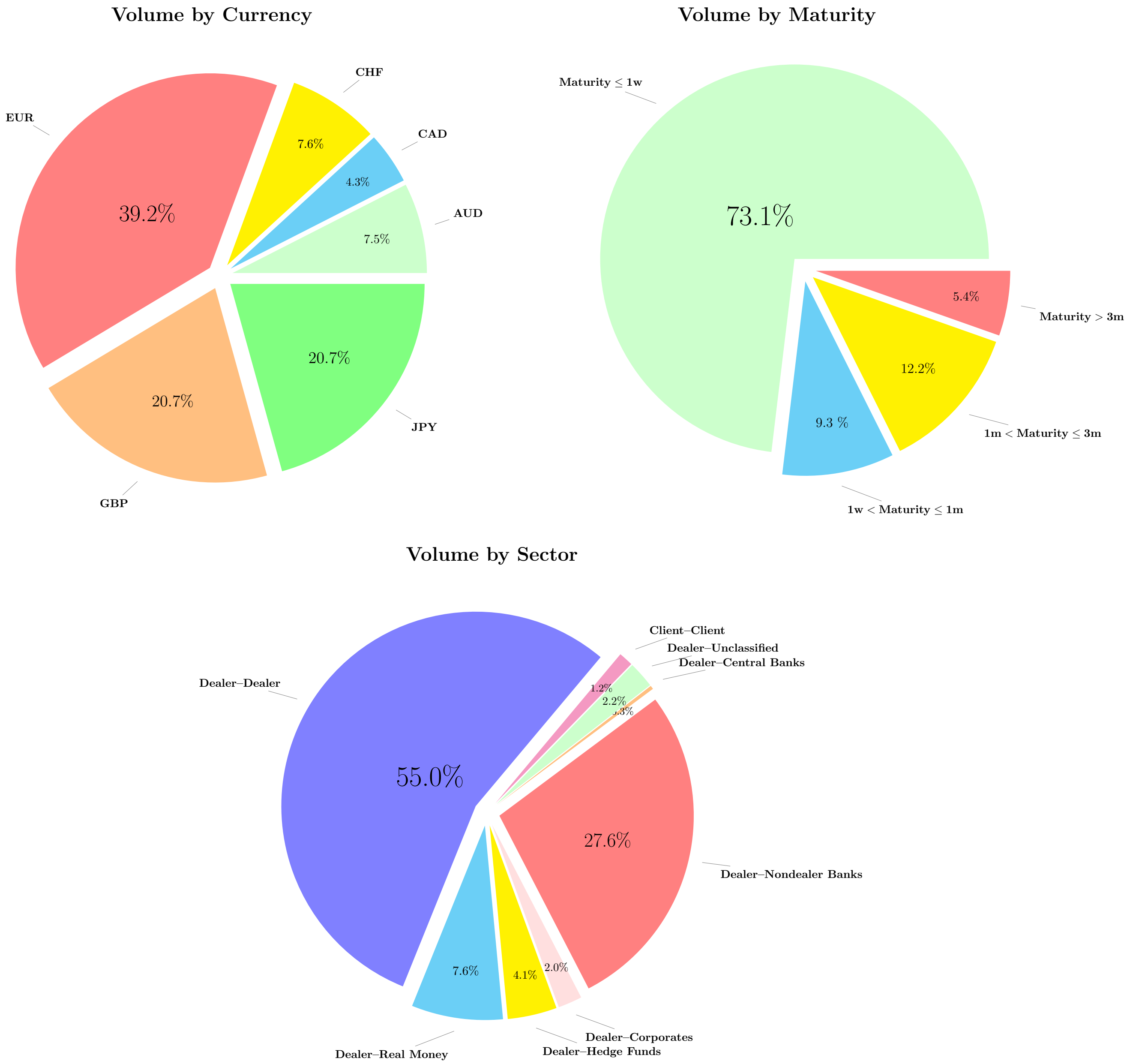

Figure 2: Breakdown of the FX Forward Volume

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

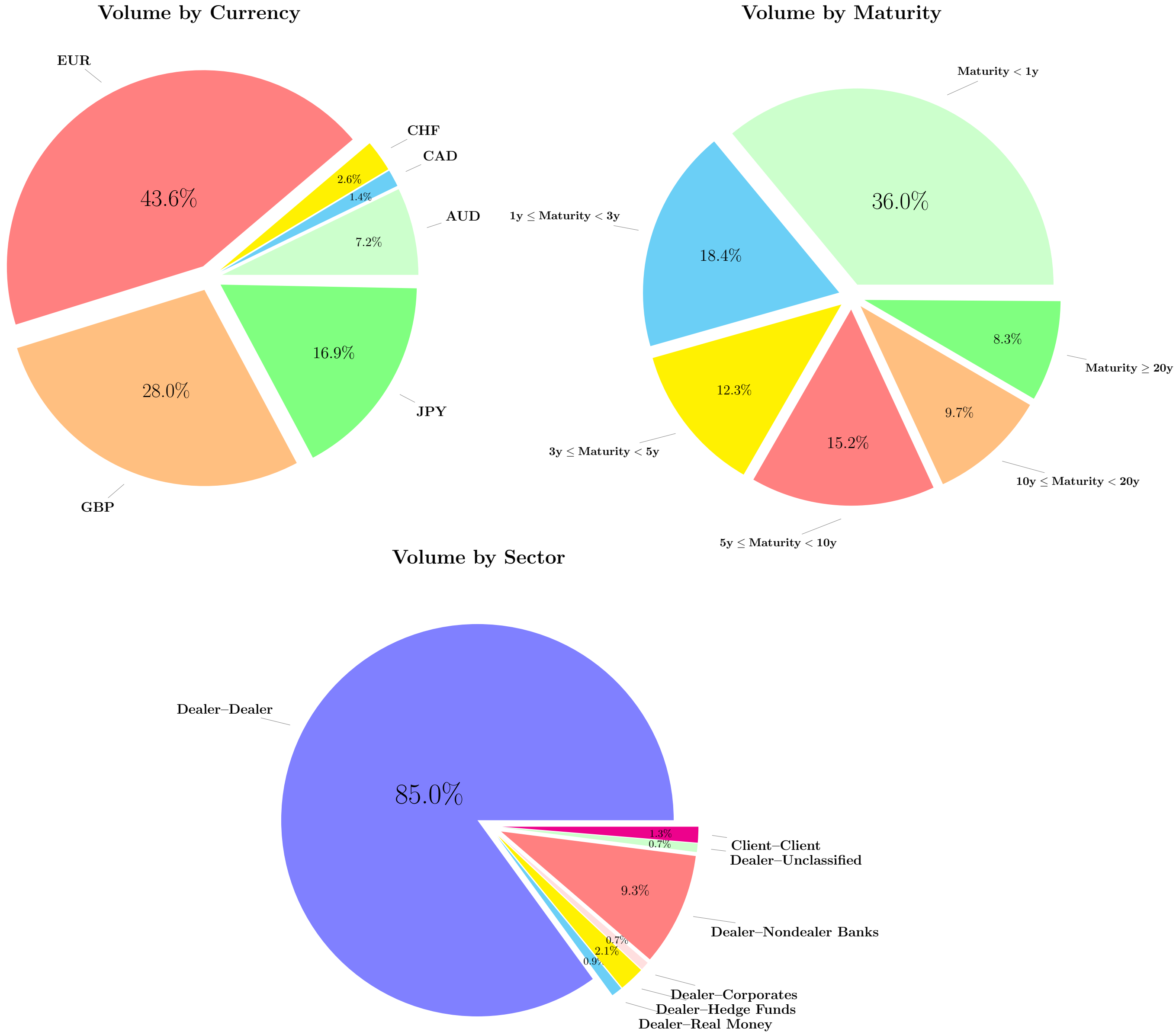

Figure 3: Breakdown of the Currency Swap Volume

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

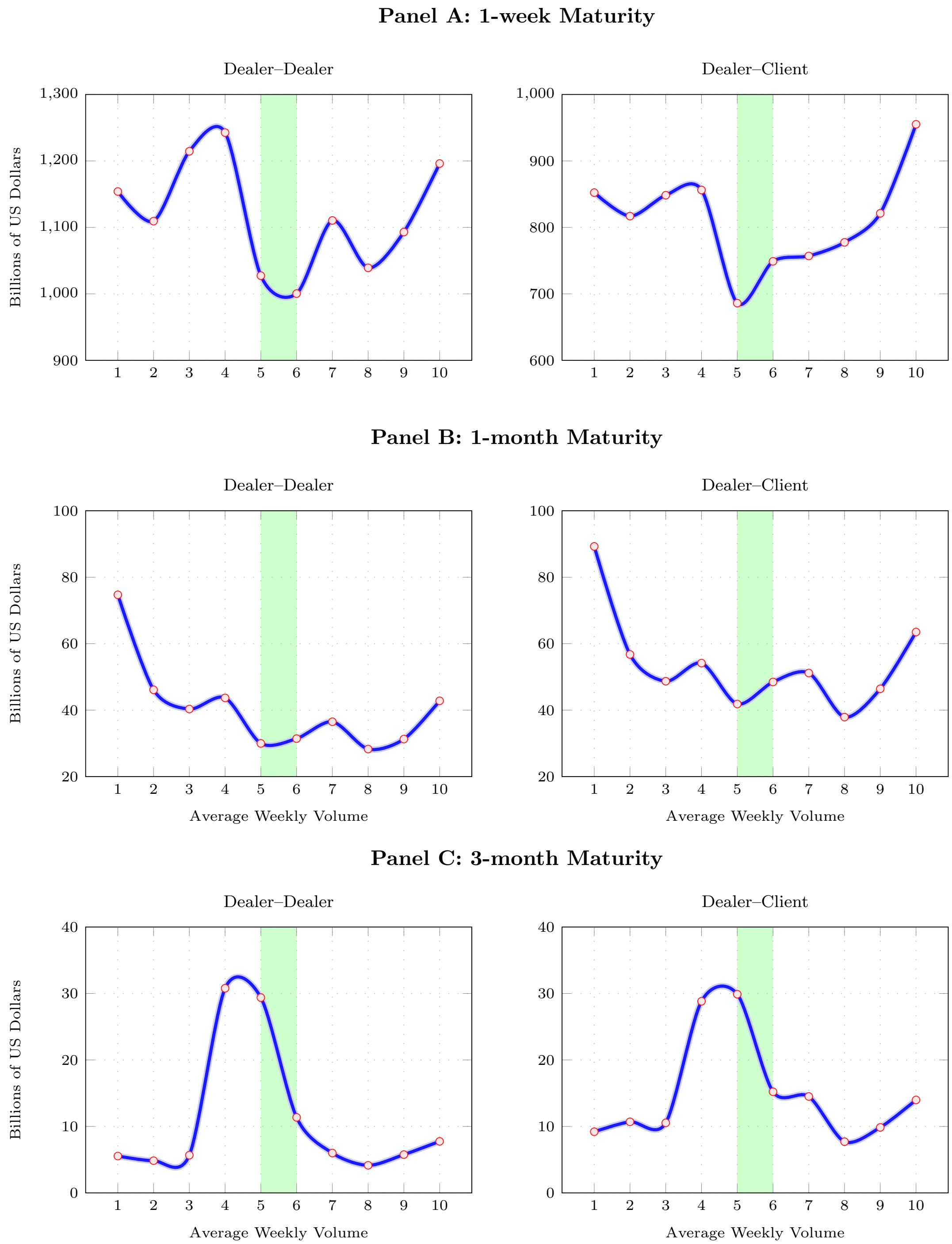

Figure 4: Quarter-End Effect and FX Forward Volume

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

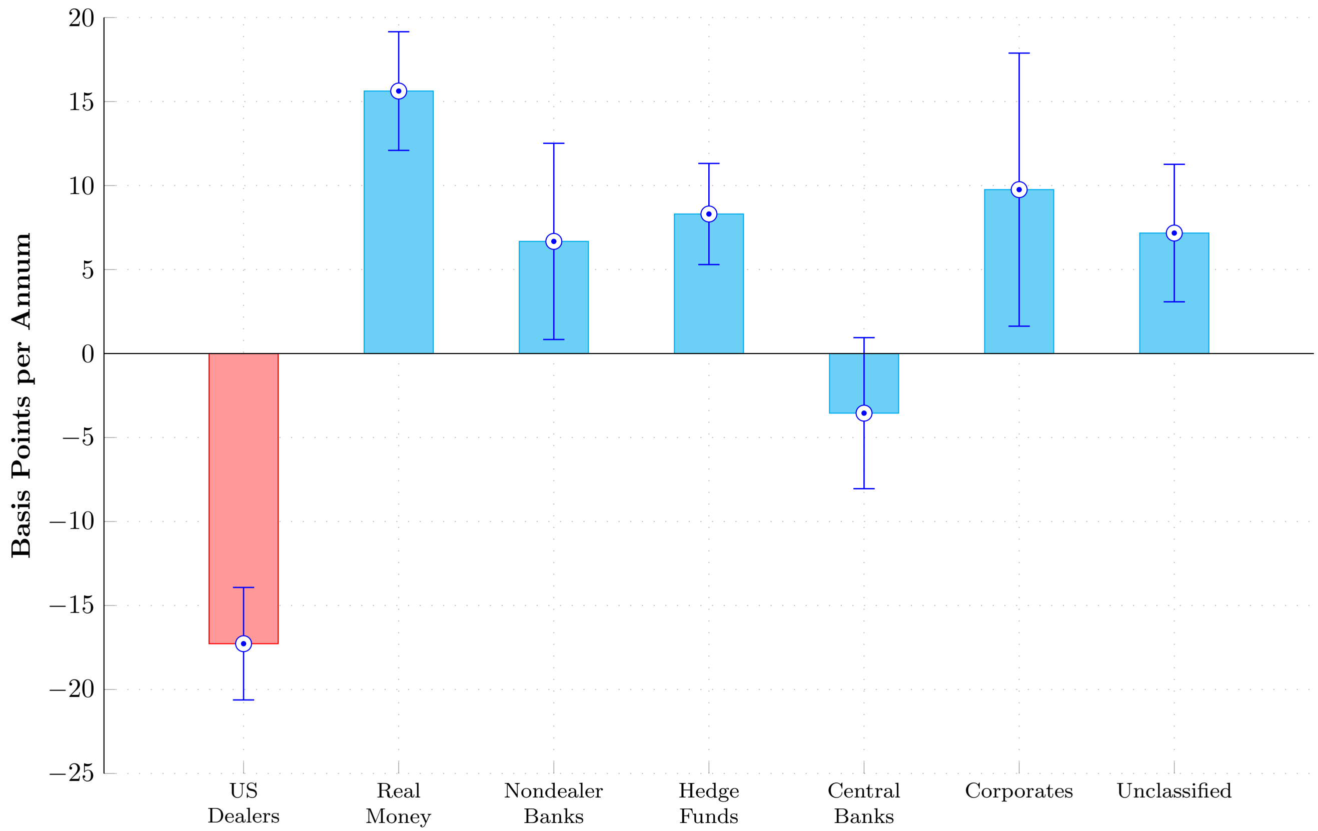

Figure 5: CIP Spread relative to the Interdealer Market

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

Table 1: Descriptive Statistics: Transaction-level CIP Deviations

This table presents average covered interest parity (CIP) deviations with standard deviations in parentheses for major currencies relative to the US dollar. CIP deviation is measured in basis points per annum using (a) daily data on LIBOR rates and spot/forward exchange rates from Bloomberg as in Du, Tepper, and Verdelhan (2016), (b) daily data on OIS rates (sampled at 11.00 am London time) from Reuters Tick History and spot/forward exchange rates from Bloomberg, and (c) transaction-level data from the Depository Trust & Clearing Corporation (DTCC) on FX forwards (outright forwards and forward legs of FX swaps) synchronized with second-level data on OIS/spot exchange rates from Reuters Tick History, and then averaged intraday for ease of comparison. DTCC data consists of OTC transactions undertaken by UK legal entities under the European Market Infrastructure Regulation (EMIR) on derivatives. The sample runs between December 2014 and December 2016.

