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Demand Effects in the FX Forward Market: Micro Evidence from Banks' Dollar Hedging

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Abstract:
Using contract-level supervisory data, we show that dollar forward sales by non-US banks that are initiated at the end of a quarter and mature shortly after it concludes trade at higher prices and higher volumes. These effects are driven by banks with large net on-balance-sheet dollar assets that they can hedge around quarter-ends by selling dollars forward (increasing off-balance-sheet short positions), which suggests regulatory arbitrage to reduce capital charges for open foreign exchange (FX) exposure. Our results indicate that demand effects related to banks' management of FX exposure are an important driver of deviations from covered interest rate parity.

JEL Classifications: D40, E43, F30, F31, G15
Keywords: FX markets, demand shifts, hedging, price determination, global banks, international finance

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I. Introduction

An emerging line of research addresses the impact of post-crisis regulation—in particular, tighter bank-capital regulation—on the efficient allocation of resources in financial markets and deviations from arbitrage pricing. In the context of the foreign exchange (FX) market, Du, Tepper, and Verdelhan (2018), Avdjiev et al. (2019) and others argue that dealers' capital constraints limit their ability to supply FX forward contracts and similar derivatives, thereby creating a wedge between the forward premia and cross-country interest rate differentials, i.e., deviations from covered interest parity. In particular, Du, Tepper, and Verdelhan (2018) show that the forward premia of contracts that are initiated before a calendar quarter ends and mature shortly after it concludes are substantially higher than those of comparable contracts that are initiated and mature within the same quarter. They argue that this is the result of *reduced supply* by dealer banks, which seek to reduce exposure before quarter-end reporting dates in order to comply with regulatory capital requirements. In this paper, we complement this reasoning by highlighting the importance of *demand factors* related to banks' FX exposure for the pricing of forwards.

Our empirical identification of this demand effect in the forward market rests on two key features. First, we utilize novel transaction-level data on USD/EUR FX forward contracts for all banks in Germany for the period 2014 through 2016. These data allow us to study both the prices and the volumes of contracts, as well as other contract characteristics, which is important for separating demand effects from supply effects. We merge the contract-level data with detailed supervisory information on banks' balance sheets, including monthly data on dollar assets and liabilities. Second, we exploit an important element of current banking regulation under the Basel framework: Banks face regulatory capital charges on unhedged on-balance-sheet FX exposure. Crucially for our identification though, the financial regulator assesses banks' overall currency mismatch only on the final day of each calendar quarter, using end-of-quarter snapshots of both on-balance-sheet and off-balance-sheet positions to do so. (We show that the national implementation of the Basel guidelines on FX risk capital charges is the same across most developed countries and not specific to Germany.)

Aggregate data suggest that all major banking sectors outside the United States have sizable dollar funding gaps; that is, a large percentage of their on-balance-sheet dollar assets is not funded with on-balance-sheet dollar liabilities.[1] German banks are no exception with respect to having large on-balance-sheet dollar exposure: Their dollar funding gaps amount to 17 percent on aggregate, and, as our detailed bank-level analysis finds, for 10 percent of German banks, this gap is larger than 60 percent. They thus could face substantial capital charges if their on-balance-sheet dollar exposure were to remain unhedged on the regulatory reporting day. However, by entering into a dollar forward sale that matures after the regulatory assessment day (a cross-quarter contract), a bank could decrease (hedge) its overall currency exposure, thereby reducing regulatory capital charges.[2] Therefore, our main hypothesis is that banks with large dollar funding gaps have a strong incentive to sell dollars forward before the quarter ends in order to reduce their dollar exposure on the regulatory assessment day. We expect these demand shifts to be particularly pronounced in cross-quarter contracts with short maturities, which—given the upward sloping term structure of forward premia—provide a cost-efficient way to temporarily hedge dollar exposure around the regulatory quarter-end reporting date.

Our robust key results are as follows. Consistent with a shift in demand, we find that, on average, banks in our sample engage in short-term (maturity of less than one month) cross-quarter dollar forward sales at higher prices (15 basis points higher) and higher volumes (20 percent higher) compared with those of similar contracts that mature in the same quarter in which they are initiated. Moreover, by comparing prices and volumes of contracts involving the same counterparty that were initiated on the same day and with the exact same maturity, we show that banks with ex-ante larger dollar funding gaps are associated with higher prices and higher volumes, which is consistent with the specific demand channel conjectured in this paper. The effects are also large; on average a bank with a one standard deviation larger dollar funding gap (about 34 percentage points) pays a 118 basis points higher forward premium and obtains a 230 percent higher contract value for cross-quarter contracts. We find that cross-quarter effects on prices and volumes identified at the contract level also have aggregate implications. For example, we document that at quarter-ends, not only do market-wide forward premia increase, but we also find

[1] For example, aggregate data form the Bank for International Settlements (BIS) indicate that in 2016:Q2, Japanese banks' dollar funding gap exceeded $1.1 trillion, or 45 percent of their total dollar assets; Canadian banks' consolidated dollar funding gap was about $335 billion, or 25 percent of their total dollar assets; and for euro-area banks the funding gap was $325 billion, or 12 percent of total dollar assets.

[2] For example, a bank with a positive dollar funding gap that, before the regulatory quarter-end day, agrees to deliver dollars (i.e., sell dollars) at some point in the future after the quarter-end day effectively enters a dollar liability and thereby reduces its currency exposure.

an increase in the number of contracts and the total turnover, driven by a strong increase in the relative turnover in short-term contracts that mature right after the quarter-end. Moreover, we show that the identified increase in short-term cross-quarter forward sales has nontrivial implications for banks' total (net) dollar exposure, which drops about 20 percent for the average bank at the quarter-end relative to the first month in a quarter.

Consistent with the demand channel postulated in this paper, we find additional heterogeneity in our main effect depending on contract maturity and a bank's ex-ante shadow cost of capital. First, we show that end-of-quarter dynamics in the forward market are more pronounced in the short-term segment, i.e., for contracts that are a cost-efficient way to temporarily hedge an exposure over the quarter-end, compared with long-term contracts with a maturity of longer than three months. We estimate that a one standard deviation larger dollar funding gap is related to a sizable, 48 basis points increase in the forward premium of short-term contracts versus long-term contracts and an increase in notional value of short-term contracts versus long-term contracts of about 19 percent. Second, we find that the effects are substantially greater (as much as four times greater) for banks with low equity capital compared with high-equity banks, for which our estimates are muted or insignificant. Similarly, we find that ex-ante large-dollar-funding-gap banks are more likely to use unsecured contracts (in which they do not have to pledge collateral) as opposed to collateralized contracts to temporarily hedge exposure at the quarter-end. In fact, we also find that if such banks enter collateralized cross-quarter contracts, they do so at lower prices, which speaks to the important role of banks' shadow cost of capital.

We test the robustness of our results along several dimensions. First, to rule out that our findings are driven by counterparty credit risk concerns, we explicitly control for bank risk using daily bond yield spreads and credit default swap spreads. Similarly, we control for banks' equity capitalization to account for potential confounding factors related to incentives to avoid derivative exposure around the quarter-end to comply with leverage regulation. Second, we comprehensively control for counterparty-specific supply factors by including Counterparty*Day or even Counterparty*Day*Maturity fixed effects to isolate demand drivers (in addition to looking at the movement of both prices and volumes). Also, we include, among other controls, Bank*Quarter fixed effects to account for potential observable and unobservable additional time-varying bank heterogeneity, as well as Bank*Counterparty fixed effects to address compositional shifts in trading partners at quarter-ends. Third, we show opposite results for banks purchasing dollars forward, that is, contracts that would add to a bank's dollar long exposure at the quarter-end. Consistent with the fact that long contracts would increase overall dollar exposure, we find that banks with ex-ante larger dollar funding gaps trade those contracts at lower prices and lower volumes compared with banks that have smaller (including negative) funding gaps. Thus, banks reduce their funding gaps around quarter-ends by temporarily increasing their short derivative exposure *and* decreasing their long derivative exposure.

RELATED LITERATURE Our results contribute to the literature in several ways. First, our paper most closely relates to the recent literature that studies the pricing of FX forwards and swaps, in particular, persistent violations of covered interest parity (CIP). For example, using aggregate data, Avdjiev et al. (2019) and Du, Tepper, and Verdelhan (2018) argue that deviations from the parity condition are caused by constraints on the supply side, where arbitrageurs cannot expand their balance sheet due to regulatory capital constraints.[3] Consistent with these supply-side arguments, Cenedese, Della Corte, and Wang (2019) show that CIP deviations have become larger for high-leverage dealers following a change in the UK leverage ratio framework. Borio et al. (2016) use aggregate data to argue that both supply shifts and demand shifts may be important for understanding CIP deviations. We complement these studies by using novel contract-level data and identify significant demand-driven price variation in similar forward contracts. We identify the demand effects by using a regulatory setup showing that, after we control for time-varying supply-side heterogeneity at the counterparty level, cross-sectional price and volume differentials still exist and depend crucially on banks' dollar funding gaps (demand side). Our results are thereby also closely connected to a broader literature on the impact of demand effects on deviations from arbitrage pricing in a range of markets (e.g., Acharya et al. 2013, on commodity markets, Ellul et al. 2011 on corporate bond markets). To the best of our knowledge, ours is the first paper to highlight the role of demand effects in FX forward pricing.

Second, our paper relates to the literature that studies the effects of regulation on financial markets and banking in a broader context (e.g., Allen and Saunders 1992 and Hamilton 1996 in banking, Koijen and Yogo 2016 in insurance). Recent studies focus on how post-crisis banking regulation has substantially tightened capital and liquidity requirements, thereby affecting banks' cost of capital (Kisin and Manela 2016). Abbassi et al. (2020) find that banks adjust their asset

[3] Using more granular data, Goulding (2019) shows that the counterparty credit risk portion of the regulatory leverage constraint has the effect of reducing volume and increasing prices in FX swap markets.

holdings of riskier securities and loans before supervisory audits but undo these changes after the audits. Similarly, recent papers argue that end-of-period effects in several financial markets are related to this increased bank capital regulation (e.g., Munyan 2015 in the repo market, Anderson and Huther 2016 for the Fed's reverse repo facility). Using unique contract-level data, which are crucial for identification, we show the effect of banking regulation, particularly end-of-quarter reporting, on the FX forward market. Our results suggest that the increased cost of forwards that cross the quarter-end are driven by banks' desire to close FX exposure and avoid capital surcharges when the regulator assesses banks' on- and off-balance-sheet positions (i.e., regulatory arbitrage strategy).

Third, we contribute to the growing body of research on the dollar's dominance in international financial markets and the special role (non-US) banks play in global dollar intermediation. For example, Shin (2016) and Avdjiev et al. (2019) discuss the relationship between the strength of the dollar and global financial conditions. Ivashina, Scharfstein, and Stein (2015) and Bräuning and Ivashina (2020) document a strong dollar dominance in international bank credit, which Gopinath and Stein (2018) link to the importance of the dollar as the invoicing currency in global trade. Non-US banks' crucial reliance on direct wholesale dollar funding markets due to their lack of a strong dollar deposit base is discussed, for example, in Aldasoro, Ehlers, and Eren (2017) and Rime, Schrimpf, and Syrstad (2017), while the importance of the derivatives market for synthetic borrowing is discussed in Borio, McCauley, and McGuire (2017). We add to this literature by providing micro-evidence that the cost of synthetic dollar funding when using the FX derivatives market depends on banks' dollar funding gaps, particularly through banks' shadow cost of capital. Our analysis also highlights substantial unhedged dollar exposure of foreign banks and the associated financial stability risks.

Finally, our study relates to the asset-pricing literature that studies the role of an over-the-counter (OTC) market structure as well as margin requirements. This literature shows that assets with similar cash flows can have substantially different prices due to market liquidity (Brunnermeier and Pedersen 2009, Gorton and Metrick 2012) and institutional frictions such as search and bargaining frictions in OTC markets (Duffie, Gârleanu, and Pedersen 2005 and 2007, Vayanos and Weill 2008). Consistent with the theoretical OTC asset-pricing literature, we provide empirical evidence that heterogeneous bargaining power generates price dispersion in the FX forward market.[4] Moreover, we provide direct empirical evidence of the margin-based asset-pricing model of Gârleanu and Pedersen (2011) by showing that price gaps exist between forwards with identical cash flows but different margins (collateralized versus uncollateralized forwards) and that the size of the gaps depends on relative capital positions in the cross section of banks.

The remainder of the paper is organized as follows. Section II describes our data. Section III provides institutional background, and Section IV contains our empirical results. Section V concludes.

II. DATA DESCRIPTION AND SUMMARY STATISTICS

We study the demand effect on the pricing of FX forward contracts using supervisory data on FX derivatives that we obtained from the Deutsche Bundesbank, which, in conjunction with the European Central Bank and the German Federal Financial Supervisory Authority (BaFin), is the prudential bank supervisor in Germany. More precisely, the European Markets Infrastructure Regulation (EMIR)—the European analog to the US Dodd-Frank Act—grants the Deutsche Bundesbank access to all derivatives trades when at least one of the involved parties is based in Germany. Our raw data include all FX derivatives contracts that were initiated during the period January 2014 through December 2016, including information on the contracting parties, the initiation day, contract maturity, the type of contract, the currency traded, the notional value (expressed in both currencies), the forward rate, and the type of collateralization.

For our analysis, we process this raw data as follows. We focus on the most liquid and economically most relevant FX derivatives market, the USD/EUR market (BIS 2016), and restrict the data set to forward contracts, which is by far the most frequently used FX derivatives instrument (forwards account for more than two-thirds of all contracts in our sample).[5] Given our research question, we also devote our attention primarily to all forward transactions in which a

[4] Hau et al. (2018) show that dealers practice price discrimination against clients in OTC derivatives markets.

[5] Under EMIR, derivatives transactions carry a flag that allows us to identify forwards explicitly and thus distinguish outright forwards from FX swaps. This is important for the economic channel that we seek to identify. An FX swap includes both a spot transaction (buying foreign currency with local currency) and a forward leg (agreeing to sell foreign currency against local currency at a future time). Both of these legs increase the assets (foreign currency on the asset side) and liabilities (commitment to deliver foreign currency in the future) to the same extent and thus leave the foreign currency funding gap unaffected. This is the opposite of a transaction that involves only a forward leg (outright forward), in which the liability side increases and, ceteris paribus, the foreign currency funding gap decreases (which is the story of our paper). But even in the unlikely (and illegal) case that some of the transactions in our *supervisory* data were misreported by banks as forwards, when in fact they represent a second leg of an FX swap, this should work against the main channel that we are after and thus hamper our ability to identify economically and statistically strong estimates.

German bank *sells a dollar forward*.[6] Economically, this means that our focus is on forward rates of contracts in which German banks take on a dollar liability when they enter an agreement to sell dollars in the forward market.

Moreover, we consider only transactions in which banks act as the principal on their own account, as opposed to contracts where they act as brokers for clients. Because we observe forward contracts at the institution (bank) level, we also exclude intragroup transactions, that is, contracts between any two banks that are part of the same bank holding company. In our main analysis, we exclude collateralized transactions and focus only on forward contracts, in which neither the seller nor the buyer posts any initial or variation margin.[7] By focusing on uncollateralized forwards, we can compare prices of contracts with otherwise similar characteristics, i.e., the same counterparty, same maturity, same contract value, and same initiation time and date. For collateralized contracts, one would need the exact type of collateral pledged and the haircuts imposed for a similarly clean comparison across contracts, which we do not observe in the data. Moreover, uncollateralized contracts account for the bulk of our sample (46 percent of all trades; 43 percent of the contracts are collateralized and 11 percent are undefined; see Table 1). Finally, to ensure that our results are not driven by outliers, we trim the data by removing contracts with the highest and lowest 1 percent of forward rates during any given month.

