Topography of the FX Derivatives Market: A View from London*

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Abstract

We analyze the behavior of all financial and non-financial firms active in the UK FX derivatives market—the largest center for currency trading globally—using transaction-level data. Based on firm-level net currency derivatives exposures, we find that UK and EU pension funds, investment funds, insurers, and non-financial corporations use FX derivatives primarily for hedging purposes, with dealer banks accommodating these clients' hedging needs. In contrast, hedge funds predominantly utilize FX derivatives to speculate, with their trading activity consistent with the carry trade, momentum, and macroeconomic news investment strategies.

Keywords: FX Derivatives, Exchange Rates, Non-Bank Financial Institutions, Banks, Non-Financial Corporations, Hedging, Speculation, Macro News.
JEL Codes: F30, F31, G15, G20

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1 Introduction

Exchange rate (FX) markets are at the center of trade and financial flows. They affect financial stability, economic activity and the transmission of monetary and fiscal policies. Borio et al. (2022) point out that US dollar debt from FX derivatives is huge and growing. They alert to the fact that the $80 trillion in outstanding obligations to pay USD via FX swaps, forwards and currency swaps exceeds the value of the stock of Treasury bills. Yet the inner workings of FX markets remain largely unknown. Academic papers have had to make assumptions about the hedging practices of financial and non-financial firms based on a limited empirical foundation. Such assumptions are usually very consequential for the theoretical predictions and policy implications of these models (see, e.g., Gopinath and Stein, 2021 and Camanho et al., 2022). This paper provides the first detailed topography of the largest FX market in the world to fill this gap.

We document the behavior of participants in the over-the-counter (OTC) FX derivatives market in the UK using high-frequency contract-level data.[1] Our analysis is underpinned by the construction of daily *net* FX derivatives exposures at the firm level for the over 16,000 firms active in the UK FX market over our sample of January 1 2015 to December 31 2020. To our knowledge, we are the first to construct and study in detail firm-level net FX derivatives exposures at a daily frequency for a meaningful share of the global FX market—in our case, for the near-universe of firms trading in the UK. Existing studies with wide coverage have instead used either snapshots of sector-level gross exposures, as in the BIS Triennial Survey, or, more recently, snapshots of sector-level net exposures, as in Du and Huber (2024).

Studying net rather than gross FX derivatives exposures at the firm level is crucial since net exposures link directly to firms' profits, making them key firm-level choice variables. As a result, firms' net FX derivatives exposures can shed light on whether they use FX

[1] As of 2022, over 70% of global FX turnover takes place in derivatives markets, as compared to only 30% in spot markets. FX turnover in the UK represents 38% of the global total turnover, twice the share of the second largest center for FX trading, the US (see the 2022 BIS Triennial Central Bank Survey of FX and OTC Derivatives Markets, henceforth "BIS Triennial Survey").

derivatives to hedge or speculate. This is a key ingredient in any model with firms and financial intermediaries in the international economy.

We begin with a model in which firms trade FX derivatives for two reasons: (i) to speculate, based on their expectations for future exchange rates; and (ii) to hedge the currency risk associated with their non-derivatives profits. A key distinction between firms' speculative and hedging demand is that their hedging demand is often one-directional, since firms' non-derivatives operations tend to persist over time. For example, UK (EU) investment funds that are consistently long the US S&P500 would hedge the currency risk associated with their non-derivatives portfolio by maintaining persistently net-short USD and net-long GBP (EUR) exposures via FX derivatives. Similarly, non-financial corporations that are net exporters to the US and net importers from the Eurozone would maintain persistent net-short USD and net-long EUR derivatives exposures to hedge currency risk. In contrast, firms' speculative demand is unlikely to be one-directional since their expectations for future exchange rates should adjust frequently in response to market developments. This should be especially true for the currencies of advanced economies, for which it is rare to have persistent trends in nominal exchange rates. Thus, to assess whether firms in each sector use FX derivatives to speculate or hedge "on average", we inspect the direction and persistence of firms' net FX derivatives exposures over time.

We find, at the sector level, persistent net-short USD and net-long GBP (EUR) derivatives exposures for UK (EU) pension funds, investment funds, insurers and non-financial corporates, consistent with these non-US firms using FX derivatives largely for hedging purposes. On the other side, dealer banks accommodate client's hedging demand by taking large net-long USD and net-short GBP and EUR exposures. By contrast, non-bank market makers, despite their significant transaction volumes, have near-zero net exposures. Different to the other players in the market, the hedge fund sector's USD, GBP and EUR exposures frequently shift from net-long to net-short over time, consistent with their use of FX derivatives to speculate "on average". Non-dealer banks' net USD exposures are also volatile, suggesting that speculative demand may play a role for their net exposures as well.

Importantly, we document significant within-sector heterogeneity in the size and direction of firms' net FX derivatives exposures in many sectors. As a result, sector-level exposures may be obscuring whether individual firms' net exposures are one-directional or change signs frequently over time. To address this, we report the share of firms in each sector that maintain one-directional net exposures over various fractions of our sample.

We find that over 70% of individual pension funds, insurance companies, and non-financial corporations maintain one-sided net exposures in the same direction to the USD, EUR and GBP over at least 80% of our sample. This suggests that hedging demand is the primary factor driving FX derivatives use among most individual firms in these sectors. The proportion is slightly lower for the investment fund sector, where about 65% of individual investment funds maintain the same one-directional net exposure at least 80% of the time. Individual hedge funds and non-dealer banks are even less likely to maintain persistent one-sided net exposures, with shares ranging from only about 50% to 60%. This suggests that speculative demand may play a larger role in the FX derivatives use of firms in these sectors. Overall, these firm-level findings are consistent with the results from our sector-level analysis.

Next, we shift attention to firms' speculative FX derivatives demand by examining which firms adjust their net exposures "on the margin" in line with three well-known FX investment strategies, namely, the carry trade, momentum, and trading on the arrival of macroeconomic news. We find that hedge funds adjust their net exposures in accordance with all three investment strategies, which is consistent with hedge funds rebalancing their FX derivatives portfolios primarily for speculative purposes. In addition, we find some evidence that non-dealer banks perform the carry trade and trade on the arrival of macro news in a manner consistent with speculation, although the results are weaker than for hedge funds. Further, while investment funds appear to carry trade at short horizons, most of their adjustments occur at lower frequencies, which is suggestive of a hedging motive for rebalancing. Such longer-horizon rebalancing is also typical for pension funds, as well as for non-financial corporates, who consistently adjust their net exposures in the opposite direction to these investment strategies. This may reflect a strong correlation between corporates' hedging demand and the variables defining FX investment strategies. Finally, we find that non-bank market makers often appear to accommodate firms' speculative rebalancing, whereas dealer banks are largely able to insulate themselves from exposures to these strategies.

Lastly, throughout the paper, we present many novel facts about the largest FX derivatives market globally. These facts range from a breakdown of the market's participants—*e.g., 95% of all firms in the market are either asset managers or non-financial corporations*—and their countries of residence—*e.g., 80% of hedge funds are resident outside the UK and EU, with many in tax havens*—to a breakdown of their transaction volumes—*e.g., 70% of all transactions are taken by 21 dealer banks*—to a new measure of the market's size based on firms' <u>net</u> currency-cross exposures—*estimated to be 3 trillion USD, far less than the 37 trillion USD <u>gross</u> figure implied by Borio et al. (2022).*[2] Furthermore, our firm-level analysis allows us to highlight within-sector heterogeneity—particularly by investment funds and non-financial corporations—and concentration in firms' net currency derivatives exposures. These facts will be important for new theoretical models to match.

Related Literature

While the literature is growing rapidly, there are relatively few papers that study FX derivatives use in advanced economies. Du and Huber (2024) document stylized facts about foreign investors' USD securities and derivatives positions using sector-level data across various jurisdictions. Abbassi and Bräuning (2021) use transaction-level FX derivatives data in Germany to show show that German banks use FX derivatives to "window-dress" end-of-quarter FX exposure while Abbassi and Bräuning (2023) use the same data set to argue that the Brexit shock combined with German banks' currency derivatives positions affected local credit sup-

[2]Our measure corresponds to the average market size over our sample period (2015 to 2020). The latter value is calculated from the 97 trillion USD gross size of the global FX market in 2022 quoted by Borio et al. (2022), times the 38% UK market share quoted by the 2022 BIS Triennial Survey.

ply by impacting banks' profits and net worth. Based on quarterly SEC filings, Sialm and Zhu (2021) study the use of currency derivatives by US international fixed income funds and conclude that, while a large fraction of the positions are for risk management purposes, some funds appear to use carry and momentum trading strategies. Using similar data, Opie and Riddiough (2024) find that US international equity funds' FX derivatives use does not, on average, affect the mean or variance of their portfolio returns, which they attribute to sub-optimal use. Kuzmina and Kuznetsova (2018) use hand-collected data to show that German corporates are more likely to use FX derivatives if they are net exporters or importers and when exchange rate movements are larger, while Lyonnet et al. (2021), relying on survey data, show that large EU corporates are more likely to hedge currency risk if they price in foreign currency.[3] Finally, Brunnermeier et al. (2009) use aggregate CFTC currency futures data to examine non-commercial traders' (speculators') unwinding of carry trades during risk-off episodes while Ostry (2023) uses the same data to document a flight-to-USD by commercial traders (hedgers) during such episodes.

There is also a vibrant literature that studies the link between hedging flows and asset prices, in particular exchange rates, both empirically and theoretically (see e.g., Liao and Zhang, 2024, Czech et al., 2021, Ben Zeev and Nathan, 2023, Brauer and Hau, 2023).[4] Several papers also use data on derivatives to study various aspects of covered interest rate parity (CIP) deviations. Avdjiev et al. (2019), Du et al. (2018), Ben Zeev and Nathan (2022), and Aldunate et al. (2023) examine hedging demand and CIP deviations. Bahaj and Reis (2022) show that central bank swap lines put a ceiling on CIP deviations. Hau et al. (2021) use contract-level data to document price discrimination in OTC FX derivatives markets that is consistent with the failure of CIP since the financial crisis. Cenedese et al. (2021) use UK

[3]Much of the earlier literature on FX derivatives use has focused on non-financial corporations in emerging markets, where data has been more readily available. In a recent application to Chile, Alfaro et al. (2021) show that granular corporates supplement their limited operational hedging with significant financial hedging via FX forwards.

[4]This literature builds on models of spot exchange rate determination in imperfect financial markets, e.g., Hau and Rey 2006, Gabaix and Maggiori 2015, Ivashina et al. 2015, Stavrakeva and Tang 2021, Gourinchas et al. 2021, Greenwood et al. 2023.

transaction-level FX derivatives data to relate the breakdown of CIP to the dealer balance-sheet constraints resulting from post-crisis financial regulations. Ferrara et al. (2022) use the same data to examine how dealer banks that drew on swap lines adjusted their FX exposures during the Covid-19 recession. Kubitza et al. (2024) use euro-area transaction-level FX derivatives data to show that investors' sell USD bonds when they want to roll over their existing currency derivatives positions but CIP deviations widen.

Relative to this existing research, we provide the first detailed assessment of firm-level currency derivatives use by all types of financial and non-financial firms active in a significant share of the global FX market. Our analysis illuminates new facts related to the overall structure of the market, the hedging vs. speculative behavior of the market's players, as well as which players adjust their net FX derivatives exposures in a manner consistent with classic FX investment strategies and with the transmission of macroeconomic news to exchange rates. Our analysis strives to inform the design of theoretical models of exchange rate determination, which sits at the heart of international finance.

The remainder of the paper is structured as follows. In Section 2, we introduce notation, define our key variables of interest and provide a theoretical framework for decomposing firms' FX derivatives holdings into speculative and hedging components. Section 3 then discusses the UK FX derivatives data we use throughout the paper. Leveraging insights from these previous sections, Sections 4 and 5 detail the behavior of participants in the UK FX derivatives market, focusing on the market's structure and firms' net FX derivatives exposures, respectively. Lastly, Section 6 examines how firms' adjust their net FX derivatives exposures with respect to well-known FX investment strategies. Section 7 concludes.

2 Notation and Theoretical Framework

Before turning to the data, we first introduce notation and define the two key variables we study in this paper: firms' *net* currency-cross and currency derivatives exposures. We then present a theoretical framework that decomposes these net FX derivatives exposures into speculative and hedging components, which we will use to interpret our empirical results.

Beginning with notation, each FX derivatives contract refers to a currency pair, denoted by $\{k, m\}$, with k and m indexing the two different currencies. The contract reports two notional values linked to these two currencies. For example, if firm i is long currency k and short currency m via an n-period $\{k, m\}$ FX forward contract entered into at time t, the contract specifies that the firm will receive the notional amount $N^{i,\{k,m\}}_{t,t+n} > 0$ in currency k and will pay the notional amount $-\tilde{N}^{i,\{k,m\}}_{t,t+n} > 0$ in currency m in n periods.[5] The transaction-and-firm specific n-period FX forward rate is then defined as $F^{i,m/k}_{t,n} = -\frac{\tilde{N}^{i,\{k,m\}}_{t,t+n}}{N^{i,\{k,m\}}_{t,t+n}}$, such that an increase implies a forward appreciation of currency k against currency m.[6]

Let c^i denote the currency of operation of firm i. Firm i's profits in units of currency c^i from this derivatives transaction, realized in $t + n$, are:

$$\pi^{i,\{k,m\},deriv}_{t,t+n} = N^{i,\{k,m\}}_{t,t+n} S^{c^i/k}_{t+n} + \tilde{N}^{i,\{k,m\}}_{t,t+n} S^{c^i/m}_{t+n} = S^{c^i/m}_{t+n} \left(S^{m/k}_{t+n} - F^{i,m/k}_{t,n} \right) N^{i,\{k,m\}}_{t,t+n}, \tag{1}$$

where $S^{m/k}_{t+n}$ is the bilateral m/k spot exchange rate that prevails at $t + n$, with units of currency m per one unit of currency k. So long as firm i is long currency k and short currency m ($N^{i,\{k,m\}}_{t,t+n} > 0$), the transaction is profitable if $S^{m/k}_{t+n} > F^{i,m/k}_{t,n}$. That is, the transaction is profitable if the relative value of currency k to currency m in the spot market at $t + n$ is greater than the relative value implied by the n-day forward rate. We refer to $N^{i,\{k,m\}}_{t,t+n}$, our first key variable, as firm i's net currency-cross exposure with respect to the $\{k, m\}$ cross at horizon n from this contract.[7]

In practice, firm i may enter into multiple n-period derivatives contracts across a range

[5] If firm i is short currency k and long currency m via a $\{k, m\}$ contract, then it pays the notional amount $-N^{i,\{k,m\}}_{t,t+n} > 0$ in currency k and receives the notional amount $\tilde{N}^{i,\{k,m\}}_{t,t+n} > 0$ in currency m in n periods.