	LIBOR Daily		OIS Daily		OIS Transaction	
Panel A: 1-month CIP Deviations						
AUD	10.61	(15.77)	12.97	(16.14)	−0.64	(62.16)
CAD	−41.76	(13.99)	−15.48	(12.23)	−15.84	(55.79)
CHF	−51.87	(39.02)	−85.30	(41.46)	−72.34	(49.16)
EUR	−40.49	(28.74)	−46.92	(33.42)	−36.69	(39.14)
GBP	−23.17	(22.94)	−24.19	(24.32)	−17.55	(38.55)
JPY	−58.33	(39.14)	−65.73	(41.05)	−51.50	(51.73)
Panel B: 3-month CIP Deviations						
AUD	5.89	(6.53)	10.69	(18.04)	4.51	(40.35)
CAD	−27.19	(6.24)	−13.13	(9.26)	−12.29	(43.02)
CHF	−40.91	(18.68)	−80.64	(24.99)	−73.63	(39.19)
EUR	−29.74	(12.98)	−43.23	(23.36)	−38.08	(25.79)
GBP	−13.07	(11.59)	−20.36	(16.54)	−14.06	(24.73)
JPY	−46.94	(17.50)	−64.60	(25.58)	−60.66	(34.64)

Table 2: Descriptive Statistics: Transaction-level Cross-currency Basis

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

	Bloomberg Quotes		Transaction Data	
Panel A: 1-year Cross-currency Basis				
AUD	17.97	(10.15)	14.14	(4.42)
CAD	−12.52	(10.22)	−17.48	(4.72)
CHF	−35.39	(10.63)	−37.19	(8.49)
EUR	−31.92	(9.89)	−31.35	(8.25)
GBP	−9.45	(7.03)	−9.70	(6.98)
JPY	−55.41	(15.97)	−53.49	(13.91)
Panel B: 5-year Cross-currency Basis				
AUD	23.96	(7.25)	22.78	(3.26)
CAD	1.24	(7.74)	−2.49	(3.61)
CHF	−44.28	(13.56)	−47.83	(8.08)
EUR	−36.13	(11.02)	−37.45	(8.36)
GBP	−8.32	(4.76)	−8.10	(4.25)
JPY	−73.74	(18.32)	−78.37	(10.97)
Panel D: 10-year Cross-currency Basis				