Throughout the analysis, we express the forward exchange rate in terms of US dollars per euro. That is, all else being equal, a higher forward rate requires the seller to deliver more US dollars for any given value of euros received, making a USD/EUR forward contract more expensive from the seller's perspective. In Figure 1, we show that daily median USD/EUR forward rates from the transactions in our sample closely follow the aggregate forward rates that we retrieved from Bloomberg, providing external validity for our sample of contracts (see also the validation exercise in Goulding 2019 for the US analog of our data). Following the standard practice in the literature (e.g., Du, Tepper, and Verdelhan, 2018), we express the forward rate as the forward premium throughout our analysis; that is, we rewrite it as the *relative difference* (in basis points) between the rate of the individual USD/EUR forward contract and the USD/EUR spot exchange rate prevailing on the day of the contract's initiation: $Forward\ Premium = (Forward\ Rate/Spot\ Rate - 1) * 10{,}000$. Hence, the forward premium measures the premium

[6] In robustness regressions, we show that our results also hold for institutions buying a dollar forward (see Section IV.5).
[7] However, below, we further exploit demand effects on the pricing of collateralized FX forwards.

(or discount if negative) that the seller pays to lock in the forward rate relative to the spot rate prevailing on the same day.

In Table 2, we provide summary statistics on key contract characteristics, notably the forward premium, contract value, and maturity. Our final data set contains 271,230 forward contracts between 145 different German banks and a total of 14,485 distinct counterparties. On average, we observe 732 forward contracts per day, with an average notional value of USD 16.27 million per trade. The average maturity is 79 days, but 50 percent of all contracts have maturities shorter than one month, while contracts with a maturity of longer than three months account for less than 15 percent of all contracts. Thus, the forward market, similar to other liquidity markets, is very short term in nature (see also Appendix Figure A.1 for the maturity breakdown). The average forward premium amounts to 64 basis points and varies substantially, with a standard deviation of 257 basis points during our sample period; that is, on average, a forward dollar sale settles at 64 basis points above the respective FX spot rate prevailing on the same day.[8]

However, based on aggregate data, we already know that forward premia differ across contracts, depending particularly on the maturity and initiation day of the contracts, as suggested by the covered interest parity equation. Moreover, the forward premium may also vary across different counterparties (e.g., dealers versus non-dealers). Therefore, we clean the forward premium by Counterparty*Maturity*Day fixed effects to isolate the variation of forward premia for contracts of the same maturity that are initiated with the same counterparty on the same day.[9] The remaining variation is thus related to different premia across banks for otherwise identical contracts, precisely the variation that we seek to explain in this paper. Table 2 shows that even these cleaned forward premia have substantial cross-sectional variation, with a standard deviation of 104 basis points. This price dispersion is economically meaningful, particularly considering that the premia are charged for contracts with the same counterparty that are of the same maturity and are initiated on the same day. Moreover, as Figure 2 shows, the cross-sectional price dispersion is a persistent phenomenon throughout the entire sample period.

[8] In Appendix Table A.1, we show that this heterogeneity in forward premia is not only specific to uncollateralized transactions, but can also be found in the rates faced by German banks when they enter into collateralized forward contracts.

[9] We achieve this by regressing the forward premium on counterparty*maturity*day fixed effects. The residuals of this regression will then be filtered by this dimension and any remaining variation comes from a dimension that is related to the dollar forward selling bank.

It is important to highlight that the documented cross-sectional variation in forward premia is not specific to contracts traded by German banks. In fact, using analogous supervisory data from the US, Goulding (2019) reports substantial cross-sectional variation in forward premia, and similar results are found for the UK by Cenedese, Della Corte, and Wang (2019). Thus, the German dataset that is at the core of our analysis is in that respect no different from what is reported in studies using data from other jurisdictions, and, as we will discuss below, our findings are likely to have broad implications for FX markets in other countries.

To better understand the price variation across banks for otherwise similar forward contracts, we merge the contract-level data on forward sales with confidential bank-level information, which allows us to relate pricing differences to individual bank characteristics. First, we merge our data set on forward contracts with confidential supervisory balance-sheet information that is available at a monthly frequency. The information includes each bank's equity and total assets. Second, from reports on external positions (Auslandsstatus) maintained by the Deutsche Bundesbank, we obtain data on each bank's FX-denominated on-balance-sheet assets and liabilities.[10] These reports provide, for each bank in Germany, comprehensive information on all non-euro-denominated claims and liabilities (held domestically and abroad) at the currency level in each month (stock at the end of each month). In addition, the reports include information on the maturity and on the sector (interbank, retail, and affiliated offices) that are related to the liability or asset position.

In Table 3, we present summary statistics for the 145 German banks that participated in the dollar forward market during our sample period (statistics are computed at the bank-institution level; for each bank, we take the mean of balance sheet statistics across time). The summary statistics reveal substantial heterogeneity in bank size (total assets), with a mean and median of total assets of EUR 26 billion and EUR 4 billion, respectively, and a standard deviation of EUR 97 billion. While the sample includes smaller banks, large banks with assets exceeding EUR 25 billion comprise 10 percent of the sample (i.e., 14 banks). Moreover, contract-weighted summary statistics, reported in Table 2, show that larger banks are also more active in the forward market compared with smaller banks. In fact, Appendix Table A.2 shows that the largest 25 percent of banks account for about 91 percent of all forward transactions in our data set.

[10] Gomolka, Schäfer and Stahl (2020) and Gomolka, Munzert, and Stahl (2020) provide more details on the balance sheet statistics and banks' exernal positions, respectively.

Further, Table 3 shows that the average bank in our sample has about 3.7 percent of its total assets invested in dollar-denominated assets. However, several banks in the sample hold a sizable amount of dollar-denominated assets, both in terms of total balance sheet size (for 10 percent of the banks, dollar assets represent more than 8.5 percent of total assets) and in terms of equity (for 10 percent of the banks, dollar assets are more than 152 percent of equity). Thus, dollar intermediation is an economically significant part of the business model of a broader set of German banks and not peculiar to only the largest one or two German banks. Contract-weighted summary statistics in Table 2 reveal that banks with a large dollar book are more active in dollar forward sales, with 75 percent of all contracts being initiated by banks with dollar assets that are more than 9 percent of their total assets. A correlation analysis shows that banks with a larger dollar book tend to be larger in terms of total assets (see Appendix Table A.3).

Table 3 reveals another important characteristic of our sample of banks: While a significant share of German banks invests substantially in dollar-denominated assets, many German banks do not fund this activity fully through direct (on-balance-sheet) dollar liabilities. We measure the mismatch between on-balance-sheet dollar investments and funding by the dollar funding gap, which we compute as (total dollar assets – total dollar liabilities)/total dollar assets*100. Thus, this variable measures the percentage of dollar-denominated on-balance-sheet assets that is *not* directly funded through dollar-denominated on-balance-sheet liabilities. Table 3 shows that, on average, 4 percent of banks' total dollar assets are not directly funded by dollars, but need to be raised synthetically. For 25 percent of all banks in our sample, the funding gap is larger than 6 percent, and for 10 percent of the banks, the dollar funding gap is larger than a sizable 56 percent.[11] Consistent with the supposition that banks use forward contracts to hedge dollar exchange rate risk, Table 2 shows that banks with larger dollar funding gaps also dominate trading in the forward market, as contract-weighted summary statistics of the dollar funding gaps are substantially higher than corresponding bank-level statistics (mean of 46 percent, median of 60 percent).

We further enrich our data set with the list of global FX dealers that are reporting institutions in the 2016 BIS Triennial Central Bank Survey of Foreign Exchange and Derivatives Market Activity. This comprehensive list comprises 1,283 FX dealers globally; 37 of these institutions are

[11] The dollar funding gap accounts on average (median) for 159 percent (198 percent) of total equity. Using a simple correlation analysis, we further find that banks with larger dollar funding gaps are positively correlated with total assets and total dollar assets (see Appendix Table A.3). As a result, the funding gap of the median bank in our sample is smaller than aggregate data suggest (e.g., BIS report 2016:Q2). However, the size of the dollar funding gap for the entire German banking system will be driven by the large institutions and thus yield to a higher level in aggregate data.

based in Germany (including German banks and German offices of foreign banks).[12] Information on dealer banks allows us to identify inter-dealer trades and dealer-to-non-dealer trades (non-dealer trades). Table 1 shows that about 15 percent (34.7 * 45.7 percent) of the trades in our sample of uncollateralized contracts are inter-dealer trades; thus our sample includes both inter-dealer and non-dealer trades, a feature that we will exploit in our empirical analysis.

Despite the heterogeneity in market participants and contracts, Appendix Table A.2 shows that the price variation prevails, although to a varying degree, for different types of banks and contracts (e.g., large and small banks, large-funding-gap versus small-funding-gap banks, dealer and non-dealer banks, contracts that cross quarter-ends and those that do not, etc.). That is, the price variation that we discover in our contract-level data is not driven by peculiar groups of banks or contracts; rather, it is a broad phenomenon of the forward market.

III. INSTITUTIONAL BACKGROUND

Our main hypothesis is that the variation in the pricing of dollar forward contracts shown above is (at least partly) demand driven and related to the desire to hedge on-balance-sheet dollar exposure. We identify these demand effects using a specific institutional feature of the current banking regulation. In particular, we argue that a bank's desire to hedge its dollar funding gap through forward contracts is especially pronounced at quarter-ends, when key regulatory constraints become binding. Our approach rests on the notion that FX risk is widely acknowledged as a major financial risk (Stein 2012, Shin 2016), which has led the financial regulator to impose capital charges on any bank with currency imbalances between assets and liabilities.[13] As a result, the Basel banking regulation guidelines impose a general capital charge on an institution's overall net FX position, computed based on both on- and off-balance-sheet positions.

The capital charge on banks' FX exposure is part of a key component of the Basel framework that requires banks to fund part of their risky operations with equity capital. In particular, the Basel

[12] Reporting dealers are primarily large commercial and investment banks (but also other financials) that participate in the inter-dealer market and maintain an active business with financial and nonfinancial firms, and government entities. For Germany, the central bank requires mandatory reporting for banks with more than EUR 1 billion in foreign-currency-denominated assets and liabilities (combined), see https://www.bundesbank.de/Redaktion/DE/Standardartikel/Service/Meldewesen/triennial_central_bank_survey_biz.html

[13] For more details, see EBA/Chapter 3 Article 351. Regulatory charges apply to on- and off-balance-sheet exposures on the reporting date; that is, only the positions held at the reporting date are used to determine compliance.

framework mandates that a bank's risk-weighted capital ratio (the capital adequacy ratio, or CAR) is greater than a regulatory minimum:

$$Capital/RWA \geq \alpha,$$

where *Capital* is a bank equity measure, *RWA* refers to risk-weighted assets, and α is the regulatory minimum requirement (e.g., 8.5 percent). Following the simplified standardized approach for computing market risk, we can illustrate the quantitative impact of FX exposure on the CAR through its effect on RWA.[14] Under the simplified standardized approach, RWA are determined by multiplying the capital requirements for FX exposure by 12.5, where the capital requirements for FX risks are given by 1.2*0.08, with 1.2 being a scaling factor applied to FX risk and 0.08 (8 percent) being the general capital charge for FX exposure.[15] Thus, any euro of open FX exposure increases the denominator of the CAR by a total of 1.2 (=0.08*1.2*12.5) euros.

The strong impact of FX exposure on the CAR is at the core of the mechanism in this paper, as banks can use FX forward contracts to reduce or eliminate open on-balance-sheet FX exposure (such as a dollar funding gap), thereby increasing their CAR. Subfigure 3(A) shows a quantitative example of how hedging FX exposure with forward contracts increases the CAR for different levels of initial RWA. While the exact impact on the ratio depends on the initial value of the ratio, the effects are sizable, with an increase in the ratio of about 1 percentage point if banks hedge the entire FX exposure, which equals 1 times the equity value in our example.

However, while the use of forward contracts allows a bank to reduce (on-balance-sheet) FX exposure, thereby improving its capital adequacy ratio, it also leads to an increase in off-balance-sheet derivatives exposure. Under the current Basel framework, such derivatives exposure contributes to the regulatory leverage ratio, the second key capital constraint. The leverage ratio regulation requires that core equity capital exceeds 3 percent of the bank's on- and off-balance-sheet exposure. Using a simplified numerical example similar to Goulding (2019), we show that any euro increase in derivatives exposure increases the denominator of the leverage ratio by 1 cent (compared with 1.2 *euros* for the CAR).[16] Subfigure 3(B) graphically illustrates the quantitative

[14] Subject to national supervisory approval, banks are allowed to employ different methodologies to compute RWA, including bank-internal models that rely on various input factors. Since these models and input parameters are unknown and bank specific, employing a realistic numeric assessment of the effects of unhedged FX risk on capital ratio in this paper is not possible. See also https://www.bis.org/basel_framework/chapter/RBC/20.htm and, for details on the simplified standardized approach, https://www.bis.org/basel_framework/chapter/MAR/40.htm?inforce=20220101.

[15] FX exposure that is less than 2 percent of equity is exempt from the regulatory capital charge.

[16] For derivatives, the exposure is in general computed as the sum of the replacement cost (RC) and the potential future exposure (PFE). See https://www.bis.org/publ/bcbs270.pdf for more details. In our numerical example, we follow Goulding (2019) and focus

impact on the leverage ratio for our example. Irrespective of the initial leverage ratio, adding forward exposure of the size of bank equity to hedge currency risk thus does not materially affect the leverage ratio (while it strongly reduces the CAR).[17]

In most jurisdictions, the national implementation follows the outlined Basel guidelines on capital requirements very closely (see Section C of our Supplementary Appendix). In fact, the Basel Committee, together with central bank governors and heads of supervision, established the comprehensive Regulatory Consistency Assessment Programme (RCAP) to monitor and assess the adoption and implementation of its standards across different jurisdictions and to ensure a full and effective implementation of Basel standards among members.[18] Moreover, as Section C of our Supplementary Appendix highlights, for banks from most countries—including all Eurozone countries, the United Kingdom, and Switzerland—the financial regulator assesses banks' currency imbalances and judges compliance with regulatory *risk-weighted* capital requirements on the final day of each calendar quarter using the end-of-quarter snapshot of both the on- and off-balance-sheet items of a bank.[19] That is, our empirical setup and findings are *not* based on Germany-specific regulation and thus are likely to hold similarly for banks from other jurisdictions where regulatory compliance is judged based on the quarter-end reporting of key regulatory capital measures.

While we exploit this specific institutional setup of banking regulation in our empirical identification, the fact that assessment of regulatory compliance happens only at quarter-ends does not mean that hedging demand to close currency mismatches is present only near quarter-ends. Indeed, banks' internal risk-management practices are another key driver of hedging FX risk. We exploit the regulatory setup (FX capital charges and end-of-quarter assessment) to infer that if hedging *demand* differentially affects the pricing of FX forwards, the impact should be more pronounced near the end of a regulatory binding quarter due to *additional* demand shifts introduced by regulation. As discussed above, our focus is on dollar forward contracts given the large on-balance-sheet dollar exposure of all major banking systems.

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on the case of uncollateralized forward contracts that are not subject to netting rules (which would reduce exposure) and which have a zero replacement cost (marked-to-market value). For contracts with a maturity of less than one year, which account for the vast majority of the market and are at the core of our paper, the PFE is 1 percent of the notional value.

[17] Qualitatively similar results hold if we assume positive, reasonable replacement costs. Moreover, the possibility of netting would further reduce the exposure and thus the impact on the leverage ratio.

[18] See https://www.bis.org/bcbs/implementation.htm?m=3%7C14%7C656%7C80 for more details.

[19] This is in contrast to the assessment practice of the straight leverage ratio requirement, which differs across jurisdictions; see Section C of our Supplementary Appendix.

The basic intuition of the conjectured mechanics of arbitrage strategy arising from this institutional framework is as follows: By selling a dollar forward that matures after the next quarter-end, a bank can reduce the exposure associated with a positive on-balance-sheet funding gap (more dollar assets than liabilities), thereby reducing regulatory capital charges. Therefore, if banks want to economize on regulatory capital charges, they should have a higher valuation (and thus a greater willingness to pay) for a cross-quarter forward dollar sale that allows them to reduce their net FX position and associated capital charges, which should be reflected accordingly in transaction prices. Moreover, if prices for quarter-crossing contracts increase due to demand shifts, one would expect *both prices and quantities to be high*. We expect these demand shifts to be particularly pronounced in cross-quarter contracts with short maturities, which allow banks to temporarily hedge dollar exposure around the regulatory quarter-end reporting. In addition, we argue that the incentives to engage in such behavior should be stronger for banks with larger (ex-ante) funding gaps, which would face larger regulatory capital charges. Thus, we expect to see differential effects, in the sense that volumes and prices are higher for banks with larger versus smaller dollar funding gaps. In the next section, we will lay out our empirical approach to test these core implications.