[6] A client i chooses the notional for only one leg of the contract, $N^{i,\{k,m\}}_{t,t+n}$, and is quoted the forward rate by a market maker or dealer bank. Together, these determine the notional of the second leg of the contract.

[7] We use this terminology since $N^{i,\{k,m\}}_{t,t+n}$ reflects firm i's net exposure to the bilateral exchange rate $S^{m/k}_{t+n}$ from this FX derivatives contract. When we move to the data, we will account for the fact that firm i may enter into multiple contracts in the same currency cross $\{k, m\}$ (and $\{m, k\}$) by netting the exposures from each contract, as we detail below.

of currency crosses. Firm i's total profits in units of currency c^i from all time-t n-period FX derivatives transactions can be expressed as:

$$\begin{aligned}
\pi_{t,t+n}^{i,FX,deriv} &= \sum_{\{k,m\}\in\Omega_n} \pi_{t+n}^{i,\{k,m\},deriv} = \sum_{\{k,m\}\in\Omega_n} \left(N_{t,t+n}^{i,\{k,m\}} S_{t+n}^{c^i/k} + \tilde{N}_{t,t+n}^{i,\{k,m\}} S_{t+n}^{c^i/m} \right) \\
&= \sum_{l} S_{t+n}^{c^i/l} \underbrace{\left(\sum_{m} N_{t,t+n}^{i,\{l,m\}} + \sum_{k} \tilde{N}_{t,t+n}^{i,\{k,l\}} \right)}_{N_{t,t+n}^{i,l}}, \qquad (2)
\end{aligned}$$

where Ω_n is the set of all derivatives contracts issued at t of horizon n, indexed by their currency pair $\{k,m\}$. We refer to $N_{t,t+n}^{i,l}$, our second key variable, as firm i's net currency exposure with respect to currency l at horizon n. $N_{t,t+n}^{i,l}$ captures the net amount of currency l that firm i will receive (or pay if negative) at $t+n$, which is constructed by netting out all bilateral net currency-cross exposures in which firm i receives or pays currency l.[8]

In summary, from equation (2), we see that firm i's profits from trading FX derivatives are a function of their net currency exposures, which in turn, via equation (1), depend on their net currency-cross exposures. This is why these two net FX derivative exposure measures are the two key variables we study in this paper.

There are advantages to studying *both* variables. On the one hand, it is very common for firms to transact "through the USD" due to the liquidity of crosses involving the USD in FX derivatives markets. For example, if a firm wants to short the MXN and long the EUR, it will often short the MXN and long the USD and, simultaneously in a second transaction, short the USD and long the EUR. These two contracts together are neutral with respect to the USD, a feature that would be ignored if we examine firms' net exposures at the currency-cross level, which highlights a key benefit of focusing on firms' currency exposures. On the other hand, investment strategies that use FX derivatives, such as the carry trade, are typically defined with respect to a currency cross, i.e., to go net-long a 'higher-interest-rate' country's currency and net-short a 'lower-interest-rate' country's currency. Thus, in order

[8] $N_{t,t+n}^{i,l}$ captures firm i's net exposure to the $S_{t+n}^{c^i/l}$ exchange rate from all n-period FX derivatives contracts entered into at t.

to investigate whether firms adjust derivatives positions in line with these FX investment strategies, we also consider firms' net currency-cross exposures.

Building on these definitions, we introduce a framework for decomposing firms' FX derivatives holdings into hedging and speculative components.[9] Consider, for simplicity, a UK-based firm, whose currency of operation is the GBP, that trades only the $\{USD, GBP\}$ cross using one-period FX derivatives. The firm solves a two-period optimization problem, $t = \{0, 1\}$, in which the total profits of firm i in GBP are given by $\pi_1^i = \pi_{0,1}^{i,FX,deriv} + X_1^{i,H}$, with $X_1^{i,H}$ denoting the non-FX derivatives profits of firm i, which are potentially exposed to the USD/GBP exchange rate. If firm i is a financial institution, $X_1^{i,H}$ reflects profits from the rest of the investment portfolio. If, instead, firm i is a non-financial corporation, $X_1^{i,H}$ reflects its operating profit. Assuming that firm i has mean-variance preferences and takes $X_1^{i,H}$ as given (e.g., because FX derivatives decisions are operationally disjoint from the rest of the firm), then firm i solves the following optimization problem:

$$\max_{N_{0,1}^{i,\{USD,GBP\}}} \tilde{E}_0^i \left(\pi_{0,1}^{i,FX,deriv} + X_1^{i,H}\right) - \frac{\rho}{2} Var\left(\pi_{0,1}^{i,FX,deriv} + X_1^{i,H}\right),$$

where $\pi_{0,1}^{i,FX,deriv} = \left(S_1^{GBP/USD} - F_{0,1}^{i,GBP/USD}\right) N_{0,1}^{i,\{USD,GBP\}}$ and $\tilde{E}_0^i$ denotes firm i's expectations, which can be subjective or objective. Firm i's optimal net $\{USD, GBP\}$ derivatives exposure is:

$$N_{0,1}^{i,\{USD,GBP\}} = \underbrace{\frac{\tilde{E}_0^i\left(S_1^{GBP/USD} - F_{0,1}^{i,GBP/USD}\right)}{\rho Var_0\left(S_1^{GBP/USD}\right)}}_{Spec_{0,1}^{i,\{USD,GBP\}}} - \underbrace{\frac{Cov_0\left(S_1^{GBP/USD}, X_1^{i,H}\right)}{Var_0\left(S_1^{GBP/USD}\right)}}_{Hedge_{0,1}^{i,\{USD,GBP\}}}, \tag{3}$$

where we define $Spec_{0,1}^{i,\{USD,GBP\}}$ as the speculative component of firm i's net FX derivatives exposure and $Hedge_{0,1}^{i,\{USD,GBP\}}$ as the hedging component.[10] The sign of $Spec_{0,1}^{i,\{USD,GBP\}}$ is governed by firm i's expectations about how the future spot exchange rate will compare to

[9] This theoretical framework is suited to analyze the behavior of clients in the FX derivatives market.

[10] Since firm i trades only the $\{USD, GBP\}$ cross and its currency of operation is the GBP, its net $\{USD, GBP\}$ currency-cross exposure $N_{0,1}^{i,\{USD,GBP\}}$ is equivalent to a net USD currency exposure $N_{0,1}^{i,USD}$.

their contract-specific forward rate. Intuitively, the speculative component does not depend on firm i's profits from their non-derivatives investments. Instead, these non-derivatives profits determine the sign of $Hedge_{0,1}^{i,\{USD,GBP\}}$ via their covariance with the future spot exchange rate. The relative magnitude of these two components is a function of firm i's risk aversion ρ, where lower risk aversion increases the relative size of the speculative component compared to the hedging component.

To gain further intuition, consider the following concrete examples. First, assume firm i is an investment fund that holds the US stock market in its non-derivatives portfolio. In this case, $X_1^{i,H}$ increases if the USD appreciates against the GBP, i.e., $\frac{Cov_0\left(S_1^{GBP/USD}, X_1^{i,H}\right)}{Var_0\left(S_1^{GBP/USD}\right)} > 0$. This covariance results in a hedging component of FX derivatives holdings in which firm i is net-short the USD. Such a position is profitable when the USD depreciates against the GBP, providing a hedge against the FX risk from firm i's non-derivatives portfolio. If firm i's position in the US stock market is persistent and its hedging demand for FX derivatives dominates its speculative demand, then we would expect firm i to be net-short the USD ($N_0^{i,\{USD,GBP\}} < 0$) over the whole sample.

Another example is if firm i were a non-financial corporation that operates in the UK (i.e., produces and pays wages primarily in the UK) and also, on net, exports to the US. As was the case for the UK investment fund, we would expect that $Hedge_{0,1}^{i,\{USD,GBP\}} > 0$, i.e., net-short the USD, if firm i's USD exports are priced in USD. This is because the firm's operating profits $X_1^{i,H}$, which depend on its USD sales revenue and its GBP input costs, increase as the USD appreciates against the GBP. The opposite is true if firm i is a net importer from the US, with imports priced in USD. Since the speculative component of non-financial corporations' FX derivatives positions are likely small (due to high risk aversion), and their net importer/exporter statuses and currencies of invoicing are relatively persistent, we would also expect non-financial corporates to have one-directional net currency exposures over the whole sample.[11]

[11]Interestingly, Garofalo et al. (2024) document a significant decrease (increase) in the extent to which

In contrast, if firm i's speculative demand, $Spec_{0,1}^{i,\{USD,GBP\}}$, dominates its hedging demand for FX derivatives, which might be the case if firm i is a financial firm with low risk aversion such as a hedge fund, we are unlikely to observe one-directional net currency derivatives exposures over the *whole* sample. This should be especially true for the currencies of advanced economies, for which it is rare to have persistent trends in nominal exchange rates that would show up in firms' exchange rate expectations and thereby lead to persistent one-directional exposures for speculative reasons. Instead, we would expect that firms' overall currency exposure should fluctuate and change sign in response to changes in firms' expectations, which may be linked to classic FX investment strategies such as the carry trade, momentum or macro-news based strategies. We investigate this hypothesis in detail in Section 6.

Online Appendix A.1 presents derivations for the general optimization problem with a firm that trades a range of currency crosses. The main difference is that the hedging component of the firm's FX derivatives holdings also include an "across" FX derivatives hedging term. This additional term takes into account that the firm might trade the $\{USD, GBP\}$ currency cross, for example, to hedge FX risk that arose from the trading of different currency crosses.

3 Data

Turning to the data, this paper uses the UK segment of the European Market Infrastructure Regulation (EMIR) Trade Repository (TR) dataset of FX derivatives transactions, which we access via the Bank of England.[12] This data contains all FX derivatives (e.g., swaps, forwards and futures) transactions that have either a UK entity as a counterparty or that have an EU entity as a counterparty, provided that the transactions take place on a UK

UK non-financial firms invoice in GBP (USD) following the Brexit referendum. Our data will allow us to see whether this was accompanied by a similarly dramatic change in UK firms' USD/GBP currency-cross exposures.

[12] This data was collected under EU EMIR.

trading venue or include the GBP.[13] We retrieve these transactions from the two largest trade repositories for FX derivatives in the UK, Depository Trust & Clearing Corporation (DTCC) and UnaVista.[14]

Our analysis is conducted at a daily frequency and at the firm-level. To construct our final dataset from the raw second-by-second transaction-level data, we use two types of TR files: (i) daily activity files, which record the flow of new transactions that occurred on a given date; and (ii) end-of-month state files, which contain all open transactions, i.e., transactions that have not yet matured, as of that date. Using these two types of files, we construct a list of clean transactions, as described in Online Appendix B.[15] We then aggregate each firms' transactions on a given day to construct a series of end-of-day firm-level variables. We discuss how we construct these firm-level variables throughout the paper.

Our daily firm-level analysis begins on January 1, 2015, except for banks, where it begins on July 1, 2016. Although EMIR commenced in early 2014, the data quality is not adequate for our analysis in the beginning of the sample due to the transition to EMIR reporting.[16] We also end our analysis on December 31, 2020. Due to the regulatory and reporting changes after the UK's exit from the EU, the data after December 31, 2020 ceases to include reporting by EU-based entities, affecting data coverage.

Finally, to facilitate our analysis, we manually classify individual firms into broad sectors and sub-sectors. The five broad sectors we consider are: (i) asset managers; (ii) non-financial corporates; (iii) insurance companies; (iv) (non-bank) market makers;[17] and (v)

[13] As only one of the counterparties needs to be a UK or EU firm—and because the UK is the world's largest centre for currency trading—we also observe transactions involving non-UK and EU firms.

[14] Having examined other TRs, we are confident our sample covers the vast majority of UK FX derivatives trading over our sample. Of note, UnaVista is now known as LSEG Regulatory Reporting Limited.

[15] We have carefully cleaned the data and addressed the various data issues we detected, of which there were many, while still keeping as many transactions as possible. Figures B.1 and B.2 in the Online Appendix underscore the critical importance of data cleaning.

[16] We detected data issues for banks in 2015 and the first half of 2016, which were not present for other types of firms, and so begin analyzing banks on July 1, 2016.

[17] Within non-bank market makers are all agents that plausibly play a market-making role in FX derivatives market, namely, FCA-authorized market makers, FX brokers, FX services firms, clearinghouses and financial market administrators.

banks. Within the asset management sector, we consider three sub-sectors: hedge funds, investment funds and pension funds. Within the banking sector, we consider two sub-sectors: dealer and non-dealer banks. In addition, we also sort firms based on their country of residence. Online Appendix B.4 provides further details on our sector classifications.

4 Overview of the UK OTC FX Derivatives Market

To introduce the OTC FX derivatives market in the UK, we provide summary statistics on the market's participants, their transactions, and the market's average size over our sample.

4.1 Firms and Transactions

We begin by tabulating the number of firms in each sector that transact in the UK OTC FX derivatives market at least once over our six-year sample. Figure 1a summarizes the statistics, which highlight that asset managers make up roughly 70% of the over 16,000 individual firms that we observe.[18] The next largest segment are non-financial corporations, which make up close to 25% of all firms. The remaining 5% of firms are split roughly evenly between banks, insurance companies, and market makers. Within banks, we identify 21 dealers, with the remainder classified as non-dealer banks.