AUD	23.60	(8.14)	23.56	(6.94)
CAD	9.59	(13.08)	4.60	(3.30)
CHF	−53.96	(17.51)	−58.20	(11.29)
EUR	−37.36	(11.32)	−36.82	(9.56)
GBP	−10.32	(3.78)	−10.10	(3.39)
JPY	−74.33	(17.24)	−76.87	(9.71)

Table 3: Descriptive Statistics: Control Variables

This table presents descriptive statistics of the quarter-end leverage ratio (LR) and capital ratio (CR) for major dealers, change in the weekly average dealer's credit default swap (ΔCDS), weekly average spot FX return (FXR), change in the weekly average FX forward bid-ask spread (ΔBAS), change in the weekly average at-the-money implied volatility from 1-week FX options (ΔIV), change in the weekly average 10δ risk-reversal from 1-week FX options ($RREV$), and change in the weekly average spread between the 3-month LIBOR rate and 3-month T-bill interest rate (ΔTED). V denotes the weekly FX forward volume whereas ΔV (ΔV^o) is the change in FX forward (option) volume. Volume is based using transaction-level data on FX forwards (outright forwards and forward legs of FX swaps) and options from Depository Trust & Clearing Corporation (DTCC) undertaken by UK legal entities under the European Market Infrastructure Regulation (EMIR) on derivatives. Quarterly data on leverage and capital ratio are from the Bank of England. All other data are collected from Blomberg. These variables (with the exception of LR and CR) are averaged intra week and Δ denotes the weekly log change. The sample runs between December 2014 and December 2016.