IV. EMPIRICAL STRATEGY AND RESULTS

IV.1 Aggregate Quarter-End Dynamics

We start our analysis by estimating aggregate end-of-quarter dynamics for the dollar-euro forward market. For this purpose, we collapse the contract-level data at the bank-day level and test for price and volume differentials at the end of the quarter. Formally, we run the following regression:

$$\text{Forward} \;=\; \beta_0 \text{End-of-Quarter} + Fixed\ Effects + \varepsilon, \qquad (1)$$

where *End-of-Quarter* is a dummy variable that takes the value of 1 on the final five days of each quarter, and 0 otherwise.[20] *Forward* is an aggregate measure of the forward market (either a price measure, quantity measure, or maturity measure), and *Fixed Effects* refers to bank*quarter fixed effects to control for any time-varying bank heterogeneity and compositional shifts in the sample

[20] These results are robust to using different definitions of quarter-ends, for example when defined as the final seven or final ten days of a quarter (see Appendix Table A.4).

of banks. To estimate aggregate market effects, we weight observations with the daily market share (based on total notional values). The idea is that if demand is high for selling dollars close to the quarter-end, selling pressure should be measurable at the aggregate level across all relevant margins.

Results presented in Table 4 show that forward premia are significantly higher before quarter-ends than they are during the quarter. As shown in column (1), we find that during the final five days of the quarter, the (value-weighted) forward premium is about 12 basis points higher across all contracts. At the same time, we observe a strong increase in measures of market activity. As shown in columns (2) and (3), we estimate that the total turnover (notional value) and number of contracts increase about 29 percent and 18 percent, respectively, at the end of the quarter. These findings support the notion of a demand-driven increase in prices.

In addition to the increases in prices and volumes, Table 4, specifically column (4), documents another important quarter-end dynamic: On average, the (value-weighted) maturity of a forward contract initiated in the final five days of the quarter is more than one month shorter than that of a contract initiated earlier in the quarter. The increase in the number short-term contracts at quarter-ends is consistent with regulatory arbitrage, given that short-term contracts have a lower forward premium and thus provide a cost-efficient way to cover an exposure over a short horizon (quarter-end). We show the increasing maturity premium graphically in Figure 4.[21] The increasing maturity premium suggests that if a bank intends to sell a dollar forward for the purpose of hedging its dollar exposure only on the regulatory reporting day, it can minimize its cost by selling a short-term forward contract that is initiated right before the quarter-end day and then matures just after the start of the next quarter. This would minimize the cost of hedging and, at the same time, allow the bank to cover its dollar exposure on the regulatory reporting day.[22]

Figure 5 shows additional evidence on the important role of short-term contracts around quarter-ends. In particular, the figure compares average relative daily market turnover by maturity depending on whether a contract matures *before* the upcoming quarter-end (within-quarter) or *after* the upcoming quarter-end (cross-quarter). These cross-quarter contracts are the type that allow the seller to cover an exposure over the regulatory key date. The figure reveals a stark result that

[21] The term structure of forwards is also upward sloping in the sample of cross-quarter contracts.

[22] Pushing this argument to the extreme, one might argue that a bank would want to hedge its exposure *only* on the reporting day. However, liquidity differences across maturities, risk aversion, search frictions, or other frictions are likely at play.

highlights the role of short-term contracts in demand-driven quarter-end dynamics. The steepest increase in the turnover of contracts with very short maturities occurs right before quarter-ends. For example, contracts with a five-day maturity account for less than 10 percent of the total within-quarter turnover on average. However, once we condition the sample on the set of cross-quarter contracts, five-day contracts account for more than 45 percent of the total turnover. A similar pattern emerges for other contracts with very short maturities, consistent with their role as cost-efficient ways to hedge exposure on regulatory key dates.[23]

IV.2 Baseline Results: Volume and Prices of Cross-Quarter Contracts

A key challenge in identifying hedging demand as a driver of the cross-quarter premium is the possibility that the supply of dollar forwards may be different for cross-quarter contracts. For example, capital-constrained dealers may reduce the supply of cross-quarter forward contracts to comply with leverage regulation, which could also explain why forward premia increase before quarter-ends (e.g., Du, Tepper, and Verdelhan 2018). While our aggregate results from above show increases in volumes and prices, and thus are consistent with a demand-driven increase in end-of-quarter forward premia, we proceed to identify the specific demand channel conjectured in this paper more carefully by exploiting contract-level data.

Our identification strategy relies on the comparison of the prices and volume of short-term cross-quarter contracts—which are suitable for temporarily closing an exposure on the regulatory reporting date—with a comparable control group of contracts. Therefore, in our baseline analysis, we focus on short-term cross-quarter contracts that have a maturity of less than one month as the "treated" group of contracts, while the "control group" includes short-term contracts with a maturity of less than one month that mature in the same quarter they were initiated. (We discuss the design of alternative control groups and robustness to different maturity thresholds in the following subsections.) In our empirical specification, we use an expansive fixed effects structure to control for potential confounding factors. Most importantly, our set of fixed effects allows us to compare (treaded versus control) contracts of the same maturity that were initiated on the same

[23] The increased volume of short-term dollar forward sales at quarter-ends implies that, at the beginning of the new quarter, a bank will need to deliver US dollars, which it can obtain either by (i) buying them in the spot market (or by entering a respective shorter-term forward dollar purchase right *after* the quarter-end) or (ii) by borrowing the dollars directly, e.g., in the dollar money market. Option (i) means that the bank is taking on FX risk due to the exchange rate movements between the forward dollar sale and the day of its delivery, and option (ii) implies that the bank is following a rollover strategy that leads to increasing leverage in the long run.

day and with the same counterparty, which helps isolate the demand effect by controlling for time-varying supply-driven (i.e., counterparty-driven) changes in prices and volumes. To measure the impact of dollar exposure on cross-quarter differentials, we relate the remaining variation in prices and volume (net of "supply" effects) to banks' heterogeneous dollar funding gaps.

Our baseline regression equation is given by:

$$\text{Contract} = \beta_0 \text{Cross-Quarter} + \beta_1 \text{Cross-Quarter} * \text{Dollar Funding Gap} + \text{Controls} + \text{Fixed Effects} + \varepsilon \, , \quad (2)$$

where Contract refers to the either (i) the forward premium (in basis points) of a contract between the dollar forward seller (henceforth bank) and the dollar forward buyer (henceforth counterparty), or (ii) the (logarithm of the) notional contract value of the same contract. Cross-Quarter is a binary variable that equals the value of 1 if the contract matures after the upcoming quarter-end day, and 0 otherwise (i.e., when it matures during the ongoing quarter). Dollar Funding Gap denotes the difference between on-balance-sheet dollar assets and on-balance-sheet dollar liabilities (in percent of on-balance-sheet dollar assets), according to the previous month's balance sheet data. Thus, because our data are at the contract level, for each contract, we merge the selling bank's funding gap using the most recent balance sheet data available. If our a priori prediction regarding cross-quarter contracts is correct, we expect β_0 to be positive and statistically significant, both for prices and for volumes. Moreover, if banks' desire to close dollar exposure is a key driver of end-of-quarter dynamics, we expect β_1 to be positive and statistically significant (again both for prices and volume).

The granularity of the data allows us to control for a tight set of controls and fixed effects and strengthen the identification of the channel by controlling for potential confounding factors. Our tightest identification includes four key sets of fixed effects.

First, we include *Bank*Quarter fixed effects* to suppress general time variation in banks' demand for forward contracts and focus on identifying the differential impact on cross-quarter contracts. This set of fixed effects, for instance, accounts for the fact that some banks with larger funding gaps in a given quarter may, in general, have a higher demand for forwards compared with other banks. Moreover, it also captures (potentially correlated) time-varying bank heterogeneity in business models or funding costs in both dollar and euro markets, which could affect the pricing of forward contracts in light of the covered interest parity equation.

Second, we include *Bank*Maturity fixed effects* to control for differences in the within- and across-bank maturity composition of cross-quarter contracts and within-quarter contracts. For example, given the upward-sloping term structure of forward premia, banks with larger funding gaps may have, in general, a higher demand for short-term contracts than for longer-term forwards. Moreover, a given bank may shift its maturity profile at quarter-ends (as documented in aggregate in the previous section). Not accounting for these factors would confound our estimates of the cross-quarter differentials. Instead, by including *Bank*Maturity fixed effects*, we identify, for a given bank, differential prices and volumes of contracts of the same maturity.

Third, banks may approach new counterparties to satisfy their demand for cross-quarter forward contracts, in which case they may be required to pay a premium to account for the absence of a trading partnership (e.g., due to information asymmetry). Moreover, formation of new trading relationships at quarter-ends may occur for contracts of specific maturities. We therefore saturate our specification with *Bank*Counterparty fixed effects* to rule out the possibility that the effects are driven by compositional differences in the pool of trading partners for forward contracts. That is, we identify cross-quarter differentials in prices and volumes within the same trading relationship.

Fourth, and most importantly, to control for supply-side variation, we saturate our regression with *Counterparty*Maturity*Day fixed effects.* These fixed effects allow for comparison of cross-quarter versus within-quarter contracts provided by the *same* counterparty on the *same* day and of the *same* maturity. That is, the identification comes from netting out observed and unobserved time-varying counterparty-maturity specific heterogeneity, such as differential time-varying supply across different maturities by the same counterparty. Other time-varying counterparty characteristics that are accounted for in this way include changes in the counterparty's credit risk, its leverage constraints, its funding value adjustments, and its bargaining power (e.g., dealer).

While such a strong set of fixed effects is, in general, comprehensive with regard to ruling out supply-side stories as the driver behind end-of-quarter dynamics, identification of the large set of parameters poses challenging data requirements that we cannot meet in all of the subsamples that we use in our analysis. Not all banks seek both cross-quarter and within-quarter short-term forward contracts from the same counterparty in the same quarter that have the same maturity.[24] Thus, in some parts of our analysis, we also work with a slightly less stringent set of fixed effects, where

[24] In the tightest specification estimated on the full sample, we have 14 banks in the short-term cross-quarter segment.

we include Counterparty*Day fixed effects instead of Counterparty*Maturity*Day fixed effects. Note, however, that these fixed effects will still capture time-varying counterparty heterogeneity (e.g., leverage constraint, counterparty risk, funding value adjustments, and bargaining power). We call the specification with this slightly weaker set of fixed effects our baseline specification.

In addition to fixed effects, our model in equation (2) includes control variables, in particular, the level of the dollar funding gap to isolate the effect of the interaction term with the cross-quarter dummy. In addition, for price regressions, we follow the theoretical literature and control for the Log(Value) of the contract given that cross-quarter forward contracts may differ in value from their counterparts that mature during the current quarter, thereby introducing price variation (e.g., Lagos and Rocheteau 2009). Moreover, we control for bank size (logarithm of total assets) and the equity-to-assets ratio, both in levels and interacted with the cross-quarter dummy variable. The latter is important because banks with larger dollar funding gaps tend to have greater leverage (Appendix Table A.3), which could have separate and different effects on end-of-quarter forward usage and thus introduce an omitted variable bias if it is not included. In particular, banks with low equity could have low demand for derivative contracts if greater leverage discourages derivatives exposure across quarters (Du, Tepper, and Verdelhan 2018). By inclusion of this control, we thus identify the effect of the dollar funding gap on cross-quarter differentials, holding constant the level of equity capitalization. We estimate equation (2) using the method of least squares and cluster standard errors at the bank-maturity level.[25]

Table 5 presents our baseline results. Columns (1) through (5) refer to models with the forward premium as the dependent variable, and columns (6) through (10) refer to models with the logarithm of the notional contract value as the dependent variable. As the column headers indicate, the results are based on two different sets of contracts, which we explain in more detail below. In column (1), where we include our baseline set of controls, we show that contracts that cross the upcoming quarter-end trade at a significantly higher forward premium. Our estimate of the cross-quarter premium amounts to 15 basis points. In column (6), we show that the notional contract values for cross-quarter contracts increase 21 percent compared with within-quarter contracts. These results are consistent with the previously documented aggregate end-of-quarter dynamics

[25] Our results are also robust to two-way clustering at the bank and day levels and multiway clustering at the bank, maturity, and day levels.

and hold after the inclusion of various fixed effects, thus addressing issues of compositional differences in maturity or trading partners for cross-quarter and within-quarter contracts.

We next test whether price and volume differentials for cross-quarter contracts depend on banks' dollar funding gaps. Therefore, we include the interaction term between the cross-quarter dummy and the bank's dollar funding gap. In column (2), the positive estimate indicates that the cross-quarter differential in prices is larger for banks with larger (ex-ante) dollar funding gaps. The point estimate on the interaction term suggests that the cross-quarter premium is about 37 basis points higher for a bank that has a one standard deviation (i.e., 33.6 percentage points) larger dollar funding gap. We show a similarly signed effect for contract values in column (7): Banks with larger dollar funding gaps are associated with cross-quarter contracts that have greater values. The point estimate indicates a sizable differential effect of about 50 percent for a one standard deviation larger dollar funding gap. Thus, also with the microdata, we find evidence consistent with demand shifts being the driver of end-of-quarter spikes in forward premia. Recall that we control for equity (both in levels and interaction with the cross quarter) such that we effectively compare banks with different dollar funding gaps but with the same level of equity.

In columns (3) and (4) and columns (8) and (9), we re-estimate our specifications from columns (1) and (2) and columns (6) and (7), respectively, but restrict the sample to those contracts that we observe after imposing our tightest set of fixed effects (including counterparty*maturity*day fixed effects). That is, we employ the exact same fixed effects structure in columns (2) versus (4) and columns (7) versus (9), but just change the underlying sample of contracts (the column headers indicate the sample used in each estimation). The results are qualitatively robust but are somewhat stronger for this subset of contracts, potentially driven by the average contract maturity being shorter in this subsample (higher turnover in short maturities allows for identification of fixed effects), which would be consistent with the previously documented steep increase in turnover in very short cross-quarter contracts.

Finally, in columns (5) and (10), we estimate the models with our most comprehensive set of fixed effects, allowing us to compare prices and volumes of contracts of the same maturity traded on the same day with the same counterparty by different banks (note that we cannot employ this set of fixed effects for the broader sample in columns [1] and [2] and columns [6] and [7]). This set of fixed effects allows us to effectively control for any supply-driven variation that could potentially drive our results. We find that our results are robust to the inclusion of these additional controls. In fact, we find that the point estimates on the interaction term roughly double, for both contract prices and volumes. In economic terms, this means that, we estimate, a bank with a one standard deviation larger dollar funding gap pays a 118 basis points higher forward premium and obtains a 230 percent higher value for cross-quarter contracts.

Table 5 also shows coefficient estimates for our control variable Cross-Quarter*Equity (other controls are not presented in the table to avoid clutter). For our models with price as the dependent variable and for those with volume as the dependent variable, we find significant positive effects on this interaction term, suggesting that, in line with findings reported in previous studies, banks with lower equity ratio have reduced demand for cross-quarter contracts. The size of the estimates also indicates quantitatively large effects. For example, the point estimates in columns (4) and (9) suggest that a one standard deviation (0.78) lower equity-to-assets ratio is associated with a reduction in the cross-quarter differential of 54 basis points for prices and 84 percent in volumes, respectively.[26] Given the negative correlation between a bank's funding gap and equity, not accounting for separate effects of equity on cross-quarter contracts would downward bias our estimate of the effect of the funding gap on cross-quarter contracts. Indeed, in unreported results, we verify that omitting this control leads to smaller, yet significant, coefficient estimates on the interaction term between the dollar funding gap and the cross-quarter dummy. As a result, we include this control throughout the paper, although we suppress the estimated coefficient in subsequent table output to avoid clutter.

From our previous analysis, we know that contracts of short maturity are cost efficient for short-term reductions of currency imbalances. Therefore, we estimate our baseline results in Table 5 for forward contracts with a short-term maturity of less than one month. Appendix Table A.5 shows our baseline results when we relax our baseline maturity threshold and include contracts with a maturity longer than one month (but shorter than two months). When we do so, we find that our key coefficient on the interaction terms becomes smaller (for prices) or insignificant (for volumes).