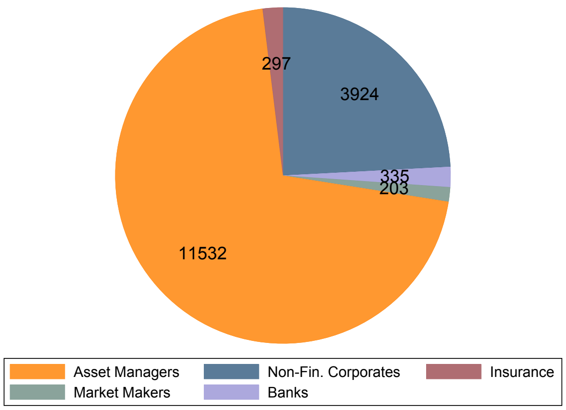
Investment funds are by far the most common type of asset manager trading FX derivatives (see Figure 1b), making up 89% of the 11,500 asset managers in our sample. Pension funds' share sits significantly lower at 8% while hedge funds' share is even lower at 3%. Overall, since the vast majority of FX derivatives transactions have a dealer bank or market maker on (at least) one side of the contract, these statistics showcase the significant asymmetry between the number of clients and dealers/market makers in the OTC FX derivatives market.[19]

[18] Recall that the entity of observation is at the fund-level, e.g., "Blackrock US Small Cap", not at the institution-level, e.g., "Blackrock".

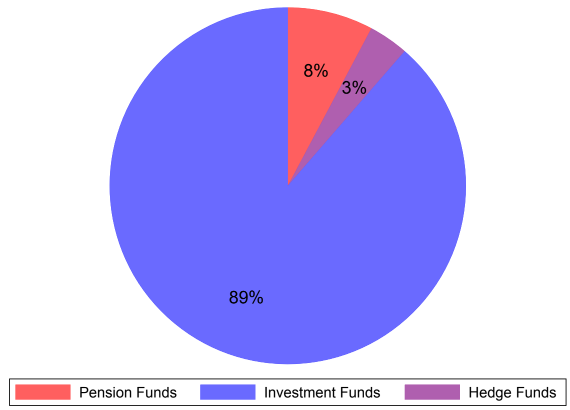
[19] Figure A.1 in the Online Appendix presents the number of firms in each sector trading FX derivatives in 4 "major" crosses. Figure A.2 presents the same for types of asset managers.

Figure 1: Firms in the UK FX Derivatives Market

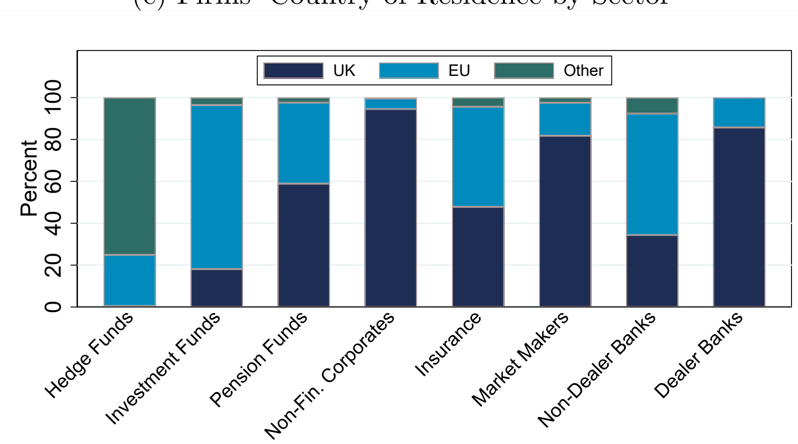
(a) Number of Unique Firms by Sector



(b) Share of Types of Asset Managers



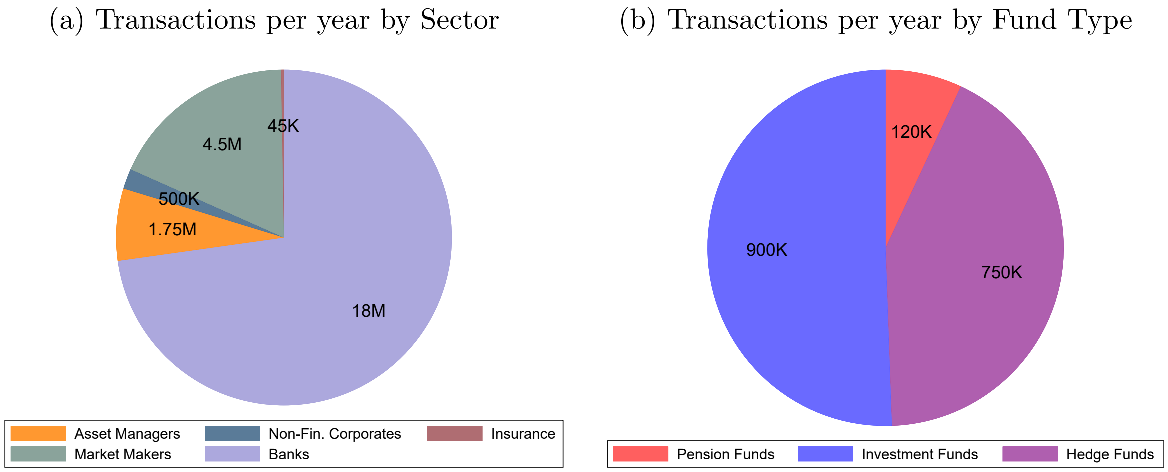
(c) Firms' Country of Residence by Sector



Note. Number of unique firms in the UK FX derivatives market, by sector and type of Asset Manager, and their countries of residence. Firms included are those reporting under EMIR to the DTCC and UnaVista trade repositories between January 1 2015 (July 1 2016 for Banks) and December 31 2020.

Figure 1c sorts firms according to their country of residence. At one extreme, the vast majority of individual non-financial corporates, dealer banks and market makers in the UK FX derivatives market over our sample are UK-resident entities. At the other, over 2/3s of the individual investment funds and non-dealer banks in the UK market are resident in Europe. Lying in between are pension funds and insurance companies, whose countries of residence are split roughly evenly between the UK and EU. Interestingly, nearly 80% of the hedge funds in our sample are resident outside the UK and EU, with many in offshore tax havens. The significant share of non-UK entities in our sample highlights London's role as a

Figure 2: FX Derivative Transactions by Sector



Note. Average number of transactions per year across all currency-crosses and maturities, by sector and type of Asset Manager (i.e., type of fund). Firms included are those reporting under EMIR to the DTCC and UnaVista trade repositories between January 1 2015 (July 1 2016 for Banks) and December 31 2020.

global center for currency trading.

Moving from firms to their transactions, Figure 2a presents the yearly average number of FX derivatives transactions taken by all firms in each sector. The banking sector, as a whole, transacts 18 million times per year, on average, across all maturities and currency crosses, by far the most of any sector. This transaction volume is dominated by dealer banks (17 million per year). Market makers transact the second most, at about 4.5 million per year. Among clients, the asset management sector transacts the most, at nearly 2 million per year, followed by non-dealer banks (1 million per year), non-financial corporates (500 thousand per year) and insurance companies (50 thousand per year). Within the asset management sector, as shown in Figure 2b, the investment fund sector (900 thousand per year) and hedge fund sector (750 thousand per year) transact significantly more than the pension fund sector (120 thousand per year). On a per fund basis, however, individual investment funds and pension funds transact in similar amounts, whereas individual hedge funds transact over 20 times more frequently. That dealers transact significantly more than their clients showcases that the vast majority of transactions in the UK FX derivatives market occur between dealers.

In the Online Appendix, we break down each sector's and sub-sector's transactions by maturity (Figures A.3, A.4 and A.5) and currency-cross (Figures A.6, A.7 and A.8). Focusing first on the maturity profile, we find that 80% of market makers' transactions have a maturity of under 1 week, consistent with their use of high-frequency trading to limit the currency risk on their balance sheets. On the other hand, non-financial corporations tend to have much longer investment horizons, with over a third of their FX derivatives transactions having maturities of longer than 3 months. These longer-maturity contracts may be chosen to more-closely match the maturity of corporates' foreign-currency revenues and liabilities.[20] The majority of asset managers', banks' and insurers' derivatives transactions have maturities between 1 week and 2 months, with pension funds and insurers opting for slightly longer-maturity contracts than investment and hedge funds.

Shifting to the currency-cross composition of firms' transactions, we document that although the EUR/USD, EUR/GBP and USD/GBP crosses dominate as a share of firms' transactions, there is significant heterogeneity across sectors. For example, transactions in these three crosses account for between 44% and 58% of all FX derivatives transactions by investment funds, pension funds, insurers and non-financial corporations. However, the fraction is significantly less for dealer banks and hedge funds, where these three crosses account for only 26% and 21%, respectively, of all their transactions.

4.2 Market Size

From firms and transactions, we next move to a notion of market size based on the *stock* of firms' net currency-cross derivatives exposures.[21]

To calculate firm i's net currency-cross stock exposure for the $\{k, m\}$ currency cross at time (end-of-day) t, we net-out, across all maturities, all of firm i's transaction-level $\{k, m\}$

[20] Longer-maturity contracts are well-suited to the hedge FX risk associated with long-term foreign-currency investments. However, it is common for firms to hedge long-maturity FX exposures by continually rolling over short-maturity derivatives contracts, which are more liquid.

[21] Our measure of 'net market size' is constructed at the currency-cross level in order to compare with the 'gross market size' measure used by the BIS Triennial Survey.

cross exposures from all non-expired FX derivatives contracts, indexed by μ, as of t:

$$Stock_t^{i,\{k,m\}} = \sum_{\mu:\tau^{\mu}_{start} \le t < \tau^{\mu}_{end}} N^{\mu,i,\{k,m\}}_{\tau^{\mu}_{start},\tau^{\mu}_{end}} + \sum_{\mu:\tau^{\mu}_{start} \le t < \tau^{\mu}_{end}} \tilde{N}^{\mu,i,\{m,k\}}_{\tau^{\mu}_{start},\tau^{\mu}_{end}}, \tag{4}$$

where $N^{\mu,i,\{k,m\}}_{\tau^{\mu}_{start},\tau^{\mu}_{end}}$ and $\tilde{N}^{\mu,i,\{m,k\}}_{\tau^{\mu}_{start},\tau^{\mu}_{end}}$ are defined in Section 2.[22] The start and end timestamps for a contract μ are τ^{μ}_{start} and τ^{μ}_{end} and are measured in seconds while the time index t is at a daily frequency and is measured end of day. Therefore, $Stock_t^{i,\{k,m\}}$ reflects the net amount of currency k that firm i will receive (or pay if negative) in the future from all non-expired FX derivatives contracts in the $\{k,m\}$ cross as of the end of day t.[23]

To measure the size of the UK FX derivatives market, we examine the sum of firms' *absolute* net currency-cross stock exposures, in USD and averaged over time, for each sector S, which is given by $|\overline{Stock}|^{S,\{k,m\}} = \frac{1}{T}\sum_t S_t^{USD/k} \sum_{i\in S} |Stock_t^{i,\{k,m\}}|$. This variable represents a measure of sector S's daily footprint in the market for $\{k,m\}$ FX derivatives in the UK based on how exposed firms in sector S are, on average, to the m/k bilateral exchange rate. The more firms there are in sector S, and the larger are these firms' net stock exposures, the greater is sector S's footprint. Summing across all currency crosses yields sector S's average daily footprint in the UK FX derivatives market $|\overline{Stock}|^{S,FX,deriv} = \sum_{\{k,m\}\in\Omega^{cross}} |\overline{Stock}|^{S,\{k,m\}}$, where Ω^{cross} is the set of all currency crosses.[24] We refer to this quantity as sector S's "Market Size" in Figure 3. Finally, summing over all sectors gives the average daily size of the entire UK FX derivatives market $|\overline{Stock}|^{FX,deriv} = \sum_S |\overline{Stock}|^{S,FX,deriv}$ based on firms' net currency-cross stock exposures.

Figure 3 showcases that, across all sectors and crosses, the average (absolute) size of the UK FX derivatives market in net terms, $|\overline{Stock}|^{FX,deriv}$, is about 3 trillion USD, far less than the 37 trillion USD gross figure quoted in Borio et al. (2022).[25] The large discrepancy

[22] In Section 2, we omitted the contract index μ since firm i traded only one contract in the $\{k,m\}$ cross.

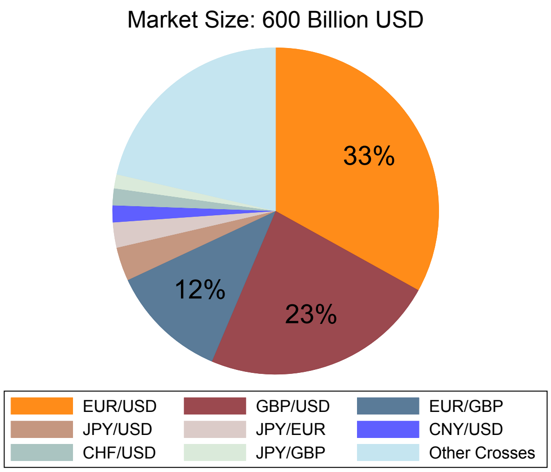
[23] To give a concrete example, to construct the net stock exposure on the 5^{th} of January 2020, we consider all contracts that were entered into *prior* to the end of the day on the 5^{th} of January 2020 and that are still open as of the end of the day on the 5^{th} of January 2020.

[24] We ensure there is no double counting since if $\{k,m\}\in\Omega^{cross}$ then $\{m,k\}\notin\Omega^{cross}$ as the definition in equation (4) ensures that we consider both orderings when constructing our net stock exposure variable.