	unit	mean	sdev	Q_{25}	Q_{75}
		Dealer-specific Variables			
LR	(%)	3.922	1.407	3.020	4.610
CR	(%)	11.422	1.800	10.050	12.670
ΔCDS	*bps*	0.253	8.085	−3.100	3.330
		Currency-specific Variables			
FXR		0.001	0.016	−0.008	0.011
ΔBAS	*bps*	0.010	5.515	−0.197	0.202
ΔIV	(%)	0.032	3.421	−1.385	1.290
$RREV$	(%)	−0.003	0.697	−0.155	0.170
		Global Variables			
ΔTED	*bps*	0.252	5.061	−2.000	2.000
		FX Forward Volume			
V Total		9.272	21.654	0.320	6.238
V Dealer–Dealer		5.363	13.141	0.137	3.315
V Dealer–Client		4.023	9.838	0.122	2.902
		Change in FX Forward Volume			
ΔV Total		−0.011	0.623	−0.318	0.298
ΔV Dealer–Dealer		−0.010	0.779	−0.386	0.345
ΔV Dealer–Client		−0.010	0.704	−0.341	0.337
		Change in FX Option Volume			
ΔV^o Total		−0.014	0.941	−0.540	−0.540
ΔV^o Dealer–Dealer		−0.012	1.035	−0.557	0.513
ΔV^o Dealer–Client		−0.029	1.287	−0.752	0.690

Table 4: Transaction-level CIP Deviations and Dealer Balance Sheets

This table presents fixed-effects panel regression estimates of transaction-level covered interest parity deviations in absolute value ($|CIP|$) on the lagged quarter-end leverage ratio (LR) and capital ratio (CR) for major dealers, lagged change in the weekly average dealer's credit default swap (ΔCDS), lagged weekly FX forwards volume (V), lagged weekly average spot FX return (FXR), lagged change in the weekly average FX forward bid-ask spread (ΔBAS), lagged change in the weekly average at-the-money implied volatility from FX options (ΔIV), lagged change in the weekly average 10δ risk-reversal from FX options ($RREV$), and lagged change in the weekly average TED spread (ΔTED). CIP deviations are constructed using transaction-level data on FX forwards (outright forwards and forward legs of FX swaps) from Depository Trust & Clearing Corporation (DTCC) synchronized at second level with OIS/spot exchange rates from Reuters Tick History. DTCC data consist of OTC transactions undertaken by UK legal entities under the European Market Infrastructure Regulation (EMIR) on derivatives. Quarterly data on leverage and capital ratio are from the Bank of England. Other data are from Bloomberg. The regressions include dealer, currency, maturity, and quarter time fixed effects. Standard errors clustered by currency and time dimension are reported in parentheses. The superscripts *, **, and *** indicate statistical significance at 10%, 5%, and 1%, respectively. The sample runs between December 2014 and December 2016.

	(1)	(2)	(3)	(4)	(5)	(6)
	$\|CIP\|$	$\|CIP\|$	$\|CIP\|$	$\|CIP\|$	$\|CIP\|$	$\|CIP\|$
LR	6.604**	6.311**			7.267***	7.111***
	(2.832)	(2.634)			(1.993)	(1.970)
CR			1.549	1.436	−0.310	−0.376
			(1.054)	(0.985)	(0.954)	(0.940)
ΔCDS		0.060		0.050		0.061
		(0.056)		(0.057)		(0.057)
V		−0.694		−0.733		−0.686
		(0.530)		(0.544)		(0.526)
FXR		−25.589		−26.688		−25.666
		(58.160)		(57.739)		(58.282)
ΔBAS		1.758**		1.894**		1.766**
		(0.812)		(0.853)		(0.801)
ΔIV		0.404**		0.398**		0.403**
		(0.205)		(0.203)		(0.203)
$RREV$		−0.908		−0.928		−0.911
		(1.423)		(1.415)		(1.416)
ΔTED		−0.061		−0.062		−0.063
		(0.235)		(0.240)		(0.237)
R^2	0.075	0.076	0.074	0.075	0.075	0.076
Obs	3,587,502	3,587,502	3,587,502	3,587,502	3,587,502	3,587,502

Table 5: FX Forward Volume and Dealer Balance Sheets

This table presents fixed-effects panel regression estimates of weekly FX forward volume (V) on the quarter-end dummy (Q), the lagged quarter-end leverage ratio (LR) and capital ratio (CR) for major dealers, lagged change in the weekly average dealer's credit default swap (ΔCDS), lagged weekly average spot FX return (FXR), lagged change in the weekly average FX forward bid-ask spread (ΔBAS), lagged change in the weekly average at-the-money implied volatility from FX options (ΔIV), lagged change in the weekly average 10δ risk-reversal from FX options ($RREV$), and lagged change in the weekly average TED spread (ΔTED). Volume is constructed using transaction-level data from Depository Trust & Clearing Corporation (DTCC) on FX forwards (outright forwards and forward legs of FX swaps) undertaken by UK legal entities under the European Market Infrastructure Regulation (EMIR) on derivatives. Quarterly data on leverage and capital ratio are from the Bank of England. Other data are from Bloomberg. The regressions include dealer, currency, maturity, and quarter time fixed effects. Standard errors clustered by currency and time dimension are reported in parentheses. The superscripts *, **, and *** indicate statistical significance at 10%, 5%, and 1%, respectively. The sample runs at weekly frequency between December 2014 and December 2016.