Our results in Table 5 explore contract-level variation in prices and volumes to identify the cross-quarter differential effects. We can aggregate the data at the bank level to understand the

[26] The standard deviation of the equity-to-assets ratio of 0.78 is reported in Table 2. The larger coefficient estimates in columns (5) and (10) have to be viewed in light of the smaller sample, specifically the smaller set of banks, which leads to a reduction in the standard deviation of equity to assets.

overall increase in price and volume for any given bank. In particular, it helps us understand whether these demand shifts, which we identify under an expansive set of controls, are also binding at the bank level. Therefore, we next aggregate the data at the bank*day level; that is, for each bank and each day in our sample we estimate a value-weighted forward premium and total notional value for both quarter-end contracts and non-quarter-end contracts. The results, presented in Table 6, show that, indeed, across all forward contracts, large-funding-gap banks have significantly higher volumes and prices for their quarter-end contracts.[27] Also, economically, the bank-level estimates reveal sizable effects: A bank with a one standard deviation larger funding gap pays about 51 basis points more and obtains about 57 percent more notional value for its quarter-end forwards.

IV.3 Additional Bank Heterogeneity: Cost of Capital and Credit Risk

We argue above that banks with large dollar funding gaps have an incentive to hedge their dollar exposure before quarter-end reporting dates to avoid regulatory penalties, e.g., in the form capital charges. In the previous subsection, we show evidence consistent with demand shift along this dimension. In particular, we show that, when equity capital is held constant, banks with larger funding gaps are associated with contracts that have higher prices and higher notional values. We next provide an additional test of this channel by investigating whether the relationship between cross-quarter differentials and dollar funding gaps is greater/stronger for banks with a high shadow cost of capital. For those banks, we would expect that leaving a large dollar exposure unhedged is particularly costly and, consequently, they should have particularly strong demand for cross-quarter hedges to avoid regulatory capital surcharges.

We show the results from our investigation of the role of equity in Table 7, where we estimate our main model from Table 5 for different subsets of the data and estimate heterogeneous cross-quarter effects depending on capitalization. In particular, we separate the banks in our sample into two groups: those with a high shadow cost of capital and those with a low shadow cost of capital. We use two approaches to identify banks with a high-shadow cost of capital. In the first approach, for each month, we flag all banks that have an equity-to-assets ratio below the median of the cross-

[27] An alternative specification would be to aggregate the data at the bank*cross-quarter level, where for each bank there are two observations (i.e., one for cross-quarter and another for within-quarter) for prices and volumes, respectively. We do this as part of our robustness analysis in Appendix Table A.6 and show that our results are similar.

sectional distribution (between banks). In the second approach, for each bank, we flag all months in which the bank has an equity-to-assets ratio below the median of this ratio in the entire sample (within bank).[28] We then compare, for each month, the coefficient estimates on Cross-Quarter*Dollar Funding Gap of these two groups of low-equity banks with the estimates for contracts of high-equity banks, defined as those above the median of the across-bank distribution.

Columns (1) and (4) show that the results for high-equity banks are smaller compared with those for the full sample, and we do not find significant effects on volumes at the 10 percent level. On the other hand, we find that low-equity banks have larger estimates (columns [2] and [5]), particularly if they have a low capital ratio relative to their sample average (columns [3] and [6]). For example, columns (3) and (4) show that the effects on prices are three times greater and the effects on volume about two times greater, respectively. Reported statistical tests show that these differences are also significant, although only at levels below 10 percent for rates and 15 percent for volumes.[29] We attribute the lack of strong statistical significance of the differential effect to the small number of banks in each subsample as well as the strong negative correlation between equity and funding gaps, which substantially reduces the variation in funding gaps in each subsample, leading to larger standard errors. Recall again that all specifications control for Equity*Cross-Quarter (not shown to avoid cluster) and thus identification comes from comparing the price and volume cross-quarter differentials of banks that have different funding gaps, but after we control for heterogeneous equity-to-assets ratios.

Concerns may arise that banks that have larger dollar funding gaps, in particular those with low equity, are riskier (e.g., Du, Tepper, and Verdelhan 2018). Such concerns may lead to the notion that higher cross-quarter premia could be related to a supply reduction due to concerns about counterparty risk.[30] However, such a supply-driven explanation is, in general, hard to reconcile with our findings of increased cross-quarter *volumes* for banks with large funding gaps. Moreover, unsecured forwards, which are in our baseline sample, do not require upfront payment or collateral on either side, limiting counterparty risk concerns. Similarly, explanations related to counterparty risk would need to rationalize why only short-term contracts have higher prices.

[28] This approach is motivated by a large literature that finds that different banks may have different target capital ratios (e.g, Diamond and Rajan 2000, and Allen, Carletti, and Marquez 2011)

[29] Note that these effects are identified for our baseline set of fixed effects; as discussed above, we cannot include additional Counterparty*Maturity*Day fixed effects due to data constraints in subsamples.

[30] In addition, counterparty risk concern, even if not priced directly in forward contracts in the form of risk premia, would affect a bank's funding cost, which could, in light of the covered interest parity condition, affect its pricing of forward contracts.

Additionally, our baseline identification controls for observed and unobserved time-varying counterparty-specific and bank-specific heterogeneity, including changes in the counterparty risk.

Our next test confirms this line of reasoning, i.e., that counterparty risk is unlikely to drive our results. In Appendix Table A.7, we show that our results are robust to the inclusion of time-varying, bank-specific credit-risk measures, also in interaction terms with the cross-quarter dummy, in our main specifications. Thus, we explicitly control for high-frequency changes in credit risk and their differential effect on cross-quarter contracts. As credit risk measures, we use (i) the bond spread measured as the difference between the average yield on the bank's outstanding bonds and the maturity-matched German government bond yield, or (ii) the daily five-year senior credit-default-swap spread. While our sample size decreases due to data availability, our key results are both statistically and quantitatively robust to the inclusion of these bank risk measures, suggesting demand-driven price and volume differentials related to banks' shadow cost of capital. That is, banks with higher on-balance-sheet dollar exposure have higher demand for cross-quarter contracts to avoid regulatory capital charges.

We further examine the role of banks' shadow cost of capital in the pricing of cross-quarter contracts by exploiting supervisory data on collateralized contracts where initial and/or variation margins are posted. As discussed in Section II, we restrict our main analysis to uncollateralized contracts only to ensure a clean comparison across contract details, given that the exact collateral type and haircuts are unknown but that they do influence the prices and volumes of contracts. However, in this section, to identify the effect of heterogeneous capital valuation on the pricing of forwards, we extend our analysis to collateralized transactions and compare the forward premia of uncollateralized and collateralized contracts that have otherwise similar features. We expect that the requirement to post collateral, on average, would make the contract less attractive for banks concerned with capital charges associated with currency imbalances at quarter-ends, and so the seller would require a discount compared with a similar uncollateralized contract (Gârleanu and Pedersen 2011, Ivashina, Scharfstein, Stein 2015).[31] In line with our narrative, we expect this channel to be specifically operational for cross-quarter contracts of large-funding-gap banks.

In Table 8, we present our estimates of the likelihood of entering a collateralized (versus uncollateralized) cross-quarter contract, as well as our estimates of the price differential between

[31] Given that we do not observe the type of collateral posted nor the haircut, we cannot identify a true partial effect. As discussed above, the lack of collateral detail in our data set is the main reason why we focus on uncollateralized contracts in the main part of the paper.

collateralized and uncollateralized cross-quarter contracts depending on a bank's dollar funding gap. Our specification and identification strategy closely follows our approach so far and builds upon equation (2).

Column (1) presents results from linear probability models of the choice between collateralized and uncollateralized cross-quarter contracts using our most comprehensive set of fixed effects. The results show that banks with larger dollar funding gaps are significantly less likely to enter a cross-quarter contract in which they have to post collateral. Columns (2) through (4) show that, conditional on entering into a collateralized contract, large-funding-gap banks, however, are associated with contracts that have significantly lower prices. This result holds for both one-way and partially collateralized contracts, but we do not find statistically significant differential effects for fully collateralized contracts, presumably due to the very low number of contracts observed in this bucket.[32] Surprisingly, we do not find respective differential effects for contract values.[33]

Overall, the analysis of collateralized contracts is consistent with the prediction that banks' with larger dollar funding gaps close their dollar exposure by using unsecured contracts , which do not require them to pledge collateral, but if they enter collateralized contracts they do so only at a discount. This finding is in line with that of Gârleanu and Pedersen (2011), who argue that price differentials (positive for unsecured and negative for secured) are driven by banks' shadow cost of capital. In this regard, our results for collateralized contracts further supports the insight drawn from findings presented in Table 7.

The central results from this paper are consistent with demand shifts. We therefore identify changes in prices and volumes moving along the upward-sloping individual supply curve of each counterparty. To better understand how heterogeneous demand for cross-quarter forward contracts can create such large price differentials for similar forward contracts, we examine—in accordance with the literature on over-the-counter markets, e.g., Afonso and Lagos (2015)—whether search and bargaining frictions interact with demand heterogeneity to generate price dispersion. To that end, we compare contracts of large-dollar-funding-gap banks and provide evidence that more

[32] The data allow us to distinguish between three different types of collateralization. A forward contract is considered (i) Partially Collateralized (PC) when the agreement between the counterparties states that either one or both counterparties will regularly post the variation margin, and either they do not exchange the initial margin at all or only the reporting counterparty receives the initial margin; (ii) 'One-way Collateralized (OC) when the agreement between the counterparties states that only the reporting counterparty to such a derivative contract agrees to post the initial margin, regularly post the variation margin, or both with respect to the derivative contract; or (iii) 'Fully Collateralized (FC) when the agreement between the counterparties states that initial margin must be posted and the variation margin must regularly be posted by both counterparties.

[33] Note that due to data restrictions we cannot estimate our models for the intensive margins with the tightest set of fixed effects.

sophisticated banks are able to obtain better prices for their cross-quarter forward dollar sales compared with less sophisticated banks that have a similar funding gap. Appendix Table A.8 shows that, among the set of cross-quarter contracts, dealer banks (BIS definition) in our sample have a lower sensitivity of prices and volumes to their dollar funding gaps. This is in line with the notion that counterparties (dealers) with market power anticipate skewed demand by large-funding-gap banks before financial reporting days to extract rents. However, we do not find evidence that access to internal capital markets helps banks negotiate more favorable terms, as is usually discussed in the context of effective liquidity management by international banks (e.g., Ceterolli and Goldberg 2012).

IV.4 Alternative Control Group: Within Cross-Quarter Variation

Previous results focus on comparing prices and volumes of cross-quarter contracts with similar contracts (in terms of maturity, counterparty, collateralization, etc.) that mature in the same quarter in which they are initiated (within-quarter). Moreover, for identification, we focus in the main part of our analysis on short-term contracts, which are suitable for regulatory arbitrage purposes. An alternative and complementary approach to identify the demand effects is to compare prices and volumes of contracts within the set of cross-quarter contracts *depending on maturity*. For example, any contract with a maturity longer than three months will always cover an open exposure at the quarter-end and will thus reduce the funding gap. Yet, these contracts are more expensive compared with short-term alternatives and thus are not suitable for cost-efficient hedging of currency imbalances for short horizons.[34] Therefore, we expect that demand pressure from banks with large dollar funding gaps would lead to larger differential price and volume increases for short-term (treated) versus long-term (control) contracts *within* the set of cross-quarter contracts.

The results shown in Table 9 confirm demand shifts in short-term cross-quarter contracts relative to this alternative control group. Banks with large dollar funding gaps pay significantly more for short-term cross-quarter contracts and, at the same time, sell contracts of significantly higher notional values. Consistent with the rest of the paper, we define short term as a maturity of less than one month, and long term as a maturity longer than three month. That is, we effectively keep the set of treated contracts the same as before, but change our control group to long-term

[34] In Section B of the Supplementary Appendix, we discuss this issue in greater detail.

cross-quarter contracts (as opposed to short-term within-quarter contracts). Also, in terms of magnitudes, the results estimated under this complementary approach are in the same ballpark as our baseline results presented in Table 5. For example, we estimate that a one standard deviation larger dollar funding gap is related to an increase in the forward premium of short-term versus long-term contracts of about 48 basis points and an increase in the notional value of short-term versus long-term contracts of about 19 percent. These effects are identified, analogously to our baseline approach, by including Equity*Short-Term Contract as a control.

While it is reassuring that we find consistent results using this alternative approach, we cannot use a similarly rich set of fixed effects compared with our baseline approach given that the turnover in long-term contracts is significantly lower. That is, we are able to estimate the within-cross-quarter differential only with our baseline set of fixed effects, not with the tightest set of fixed effects, which also includes Counterparty*Day*Maturity fixed effects, Bank*Counterparty fixed effects, and Maturity*Bank fixed effects. The data availability is also the reason why we focus on estimating cross-quarter differentials for short-term contracts in our analyses throughout the paper.

IV.5 Implications for Banks' Overall Dollar Exposure

Our previous evidence shows large increases in cross-quarter dollar forward sales just before quarter-ends, consistent with the demand channel conjectured in his paper. A natural question that could emerge in this context is whether we would see the opposite effects if we looked at banks' *purchases* of dollars just before quarter-ends. Indeed, if our conjecture that banks manage their dollar exposure in the derivatives market around quarter-ends were true, we would expect banks with larger (positive) dollar funding gaps to have *reduced* demand for long positions compared with banks that have smaller dollar funding gaps, as these positions would inflate their overall long exposure to the dollar.[35] In fact, any bank can most effectively close a positive dollar funding gap by jointly reducing its off-balance-sheet long exposure *and* increasing its short exposure. (Nevertheless, in our main analysis we focus on short positions, because reducing only the long forward exposure will not be sufficient to reduce a positive on-balance-sheet funding gap.)

[35] In fact, banks with negative funding gaps may have increased demand for cross-quarter forward purchases. However, we do not analyze banks with negative funding gaps separately because, also in the buying data set, they account for only a small share of all contracts. Moreover, unlike with banks with positive dollar funding gaps, the negative funding gap relative to equity is small, thereby not providing a strong incentive for regulatory arbitrage.

Table 10 shows results for banks' cross-quarter dollar purchases. The estimated models are in all other aspects analogous to our main Table 5. Based on our empirical strategy that imposes the most comprehensive set of fixed effects, we find a negative coefficient on the interaction term between the cross-quarter dummy and the dollar funding gap, both for prices and volumes. Thus, opposite of what we find for short contracts, banks with larger dollar funding gaps have lower contract values and lower prices for cross-quarter long contracts, consistent with a decreased demand to buy dollar forwards. We highlight that these results are significant only when we include Counterparty*Day*Maturity fixed effects. Given our previous finding of increased demand for short contracts (specifically in shorted maturities) by large-funding-gap banks, some of which trade with other German banks (which then buy dollars), it is not surprising that we need to control for this type of heterogeneity in the data to isolate the demand effect for long contracts.

Finally, we study how banks' increase in forward sales of dollars (combined with their decrease in long position) in the final days of each quarter affects their overall dollar exposure (net of forward exposure) at quarter-ends. That is, we try to gauge the extent to which the end-of-quarter dynamics in the forward market documented in this paper allow banks to close their dollar funding gaps near the end of the quarter and how the overall dollar exposure looks during the quarter. To this end, we use the forward data to estimate the outstanding net short dollar exposure (forwards sold minus forwards bought) on the last day of each month.[36] We then add this off-balance-sheet liability to the on-balance-sheet dollar funding gap, which we observe for the final day of each month from the supervisory balance sheet data, to compute a monthly series of any bank's total dollar exposure (*net* dollar funding gap).

In Figure 6, we compare banks' dollar funding gaps and their net dollar funding gaps (i.e., including forward exposure) on the final day of a quarter, i.e., when the regulator assesses banks' currency mismatches. Indeed, consistent with banks' ability to (nontrivially) reduce their dollar exposure on the quarter-end using forward contracts, we find substantially larger dollar funding gaps when derivative exposure is not included. For example, we estimate that the dollar funding gap of all banks in our sample is about 17 percent; that is, 17 percent of the banks' on-balance-sheet dollar assets are not funded with on-balance-sheet dollar liabilities. Importantly, this number

[36] Arguably, this approach represents only a back-of-the-envelope computation of the total currency imbalance, because it accounts for only forward derivatives and focuses only on dollar exposure. While both forwards represent the bulk of derivatives and dollar exposure the bulk of FX exposures, we are in this study not considering other currencies and are thus not able to exactly measure the net FX exposure.

is consistent with the aggregate data (BIS 2016). However, once the derivative exposure is included, this figure shrinks to 11 percent, a sizable reduction of about 37 percent. Similarly, we find that the end-of-quarter dollar funding gap of the mean and median bank is reduced strongly when dollar derivative exposure is taken into account.