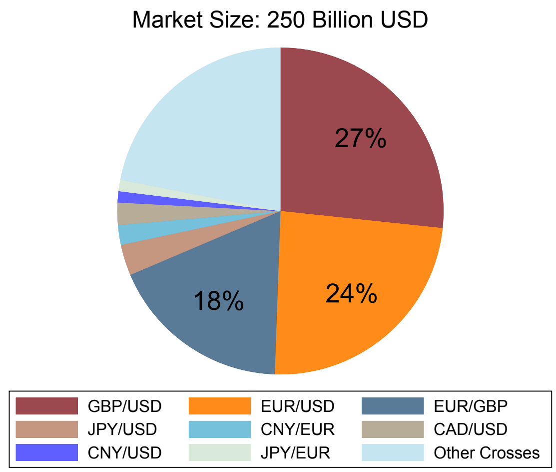
[25] The latter value corresponds to the 97 trillion USD gross size of the global FX market in 2022 quoted by

Figure 3: Average Absolute Value of Firms' Net Currency-Cross Stock Exposures by Sector

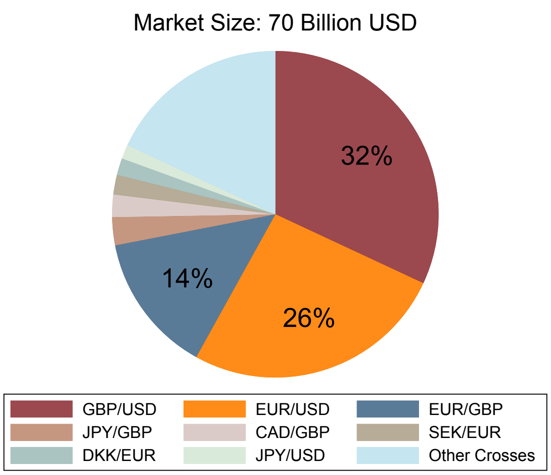
(a) Asset Managers



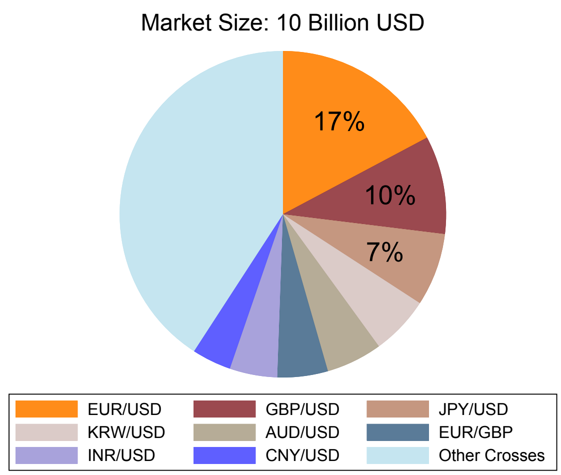
(b) Non-Financial Corporates



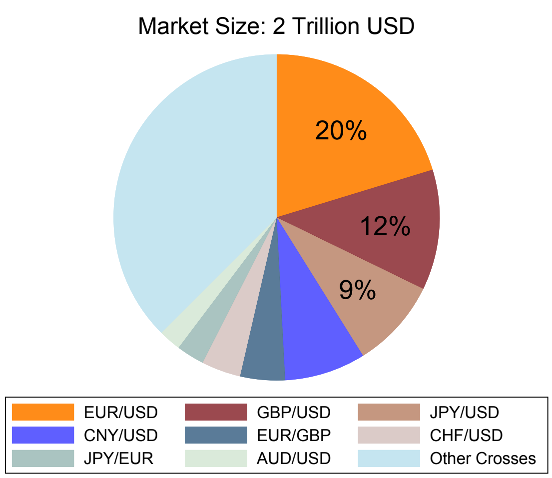
(c) Insurers



(d) Market Makers



(e) Banks



Note. Average absolute value of firms' *net* currency-cross stock exposures in USD across all firms in a sector $|\overline{Stock}|^{S,\{k,m\}}$ and across all currency crosses $|\overline{Stock}|^{S,FX,deriv}$. Firms included are those reporting under EMIR to the DTCC and UnaVista trade repositories between January 1 2015 (July 1 2016 for Banks) and December 31 2020.

between measures of the gross and net size of the UK FX derivatives market points to a substantial amount of long and short derivatives positions in the same currency cross at the same time for the same firm.

In terms of the market sizes of individual sectors, $|\overline{Stock}|^{S,FX,deriv}$, the banking sector averages 2 trillion USD in absolute net stock exposure over our sample, the largest of any sector in the UK FX derivatives market. These stock exposures are taken predominantly by dealer banks (1.6 trillion USD see Figure A.10). This stands in marked contrast to market makers, who, despite their significant transaction volume, average only 10 billion USD in stock exposures over our sample. This highlights an important distinction between the behaviour of dealer banks and market makers in UK FX derivatives markets.[26]

In terms of clients, asset managers have the largest footprint in FX derivatives markets, with absolute currency-cross net stock exposures averaging 600 billion USD, followed by non-dealer banks (450 billion USD), non-financial corporates (250 billion USD), and insurance companies (70 billion USD). Within asset managers, as shown in Figure A.9, hedge funds have limited net stock exposure, averaging only 40 billion USD, despite their significant transaction volume. Investment funds, by contrast, have significant net stock exposures averaging nearly 350 billion USD, with pension funds lying in between at 200 billion USD.[27]

Turning to the composition of sectors' FX market footprint, $|\overline{Stock}|^{S,\{k,m\}}$, the EUR/USD and GBP/USD crosses represent the two largest currency-cross markets, as measured by firms' net stock exposures, for all sectors. For asset managers, namely pension funds and investment funds, as well as non-financial corporates and insurers, the EUR/USD and

Borio et al. (2022), times the 38% UK market share quoted by the 2022 BIS Triennial Survey of FX Markets. The gross size is constructed by adding up the notionals of all outstanding contracts across all firms, rather than netting contracts at the firm-level.

[26]Note that we do not observe the FX derivatives positions of UK dealer banks in other jurisdictions, such as the US, and, as a result, do not observe dealer banks' global net exposure across all jurisdictions. In contrast, the non-bank market makers in our dataset are unlikely to have significant FX derivatives positions elsewhere, which explains their limited net exposures from contracts reported in the UK.

[27]Of note, the average absolute net cross exposures of dealers (1.6 trillion USD) and clients (1.3 trillion USD) need not be equal for two reasons: 1. dealers take cross exposures with other dealers; and 2. dealers take cross exposures with foreign entities, especially through intra-group transactions.

GBP/USD crosses capture a majority of their sectors' overall net stock exposures, with shares ranging from 51% to 70%. By contrast, for banks, market makers and hedge funds, the share of sector-wide stock exposures accounted for by these two "major" crosses are smaller, ranging from only 27% to 34%, since these sectors take positions in a much wider array of currency crosses. Aside from these two major crosses, the EUR/GBP and JPY/USD crosses also represent a significant share of each sectors' overall net cross stock exposure. More generally, sectors' net cross stock exposures are dominated by crosses involving G7 currencies. In terms of emerging market currency crosses, the CNY/USD cross is the most prevalent, especially for banks and hedge funds, although these average figures are skewed by the large exposures that these sectors built up during the US-China trade war. Overall, differences in the currency-crosses traded across sectors may reflect differences in the size and currency denomination of their assets/liabilities as well as differences in the degree to which they use derivatives to hedge versus speculate.

5 Currency Positions

This section documents a series of novel facts related to firms' and sectors' net *currency* stock exposures from FX derivatives. We focus on net currency exposures since firms' profits and losses when trading FX derivatives depend on the net amount of, e.g., USD, they are set to receive or pay in the future, regardless of the underlying composition of trades across different currency crosses (see Section 2). This makes firms' net currency stock exposures central in theoretical models.

Based on equation (2), firm i's net currency-l stock exposure is constructed by netting all of firm i's transaction-level currency-cross exposures from all non-expired contracts in which it receives or pays currency l:

$$Stock_t^{i,l} = \sum_{m \neq l} \left\{ \sum_{\mu:\tau^{\mu}_{start} \leq t < \tau^{\mu}_{end}} N^{\mu,i,\{l,m\}}_{\tau^{\mu}_{start},\tau^{\mu}_{end}} + \sum_{\mu:\tau^{\mu}_{start} \leq t < \tau^{\mu}_{end}} \tilde{N}^{\mu,i,\{m,l\}}_{\tau^{\mu}_{start},\tau^{\mu}_{end}} \right\}. \tag{5}$$

$Stock_t^{i,l}$ therefore measures firm i's net exchange-rate exposure to currency l from all FX derivatives contracts that remain open as of time t. To help interpret $Stock_t^{i,l}$ in the data, we leverage insights from our theoretical framework in Section 2, which showed that firms' net currency exposures are comprised of a hedging component—which is often one-directional due to persistence in firms' non-derivatives operations—and a speculative component—whose direction is likely to fluctuate over time due to changes in exchange-rate expectations.

5.1 Net Currency Stock Exposures

We begin by presenting sector-level net currency stock exposures, constructed by summing the positive and negative net stock exposures of firms in a given sector S, i.e., we report $Stock_t^{S,l} = \sum_{i \in S} Stock_t^{i,l}$. This variable captures how exposed sector-level aggregate profits from FX derivatives are to movements in the currency-l exchange rate (vis-à-vis the firms' currencies of operation). Figures 4 and 5 display sector-level net currency stock exposures for the three major currencies traded in the UK: the USD, EUR, and GBP. We further break down these sector-level net exposures into the net exposures taken by UK- and EU-resident firms, which are presented in Figures A.11 and A.12 in the Online Appendix.[28] Together, these figures reveal a number of noteworthy facts.

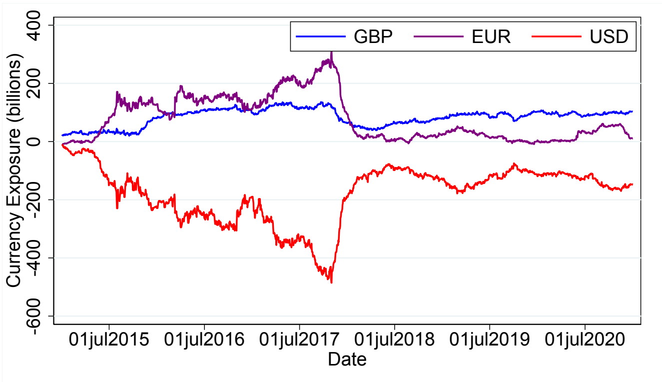
I. Direction

The first set of facts relate to the direction of firms' net currency stock exposures. The asset management sector—namely pension funds and investment funds—along with the insurance sector, always maintain a stock of net-long exposures to both the EUR and GBP and net-short exposures to the USD. Strikingly, these positions are highly stratified according to firms' country of residence: EU-based firms in these financial sectors carry net-long EUR and net-short USD exposures while UK-based firms hold net-long GBP and net-short USD

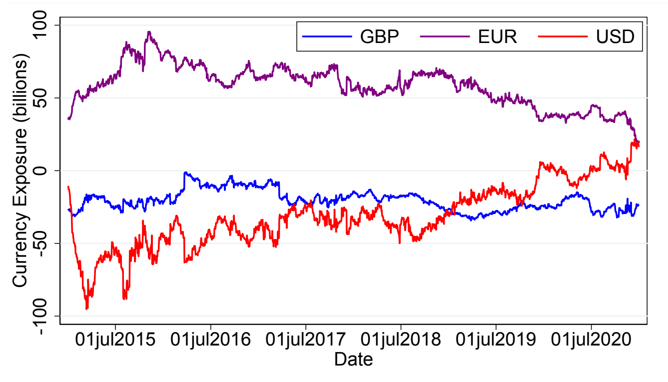
[28] We present this decomposition by country of residence only for the client sectors, since there are too few market makers and dealer banks in some cases to preserve anonymity. Similarly, since there are very few UK hedge funds in our sample, we decompose the hedge fund sector's net exposures into the exposures by EU and non-EU hedge funds.