	Panel A: Total				Panel B: Dealer–Dealer				Panel C: Dealer–Client			
	(1) V_{t+1}	(2) V_{t+1}	(3) V_{t+1}	(4) V_{t+1}	(5) V_{t+1}	(6) V_{t+1}	(7) V_{t+1}	(8) V_{t+1}	(9) V_{t+1}	(10) V_{t+1}	(11) V_{t+1}	(12) V_{t+1}
Q_t	−1.303*				−0.898**				−0.412			
	(0.753)				(0.450)				(0.319)			
LR_t		−0.191***		−0.200**		−0.144***		−0.144**		−0.104**		−0.119**
		(0.065)		(0.081)		(0.051)		(0.062)		(0.051)		(0.056)
CR_t			−0.017	0.011			−0.020***	0.001			0.001	0.016
			(0.011)	(0.017)			(0.005)	(0.012)			(0.009)	(0.010)
ΔCDS_t	−0.002	−0.008	−0.008	−0.008	0.000	−0.005	−0.005	−0.005	−0.001	−0.003	−0.003	−0.003
	(0.010)	(0.011)	(0.011)	(0.011)	(0.007)	(0.007)	(0.007)	(0.007)	(0.005)	(0.006)	(0.006)	(0.006)
V_t	0.879***	0.879***	0.879***	0.879***	0.860***	0.859***	0.860***	0.859***	0.874***	0.874***	0.874***	0.874***
	(0.020)	(0.025)	(0.020)	(0.024)	(0.021)	(0.021)	(0.020)	(0.021)	(0.017)	(0.020)	(0.017)	(0.022)
FXR_t	9.526	8.935	8.942	8.935	4.383	3.973	3.978	3.973	5.457	5.274	5.269	5.273
	(8.734)	(8.714)	(8.718)	(8.714)	(4.706)	(4.824)	(4.825)	(4.824)	(4.288)	(4.228)	(4.230)	(4.228)
ΔBAS_t	−0.023	−0.052**	−0.052**	−0.052**	−0.013	−0.033**	−0.033**	−0.033**	−0.009	−0.019	−0.019	−0.019
	(0.035)	(0.024)	(0.025)	(0.025)	(0.018)	(0.014)	(0.013)	(0.014)	(0.017)	(0.013)	(0.012)	(0.012)
$\Delta IVOL_t$	0.023	0.040	0.040	0.040	0.014	0.026	0.026	0.026	0.007	0.012	0.012	0.012
	(0.059)	(0.059)	(0.058)	(0.059)	(0.030)	(0.030)	(0.030)	(0.030)	(0.034)	(0.033)	(0.032)	(0.033)
$RREV_t$	−0.281	−0.216	−0.216	−0.216	−0.184	−0.139	−0.139	−0.139	−0.100	−0.079	−0.079	−0.079
	(0.352)	(0.344)	(0.343)	(0.344)	(0.168)	(0.171)	(0.170)	(0.171)	(0.198)	(0.190)	(0.189)	(0.190)
ΔTED_t	0.001	−0.042	−0.042	−0.042	0.003	−0.026	−0.026	−0.026	−0.003	−0.016	−0.016	−0.016
	(0.032)	(0.034)	(0.033)	(0.036)	(0.018)	(0.017)	(0.017)	(0.017)	(0.015)	(0.016)	(0.017)	(0.017)
R^2	0.882	0.881	0.881	0.881	0.856	0.856	0.856	0.856	0.868	0.868	0.868	0.868
Obs	23,539	23,539	23,539	23,539	23,539	23,539	23,539	23,539	22,300	22,300	22,300	22,300

Table 6: FX Forward Volume and Dealer Balance Sheets: A Subsample Analysis

This table presents subsample fixed-effects panel regression estimates of weekly average FX forward volume (V) on the same control variables defined in Table 5. Volume is constructed using transaction-level data from Depository Trust & Clearing Corporation (DTCC) on FX forwards (outright forwards and forward legs of FX swaps) undertaken by UK legal entities under the European Market Infrastructure Regulation (EMIR) on derivatives. The regressions include dealer, currency, maturity, and quarter time fixed effects. Standard errors clustered by currency and time dimension are reported in parentheses. The superscripts *, **, and *** indicate statistical significance at 10%, 5%, and 1%, respectively. The sample runs at weekly frequency between December 2014 and December 2016.

	Panel A: EUR, GBP and JPY			Panel B: AUD, CAD and CHF		
	Total	Dealer–Dealer	Dealer–Client	Total	Dealer–Dealer	Dealer–Client
	V_{t+1}	V_{t+1}	V_{t+1}	V_{t+1}	V_{t+1}	V_{t+1}
LR_t	−0.381***	−0.273***	−0.189***	−0.149	−0.121*	−0.054
	(0.065)	(0.055)	(0.061)	(0.105)	(0.071)	(0.061)
Controls	YES	YES	YES	YES	YES	YES
R^2	0.879	0.853	0.866	0.858	0.834	0.819
Obs	12,531	12,531	12,071	11,008	11,008	10,229
	Panel C: $<$ 3-month Maturity			Panel D: $\geq$ 3-month Maturity		
LR_t	−0.406***	−0.315***	−0.172**	−0.102***	−0.067**	−0.068***
	(0.105)	(0.081)	(0.073)	(0.031)	(0.032)	(0.019)
Controls	YES	YES	YES	YES	YES	YES
R^2	0.875	0.848	0.865	0.576	0.493	0.551
Obs	12,810	12,810	12,666	10,729	10,729	9,634

Table 7: CIP Violations and FX Forward Volume: Estimation by Instrumental Variables

This table presents fixed-effects panel regression with instrumental variable estimates. $\Delta|CIP|$ denotes the change in the weekly average CIP deviation in absolute value, ΔV (ΔV^o) is the percentage change in the weekly FX forward (option) volume, FXR is the weekly average FX return, ΔBAS is the change in the weekly average FX forward bid-ask spread, ΔIV is the change in the weekly average at-the-money implied volatility from FX options, $RREV$ is the weekly average 10δ risk-reversal from FX options, and ΔTED is the change in the weekly average TED spread. OLS refers to fixed-effects panel regression estimates, whereas $2SLS_1$ ($2SLS_2$) is the first (second) step of the fixed-effect panel regression with instrumental variable estimates. $\widehat{\Delta V_t}$ denotes the fitted value of ΔV from the first-stage regression. CIP deviations are measured using data on LIBOR rates and spot/forward exchange rates from Bloomberg as in Du, Tepper, and Verdelhan (2016). Volume is constructed using transaction-level data from Depository Trust & Clearing Corporation (DTCC) on FX forwards (outright forwards and forward leg of FX swaps) and options undertaken by UK legal entities under the European Market Infrastructure Regulation (EMIR) on derivatives. Other data are from Bloomberg. The regressions include dealer, currency, maturity, and quarter time fixed effects. Standard errors clustered by currency and time dimension are reported in parentheses. The superscripts *, **, and *** indicate statistical significance at 10%, 5%, and 1%, respectively. The sample runs at weekly frequency between December 2014 and December 2016.