Further, Figure 6 shows the evolution of banks' dollar exposure throughout the quarter, as illustrated by three end-of-month snapshots. For clarity of presentation, we normalize the net dollar funding gap to the value of 100 in the first month of each quarter. The figure shows a stark pattern: In the final month of each quarter (quarter-end), the net funding gap of banks is substantially smaller than it is during the first or second month of the quarter. This holds for both the mean and median. For example, the mean dollar exposure is about 20 percent smaller on the final reporting date in each quarter as compared with the first reporting date (end of first month), roughly consistent with the relative increases in the end-of-quarter volume and the number of forward contracts documented in Table 4. In other words, end-of-quarter dollar exposure submitted to the supervisor is substantially lower at the end of the quarter as compared with the exposure during the quarter.

V. CONCLUSION

The forward premia of contracts that are initiated before a quarter ends and mature shortly after the start of the following quarter exhibit substantially higher prices than those of comparable contracts that are initiated and mature in the same quarter. The current thinking relates this pattern to *reduced supply* of these contracts by dealer banks, which seek to reduce exposure before quarter-end reporting dates in order to comply with regulatory leverage ratio requirements. In this paper, we complement this reasoning by highlighting another important driver: *increased demand*.

We identify upward shifts in demand by comparing prices *and* volumes of short-term (maturity of less than one month) cross-quarter dollar forward sales involving the same counterparty that were initiated on the same day and with the exact same maturity and find that banks with ex-ante larger dollar funding gaps are associated with higher prices and volumes. These effects identified at the contract level also have aggregate implications. For example, at quarter-ends, not only do market-wide forward premia increase, but we also find an increase in total turnover, driven by a strong increase in relative turnover in short-term contracts that mature right after the quarter-end.

Our findings have several implications. First, the dominance of short-dated maturities, especially the one-week segment, in this important market reveals that global banks roll over their hedging and therefore engage in the inherent rollover risk while reducing their FX risk in this way. The significant amount of on-balance-sheet currency imbalances of global banks, therefore, suggests non-negligible costs that could materialize under adverse market developments.

Second, banks that use short-term cross-quarter forward contracts to economize on regulatory capital charges on currency imbalances face a two-layered risk. On the one hand, they agree to deliver dollars in the near future, i.e., when the forward contract matures. Banks have to deliver on this agreement, which exposes them to funding liquidity risk. Moreover, the exchange rate may change and adversely affect a bank using the FX market to obtain dollars for delivery. Thus, the bank engaging in cross-quarter forward selling also bears FX risk that may materialize at the maturity date (after the quarter-end). Both of these risks may interact and amplify the dynamics of adverse market changes.

Third, our back-of-the-envelope calculation suggests that banks have smaller currency imbalances (and thus larger funding gaps) at the end of the quarter compared with during the quarter. One key takeaway with regard to this finding is that supervisory point-in-time reporting policy (as opposed to an averaging scheme) of regulatory measures induces further price variation through banks that engage in window-dressing behavior. Moreover, this finding challenges the assumption made in some studies that banks do fully hedge any on-balance-sheet currency exposure using derivatives.

Finally, economically sizable differences in FX hedging costs across banks, as documented in this paper, are likely to have implications for the local and international efficacy of regulatory and monetary policy transmission. For example, the transmission of monetary policy through the bank-lending channel in particular (and through portfolio allocation in general) is likely to depend on the cross section of synthetic funding costs for banks using the FX derivatives market. We leave these interesting topics open for future research.

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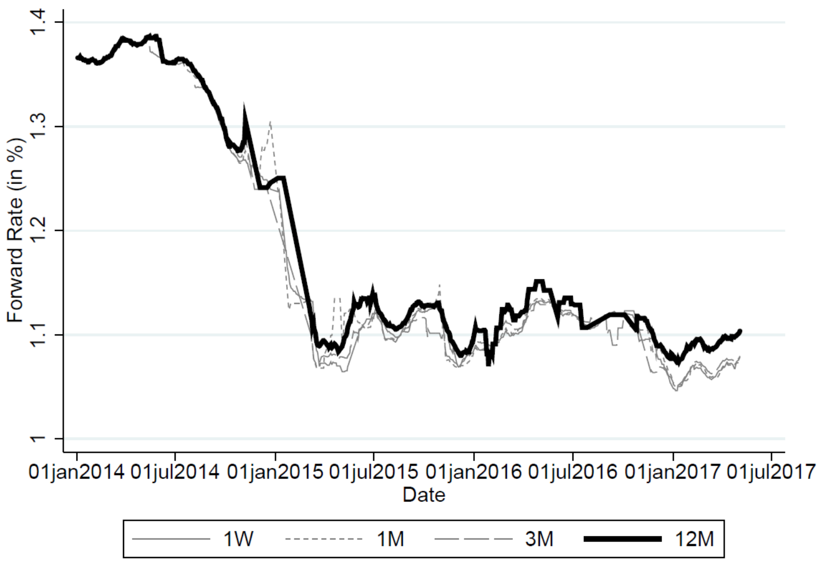
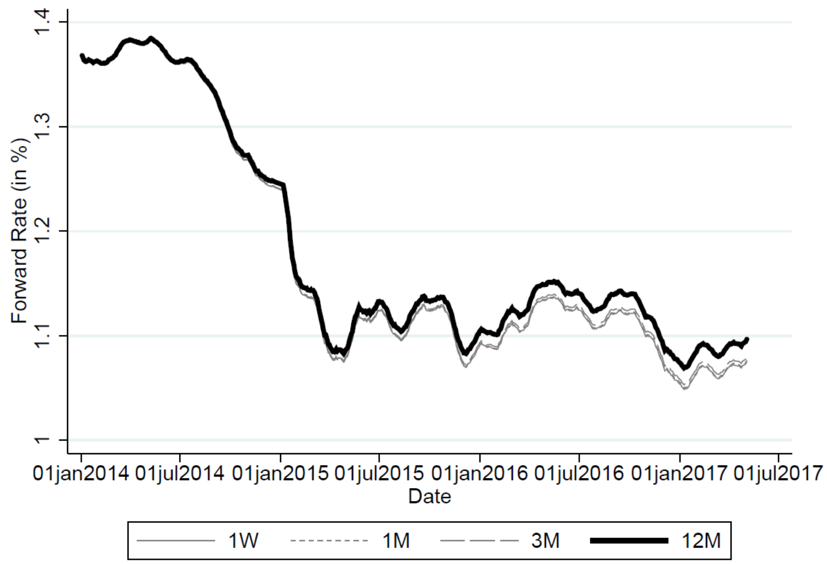
Figure 1 — Forward Rate (EMIR Data and Bloomberg)

(A) USD/EUR Forward Rates (EMIR)

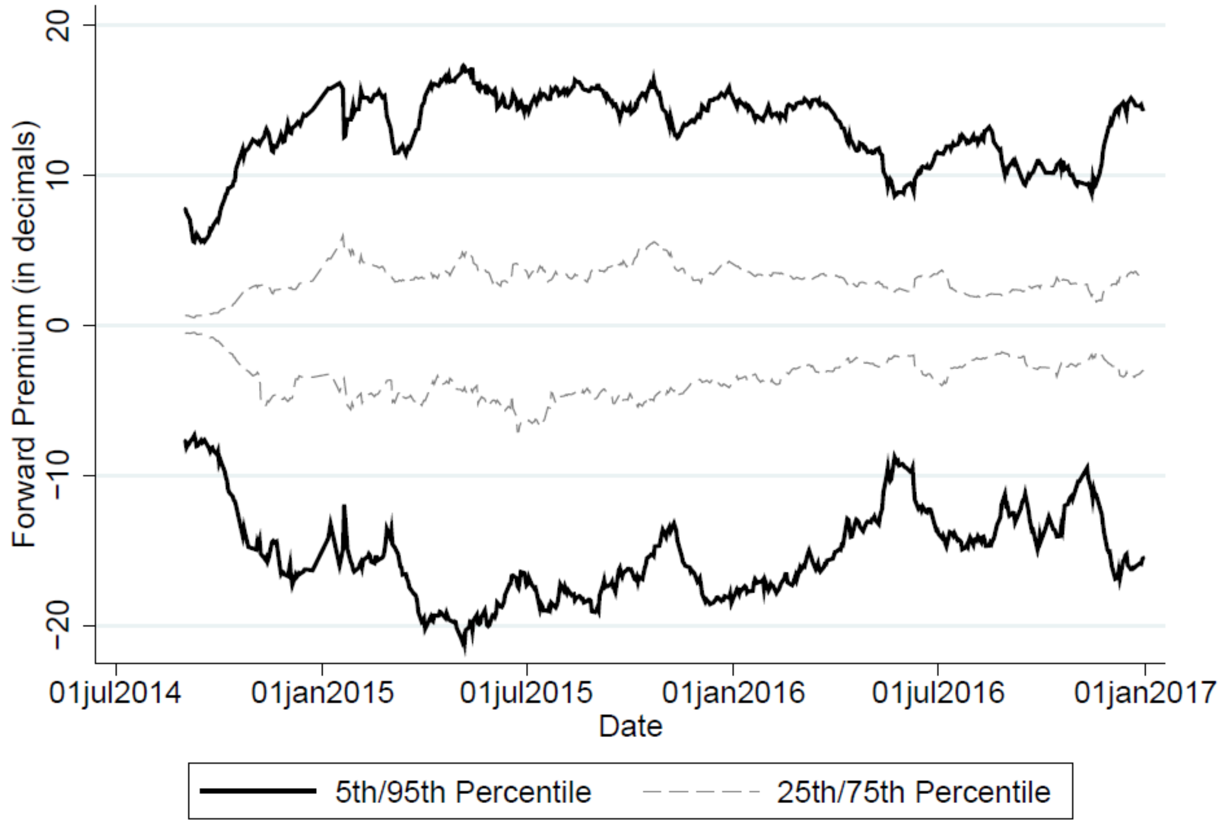


(B) USD/EUR Forward Rates (Bloomberg)



Note: This figure presents the daily time series (30-day moving average) of the USD/EUR forward rates different maturities from January 1, 2014, through December 31, 2016. The gray solid line refers to one week forwards, the gray dotted line to one-month forwards, the gray dashed line to three-month forwards, and the black solid line to twelve-month forwards. Subfigure (A) refers to the daily median of respective forward rates obtained under EMIR. Interest rates are annualized to facilitate comparison across different maturities. Subfigure (B) presents the correspondingly-dated annualized forward rates obtained from Bloomberg.

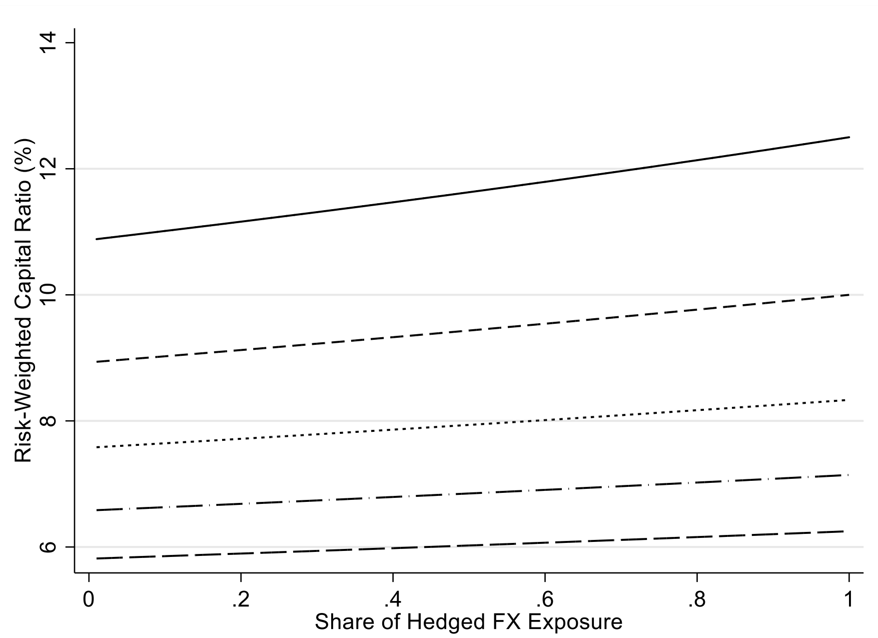
Figure 2 — Cross-Sectional Dispersion of Forward Premium



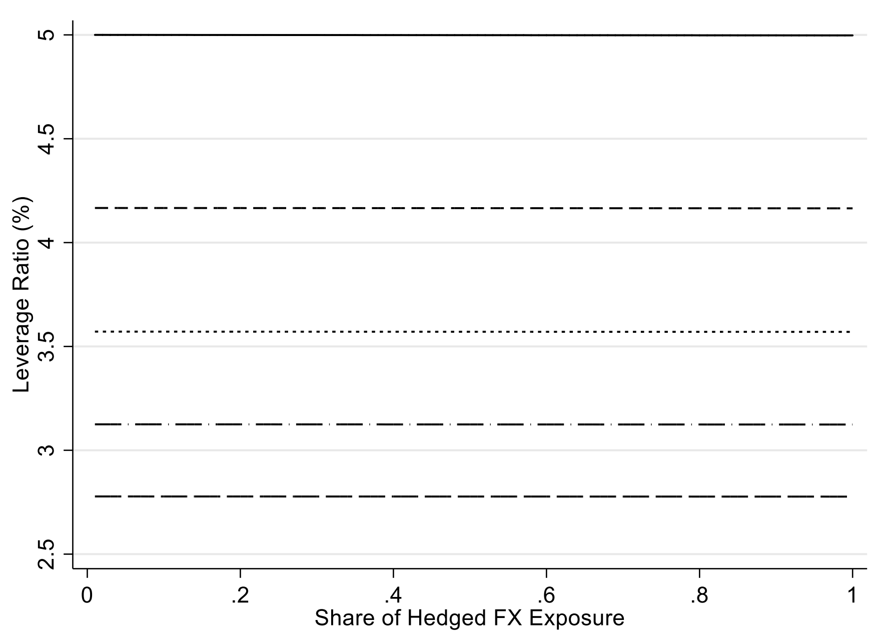
Note: This figure presents the daily time series (30-day moving average) of cross-sectional percentiles of the cleaned forward premium (in basis points) of USD/EUR forward contracts initiated in the period from January 1, 2014, through December 31, 2016. Cleaned forward premium is obtained as the residuals from a regression of the forward premium on Counterparty*Maturity*Day fixed effects (i.e., where time-varying maturity and supply effects are removed). The black solid lines refer to the 5th and 95th percentile and the gray dashed lines represent the 25th and 75th percentile, respectively.