Figure 4: Sector-Level Net Currency Stock Exposures to Major 3 Currencies

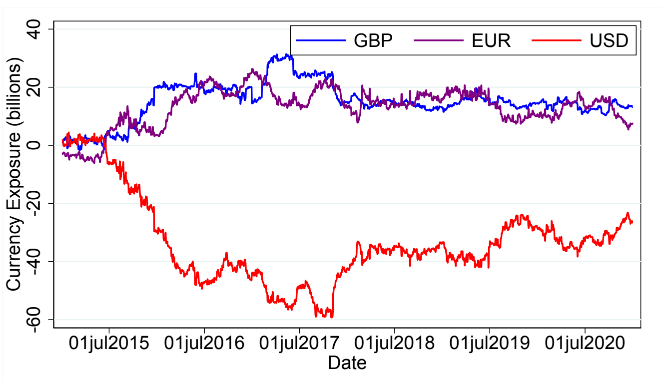
(a) Asset Managers



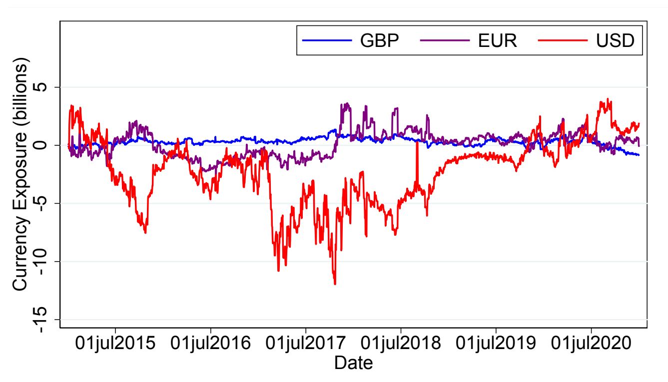
(b) Non-Financial Corporates



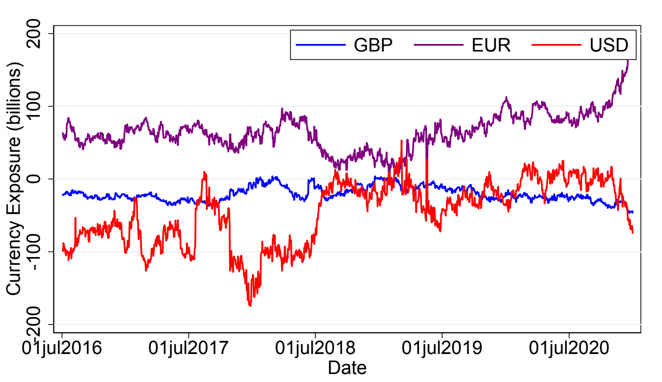
(c) Insurers



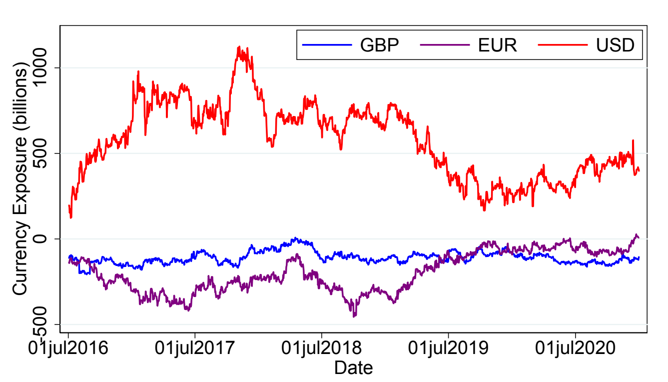
(d) Market Makers



(e) Non-Dealer Banks



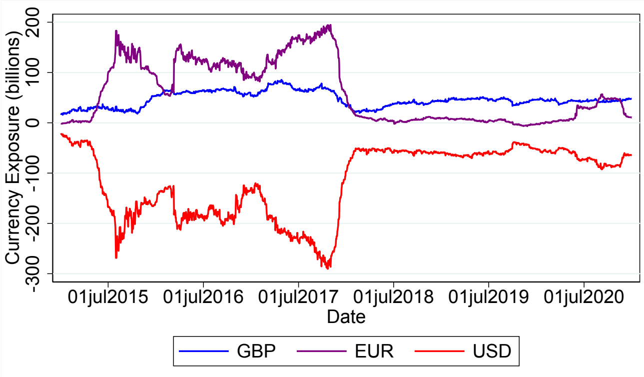
(f) Dealer Banks



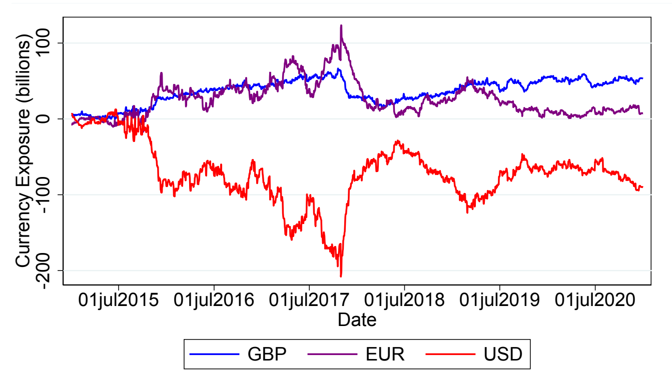
Note. Sector-level net currency stock exposures, calculated as the net currency stock exposure (see equation (5)) of firms in a particular currency vis-à-vis all other currencies and then aggregated across firms in a particular sector, for the major three currencies—USD, EUR, GBP. Currency exposures are measured in units of local currency (i.e., in GBP for GBP exposures). Firms included are those reporting under EMIR to the DTCC and UnaVista trade repositories between January 1 2015 (July 1 2016 for Banks) and December 31 2020.

Figure 5: Asset Manager Types' Net Currency Stock Exposures to Major 3 Currencies

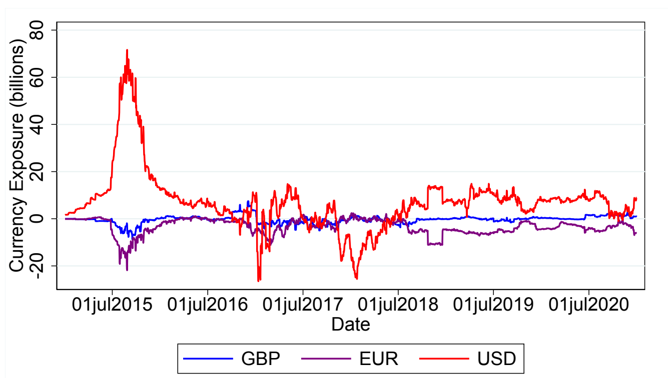
(a) Pension Funds



(b) Investment Funds



(c) Hedge Funds



Note. Types of asset managers' net currency stock exposures, calculated as the net currency stock exposure (see equation (5)) of firms in a particular currency vis-à-vis all other currencies and then aggregated across firms in a particular sector, for the major three currencies—USD, EUR, GBP. Currency exposures are measured in units of local currency (i.e., in GBP for GBP exposures). Firms included are those reporting under EMIR to the DTCC and UnaVista trade repositories between January 1 2015 and December 31 2020.

exposures. Notably, EU- (UK-) based firms in these sectors retain minimal net exposure to the GBP (EUR). Through the lens of our framework in Section 2, these one-directional net currency exposures are consistent with a strong hedging demand for FX derivatives. Specifically, these positions are consistent with the UK- and EU-based financial firms in these sectors holding persistent long positions in USD-denominated securities, with obligations indexed in either GBP or EUR, which they seek to hedge via FX derivatives.[29]

Turning to non-financial corporations, the sector is net-short the USD for most of the

[29] Although the magnitudes are small, the UK asset management and insurance sectors are persistently net-short the EUR while their EU counterparts are persistently net-short the GBP. These one-directional exposures are also consistent with a hedge by these UK (EU) firms of their EUR (GBP) denominated assets.

sample, net-long the EUR and, different to financial firms, net-short the GBP. Most of the non-financial sector's net-short USD exposure is held by EU-resident corporates, who are also commensurately net-long the EUR. These positions may once again be driven by hedging demand. Specifically, if EU corporates are net-exporters to the US and invoice US sales in USD, then they would hedge future profits from US sales by maintaining a stock of net-short USD derivatives exposures. In terms of the other currencies, the corporate sector's net-short GBP exposure, as well as much of their net-long EUR exposure, can be rationalized by the hedging demand of both UK- and EU-resident non-financials. Specifically, UK-based corporates may be net-short the GBP and net-long the EUR to hedge the cost of future intermediate inputs imported from the Eurozone Relatedly, EU-based non-financial firms may be net-exporters to the UK and choose to hedge their UK sales revenue, priced in GBP, by taking net-short GBP and net-long EUR derivatives exposures.

We next move to the currency positions of hedge funds and non-dealer banks. Different to the other sectors, hedge funds' net currency stock exposure to all three major currencies changes signs repeatedly over time. This may be due to frequent FX derivatives rebalancing in response to market developments, indicative of a stronger speculative demand for FX derivatives, as compared to hedging demand. For instance, hedge funds move to being net-long the USD at the start of the Fed hiking cycle in 2015, a period in which the USD appreciated. Similarly, non-dealer banks' USD exposure is also volatile and changes sign over our sample, which suggests that speculative demand may play a role for their overall FX derivatives positions as well. Interestingly, the direction of the net stock exposures taken by EU and non-UK hedge funds over time are similar. Conversely, the positions taken by UK and EU non-dealer banks are distinct, with EU-based entities' net exposures being more stable and one directional compared to those of UK-based entities. This suggests that hedging demand may be more prominent for EU-resident non-dealer banks than for UK-resident ones.

In the case of market makers, we would expect that if we observe all of their transactions, their net exposure should be very close to zero. This is precisely the case for the GBP. The net exposure with respect to the EUR is close to zero as well. However, their USD exposure sometimes deviate from zero, most likely due to us not observing some of their USD transactions, reported elsewhere. Having said that, the value of the market making sectors' net USD stock exposure is generally below 10 billion USD, despite the tens of thousands of daily transactions we document for market makers.

In contrast to these other sectors, the 21 large dealer banks in our sample are net-long the USD and net-short the EUR and GBP. Dealer banks therefore appear to be the primary sector accommodating clients' FX derivatives demand in the UK market by taking the complementary net currency stock exposures.

Importantly, due to potential within-sector heterogeneity in firms' FX derivatives use, sector-level net exposures may obscure whether individual firms' net exposures are one-directional or change signs frequently over time. To address this, Figure A.13 in the Online Appendix presents the fraction of days that individual firms in a given sector have net-long currency stock exposures to the EUR, GBP and USD. This firm-level analysis allows us to evaluate the share of firms within each sector that have one-directional net exposures over most of our sample.

We find that over 70% of individual pension funds, insurance companies, and non-financial corporates maintain the same one-sided exposures to the USD, EUR and GBP over at least 80% of our sample. This is consistent with strong one-directional hedging demand by the majority of individual firms in these sectors. The proportion is slightly lower for the investment fund sector, where about 65% of individual investment funds maintain the same one-directional net exposure at least 80% of the time. Individual hedge funds and non-dealer banks are even less likely to maintain persistent one-sided net exposures, especially to the USD, with shares ranging from only about 50-60%. This suggests that speculative demand may play a larger role in the FX derivatives use of firms in these sectors. Overall, these firm-level findings are in line with the conclusions from our sector-level analysis.[30]

II. Magnitude

The second set of facts relate to the magnitude of sectors' net currency stock exposures. Over our sample, the asset management sector's net currency stock exposure is significantly larger than those of the other client sectors. At its peak in 2017Q3, asset managers as a whole had a net-short position in the USD of just under 450 billion USD—reflecting the roughly 250 and 200 billion USD net-short positions by pension funds and investment funds, respectively. They were, in this period, also net-long the EUR and GBP to the tune of 300 billion EUR and 110 billion GBP, respectively. By comparison, non-financial corporates', non-dealer banks' and insurers' net currency exposures are smaller. In the case of corporates and non-dealer banks, as we document in the next sub-section, the sector's relatively small net currency exposure, as compared to their absolute exposures displayed in Figure 3, reflects significant within-sector heterogeneity in the direction of firms' currency derivatives use.

While dealer banks absorb UK clients' net currency demand, the two groups' currency exposures are not equal and opposite to one another, pointing to substantial cross-border leakage from the UK FX derivatives market. For example, in 2017Q3, dealer banks have a net-long USD exposure of over 1 trillion USD, whereas all other sectors combined have a net-short USD position of less than 700 billion USD. This discrepancy is due to dealer banks' transactions with foreign entities, in particular, with their foreign headquarters and/or subsidiaries. These intra-group transactions allow dealer banks to manage their currency exposures while continuing to meet client demand.

III. Patterns and Trends

The third set of facts relate to patterns in sectors' net currency stock exposures over time. The asset management sector's net USD and EUR stock exposures decrease dramatically from 2017Q3 to 2018Q1, shrinking from -450 billion to -100 billion USD and from 300 billion

[30] Of note, from Figures A.14 and A.15 in the Online Appendix, we see that UK investment funds (EU non-dealer banks) tend to be more one-directional than their EU (UK) counterparts.

to 30 billion EUR, respectively. While their net USD exposures partially rebound to near -200 billion USD, their net EUR exposures do not. The sector's net GBP exposure declines as well, although more mildly, before fully rebounding. As can be seen in Figure 5, about 70% of the initial decline comes from a reduction in pension funds' net exposures, with the remainder due to a fall in investment funds' net exposures. Beginning a year later, we also observe a significant but more gradual decline in the net USD and EUR exposures of non-financial corporates and dealer banks, although these are not accompanied by movements in their GBP exposures.

To interpret these trends, we decompose these sectors' net currency exposures by firms' country of residence, as well as by firms' size, in order to help distinguish between the intensive and extensive margins of adjustment. Beginning with pension funds, we observe that about 70% of the decline in this sector's USD net exposures can be attributed to the departure of a handful of very large European pension funds from our sample over this period (see Figures A.12 and A.23).[31] This extensive margin adjustment cuts the European pension fund sector's net EUR exposure in the UK derivatives market to near zero in early-2018.

The remaining 30% of the decline in pension funds' USD net exposures, as well as most the decline in the sector's GBP net exposures, comes from UK pension funds along the intensive margin (see once again Figures A.12 and A.23). UK pension funds may have had an incentive to build up larger net exposures in 2016 and 2017 as a hedge against greater economic uncertainty in the UK—tied to the Brexit referendum—and in the US—tied to the presidential election—which they then unwound from 2017Q3 to 2018Q1.

A similar pattern is present for the investment fund sector: about 70% of the decline in the sector's net USD exposure reflects reduced exposures by EU investment funds—including by the largest funds—with the remaining 30% due to reduced exposures by UK investment funds, mostly along the intensive margin (see Figures A.12 and A.24). The

[31] To assess the contribution of the departure of large funds, Figure A.23 separately aggregates the exposures of funds that are net-long and net-short as well as highlights the net exposures taken by the largest funds, as outlined in the next Section 5.2.

intensive-margin adjustment may once again reflect the unwinding of net exposures built up during the period of heightened geopolitical risk in 2016-2017. Interestingly, UK investment funds' net exposures, especially with respect to the GBP, rebound following their trough in 2018Q1.

Turning to non-financial corporates, we observe that the erosion of their USD and EUR net exposures can be almost entirely attributed to a reduction in exposures by EU-based entities (see Figures A.11 and A.21). In terms of dealer banks, the decline in their USD and EUR net exposures occurs predominantly via the EUR/USD currency cross.[32] In both cases, while these sectors' USD and EUR net exposures decline considerably, we do not observe any changes in their net GBP exposures.

In all, these patterns are consistent with the reduction of EUR trading and the departure of EU-based entities from the UK FX derivatives market in anticipation of Brexit-related regulatory changes, which eventually came into effect at the end of 2020.

5.2 Heterogeneity and Concentration

Next, we leverage our firm-level data to examine within-sector heterogeneity and concentration in firms' currency derivatives net stock exposures. Relative to the previous section, rather than netting out the positive and negative currency stock exposures across firms in a sector, we separately aggregate the exposures of firms who are net-long and net-short particular currencies to generate sector-level net-long and net-short currency stock exposures. Specifically, we construct $Stock_t^{S_t^+,l} = \sum_{i \in S_t^+} Stock_t^{i,l}$ and $Stock_t^{S_t^-,l} = \sum_{i \in S_t^-} Stock_t^{i,l}$, where S_t^+ and S_t^- correspond to the set of firms in sector S that are net-long and net-short currency l at time t, respectively. This enables us to explore within-sector heterogeneity in the direction and magnitude of firms' currency exposure.