	Panel A: Total			Panel B: Dealer–Dealer			Panel C: Dealer–Client		
	OLS	$2SLS_1$	$2SLS_2$	OLS	$2SLS_1$	$2SLS_2$	OLS	$2SLS_1$	$2SLS_2$
	$\Delta\|CIP_t\|$	ΔV_t	$\Delta\|CIP_t\|$	$\Delta\|CIP_t\|$	ΔV_t	$\Delta\|CIP_t\|$	$\Delta\|CIP_t\|$	ΔV_t	$\Delta\|CIP_t\|$
ΔV_t	−0.951**			−0.669**			−0.696		
	(0.412)			(0.275)			(0.502)		
ΔV_t^o		0.123***			0.122**			0.097***	
		(0.030)			(0.050)			(0.019)	
$\widehat{\Delta V_t}$			−13.454***			−9.751**			−15.736***
			(4.464)			(4.438)			(5.468)
FXR_t	−97.045	1.566*	−78.617	−97.323	1.775	−82.233	−97.116	1.567*	−75.699
	(88.205)	(0.700)	(83.184)	(88.198)	(0.912)	(83.294)	(88.286)	(0.654)	(78.136)
ΔBAS_t	0.001	−0.009	−0.167	0.006	−0.019**	−0.220	0.002	−0.005	−0.120
	(0.309)	(0.007)	(0.277)	(0.305)	(0.007)	(0.244)	(0.315)	(0.009)	(0.227)
ΔIV_t	1.047	0.011	1.243	1.044	0.013**	1.190	1.042	0.013	1.287
	(0.733)	(0.006)	(0.828)	(0.735)	(0.006)	(0.812)	(0.728)	(0.010)	(0.809)
$RREV_t$	−0.034	0.006	0.165	−0.043	0.000	−0.002	−0.032	0.019	0.294
	(1.155)	(0.026)	(1.375)	(1.152)	(0.022)	(1.202)	(1.145)	(0.036)	(1.467)
ΔTED_t	0.605***	−0.014**	0.422***	0.609***	−0.015**	0.461***	0.610***	−0.012**	0.386***
	(0.175)	(0.006)	(0.131)	(0.181)	(0.007)	(0.116)	(0.177)	(0.006)	(0.135)
R^2	0.068	0.063	−0.091	0.068	0.052	−0.068	0.068	0.054	−0.224
Obs	2,376	2,312	2,312	2,376	2,352	2,352	2,376	2,313	2,313

Table 8: CIP Violations and FX Forward Volume: Diff-in-Diff Exercise

This table presents difference-in-difference-in-differences estimates of $\Delta|CIP|$ (change in the weekly average CIP deviations in absolute value) on ΔV (percentage change in the weekly FX forward volume), C_t (a currency dummy that equals 1 for EUR, GBP and JPY), M_t (a maturity dummy that equals 1 for less than 3-month maturity contracts), Q_t (a quarter-end dummy that equals 1 for the last two weeks of each quarter), and their interaction terms (we omit some of them to save space). CIP deviations are measured using data on LIBOR rates and spot/forward exchange rates from Bloomberg as in Du, Tepper, and Verdelhan (2016). The volume is constructed using transaction-level data from Depository Trust & Clearing Corporation (DTCC) on FX forwards (outright forwards and forward legs of FX swaps) undertaken by UK legal entities under the European Market Infrastructure Regulation (EMIR) on derivatives. Standard errors clustered by currency and time dimension are reported in parentheses. The superscripts *, **, and *** indicate statistical significance at 10%, 5%, and 1%, respectively. The sample runs between December 2014 and December 2016.

	Panel A: Total				Panel B: Dealer–Dealer				Panel C: Dealer–Client			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	$\Delta\|CIP_t\|$	$\Delta\|CIP_t\|$	$\Delta\|CIP_t\|$	$\Delta\|CIP_t\|$	$\Delta\|CIP_t\|$	$\Delta\|CIP_t\|$	$\Delta\|CIP_t\|$	$\Delta\|CIP_t\|$	$\Delta\|CIP_t\|$	$\Delta\|CIP_t\|$	$\Delta\|CIP_t\|$	$\Delta\|CIP_t\|$
ΔV_t	0.104	−0.096	−0.026	0.045	−0.096	−0.386	−0.071	−0.093	0.290	0.300	−0.042	0.154
	(0.449)	(0.573)	(0.340)	(0.278)	(0.324)	(0.418)	(0.246)	(0.228)	(0.259)	(0.393)	(0.235)	(0.186)
C_t	0.358	0.271		0.426	0.367	0.287		0.422	0.351	0.306		0.420
	(0.491)	(0.506)		(0.499)	(0.496)	(0.508)		(0.513)	(0.490)	(0.526)		(0.511)
M_t	1.193**		1.111**	1.052***	1.197**		1.151**	1.117**	1.194**		1.160**	1.083**
	(0.518)		(0.423)	(0.419)	(0.529)		(0.444)	(0.427)	(0.517)		(0.480)	(0.469)
Q_t		1.849	3.269	3.360		2.015	2.783	3.010		1.924	3.664	3.685
		(2.983)	(3.146)	(3.152)		(2.955)	(3.030)	(3.118)		(3.012)	(3.031)	(3.021)
$\Delta V_t \times C_t$	−0.056	−0.145		−0.238	0.142	0.289		0.107	−0.407	−0.642		−0.676
	(0.342)	(0.805)		(0.568)	(0.249)	(0.740)		(0.470)	(0.417)	(0.663)		(0.453)
$\Delta V_t \times M_t$	−1.127		−0.163	−0.291	−1.060		−0.641	−1.217	−0.883		0.571	0.776
	(0.980)		(1.546)	(1.376)	(0.876)		(1.085)	(1.206)	(1.001)		(1.697)	(1.380)
$\Delta V_t \times Q_t$		−0.411	1.693	1.149		0.352	0.653	0.381		−0.919	2.150	1.478
		(1.713)	(2.394)	(2.038)		(1.453)	(1.619)	(1.390)		(1.359)	(1.762)	(1.422)
$\Delta V_t \times C_t \times M_t$	−3.547**			0.350	−2.289			1.116	−3.786**			−0.174
	(1.578)			(1.036)	(1.572)			(1.304)	(1.760)			(1.218)
$\Delta V_t \times C_t \times Q_t$		−6.396*		1.852		−5.219*		1.349		−6.008**		2.302
		(3.610)		(1.552)		(3.115)		(1.526)		(2.971)		(1.847)
$\Delta V_t \times M_t \times Q_t$			−12.137**	−4.633			−6.930	0.052			−15.406***	−8.690**
			(5.972)	(3.869)			(4.924)	(3.137)			(5.359)	(3.820)
$\Delta V_t \times C_t \times M_t \times Q_t$				−16.144**				−15.759*				−13.992*
				(8.095)				(8.244)				(7.350)
R^2	0.070	0.072	0.080	0.086	0.069	0.070	0.074	0.080	0.071	0.073	0.087	0.092
Obs	2,376	2,376	2,376	2,376	2,376	2,376	2,376	2,376	2,376	2,376	2,376	2,376