Figure 3 — Effect of Reducing FX Exposure on Key Regulatory Capital Ratios

(A) Risk-Weighted Capital Adequacy Ratio

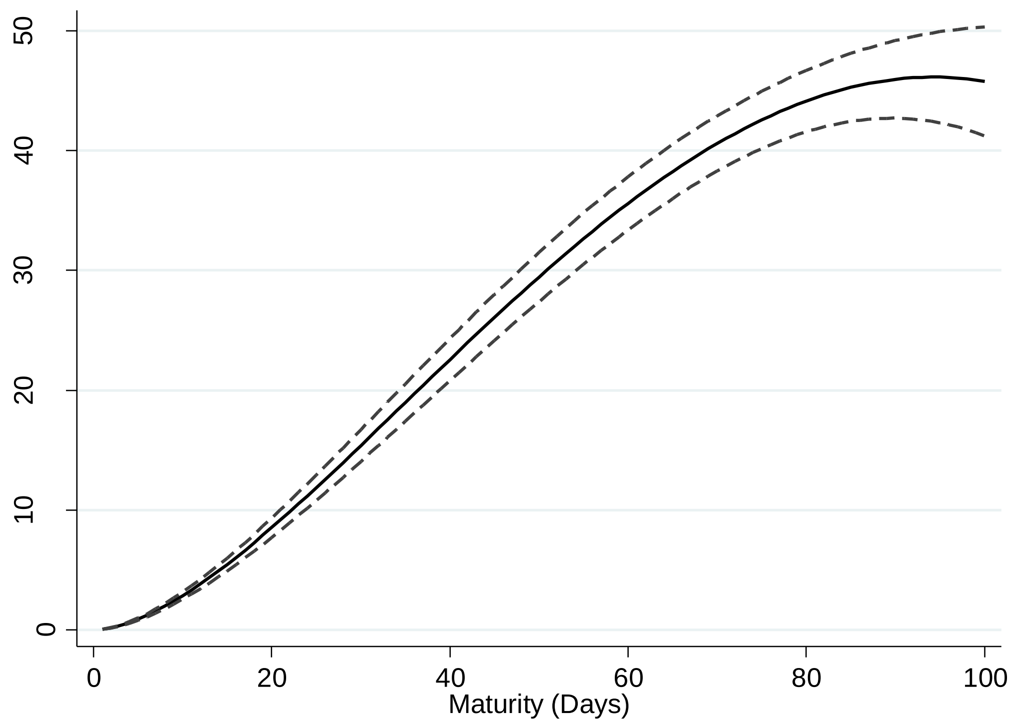


(B) Straight Leverage Ratio



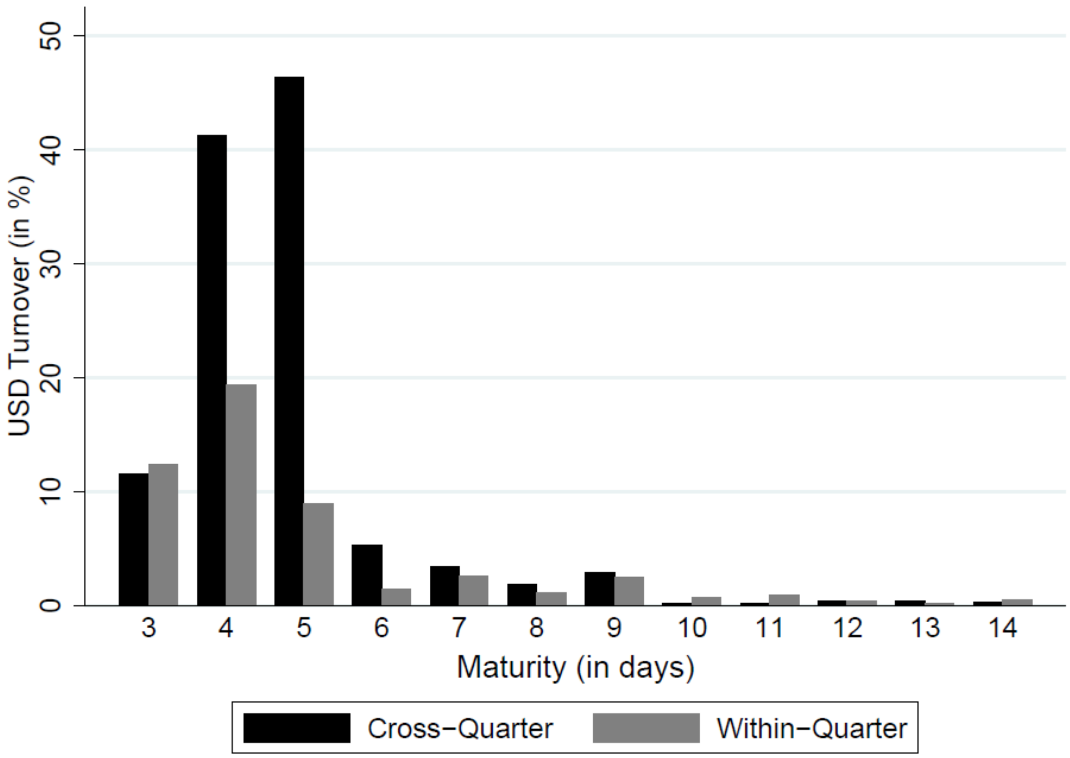
Note: Subfigure (A) illustrates the effect of reducing (hedging) on-balance-sheet FX exposure with forward contracts on the (risk-weighted) capital adequacy ratio (CAR). Subfigure (B) illustrates the effect of reducing (hedging) on-balance-sheet FX exposure with forward contracts on the leverage ratio. The different lines represent the effects for different levels of the CAR or leverage ratio. FX exposure is assumed to be 100% of equity. Contribution of forwards to derivative exposure computed for zero-replacement cost (marked-to-market value), and for contracts with maturity less than one-year.

Figure 4 — Term Structure of Forward Premium



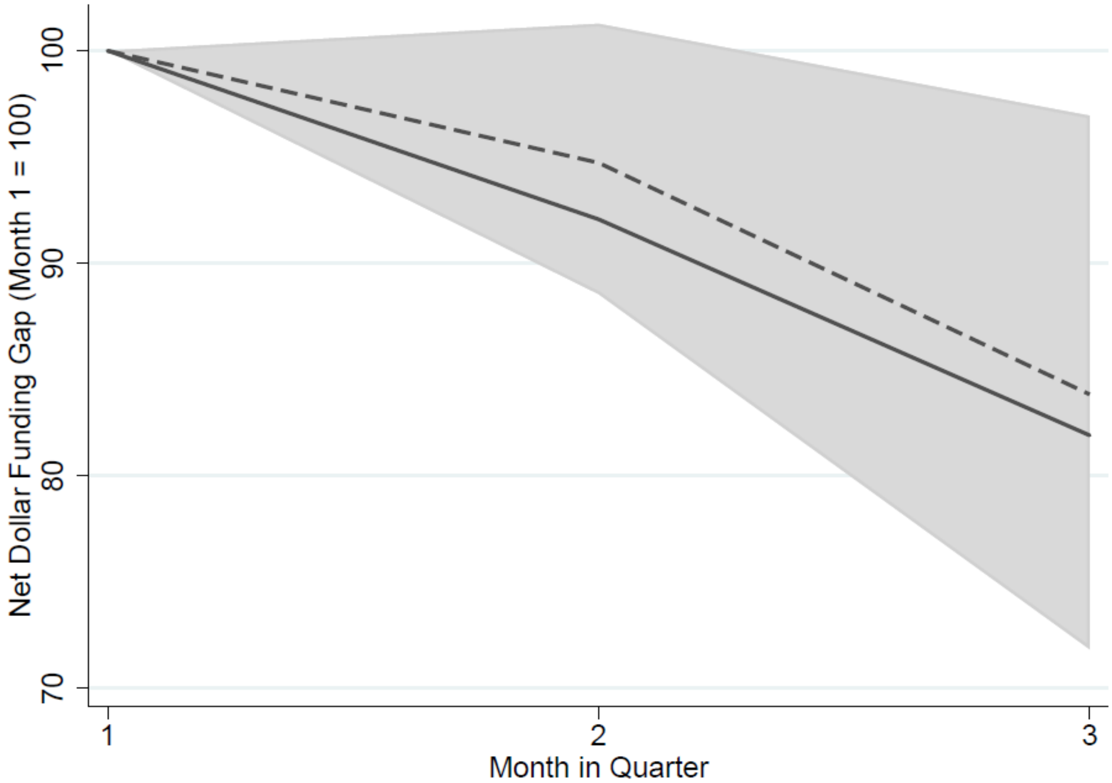
Note: This figure shows the estimated term structure of the forward premium (in basis points). The solid line represents the point estimate for the term structure of the forward premium from a (fractional) polynomial regression with the forward premium as the dependent variable and a polynomial in contract maturity on the right-hand side (optimal polynomial structure selected according to minimum deviation criterion). The polynomial regression includes, in addition to the polynomial in contract maturity, also bank, counterparty, and day fixed effects. Dashed lines correspond to 10 percent significance bounds.

Figure 5 —Turnover of Cross-Quarter Contracts



Note: This figure shows relative market turnover by maturity depending on whether the USD/EUR contract matures in the same quarter of initiation (within-quarter) or not (cross-quarter). Relative market turnover (market shares) of cross-quarter contracts and within-quarter contracts are computed based on contracts of all maturities, for each quarter separately (i.e., two observations for each quarter for each maturity), before averaging across all quarters.

Figure 6 — Evolution of Net Funding Gap Within Quarter



Net Dollar Funding Gap at Quarter-End

	Aggregate	Avg. Bank	Median Bank
Dollar Funding Gap	16.94	25.73	9.56
Net Dollar Funding Gap (including forward exposure)	10.67	3.76	1.02

Note: The figure illustrates the evolution of banks' net dollar funding gaps within the quarter. At the end of each month, 'net dollar funding gap is defined as the on-balance-sheet net dollar assets minus the outstanding net dollars sold forward, in percent of dollar assets. Net dollar funding gaps are normalized to value 100 in the first month of each quarter. The solid line represents the mean, the dashed line represents the median, and the shaded area represents the inter-quartile range. Difference in the levels of dollar funding gap and net dollar funding gap at the end of the quarter (end of third month) are presented in the table.

Table 1: Contract Collateralization

Panel A: Number of Trades				
	Type of Collateralization			
	Uncollateralized	Collateralized	Unknown	Total
# Total Trades	357,056	334,553	89,040	780,649
% All Trades	45.70%	42.90%	11.40%	100.00%

Panel B: Total Contract Value (USD Billion)				
	Type of Collateralization			
	Uncollateralized	Collateralized	Unknown	Total
Total Value	5,171	8,831	983	14,985
% All Contracts	34.51%	58.93%	6.56%	100.00%

Note: The table shows the decomposition of our data on dollar forward sales initiated in the period from January 1, 2014, through December 31, 2016 depending on the type of collateralization. 'Uncollateralized' refers to a contract where neither the selling bank nor the buying counterparty pledges any collateral, whereas 'Collateralized' represents contracts where any collateral is involved (initial margin, variation margin, for either one or both counterparties). *Unknown* refers to a contract for which no information on collateralization is available.

Table 2: Contract-Level Summary Statistics

	Mean	P10	P25	P50	P75	P90	SD	Obs.
Forward Premium (Bps)	63.55	-23.18	-3.27	15.06	46.05	112.22	256.49	271,230
Forward Premium (Bps, Cleaned)	0.00	-22.35	-6.04	0.00	4.46	19.31	103.62	117,070
Contract Value (USD Million)	16.27	0.01	0.06	0.30	1.95	14.94	140.43	271,230
Maturity (Days)	78.77	3.00	5.00	30.00	95.00	220.00	132.80	271,230
Assets (EUR Billion)	627.91	12.19	275.58	842.28	898.39	961.01	368.71	271,230
Equity (% Assets)	5.30	4.64	4.96	5.18	5.62	6.18	0.78	271,230
Dollar Assets (% Assets)	14.51	3.91	9.57	16.93	18.75	20.31	6.63	271,230
Dollar Assets (% Equity)	2.84	0.70	1.51	3.29	3.68	3.91	1.54	271,230
Dollar Funding Gap (% Assets)	46.17	2.73	34.39	59.75	63.89	64.10	27.08	271,230
Dollar Funding Gap (% Equity)	158.95	0.15	31.91	198.61	231.65	250.61	134.01	271,230

Note: This table presents summary statistics on our main variables at the forward contract level for the period from January 1, 2014, through December 31, 2016. *Forward Premium* refers to the relative difference (in basis points) between the dollar forward and spot exchange rate. Cleaned *Forward Premium* is obtained as the residual from a regression of the forward premium on Counterparty*Maturity*Day fixed effects (i.e., where time-varying maturity and supply effects are removed). *Dollar Funding Gap* is defined as the difference between total dollar assets and total dollar liabilities, and normalized with total dollar assets*100 (and equity*100, respectively). The sample includes only uncollateralized contracts.

Table 3: Bank-Level Summary Statistics

	Mean	P10	P25	P50	P75	P90	SD	Obs.
Assets (EUR Billion)	25.67	1.22	2.12	4.03	7.57	24.29	96.95	145
Equity (% Assets)	5.76	4.08	4.96	5.58	6.44	7.43	1.79	145
Dollar Assets (% Assets)	2.83	0.08	0.13	0.28	0.71	8.51	7.90	145
Dollar Assets (% Equity)	52.85	1.31	2.37	4.74	12.80	152.08	156.69	145
Dollar Funding Gap (% Assets)	3.69	-23.58	-1.03	0.33	5.52	55.92	33.59	145
Dollar Funding Gap (% Equity)	20.13	-0.59	-0.03	0.02	0.23	41.86	139.44	145

Note: This table presents summary statistics on our main variables at the bank level. For each bank, there is one observation, which is the average of each balance sheet statistics throughout our sample period from January 1, 2014, through December 31, 2016. *Dollar Funding Gap* is defined as the difference between total dollar assets and total dollar liabilities, and normalized with total dollar assets*100 (and equity*100, respectively). There are only 13 banks with non-zero dollar intragroup liabilities. Among these banks, the average (median) share amounts to 10.34% (9.17%).

Table 4: Aggregate Quarter-End Dynamics

	Forward Premium	Log(Total Volume)	Log(No. Contracts)	Log(Average Maturity)	Log(No. Counterparties)
	(1)	(2)	(3)	(4)	(5)
End-of-Quarter	12.2726***	0.2869***	0.1760*	-0.1094***	0.5048***
	(2.5845)	(0.0742)	(0.0976)	(0.0272)	(0.1412)
Observations	11,032	11,032	11,032	11,032	11,032
R-squared	0.184	0.851	0.848	0.646	0.808
Bank*Quarter Fixed Effects	Yes	Yes	Yes	Yes	Yes

Note: This table presents aggregate end-of-quarter dynamics in the forward market. *End-of-Quarter* is a dummy that takes value one during the last five days in each quarter, and zero otherwise. *Forward Premium* is measured in basis points and refers to the value-weighted average forward premium, *Log(Total Volume)* is the logarithm of the daily total notional value, *Log(No. Contracts)* is the logarithm of the daily number of contracts, *Log(Average Maturity)* is the logarithm of the value-weighted average maturity in days, and *Log(No. Counterparties)* is the logarithm of the daily number of counterparties. Data are at the bank-day level and obtained by collapsing the original contract-level data from 2014 through 2016. Appendix Table A.4 shows robustness for different end-of quarter definitions. Standard errors are clustered at the bank level and presented in parentheses. Statistical significance at the 10 percent, (5 percent), and [1 percent] levels is indicated by *, (**), and [***], respectively.

Table 5: Dollar Funding Gap and Cross-Quarter Contracts

	Forward Premium (bps)					Log(Contract Value)				
	Broader Sample		Sample for Tightest Fixed Effects			Broader Sample		Sample for Tightest Fixed Effects		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Cross-Quarter	15.0300*	-9.5390	28.2054**	-20.7158	--	0.2059*	-0.0748	0.4083**	-0.3581*	--
	(8.7192)	(15.1174)	(11.8306)	(23.8411)		(0.1196)	(0.0856)	(0.1763)	(0.1853)	
Cross-Quarter * Dollar Funding Gap	--	1.1033**	--	1.8080*	3.5362***	--	0.0147***	--	0.0292***	0.0685***
		(0.5437)		(1.0408)	(1.2519)		(0.0054)		(0.0089)	(0.0182)
Cross-Quarter * Equity	--	62.9872**	--	70.0513*	261.7356***	--	0.5694**	--	1.0354***	3.8572***
		(26.5009)		(39.9562)	(92.0024)		(0.2233)		(0.3421)	(0.8025)
Dollar Funding Gap	--	0.9021	--	2.1240	0.1691	--	0.0094	--	0.0080	-0.0181
		(1.3438)		(1.8503)	(0.7435)		(0.0084)		(0.0108)	(0.0132)
Equity	--	-95.4093*	--	-137.8791	4.0518	--	0.4600	--	0.8982	0.0886
		(54.5322)		(130.9186)	(21.1243)		(0.4614)		(1.0310)	(1.1885)
Observations	78,426	78,426	67,851	67,851	67,851	78,426	78,426	67,851	67,851	67,851
R-squared	0.776	0.776	0.793	0.793	0.823	0.811	0.811	0.802	0.802	0.822
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Maturity Fixed Effects	Yes	Yes	Yes	Yes	--	Yes	Yes	Yes	Yes	--
Counterparty*Day Fixed Effects	Yes	Yes	Yes	Yes	--	Yes	Yes	Yes	Yes	--
Counterparty*Maturity*Day Fixed Effects	No	No	No	No	Yes	No	No	No	No	Yes
Bank*Quarter Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Bank*Maturity Fixed Effects	No	No	No	No	Yes	No	No	No	No	Yes
Bank*Counterparty Fixed Effects	No	No	No	No	Yes	No	No	No	No	Yes

Note: This table presents estimates of differential pricing and volume effects for contracts that mature in the next quarter. Each observation is one contract. *Forward Premium* refers to the relative difference between the forward rate and the spot rate, prevailing at the time of the forward contract (in basis points). *Cross-Quarter* is a dummy variable that equals one for any contract that crosses the upcoming quarter-end day, and zero otherwise. *Dollar Funding Gap* is the bank's net (on-balance-sheet) dollar assets, that is dollar assets minus dollar liabilities, in percent of dollar assets. *Equity* is the bank's book equity in percent of assets. *Controls* include the logarithm of total assets and, for regressions with forward premium as the dependent variable, the (log) contract value. All balance-sheet variables are predetermined, i.e., based on the previous month's balance sheet statement. The sample includes all uncollateralized USD/EUR forwards of maturity less than one month where a German bank sells dollars forward, initiated during the period January 1, 2014, through December 31, 2016. Standard errors are clustered at the bank-maturity level and presented in parentheses. Statistical significance at the 10 percent, (5 percent), and [1 percent] levels is indicated by *, (**), and [***], respectively.