Furthermore, to investigate within-sector concentration in firms' currency derivatives po-

[32]Figures A.27 and A.28 in the Online Appendix present sector-level net *currency-cross* stock exposures for the major crosses. Figures A.29 and A.30 do the same broken down by firms' country of residence.

sitions, we also distinguish the positions taken by the largest firms in each sector—those with the largest sample-average absolute net stock exposures—from those taken by smaller players. Specifically, we decompose, e.g., $Stock_t^{S_t^+,l}$ into the exposures of three mutually exclusive groups denoted by $Stock_t^{S_t^{+,m},l}$, where $m \in \{$*5 Largest Players*, *Next 10 Largest Players*, *Smaller Players*$\}$, with $Stock_t^{S_t^-,l}$ decomposed analogously.[33]

Sectoral net-long and net-short USD stock exposures, broken down by firm size, are displayed in Figures 6 and 7. The corresponding figures for the EUR and GBP are shown in Figures A.16 – A.19 in the Online Appendix. Figures A.20 — A.26 in the Online Appendix further break down the sectoral net-long/short exposures by firms' countries of residence.[34]

I. Concentration

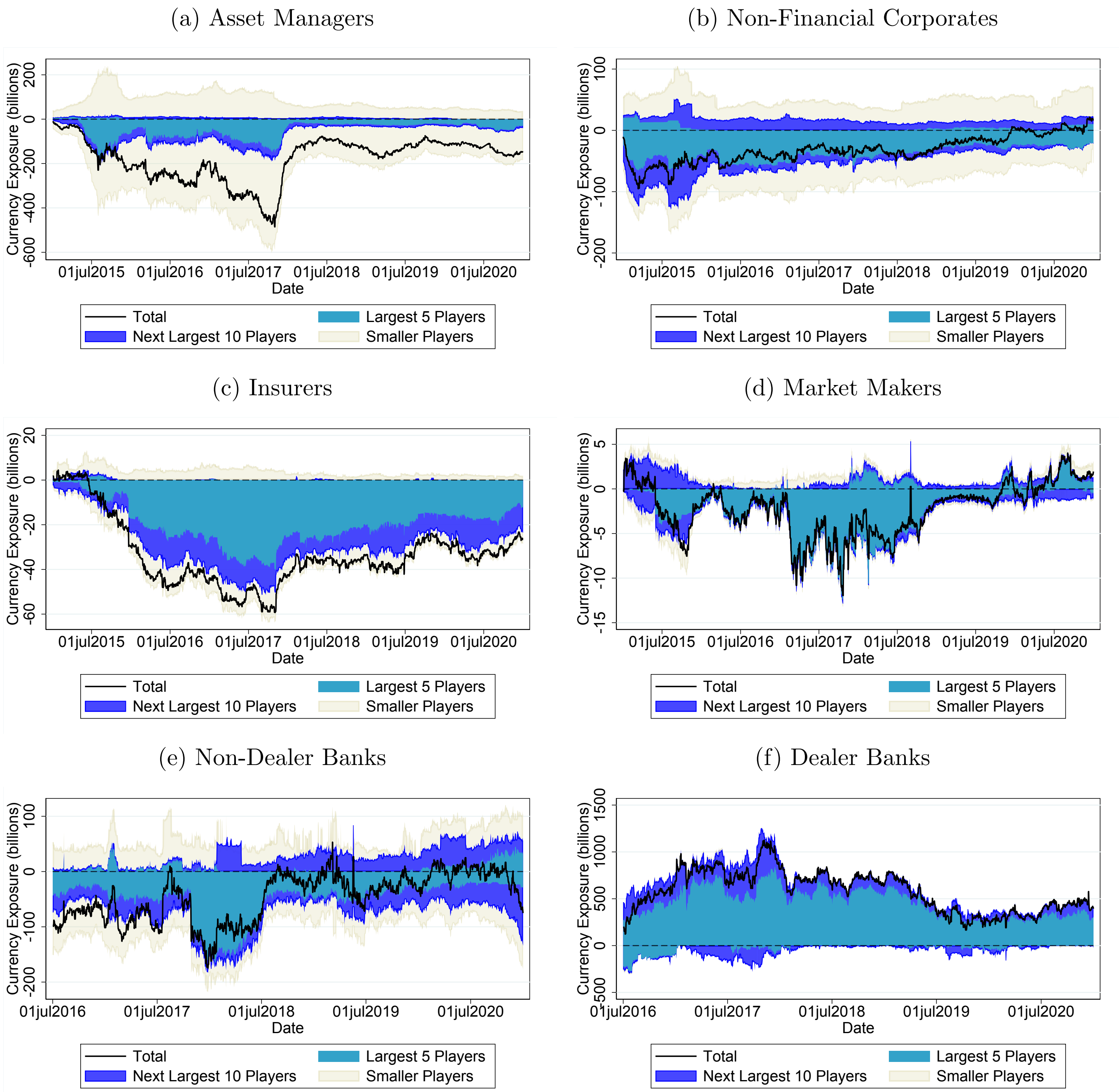
Beginning with results on sectoral concentration, we first highlight that the investment fund industry is significantly less concentrated than other sectors, as seen by the relatively small share of the sector's overall USD, EUR and GBP net stock exposures maintained by the largest 5 (and next largest 10) players, which are shaded in light (dark) blue. This result holds for both UK and EU investment funds. The corporate sector's net stock exposures are also distributed relatively evenly across firms, although this result is driven entirely by UK-based non-financials. Similarly, while the net stock exposures taken by the UK pension fund sector are more dispersed, the EU pension fund sector's net positions are attributable to only a handful of large firms. The opposite is the case for non-dealer banks, where UK-based firms' exposures are more concentrated than those of their EU-resident counterparts.

Instead, even when broken down by country of residence, the insurance, market making, hedge fund and dealer bank sectors are all highly concentrated. At the extreme, the five largest dealer banks hold on-average about 90% of the sector's entire USD net stock exposure.

[33]For example, $S_t^{+,5\ Largest\ Players}$ is the aggregated net-long currency-l stock exposure at time t of firms in sector S that are among the *5 Largest Players* in sector S in terms of sample-average absolute net stock exposure in currency l.

[34]Figures A.31–A.39 in the Online Appendix present sectoral net-long/short *currency-crosses* stock exposures for the major crosses, again distinguishing between large and small players. Figures A.40-A.46 do the same broken down by firms' country of residence.

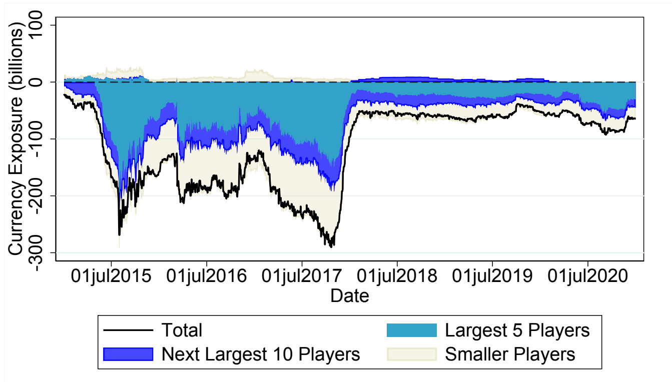
Figure 6: Firms' Net-Long and Net-Short USD Stock Exposures Across Sectors



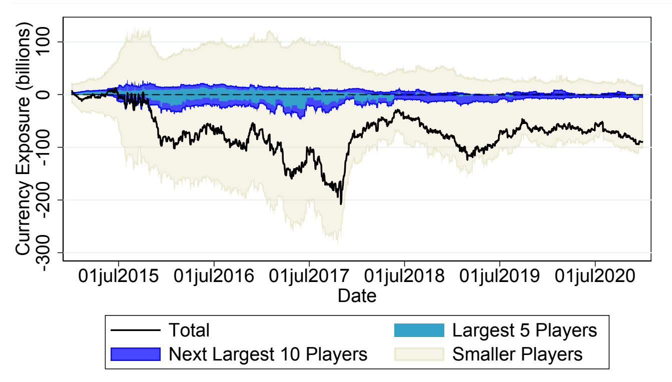
Note. Sectoral net-long and net-short USD stock exposures, highlighted in blue and beige, are calculated by separately aggregating the net stock exposures of firms in a sector that are net-long and net-short the USD vis-à-vis all other currencies. The black line refers to the sum of the net-long and net-short USD stock exposures, which is shown in Figure 4. Shaded in light and dark blue are the net-long and net-short positions of the largest 5 and next largest 10 firms (players) in the sector in terms of average net USD stock exposure over the sample. In beige are the exposures of the smaller firms. USD stock exposures are measured in units of USD. Firms included are those reporting under EMIR to the DTCC and UnaVista trade repositories between January 1, 2015 (July 1 2016 for Banks) and December 31, 2020.

Figure 7: Firms' Net-Long and Net-Short USD Stock Exposures Across Fund Types

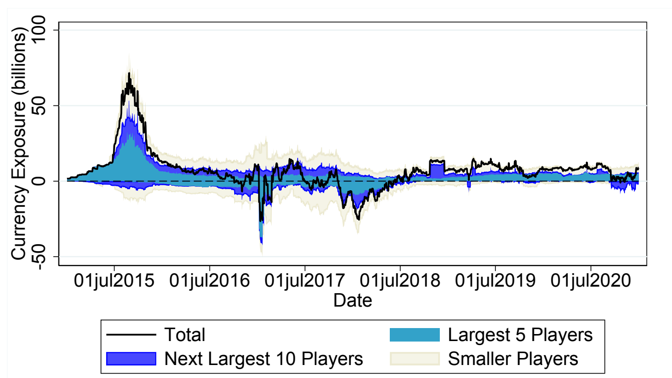
(a) Pension Funds



(b) Investment Funds



(c) Hedge Funds



Note. Types of asset managers' (funds') net-long and net-short USD stock exposures, highlighted in blue and beige, are calculated by separately aggregating the net stock exposures of firms in a sector who are net-long and net-short the USD vis-à-vis all other currencies. The black line refers to the sum of the net-long and net-short USD stock exposures, which is shown in Figure 5. Shaded in light and dark blue are the net-long and net-short positions of the largest 5 and next largest 10 firms in the sector in terms of average net USD stock exposure over the sample. In beige are the exposures of the smaller players. USD stock exposures are measured in units of USD. Firms included are those reporting under EMIR to the DTCC and UnaVista trade repositories between January 1, 2015 and December 31, 2020.

II. Heterogeneity

Second, we observe considerable heterogeneity in the direction of individual asset managers', corporates' and non-dealer banks' net stock exposures. The heterogeneity in asset managers' net exposures is primarily due to the investment fund industry. As a result, while the net USD stock exposure of the asset management industry peaks at around -450 billion USD, the sum of the absolute value of individual funds' net-short and net-long stock is nearly 750 billion USD, reflecting short positions of 600 billion USD and long positions of 150 billion

USD. This cross-sectional heterogeneity in the direction of asset managers'—namely, UK and EU investment funds'—USD positions may reflect differences across funds in the currency denomination of their assets/liabilities or the extent to which they use derivatives to hedge vs. speculate. A similar pattern is present for UK-resident non-financial corporations and EU-resident non-dealer banks.

In contrast, there is limited within-sector heterogeneity in the direction of UK and EU pension funds' and insurance companies' net exposures. This may reflect within-sector similarities in firms' non-derivatives portfolios alongside strong hedging demand.

6 FX Investment Strategies

The previous section studied patterns in the cross-section and time series of firms' net currency stock exposures, which primarily shed light on the hedging component of firms' FX derivatives use by sector and country of residence. In this section, we shift focus to the speculative component of firms' FX derivatives demand by examining how firms adjust their exposures "on the margin" with respect to three well-known FX investment strategies. These strategies include the carry trade and momentum, as well as a strategy based on the arrival of macroeconomic news that moves exchange rates.

Our empirical analysis is once again motivated by the theoretical framework outlined in Section 2, which showed that firms' FX derivatives demand is comprised of a hedging component and a speculative component. In particular, equation (3) expressed the speculative component of firms' FX derivatives demand as a function of their expected excess return. These expectations, and hence firms' net exposures, may load on classic FX investment strategies.

To evaluate this, we use firms' net *currency-cross* stock exposures, defined in equation (4), since FX investment strategies are defined with respect to a currency cross. We focus on the net exposures of the most-traded currency crosses in our dataset, namely, the EUR/USD, GBP/USD, EUR/GBP and JPY/USD. Then, for a given currency cross $\{m, k\}$ and a series of horizons (days) $h = [0, 90]$, we estimate three sets of firm-level panel regressions, by sector, to assess the extent to which the net cross exposures of firms in a given sector adjust in ways consistent with the three FX investment strategies. We outline these regressions below.

I. Carry Trade

Given the well-known forward premium puzzle, firm i may expect to earn a positive excess return from an investment strategy in which they go net-long a 'higher-interest-rate' country's currency and net-short a 'lower-interest-rate' country's currency. In other words, firm i may believe that $\tilde{E}_t^i \left(S_{t+h}^{k/m} - F_{t,h}^{i,k/m} \right)$ is increasing in the country m versus k interest rate differential, $r_t^m - r_t^k$. Applying equation (3) in changes to specific currency crosses implies a test of the following relationship:

$$\frac{Stock_{t+h}^{i,\{m,k\}} - Stock_{t-1}^{i,\{m,k\}}}{\overline{|Stock^{i,\{m,k\}}|}} = \alpha_i^h + \beta_1^h \Big[(r_{t+h}^m - r_{t+h}^k) - (r_{t-1}^m - r_{t-1}^k) \Big] + u_{i,t}^h, \qquad (6)$$

where, as before, $Stock_t^{i,\{m,k\}}$ is firm i's net currency-cross stock exposure in cross $\{m, k\}$ defined such that an increase corresponds to a greater net-long (short) stock exposure to currency m (k). The change in exposure is scaled by the sample-average absolute firm-level net exposure, $\overline{|Stock^{i,\{m,k\}}|} = (1/T) \sum_t |Stock_t^{i,\{m,k\}}|$. We winsorize the dependent variable at the 1% and 99% levels to remove outliers. α_i^h is a firm fixed effect and the horizon h captures the fact that firms may re-balance over different horizons. We use 10-year nominal government bond yields to measure interest rate differentials in our baseline.[35]

It is important to point out that the hedging component of firms' FX derivatives holdings are subsumed in the residual $u_{i,t}^h$. This will affect the interpretation β_1^h. As a concrete example, consider the EUR/USD cross where $m = USD$ and $k = EUR$. A positive coefficient β_1^h implies that as US interest rates rise relative to German yields, firms in a given sector increase their net-long (net-short) stock exposure to the USD (EUR), through the EUR/USD cross. That is, firms in this sector perform the carry trade strategy on the margin, most likely due

[35] We also present results in the Online Appendix using 1-year nominal government bond yields.

to changes in their speculative demand. A negative coefficient instead implies that firms in a given sector decrease their net-long exposure to the USD vis-à-vis the EUR as US interest rates rise relative to German ones, the opposite of the carry trade. If we were to estimate $\beta_1^h < 0$ for a particular sector, this would most likely be due to co-movement between the firms in this sector's hedging demand and changes in interest rate differentials, since it is unlikely that firms have expectations in line with uncovered interest parity (UIP) at short horizons. As a way of distinguishing between whether firms carry trade based on a desire to speculate or hedge, we consider the horizon of adjustment, since speculative rebalancing is likely to occur at higher frequencies than on-the-margin hedging. We discuss this in greater detail in the results sub-sections below.