Table 9: Transaction-level CIP Deviations: Cross-currency Swaps

This table presents fixed-effects panel regression estimates of transaction-level cross-currency basis in absolute value ($|CIP|$) on the lagged quarter-end leverage ratio (LR) and capital ratio (CR) for major dealers, lagged change in the weekly average dealers' credit default swap (ΔCDS), lagged weekly FX forward volume (V), lagged weekly average FX return (FXR), lagged change in the weekly average FX forward bid-ask spread (ΔBAS), lagged change in the weekly average at-the-money implied volatility from FX options (ΔIV), lagged change in the weekly average 10δ risk-reversal from FX options ($RREV$), and lagged change in the weekly average TED spread (ΔTED). CIP deviations are based on transaction-level data from Depository Trust & Clearing Corporation (DTCC) on cross-currency basis swaps undertaken by UK legal entities under the European Market Infrastructure Regulation (EMIR) on derivatives. Quarterly data on leverage and capital ratio are from the Bank of England. Other data are from Bloomberg. The regressions include dealer, currency, maturity, and quarter time fixed effects. Standard errors clustered by currency and time dimension are reported in parentheses. The superscripts *, **, and *** indicate statistical significance at 10%, 5%, and 1%, respectively. The sample runs between December 2014 and December 2016.

	(1)	(2)	(3)	(4)	(5)	(6)
	$\|CIP\|$	$\|CIP\|$	$\|CIP\|$	$\|CIP\|$	$\|CIP\|$	$\|CIP\|$
LR	9.407**	8.185*			3.810	3.834
	(3.822)	(4.579)			(3.402)	(3.670)
CR			2.588**	2.367**	1.937**	1.730**
			(1.058)	(1.027)	(0.872)	(0.502)
ΔCDS		−0.066**		−0.049		−0.057**
		(0.030)		(0.035)		(0.029)
V		0.058		0.074		0.070
		(0.051)		(0.050)		(0.049)
FXR		0.214		0.230		0.227
		(0.212)		(0.219)		(0.222)
ΔBAS		1.626		0.894		0.824
		(2.731)		(2.606)		(2.534)
ΔIV		0.020		0.002		0.006
		(0.040)		(0.033)		(0.038)
$RREV$		0.121		0.102		0.110
		(0.150)		(0.104)		(0.111)
ΔTED		0.077**		0.063*		0.067*
		(0.038)		(0.036)		(0.035)
R^2	0.739	0.743	0.745	0.747	0.747	0.749
Obs	89,834	89,834	89,834	89,834	89,834	89,834

Table 10: Transaction-level CIP Deviations: US Money Market Fund Reform

This table presents estimates of transaction-level covered interest parity violations in absolute value ($|CIP|$) on a dummy that equals 1 starting from the implementation of the US money market fund reform on 14 October 2016 (MMF), the lagged quarter-end leverage ratio (LR) and capital ratio (CR) for major dealers, lagged change in the weekly average dealer's credit default swap (ΔCDS), the lagged weekly FX forward volume (V), lagged weekly average FX return (FXR), lagged change in the weekly average FX forward bid-ask spread (ΔBAS), lagged change in the weekly average at-the-money implied volatility from FX options (ΔIV), lagged change in the weekly average 10δ risk-reversal from FX options ($RREV$), and lagged change in the weekly average TED spread (ΔTED). CIP deviations are constructed using transaction-level data from Depository Trust & Clearing Corporation (DTCC) on FX forward (outright forwards and forward legs of FX swaps) synchronized at second level with OIS/spot exchange rates from Reuters Tick History. DTCC data consist of OTC transactions undertaken by UK legal entities under the European Market Infrastructure Regulation (EMIR) on derivatives. Quarterly data on leverage and capital ratio are from the Bank of England. Other data are from Bloomberg. The regressions include dealer, currency, maturity, and quarter time fixed effects. Standard errors clustered by currency and time dimension are reported in parentheses. The superscripts *, **, and *** indicate statistical significance at 10%, 5%, and 1%, respectively. The sample runs between December 2014 and December 2016.

	Panel A: Full Sample		Panel B: Event Window (+/− 3 days)					
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	$\|CIP_t\|$	$\|CIP_t\|$	$\|CIP_t\|$	$\|CIP_t\|$	$\|CIP_t\|$	$\|CIP_t\|$	$\|CIP_t\|$	$\|CIP_t\|$
MMF	20.785***	21.462***	4.329***	6.922***	−5.468	−1.622	−19.722	−14.382
	(5.463)	(6.113)	(1.637)	(1.795)	(5.128)	(5.165)	(13.270)	(17.538)
LR					−1.635	−1.250		
					(1.278)	(1.652)		
CR							−1.664	−1.139
							(1.006)	(1.434)
$LR\times MMF$					2.454**	2.095**		
					(1.082)	(0.965)		
$CR\times MMF$							1.995*	1.745
							(1.039)	(1.462)
ΔCDS		0.104**		1.376**		1.346**		1.309
		(0.045)		(0.546)		(0.615)		(0.948)
V		−0.749		−1.491		−1.462		−1.471
		(0.521)		(1.446)		(0.873)		(1.090)
FXR		−58.539		147.848		143.413**		146.083**
		(51.640)		(187.391)		(68.614)		(67.323)
ΔBAS		2.083*		−0.381		−0.347		−0.361
		(0.900)		(0.565)		(0.960)		(1.874)
ΔIV		0.409*		0.589		0.556		0.640
		(0.166)		(1.536)		(0.531)		(0.821)
$RREV$		−0.840		3.770		3.769		4.115
		(1.198)		(4.517)		(3.718)		(3.402)
ΔTED		0.095		−1.733		−1.625**		−1.543
		(0.250)		(1.335)		(0.739)		(1.716)
R^2	0.082	0.084	0.124	0.130	0.125	0.131	0.126	0.131
Obs	3,587,502	3,587,502	37,537	37,537	37,537	37,537	37,537	37,537

Table 11: Transaction-level CIP Deviations: Monetary Policy Shocks

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

	(1) ΔCIP	(2) ΔCIP	(3) ΔCIP
MP	32.951***	7.022	−18.633
	(7.965)	(7.489)	(46.886)
LR		0.000	
		(0.001)	
CR			0.001
			(0.001)
$LR \times MP$		6.631*	
		(3.821)	
$CR \times MP$			4.566
			(4.578)
R^2	0.106	0.117	0.118
Obs	146	146	146