Table 6: Dollar Funding Gap and Quarter-End Dynamics

	Forward Premium	Log(Total Volume)	Log(No. Contracts)	Log(Average Maturity)	Log(No. Counterparties)
	(1)	(2)	(3)	(4)	(5)
End-of-Quarter * Dollar Funding Gap	1.0286*	0.0051**	0.0039**	-0.0001	0.0037**
	(0.6128)	(0.0025)	(0.0019)	(0.0015)	(0.0016)
End-of-Quarter	-16.1106	0.2183*	0.1213*	-0.0494	0.1695***
	(20.5202)	(0.1238)	(0.0636)	(0.0540)	(0.0405)
Dollar Funding Gap	-0.8413	0.0066	0.0054	-0.0047**	0.0045
	(0.7605)	(0.0066)	(0.0038)	(0.0021)	(0.0036)
Observations	4,853	4,853	4,853	4,853	4,853
R-squared	0.311	0.787	0.800	0.429	0.805
Controls	Yes	Yes	Yes	Yes	Yes
Bank*Quarter Fixed Effects	Yes	Yes	Yes	Yes	Yes

Note: The analysis presented in this table is similar to that of Table 4 but focuses on the role of banks' dollar funding gap on quarter-end dynamics in the short-term forward market. *Dollar Funding Gap* is the bank's net (on-balance-sheet) dollar assets, that is dollar assets minus dollar liabilities, in percent of dollar assets. *Equity* is the bank's book equity in percent of assets. *Controls* include the logarithm of total assets, equity-to-assets, and equity-to-assets*end-of-quarter. All balance-sheet variables are predetermined, i.e., based on the previous month's balance sheet statement. For further details on the variables, see Table 4. The sample includes only forwards with maturity less than one month. Standard errors are clustered at the bank level and presented in parentheses. Statistical significance at the 10 percent, (5 percent), and [1 percent] levels is indicated by *, (**), and [***], respectively.

Table 7: Dollar Funding Gap and Equity

	Forward Premium			Log(Contract Value)		
Sample of Banks:	High Equity	Low Equity (Between)	Low Equity (Between +Within)	High Equity	Low Equity (Between)	Low Equity (Between +Within)
	(1)	(2)	(3)	(4)	(5)	(6)
Cross-Quarter * Dollar Funding Gap	0.9676*	1.3100*	4.3765**	-0.0013	0.0086+	0.0149*
	(0.5064)	(0.7968)	(2.1972)	(0.0032)	(0.0054)	(0.0086)
Test for Parameter Equality (High vs Low Equity):						
Difference	--	0.3425	3.4089+	--	0.0098+	0.0162*
P-value		[0.721]	[0.132]		[0.122]	[0.079]
Observations	19,362	58,364	24,864	19,362	58,364	24,864
R-squared	0.806	0.765	0.782	0.83	0.806	0.856
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Maturity Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Bank*Quarter Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Counterprty*Day Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes

Note: This table presents our baseline results from Table 5, columns (2) and (7), for high versus low equity banks. *High Equity* banks have an equity-to-assets ratio above the median of the cross-section in each month. *Low Equity (Between)* banks have an equity-to-assets ratio below the median of the cross-section in each month. *Low Equity (Between+Within)* banks have an equity-to-assets ratio below the median of the cross-section in each month *and* an equity-to-assets ratio below the median of the distribution within bank (across time). That is, the latter group of banks has a low equity-to-assets ratio relative to other banks in the same month and a low ratio relative to its own sample median. *Controls* include the level of dollar funding gap, the cross-quarter dummy, the (log) of total assets, equity-to-assets, equity-to-assets*cross-quarter, and, for regressions with the forward premium as the dependent variable, the (log) contract value. See the text and the caption of Table 5 for more details on variable definitions and sample period. Standard errors are clustered at the bank-maturity level and presented in parentheses. Statistical significance at the 10 percent, (5 percent), and [1 percent] levels is indicated by *, (**), and [***], respectively. Significance at 15 percent level is indicate by +.

Table 8: Collateralized Contracts

	Prob. of Secured	Forward Premium				Log(Contract Value)			
Contract Types:	All	All	OC	PC	FC	All	OC	PC	FC
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Cross-Quarter * Dollar Funding Gap	-0.2671***	-0.2929**	-0.4134*	-0.5504*	0.0430	-0.0020	-0.0096	-0.0001	0.0096
	(0.0952)	(0.1265)	(0.2287)	(0.2828)	(0.1515)	(0.0081)	(0.0305)	(0.0087)	(0.0168)
Cross-Quarter	--	13.6616***	33.0193***	5.6977*	8.7737***	0.4690**	0.3368	0.3931**	-0.5524*
		(4.8225)	(9.4608)	(2.9054)	(3.1585)	(0.1905)	(0.7442)	(0.1523)	(0.3064)
Dollar Funding Gap	-0.0352	0.0144	--	0.1578	--	-0.0210**	--	-0.0156	--
	(0.0548)	(0.1948)		(0.3156)		(0.0099)		(0.0105)	
Observations	177,362	128,942	39,027	88,956	659	128,942	39,027	88,956	659
R-squared	0.956	0.739	0.856	0.704	0.892	0.890	0.655	0.828	0.904
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Maturity Fixed Effects	--	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Bank*Quarter Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Counterparty*Day Fixed Effects	--	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Counterparty*Maturity*Day Fixed Effects	Yes								
Bank*Maturity Fixed Effects	Yes								
Pair Fixed Effects	Yes								

Note: This table analyses collateralized contracts. The dependent variable in column (1) is a dummy variable that equals one if the forward contract is collateralized. Columns (2)-(9) focus on the pricing and volume of collateralized contracts. The data allows us to distinguish between three different types of collateralization. A forward contract is considered (i) ‘‘Partially Collateralized (PC)’’ when the agreement between the counterparties states that either one or both counterparties will regularly post variation margin and either they do not exchange initial margin at all or only the reporting counterparty receives initial margin, (ii) ‘‘One-way Collateralized (OC)’’ when the agreement between the counterparties states that only the reporting counterparty to such derivative contract agrees to post initial margin, regularly post variation margin or both with respect to the derivative contract, or (iii) ‘‘Fully Collateralized (FC)’’ when the agreement between the counterparties states that initial margin must be posted and variation margin must regularly be posted by both counterparties. As before, *Controls* include the (log) of total assets, equity-to-assets, equity-to-assets*cross-quarter, and, for regressions with the forward premium as the dependent variable, the (log) contract value. Standard errors are clustered at the bank-maturity level and presented in parentheses. Statistical significance at the 10 percent, (5 percent), and [1 percent] levels is indicated by *, (**), and [***], respectively.

Table 9: Variation within Cross-Quarter Contracts

	Forward Premium		Log(Contract Value)	
	(1)	(2)	(3)	(4)
Short-Term Contract	7.2414***	--	0.1714*	--
	(2.0281)		(0.1010)	
Short-Term Contract * Dollar Funding Gap	--	1.4415***	--	0.0056*
		(0.5461)		(0.0030)
Dollar Funding Gap	--	2.0331	--	0.0016
		(1.7899)		(0.0072)
Observations	58,707	58,455	58,707	58,455
R-squared	0.609	0.687	0.648	0.664
Controls	Yes	Yes	Yes	Yes
Bank Size Control	Yes	Yes	Yes	Yes
Maturity Fixed Effects	No	Yes	No	Yes
Counterparty*Day Fixed Effects	Yes	Yes	Yes	Yes
Bank*Quarter Fixed Effects	Yes	Yes	Yes	Yes

Note: This table provides an alternative approach to identify the effects of dollar funding gap on the pricing and volume of forwards, by comparing short-term with long-term contracts, which are not suitable for window-dressing purposes. The dependent variable *Short-Term Contract* is a dummy variable that equals one if the contract maturity is smaller than one month. The omitted control group are contracts with maturity larger than three month, which always cross the next quarter end. *Controls* include the (log) of total assets, equity-to-assets, equity-to-assets*short-term contract, and, for regressions with the forward premium as the dependent variable, the (log) contract value. See the text and the caption of Table 5 for more details on variable definitions and sample period. Standard errors are clustered at the bank-maturity level and presented in parentheses. Statistical significance at the 10 percent, (5 percent), and [1 percent] levels is indicated by *, (**), and [***], respectively,

Table 10: Cross-Quarter Forward Buying

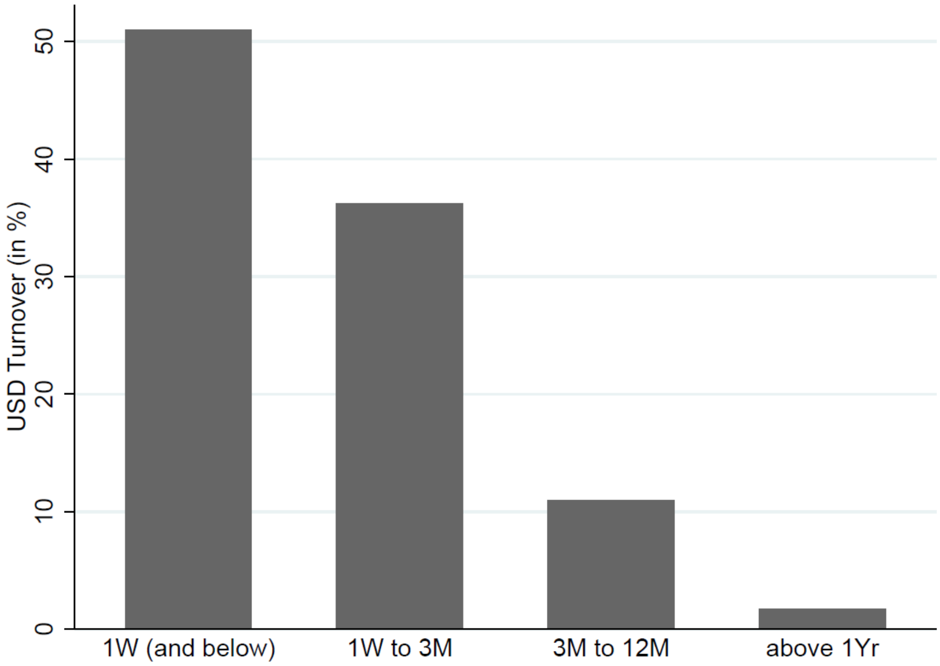
	Forward Premium		Log(Contract Value)	
	(1)	(2)	(3)	(4)
Cross-Quarter * Dollar Funding Gap	0.0910	-8.9991**	0.0082	-0.0369***
	(0.4213)	(3.9775)	(0.0056)	(0.0076)
Cross-Quarter	20.6981*	--	-0.0933	--
	(11.7240)		(0.0847)	
Dollar Funding Gap	0.0358	-3.4314**	0.0004	-0.0104
	(1.3992)	(1.7325)	(0.0082)	(0.0125)
Observations	111,517	94,834	111,517	94,834
R-squared	0.745	0.802	0.863	0.869
Controls	Yes	Yes	Yes	Yes
Maturity Fixed Effects	Yes	--	Yes	--
Counterparty*Day Fixed Effects	Yes	--	Yes	--
Counterparty*Maturity*Day Fixed Effects	No	Yes	No	Yes
Bank*Quarter Fixed Effects	Yes	Yes	Yes	Yes
Bank*Maturity Fixed Effects	No	Yes	No	Yes
Bank*Counterparty Fixed Effects	No	Yes	No	Yes

Note: This table presents results of a similar analysis as in Table 5 (columns (2), (5), (7), and (10)), but focus on contracts where banks *buy* dollars forward. Please refer to Table 5 for details on variable definitions. Standard errors are clustered at the bank-maturity level and presented in parentheses. Statistical significance at the 10 percent, (5 percent), and [1 percent] levels is indicated by *, (**), and [***], respectively.

ONLINE APPENDIX

A. ADDITIONAL FIGURES AND TABLES

Figure A.1 — Market Turnover by Maturity Segment



Note: The figure presents the maturity breakdown of USD notional amounts of USD/EUR forward contracts initiated in the period from January 1, 2014, through December 31, 2016. The maturity bucket '1W (and below)' refers to contracts of up to one week (inclusive), '1W to 3M' refers to contracts of one week (exclusive) to three months (inclusive), '3M to 12M' refers to contracts of three months (exclusive) to twelve months (inclusive), and 'above 1Yr' refers to contracts of above 12 months (exclusive).

Table A.1: Contract-Level Summary Statistics (Collateralized Forwards)

	Mean	P10	P25	P50	P75	P90	SD	Obs.
Forward Premium (Bps)	51.04	-21.92	-2.97	14.87	44.35	102.36	203	261,467
Forward Premium (Bps, Cleaned)	0	-18.77	-4.98	0	4.26	17.03	74.27	110,066
Contract Value (USD Million)	8.98	0.02	0.07	0.3	1.93	13.6	35.7	261,467
Maturity (Days)	81.43	3	5	32	97	225	134.5	261,467

Note: This table presents summary statistics of *collateralized* forward contracts for the period from January 1, 2014, through December 31, 2016. *Forward Premium* refers to the relative difference (in basis points) between the dollar forward and spot exchange rate. Cleaned *Forward Premium* is obtained as the residual from a regression of the forward premium on Counterparty*Maturity*Day fixed effects (i.e., where time-varying maturity and supply effects are removed).