II. Momentum

Another well-known FX investment strategy is momentum, where firm i may expect that if one currency has appreciated against another over the past month, it will continue appreciating in the future in excess of the forward rate, i.e., $\tilde{E}_t^i \left(S_{t+h}^{k/m} - F_{t,h}^{i,k/m} \right)$ may be increasing in the log exchange rate change, $s_t^{k/m} - s_{t-30}^{k/m}$.[36] To examine if changes in firms' net currency-cross exposures are consistent with the momentum investment strategy, we again apply equation (3) and estimate:

$$\frac{Stock_{t+h}^{i,\{m,k\}} - Stock_{t-1}^{i,\{m,k\}}}{\overline{|Stock^{i,\{m,k\}}|}} = \alpha_i^h + \beta_2^h \left[(s_{t+h}^{k/m} - s_{t-30+h}^{k/m}) - (s_{t-1}^{k/m} - s_{t-30-1}^{k/m}) \right] + u_{i,t}^h. \tag{7}$$

Continuing with the $m = USD$ and $k = EUR$ example, a positive coefficient β_2^h implies that as the 30-day USD appreciation against the EUR grows, firms increase their net-long derivatives positions in the USD and their net-short positions in the EUR, consistent with the momentum FX strategy. Conversely, a negative coefficient implies that firms decrease their net-long (net-short) USD (EUR) derivatives exposure as the USD's appreciation against the EUR grows, which is akin to a "reversal" investment strategy. Similar to the carry trade, the estimated coefficients will capture not only the co-movement between firms' speculative de-

[36] In the Online Appendix, we also present results using 90-day exchange rate changes to define momentum.

mand for FX derivatives and past exchange rate change movements, but also the correlation between their hedging demand and past currency fluctuations.

III. Macro News

Lastly, we consider how firms adjust their FX derivatives exposures based on the arrival of macroeconomic news that moves exchange rates. Specifically, firm i's expectation for future exchange rate movements, $\tilde{E}_t^i\left(S_{t+h}^{k/m} - F_{t,h}^{i,k/m}\right)$, may be related to contemporaneous and lagged macro news surprises, with each surprise defined as the difference between the actual value released for a macroeconomic variable, such as GDP, unemployment or inflation in country k or m, and the consensus expectation for that variable from survey responses. To examine how firms adjust their net FX derivatives exposures in response to macro news, we estimate:

$$\frac{Stock_{t+h}^{i,\{m,k\}} - Stock_{t-1}^{i,\{m,k\}}}{\left|\overline{Stock^{i,\{m,k\}}}\right|} = \alpha_i^h + \beta_3^h \boldsymbol{MacroNews_{t-1,t+h}^{m,k}} + u_{i,t}^h. \tag{8}$$

We specifically relate changes in net exposures to $\boldsymbol{MacroNews_{t-1,t+h}^{m,k}}$, which is an aggregate between dates t and $t+h$ of a daily FX macroeconomic news index. Similar to Stavrakeva and Tang (Forthcoming), this FX macroeconomic news index is the fitted value from the following daily regression:

$$\Delta s_t^{k/m} = \alpha + \boldsymbol{\gamma MacroSurp_t} + \varepsilon_t,$$

where $\boldsymbol{MacroSurp_t}$ contains contemporaneous and lagged macroeconomic surprises.[37] As this FX macroeconomic news index explains 50-60% of monthly and quarterly exchange rate movements (Stavrakeva and Tang, Forthcoming), it may correlate with firms' exchange-rate expectations.

Taking the $m = USD$ and $k = EUR$ example, if $\beta_3^h > 0$, firms increase their net-long stock exposure to the USD vis-à-vis the EUR over the same period in which US and

[37] We use the lag structure $\{0, 1, 2, 30, 60, 90, 120, 150, 180\}$ for the macro surprises in the estimation, where if a macroeconomic surprise is not present on a given date, we use the latest available surprise. For the full list of macro surprises, see section B.5 in the Online Appendix.

Euro-area macro news appreciates the USD against the EUR. While only a correlation, such behavior is consistent with firms adjusting their FX derivatives demand in a manner that propagates macro news to exchange rates. Conversely, a negative coefficient implies firms in a given sector adjust FX derivatives exposure in a manner inconsistent with the transmission of macro news to exchange rates. Once again, the estimated β_3^h will depend on the co-movement between firms' speculative and hedging demand and macro news.

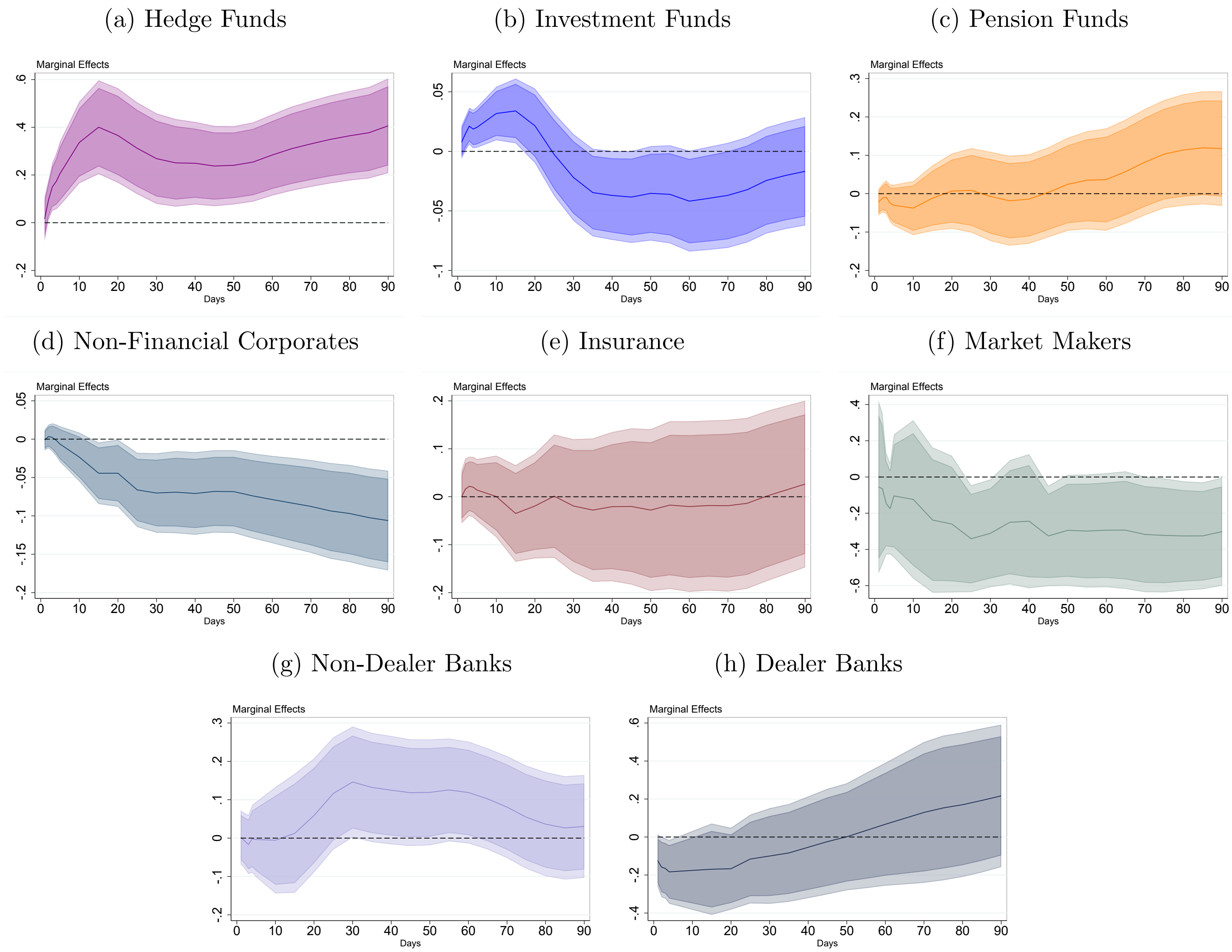
6.1 Carry Trade

The results by sector for the carry trade regression (6) in the EUR/USD currency cross are presented in Figure 8. Figures A.47–A.49 in the Online Appendix present the same for the GBP/USD, EUR/GBP and JPY/USD crosses. We also estimate regression (6) by firm country of residence and sector, with these results shown in Figures A.50–A.55 in the Online Appendix.

First, we find strong evidence that hedge funds perform the carry trade over our sample period. Quantitatively, a 1 percentage point (pp) increase in the US-EU interest rate differential over a 15-day period is associated with a contemporaneous increase in hedge funds' net-long USD position, relative to their average absolute position, of 0.4 percent. Furthermore, hedge funds' carry trade activity is evident for all horizons considered (up to 1 quarter). In addition, we find similar relationships for the GBP/USD, EUR/GBP and JPY/USD crosses, highlighting that hedge funds' use of the carry trade is active across currency crosses. We also find similar relationships using the 1-year interest rate differential for most crosses, as shown in Appendix A.4.2. Moreover, the results are similar for EU and non-EU firms. Given that FX derivatives hedging demand is likely second order for hedge funds, these estimated coefficients predominantly reflect changes in hedge funds' speculative demand for FX derivatives in response to changes in interest differentials.

In addition to hedge funds, investment funds also appear to perform the carry trade in the EUR/USD cross based on 10-year interest differentials. The magnitude of the association

Figure 8: Carry Trade: EU-US 10Y Interest Differential & EUR-USD Derivatives Exposure



Note. Figure 8 presents the β_1^hs for $h \in [0, 90]$ from estimating the firm-level panel regressions (6), with 10-year interest differentials, for 8 sectors for the EUR-USD currency cross. Inner and outer shaded areas correspond to 90% and 95% confidence intervals constructed using two-way clustered standard errors by firm and time.

is smaller than for hedge funds and exists only for horizons of about 20 days or less. We find similar relationships for the EUR/GBP and JPY/USD crosses but not the GBP/USD. When distinguishing between EU and UK investment funds, however, we see that EU funds re-balance their net FX derivatives exposures in line with the carry trade for all four currency crosses for horizons up to around 20 days. Instead, the relationship between UK investment funds' net exposures and interest differentials is largest at medium-to-long horizons (50 to 90 days), although the sign of the association varies by currency cross.[38] This lower-frequency relationship most likely reflects the co-movement between the hedging component of funds' FX derivatives demand and interest differentials, since hedging adjustments likely occur less frequently than speculative re-balancing.[39]

In terms of non-dealer banks, we find that UK non-dealer banks re-balance their net exposures in a manner consistent with the carry trade in the EUR/USD, GBP/USD and JPY/USD crosses.[40] The estimated coefficients are the largest and most statistically significant at the 20-30 day horizon. The magnitude of the adjustment generally lies between those of hedge funds and investment funds.

Turning to dealer banks and market makers, we find some evidence of a negative association between changes in their net exposures and interest differentials, i.e., the opposite direction of the carry trade. This negative association may reflect that dealer banks and market makers accommodate the carry trade activity of hedge funds, investment funds and non-dealer banks. Interestingly, the relationship tends to be stronger for market makers than for dealers, which may reflect dealer banks' ability to better insulate themselves from exposure to the carry trade by taking offsetting exposures with their foreign headquarters/subsidiaries.

Finally, we find evidence of a medium-to-long horizon co-movement between non-financial corporates', as well as pension funds', net FX derivatives exposures and interest differentials, although the direction, and the statistical significance, of the co-movement varies by currency cross and firms' country of residence. For example, the correlation tends to be robustly negative for UK corporates in the EUR/USD, GBP/USD and EUR/GBP currency crosses, and positive for EU pension funds in the EUR/USD and GBP/USD crosses. Although this suggests that pension funds sometimes employ the carry trade, the longer-horizon adjustment, as well as the negative associations for corporates, suggests that these results are driven by

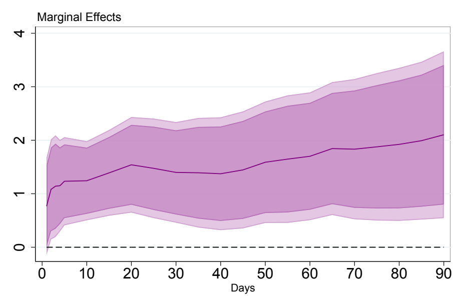
[38]The results are strongest when using 1-year interest rates.

[39]This difference between UK and EU investment funds is consistent with our earlier result that UK investment funds' net currency exposures were more one-directional than those of their EU counterparts.

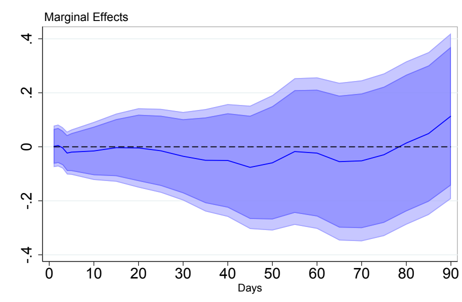
[40]The results for EU non-dealer banks are statistically insignificant, in line with our earlier result that EU non-dealer banks' net currency exposures were more one-directional than those of their UK counterparts.