Table 12: FX Forward Order Flows by Client Sector

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

Maturity	mean	t-stat	sdev	ac_1	mean	t-stat	sdev	ac_1
	Panel A: Real Money				Panel B: Nondealer Banks			
$M \leq 1w$	44.89	[16.80]	21.64	-0.10	36.19	[8.89]	24.15	0.32
$1w < M \leq 1m$	-5.43	[-3.01]	23.52	-0.37	16.09	[8.85]	11.77	0.06
$1m < M \leq 3m$	-43.04	[-15.19]	21.30	-0.07	-4.86	[-1.64]	23.89	-0.10
$M \geq 3m$	-15.91	[-14.62]	7.42	0.21	-10.83	[-7.96]	11.60	0.02
	Panel C: Hedge Funds				Panel D: Central Banks			
$M \leq 1w$	0.12	[0.14]	8.05	-0.05	-1.74	[-6.62]	1.49	0.30
$1w < M \leq 1m$	-4.19	[-3.28]	10.28	0.16	0.46	[3.60]	0.94	0.04
$1m < M \leq 3m$	-0.01	[-0.02]	6.62	0.04	0.75	[5.30]	0.95	-0.09
$M \geq 3m$	4.42	[3.06]	8.95	0.41	0.42	[4.96]	0.61	0.17
	Panel F: Corporates				Panel G: Unclassified			
$M \leq 1w$	4.27	[8.06]	3.37	0.17	6.27	[8.54]	7.60	-0.09
$1w < M \leq 1m$	-2.90	[-6.02]	3.05	0.12	-0.45	[-1.66]	1.95	0.18
$1m < M \leq 3m$	-0.53	[-1.60]	2.99	0.13	-5.93	[-7.99]	7.58	-0.06
$M \geq 3m$	0.63	[2.17]	2.46	-0.02	0.07	[0.34]	1.47	0.34

Table 13: CIP deviations and FX Forward Order Flows

This table presents fixed-effect panel regression estimates of changes in weekly covered interest parity violations (ΔCIP) on the weekly average order flow (OF), lagged quarter-end leverage ratio (LR) and capital ratio (CR) for major dealers, weekly average FX return (FXR), change in the weekly average FX forward bid-ask spread (ΔBAS), change in the weekly average at-the-money implied volatility from FX options (ΔIV), change in the weekly average 10δ risk-reversal from FX options ($RREV$), change in the weekly average TED spread (ΔTED), and interaction terms. CIP deviations are measured using data on LIBOR rates and spot/forward exchange rates from Bloomberg as in Du, Tepper, and Verdelhan (2016). Order flow is the value of buyer-initiated orders minus the value of seller-initiated orders of US dollars against foreign currencies, and a positive (negative) order flow indicates net buying (selling) pressure of US dollars in the forward market by end-user clients. Order flows are constructed using transaction-level data and buying/selling indicators from Depository Trust & Clearing Corporation (DTCC) on FX forwards (outright forwards and forwards leg of FX swaps) undertaken by UK legal entities under the European Market Infrastructure Regulation (EMIR) on derivatives. Quarterly data on leverage and capital ratio are from the Bank of England. Other data are from Bloomberg. The regressions include currency, maturity, and quarter time fixed effects. Standard errors clustered by currency and time dimension are reported in parentheses. The superscripts *, **, and *** indicate statistical significance at 10%, 5%, and 1%, respectively. The sample runs at weekly frequency between December 2015 and December 2016.

	(1)	(2)	(3)	(4)	(5)	(6)
	ΔCIP_t	ΔCIP_t	ΔCIP_t	ΔCIP_t	ΔCIP_t	ΔCIP_t
OF_t	0.061***	0.068***	−0.287	−0.240**	0.012	0.115
	(0.005)	(0.014)	(0.168)	(0.114)	(0.325)	(0.372)
LR_t			0.005	−0.036		
			(0.024)	(0.037)		
CR_t					0.002	−0.008
					(0.008)	(0.014)
$OF_t \times LR_t$			0.084**	0.074**		
			(0.041)	(0.029)		
$OF_t \times CR_t$					0.004	−0.004
					(0.025)	(0.029)
FXR_t		−0.256		−0.271		−0.261
		(0.375)		(0.387)		(0.380)
ΔBAS_t		0.003***		0.003***		0.003***
		(0.001)		(0.001)		(0.001)
ΔIV_t		−0.001		−0.001		−0.001
		(0.004)		(0.005)		(0.005)
$RREV_t$		0.015**		0.015**		0.015**
		(0.006)		(0.006)		(0.006)
ΔTED_t		−0.007***		−0.007***		−0.007***
		(0.002)		(0.002)		(0.002)
R^2	0.010	0.052	0.010	0.053	0.010	0.052
Obs	1,338	1,338	1,338	1,338	1,338	1,338

Internet Appendix to

"Currency Mispricing and Dealer Balance Sheets"

(not for publication)

Abstract

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

Table A1: Descriptive Statistics: Transaction-level CIP Deviations

This table presents average covered interest parity (CIP) deviations with standard deviations in parentheses for major currencies relative to the US dollar. CIP deviation is measured in basis points per annum using (a) daily data on LIBOR rates and spot/forward exchange rates from Bloomberg as in Du, Tepper, and Verdelhan (2016), (b) daily data on Deposit rates (sampled at 11.00 am London time) from Reuters Tick History and spot/forward exchange rates from Bloomberg, and (c) transaction-level data from the Depository Trust & Clearing Corporation (DTCC) on FX forwards (outright forwards and forward legs of FX swaps) synchronized with second-level data on Deposit/spot exchange rates from Reuters Tick History, and then averaged intraday for ease of comparison. DTCC data consists of OTC transactions undertaken by UK legal entities under the European Market Infrastructure Regulation (EMIR) on derivatives. The sample runs between December 2014 and December 2016.

	LIBOR Daily		Deposit Daily		Deposit Transaction	
Panel A: 1-month CIP Deviations						
AUD	10.61	(15.77)	−8.40	(29.37)	−21.44	(66.36)
CAD	−41.76	(13.99)	−12.03	(23.20)	−12.93	(59.05)
CHF	−51.87	(39.02)	−32.29	(38.74)	−21.10	(49.67)
EUR	−40.49	(28.74)	−26.65	(33.82)	−17.49	(40.65)
GBP	−23.17	(22.94)	−18.53	(29.43)	−11.56	(40.83)
JPY	−58.33	(39.14)	−31.52	(37.54)	−19.17	(50.90)
Panel B: 3-month CIP Deviations						
AUD	5.89	(6.53)	−44.47	(24.00)	−16.60	(42.47)
CAD	−27.19	(6.24)	−42.29	(20.67)	−8.07	(45.88)
CHF	−40.91	(18.68)	−58.97	(24.41)	−17.94	(37.00)
EUR	−29.74	(12.98)	−50.54	(21.23)	−11.77	(22.94)
GBP	−13.07	(11.59)	−48.82	(21.52)	−6.65	(25.73)
JPY	−46.94	(17.50)	−52.32	(20.61)	−16.06	(31.77)