Table A.2: Conditional Contract-Level Summary Statistics

	Cross-Quarter				Within-Quarter			
	Mean	IQR	SD	Obs.	Mean	IQR	SD	Obs.
Forward Premium (Bps)	94.59	70.80	281.43	112,352	18.23	32.94	100.38	149,115
Forward Premium (Bps, Cleaned)	0.00	6.03	107.22	36,313	0.00	10.33	50.71	73,753
Contract Value (USD Million)	5.35	0.98	25.70	112,352	11.70	2.94	41.50	149,115
Maturity (Days)	166.84	144.00	169.81	112,352	17.08	22.00	18.82	149,115
	Inter-Dealer				**Non-Dealer**			
	Mean	IQR	SD	Obs.	Mean	IQR	SD	Obs.
Forward Premium (Bps)	19.50	31.19	88.63	40,385	56.80	51.03	216.99	221,082
Forward Premium (Bps, Cleaned)	0.00	11.16	56.46	31,913	0.00	8.52	80.42	78,140
Contract Value (USD Million)	16.00	1.94	52.30	40,385	7.70	1.82	31.60	221,082
Maturity (Days)	102.22	135.00	157.00	40,385	77.64	88.00	129.60	221,082
	Large Banks				**Small Banks**			
	Mean	IQR	SD	Obs.	Mean	IQR	SD	Obs.
Forward Premium (Bps)	51.17	46.29	205.16	248,925	48.43	76.25	153.81	12,542
Forward Premium (Bps, Cleaned)	0.00	8.66	75.98	104,672	0.00	19.79	22.42	5,278
Contract Value (USD Million)	9.36	1.93	36.50	248,925	1.43	0.19	12.20	12,542
Maturity (Days)	80.63	91.00	134.32	248,925	97.39	139.00	137.02	12,542
	High Dollar-Funding-Gap Banks				**Low Dollar-Funding-Gap Banks**			
	Mean	IQR	SD	Obs.	Mean	IQR	SD	Obs.
Forward Premium (Bps)	50.90	46.01	205.54	231,578	52.14	60.44	182.13	29,889
Forward Premium (Bps, Cleaned)	0.00	8.36	76.15	97,389	0.00	15.67	52.36	12,055
Contract Value (USD Million)	9.76	2.14	37.20	231,578	2.93	0.41	19.60	29,889
Maturity (Days)	80.72	90.00	132.64	231,578	86.98	114.00	147.99	29,889

Note: This table presents summary statistics on our main variables at the forward contract level for the period from January 1, 2014, through December 31, 2016. *Forward Premium* refers to the relative difference (in basis points) between the dollar forward and spot exchange rate. Cleaned *Forward Premium* is obtained as the residuals from a regression of the forward premium on Counterparty*Maturity*Day fixed effects (i.e., where time-varying maturity and supply effects are removed). In the panel 'Cross-Quarter' ('Within-Quarter'), we restrict the sample to all cross-quarter (within-quarter) forward contracts. In panel 'Inter-Dealer' ('Non-Dealer'), we restrict the sample to all inter-dealer (non-dealer) contracts. In panel 'Large Banks' ('Small Banks'), we restrict the sample to the top-25th (bottom-75th) percentile largest (smallest) banks. In panel 'High Dollar-Funding-Gap Banks' ('Low Dollar-Funding-Gap Banks'), we restrict the sample to banks with the top-25th (bottom-75th) percentile highest (lowest) dollar funding gap. The sample includes only uncollateralized contracts.

Table A.3: Correlation Table

	Assets (EUR Billion)	Equity (% Assets)	Dollar Assets (% Assets)	Dollar Assets (% Equity)	Dollar Funding Gap (% Assets)	Dollar Funding Gap (% Equity)	Dollar Intragroup Liabilities (% Dollar Liabilities)
Assets (EUR Billion)	1.00						
Equity (% Assets)	-0.16	1.00					
Dollar Assets (% Assets)	0.24	-0.02	1.00				
Dollar Assets (% Equity)	0.17	-0.11	0.51	1.00			
Dollar Funding Gap (% Assets)	0.22	0.41	0.36	0.50	1.00		
Dollar Funding Gap (% Equity)	0.30	-0.08	0.42	0.81	0.76	1.00	
Dollar Intragroup Liabilities (% Dollar Liabilities)	0.47	-0.13	0.01	0.00	0.13	0.17	1.00

Note: The table presents a correlation matrix of our main variables at the bank-level. For each of the 145 bank in the sample, there is one observation, which is the average of each bank's monthly balance sheet statement throughout our sample period from January 1, 2014, through December 31, 2016. 'Dollar Funding Gap' is defined as the difference between total dollar assets and total dollar liabilities, expressed as a percentage of total dollar assets (and total equity, respectively) 'Dollar Intragroup Liabilities' refers to the intragroup dollar liabilities relative to total dollar liabilities (in percentages).

Table A.4: Aggregate Quarter-End Effects

(Robustness: Different Quarter-End Definitions)

	Forward Premium		Log(TotalVolume)		Log(No. Contracts)		Log(Average Maturity)		Log(No. Counterparties)	
	Last 7 Days	Last 10 Days	Last 7 Days	Last 10 Days	Last 7 Days	Last 10 Days	Last 7 Days	Last 10 Days	Last 7 Days	Last 10 Days
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
End-of-Quarter	8.8455***	4.0464*	0.2729***	0.2558***	0.1429^{+}	0.1243*	-0.0680***	-0.1242***	0.3229***	0.2804***
	(3.1373)	(2.2295)	(0.0755)	(0.0820)	(0.0878)	(0.0663)	(0.0236)	(0.0199)	(0.0929)	(0.0897)
Observations	11,032	11,032	11,032	11,032	11,032	11,032	11,032	11,032	11,032	11,032
R-squared	0.184	0.183	0.851	0.851	0.848	0.848	0.646	0.647	0.806	0.806
Bank*Quarter Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Note: The table replicates the estimation from Table 4, but uses different definitions for *End-of-Quarter*. For more details, refer to Table 4. Statistical significance at the 10 percent, (5 percent), and [1 percent] levels is indicated by *, (**), and [***], respectively.

Table A.5: Dollar Funding Gap
(Robustness: Different Maturities)

	Forward Premium			Amount		
	< 2 Weeks	< 1 Month	< 2 Months	<2 Weeks	< 1 Month	< 2 Months
	(1)	(2)	(3)	(4)	(5)	(6)
Cross-Quarter	13.2105	-9.5390	2.5953	-0.1655	-0.0748	0.1389
	(17.1390)	(15.1174)	(5.7648)	(0.1395)	(0.0856)	(0.0956)
Cross-Quarter * Dollar Funding Gap	0.5908	1.1033**	0.3209*	0.0138**	0.0147***	-0.0032
	(0.6132)	(0.5437)	(0.1872)	(0.0068)	(0.0054)	(0.0053)
Cross-Quarter * Equity	22.9693	62.9872**	24.3870**	0.4403	0.5694**	-0.2025
	(22.6768)	(26.5009)	(11.2322)	(0.2771)	(0.2233)	(0.1940)
Dollar Funding Gap	-3.1490*	0.9021	-0.3798	0.0037	0.0094	0.0039
	(1.6836)	(1.3438)	(1.5962)	(0.0085)	(0.0084)	(0.0065)
Equity	-162.7496**	-95.4093*	-118.6160**	0.9228*	0.4600	0.2975
	(75.0581)	(54.5322)	(53.7016)	(0.5195)	(0.4614)	(0.4414)
Observations	63,453	78,426	101,937	63,453	78,426	101,937
R-squared	0.831	0.776	0.753	0.823	0.811	0.797
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Maturity Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Bank*Quarter Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Counterprty*Day Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes

Note: This table replicates the baseline results from Table 5 for different definitions of short-term contracts. For more details, refer to Table 5. Statistical significance at the 10 percent, (5 percent), and [1 percent] levels is indicated by *, (**), and [***], respectively.

Table A.6: Dollar Funding Gap at the Bank-Level

	Forward Premium	Log(Contract Value)
	(1)	(2)
Cross-Quarter * Dollar Funding Gap	1.5309**	0.0170**
	(0.5135)	(0.0073)
Cross-Quarter	-4.7155	-3.1080***
	(3.1479)	(0.1210)
Dollar Funding Gap	1.7342	-0.0213
	(4.4843)	(0.1127)
Observations	100	100
R-squared	0.989	0.999
Controls	Yes	Yes
Bank*Quarter Fixed Effects	Yes	Yes

Note: This table presents bank-level estimates of differential pricing and volume effects by cross-quarter contracts. For each bank, there are two observations: cross-quarter versus within quarter. As before, *Cross-Quarter* is a dummy variable that equals one for any contract that crosses the upcoming quarter-end day, and zero otherwise (i.e., within quarter). *Dollar Funding Gap* is the bank's net (on-balance-sheet) dollar assets, that is dollar assets minus dollar liabilities, in percent of dollar assets, measured at the previous month's balance sheet statement. *Controls* include for (log) assets, equity-to-assets, and equity-to-assets*cross-quarter, and, for regressions with the forward premium as the dependent variable, the (log) contract value. The sample includes uncollateralized USD/EUR forwards initiated during the period January 1, 2014, through December 31, 2016. Also, the sample is restricted to short-term contracts with maturity less than one month. Fixed effects are either included ('Yes') or not included ('No'). Standard errors are clustered at the bank level and presented in parentheses. Statistical significance at the 10 percent, (5 percent), and [1 percent] levels is indicated by *, (**), and [***], respectively.

Table A.7: Dollar Funding Gap and Credit Risk

	Forward Premium			Log(Contract Value)		
	(1)	(2)	(3)	(4)	(5)	(6)
Cross-Quarter	9.5224	-8.4188	-110.7713	0.1446	0.2831	0.4327
	(12.7502)	(30.0238)	(147.0408)	(0.1054)	(0.2335)	(0.9895)
Cross-Quarter * Dollar Funding Gap	2.0357**	2.1302**	2.3361**	0.0211***	0.0204***	0.0191**
	(0.8725)	(0.9224)	(1.0676)	(0.0075)	(0.0069)	(0.0075)
Cross-Quarter * Equity	91.4540**	106.2279**	113.1594*	0.7176**	0.6049***	0.7468***
	(39.4777)	(50.1875)	(57.3953)	(0.2850)	(0.2186)	(0.2452)
Dollar Funding Gap	1.5636	1.6711	1.4066	0.0018	0.0016	0.0010
	(1.6768)	(1.7013)	(2.1940)	(0.0087)	(0.0088)	(0.0095)
Equity	-81.2114	-78.7771	5.9069	0.9542*	0.9563*	2.1338**
	(57.3239)	(57.8238)	(74.6769)	(0.5156)	(0.5081)	(0.9611)
Yield Spread	--	-36.7163	--	--	0.0689	--
		(44.8063)			(0.2345)	
Cross-Quarter * Yield Spread	--	19.1652	--	--	-0.1480	--
		(20.3527)			(0.1620)	
Log(CDS)	--	--	166.0936*	--	--	-0.3678
			(93.5464)			(0.7604)
Cross-Quarter * Log(CDS)	--	--	26.6303	--	--	-0.0603
			(31.0576)			(0.2114)
Observations	59,794	59,794	51,680	59,794	59,794	51,680
R-squared	0.769	0.769	0.748	0.718	0.718	0.700
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Maturity Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Bank*Quarter Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Counterprty*Day Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes

Note: This table presents robustness tests of our baseline results from Table 5, while controlling explicitly for daily-varying bank-specific credit risk measures. *Yield Spread* is the (value-weighted) difference between the yields on a bank's outstanding bonds and the (maturity-matched) yields on German government bonds. *Log(CDS)* is the logarithm of the five-year CDS spread. Columns (1) and (4) show results without credit risk controls for the same set of observations for which we can control for *Yield Spread*. Standard errors are clustered at the bank-maturity level and presented in parentheses. Statistical significance at the 10 percent, (5 percent), and [1 percent] levels is indicated by *, (**), and [***], respectively.

Table A.8: Bargaining Power and Internal Capital Markets

	Forward Premium		
	(1)	(2)	(3)
Dollar Funding Gap	1.1386***	-0.3892**	1.0920***
	(0.4070)	(0.1928)	(0.4116)
Equity	-4.3508	-5.6408	-7.5373
	(3.9055)	(5.9532)	(5.6678)
Dealer Bank	-95.4440**	--	-89.3312**
	(41.0304)		(41.4894)
Dealer Bank * Dollar Funding Gap	-1.7878***	--	-1.6641***
	(0.6319)		(0.6252)
Access to ICM	--	-0.5349	0.8344
		(11.9976)	(12.2892)
Access to ICM * Dollar Funding Gap	--	-0.5643	-0.4522
		(0.3894)	(0.3687)
Access to ICM * Equity	--	-7.7133	-4.0204
		(10.1527)	(10.0029)
Observations	4,321	4,321	4,321
R-squared	0.672	0.672	0.672
Controls	Yes	Yes	Yes
Maturity Fixed Effects	Yes	Yes	Yes
Counterparty*Day Fixed Effects	Yes	Yes	Yes

Note: This table presents the impact of bargaining power and access to internal capital markets on the pricing of cross-quarter contracts. *Dealer Bank* is a dummy variable that equals one if the bank is a reporting dealer according to the 2016 BIS Triennial Central Bank Survey of Foreign Exchange and Derivatives Market Activity. *Access to ICM* is a dummy variable that equals one if the bank has reported positive dollar liabilities with an affiliated foreign office according to the balance sheet data. Both variables are constant over time. The sample is restricted to short-term cross-quarter contracts (<1m). Standard errors are clustered at the bank-maturity level and presented in parentheses. Statistical significance at the 10 percent, (5 percent), and [1 percent] levels is indicated by *, (**), and [***], respectively.

B. ABSOLUTE VERSUS RELATIVE FX FORWARD PRICES

It is important to highlight that our estimates of the cross-quarter premium in Table 4 (and all following tables) are based on forward premia that are *not* annualized and thus are in *absolute* terms. If we estimated the cross-quarter effects on annualized forward premia, i.e., the forward premia in *relative* per-annum terms, we would find that the mark-up for cross-quarter contracts amounts to a sizable 293 basis points. To put these numbers into perspective, a back-of-the-envelope comparison with prevailing dollar and euro money market rates during our sample period may be insightful. For example, the average three-month interest rate differential between the U.S. dollar and euro was 45.6 basis points (per annum) during our sample period (LIBOR rate of 43 basis points and average EURIBOR rate of -2.5 basis points). Thus, the estimated cross-quarter premium amounts to more than 640 percent relative to the interest rate differential (an implied synthetic dollar funding cost of 290.5 basis points compared to direct dollar funding rates of 43 basis points).This is an effect of the annualization that disproportionally scales the forward premia of short maturities in combination with the previously established result that most cross-quarter contracts are executed in very short maturities. However, while in annualized terms the cross-quarter effects are very large, banks only pay these high prices for a few days each year (at quarter-ends).

Our results from Table 4 and Figure 4 suggest that long-term forward contracts are more expensive than short-term contracts, manifesting itself in higher forward premia in absolute terms, i.e., actually paid. But in relative terms, i.e., when translating these premia paid into annualized terms, the premia inherent to short-term contracts are substantially larger than those observed for long-term contracts. Thus, there is a trade-off for banks depending on the initial intention for selling the forward contract to begin with. If the investor seeks to manage its FX risk for a longer period while minimizing its costs, the investor is better off using long-term contracts as the relative costs will be lower. But if an investor intends to manage risk only over a short-term horizon, then the investor may be better off using short-term contracts that in absolute terms are cheaper. However, this also suggests that a roll-over strategy with short-term contracts is not as cost-efficient as a long-term contract over the same horizon.

C. National Implementation of Key Minimum Capital Requirements

Jurisdiction	Leverage Ratio (LR) Requirement	Reporting/ Disclosure	Scope for Arbitrage Strategies
Basel agreement	* 3% minimum + LR-buffer (0.5*G-SIB with 0.5 being the conversion factor mapping risk-weighted buffer to LR buffer) To be met on daily basis	At least quarter-end	**High** if only quarter-end values are reported
UK	3.25% minimum (excl. central bank reserves) + LR-buffer (=0.35*CCyB+0.35*G-SIB) To be met on daily basis	*** LR**: quarterly averages * Components of LR: -Tier1: Monthly average -On-balance sheet exposures: Daily average -Off-balance sheet exposures: Monthly average -LR-exposure: quarterly high and quarterly low (only reporting)	**Low** given that quarterly high and low values are reported alongside averages. The daily computation of part of the exposure measures allows for supervisory scrutiny
CH	* 3% minimum for all, 4.5% for SIFIs + LR-buffer (0.5*G-SIB) (currently sum= 5% for Swiss G-SIBs)	quarter-end	**High** as only quarter-end values are reported
EU-wide	* not implemented as a minimum requirement yet (only reporting obligation); From June 28, 2021: * 3% minimum + from January 2023 LR-buffer (0.5*G-SIB) + individual LR-P2R * NL already expect 4% LR from large banks To be met on daily basis	quarter-end	**High** as only quarter-end values are reported
Jurisdiction	**Risk-weighted Tier 1 Ratio**	**Reporting/ Disclosure**	**Scope for Arbitrage Strategies**
Basel agreement, UK, CH, EU-wide	* 8% of RWA minimum (=4.5% CET1+1.5% AT + 2% Tier2) + Conservation buffer: 2.5%; + CCyB buffer: 0-2.5%; + G-SIB surcharge: 1-2.5%; To be met on daily basis * Where the regulatory framework does not refer to RWA but directly to capital charges (eg for market risk and operational risk), banks should indicate the derived RWA number (i.e., by multiplying capital charge by 12.5). For the simplified standard approach, the scalars per risk class are: 1.3 for interest rate risk; 3.5 for equity risk; 1.9 for commodity risk; and 1.2 for FX risk	quarter-end	**High** if only quarter-end values are reported