Figure 9: Momentum: 30-day EUR/USD Appreciation & EUR-USD Derivatives Exposure

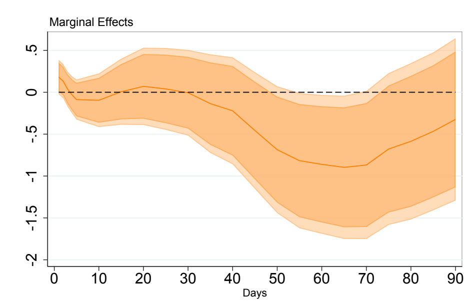
(a) Hedge Funds



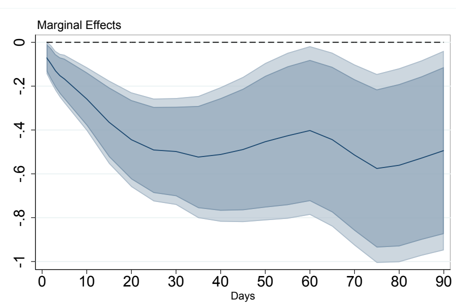
(b) Investment Funds



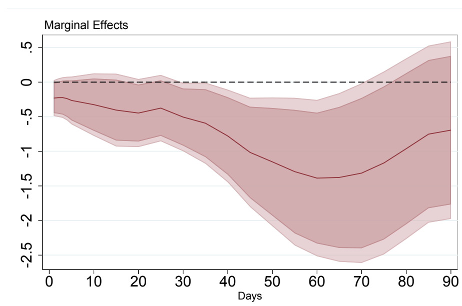
(c) Pension Funds



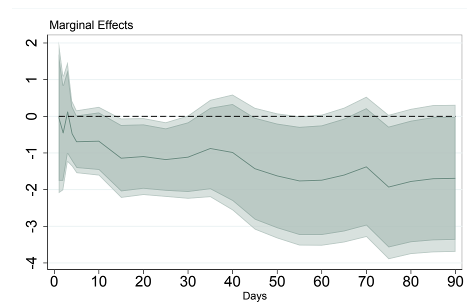
(d) Non-Financial Corporates



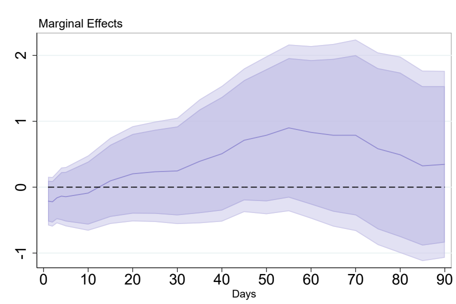
(e) Insurance



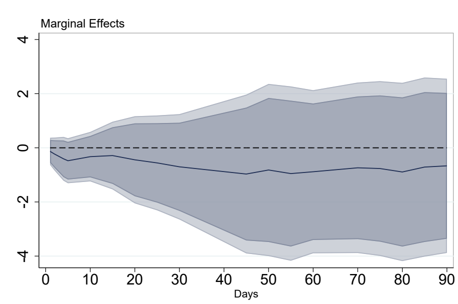
(f) Market Makers



(g) Non-Dealer Banks



(h) Dealer Banks



Note. Figure 9 presents the β_2^hs for $h \in [0, 90]$ from estimating the firm-level panel regressions (7), with 30-day exchange rate movements, for 8 sectors for the EUR-USD currency cross. Inner and outer shaded areas correspond to 90% and 95% confidence intervals constructed using two-way clustered standard errors by firm and time.

the co-movement between these firms' hedging demand and the interest rate differential.[41]

6.2 Momentum

We next turn to the results for the momentum regression (7). The results for the EUR/USD currency cross, for each sector, are presented in Figure 9, while Figures A.66–A.68 in the

[41] The results are largely insignificant for both UK and EU insurance firms.

Online Appendix present the results for the other crosses. The additional break down by firm country of residence and sector is shown in Figures A.69–A.74 in the Online Appendix.

First, we find robust evidence that hedge funds employ the momentum trading strategy using FX derivatives: as the USD's appreciation against the EUR grows, hedge funds go more net-long the USD vis-à-vis the EUR in derivatives markets. Quantitatively, a 1pp greater USD appreciation against the EUR over the previous month is contemporaneously associated with a 1 percent increase in hedge funds' net-long USD position, relative to their average absolute position, at the 15 day horizon. More generally, hedge funds' use of the momentum strategy holds across horizons, currency crosses, for both EU and non-EU entities, and for 90-day appreciations rather than 30-day. Altogether, these findings once again show that hedge funds' FX derivatives exposures exhibit a strong speculative component "on the margin".

For investment funds, the results are more mixed, and less statistically significant, for the momentum strategy as compared to the carry trade. Investment funds, in particular those resident in the EU, appear to adjust net exposures in line with the momentum strategy for the USD/GBP and EUR/GBP crosses at medium-to-long horizons, whereas the opposite is true for the JPY/USD. For the EUR/USD cross shown here, investment funds' derivatives positions instead do not load on lagged exchange-rate movements. Given the longer adjustment horizons, these results are most-plausibly explained by changes in hedging demand, with investment funds' speculative demand loading less on the momentum strategy than the carry trade. While challenging to explain, the different directions of adjustment could then reflect cross-specific correlations between investment funds' hedging demand and lagged exchange-rate movements.

Turning to banks, we find that both dealer and non-dealer banks' net derivatives exposures are uncorrelated with the momentum strategy. Conversely, and akin to the carry trade, market makers tend to take the opposite side of the momentum FX strategy "on the margin".

Similar to the carry trade, non-financial corporations, namely those based in the UK, robustly decrease their USD exposure as the USD's appreciation against the EUR grows.

This pattern holds across horizons, currency crosses (other than the JPY/USD, where corporates are less active) and for both 30- and 90-day appreciations. In fact, the results are even more statistically significant than those for the carry trade. While one explanation for these findings is that non-financial corporates exchange-rate expectations are consistent with "reversal", the negative associations are more plausibly explained by a correlation between corporates' hedging demand and exchange rates.

For pension funds, as was the case for the carry trade, we find that whether these firms adjust net exposures in line with the momentum strategy varies by currency cross and firms' country of residence. This non-systematic behaviour, along with the delayed adjustment horizon, once again suggests that the results are driven by cross-specific correlations between pension funds' hedging demand and exchange rates. Finally, aside from the result shown in the main text, the results for the insurance sector are once again statistically insignificant.

6.3 Macro News

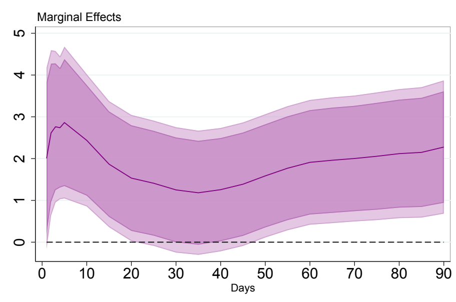
Turning to the macro news regression in equation (8), the results for each sector for the EUR/USD currency cross are displayed in Figure 10, with the results for the other crosses shown in Figures A.85–A.87 in the Online Appendix. The results broken down by firm country of residence and sector are presented in Figures A.88–A.93 in the Online Appendix.

We see clearly that hedge funds increase their net derivatives exposure to the USD vis-à-vis the EUR at the same time as macroeconomic news is appreciating the USD against the EUR. This is consistent with hedge funds helping to transmit macro news to exchange rates. Quantitatively, US and Euro-area macro news that appreciates the USD against the EUR by 1 percentage point over 15 days is associated with a 2 percent increase in hedge funds' net-long USD position, relative to their average absolute position, over the same horizon. This result is once again robust to most horizons, currency crosses and holds for both EU and non-EU firms.[42]

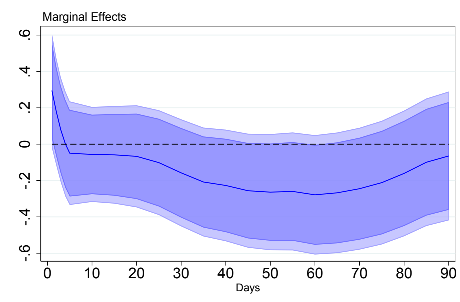
[42] The results are less statistically significant with respect to the EUR/GBP cross.

Figure 10: Macro News: US-EU News and USD-EUR Derivatives Exposure

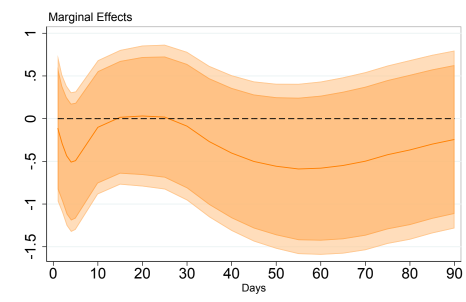
(a) Hedge Funds



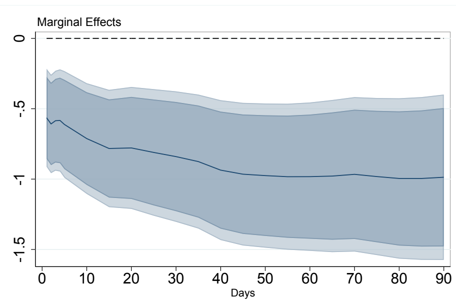
(b) Investment Funds



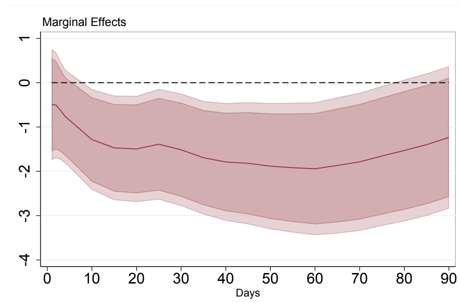
(c) Pension Funds



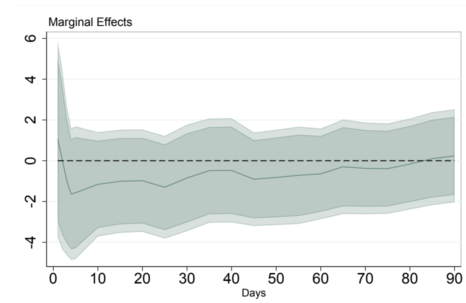
(d) Non-Financial Corporates



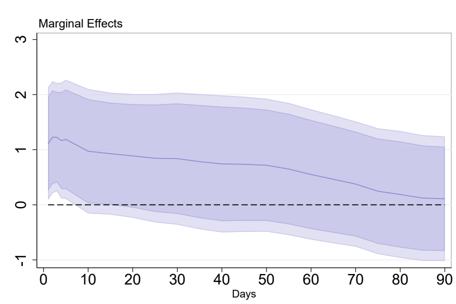
(e) Insurers



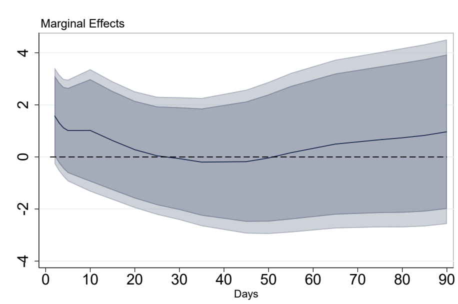
(f) Market Makers



(g) Non-Dealer Banks



(h) Dealer Banks



Note. Figure 10 presents the β_3^hs for $h \in [0, 90]$ from estimating the firm-level panel regressions (8) for 8 sectors for the EUR-USD currency cross. Inner and outer shaded areas correspond to 90% and 95% confidence intervals constructed using two-way clustered standard errors by firm and time.

Similarly, non-dealer banks that are resident in the UK also appear to speculate based on the arrival of macroeconomic news at short horizons by increasing their net exposures to currencies that macro news is contemporaneously appreciating. This result is strongest for the EUR/USD cross, but holds for all crosses other than the EUR/GBP. Interestingly, the magnitude of non-dealer banks' rebalancing is similar to that of hedge funds.

While dealer banks' net exposures do not correlate on the margin with macro news, market makers appear to take the opposite side of macro-news driven rebalancing in some crosses. The relationship between investment and pension funds' net exposures and macro news is mixed, with adjustments once again varying by currency cross and firms' country of origin. These adjustments are generally delayed, which suggests they are tied to the co-movement of these sectors' hedging demand with macro news. We also find some evidence that EU-based insurers decrease their net exposures to currencies that macro news is contemporaneously appreciating at medium-to-long horizons, consistent with hedging on the margin.

Finally, UK non-financial corporations adjust their FX derivatives exposures in the opposite direction to the speculative FX strategy based on the arrival of macro news. The estimated coefficients are highly statistically significant and large for all but JPY/USD cross, where corporates are less active. Corporates' rebalancing is therefore inconsistent with the transmission of macro news to exchange rates. The most likely explanation for these results is corporates' hedging demand co-moving strongly with the arrival of macroeconomic news.

Summary

In sum, hedge funds appear to be the primary sector trading speculatively in FX derivatives markets, with their net exposures adjusting in line with the carry trade, momentum and macroeconomic news-based FX investment strategies across currency crosses and investment horizons, independently of their countries of residence. In addition, UK-resident non-dealer banks and EU-based investment funds also appear to engage in some speculative activity using FX derivatives, although this is activity is cross-specific and is limited to the carry trade for investment funds. Taking the opposite side to this speculative rebalancing appear to be market makers, and to a much lesser extent, dealer banks. Finally, to the extent that we find correlations between the other sectors' net exposures and the the variables defining these FX investment strategies—which are notably strong for non-financial corporates—the horizons and/or directions of adjustment suggest that these sectors' on-the-margin rebalancing is due to changes in their hedging demand.

To properly understand how the observed FX derivatives rebalancing co-moves with the firms' hedging demand, we would require additional information on the rest of these firms' portfolios/balance sheets, which are not readily available for the wide-range of sectors we consider here. We leave these explorations for future work.

7 Conclusion

This paper uses contract-level data to document important facts about the use of FX derivatives by firms, both financial and non-financial, in the largest center for currency trading, the UK.

To facilitate our analysis, we construct the *net* FX derivatives exposure at the *firm-level* for the near-universe of firms trading FX in the UK over the period 2015-2020. This measure, which contrasts with the sector-level net or gross exposures used in many existing studies, enables us to better capture within- and across-sector heterogeneity in the degree to which firms' profits are exposed to exchange rate fluctuations from FX derivatives. Leveraging our firm-level net FX derivatives exposures, we show that individual pension funds, insurance companies, non-financial corporates and, to a lesser degree, investment funds, maintain persistent one-directional net-short exposures to the USD and net-long exposures to their currencies of operation over our sample, consistent with their use of FX derivatives for hedging purposes "on average".

Shifting to firms' speculative use of FX derivatives, we examine how firms adjust their net FX derivatives exposures "on the margin" with respect to three well-known FX investment strategies: the carry trade, momentum and macro news-based FX trading. Our findings show that hedge funds, and, to a lesser extent, non-dealer banks and investment funds, speculate on the margin using FX derivatives, whereas most other clients most likely adjust exposures on the margin in a manner consistent with hedging.

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