Granular Banking Flows and Exchange-Rate Dynamics*

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Abstract

Using data on the external positions of global banks in the world's largest banking hub, the UK, and a granular international-banking model, we show that large banks' idiosyncratic net flows into USD debt influence exchange-rate dynamics. UK-resident banks' USD demand is, on average, price-elastic, whereas their counterparties' USD supply is price-inelastic. We document a structural shift—from banks' being price-inelastic before the Global Financial Crisis to price-elastic afterwards—linked to a marked rise in banks' hedging on-balance-sheet USD net exposures via FX derivatives. This change may help explain the tighter link between exchange rates and macroeconomic fundamentals since the crisis.

JEL Codes: F31, F32, F41, G15, G21.

Key Words: Capital flows; Exchange rates; FX derivatives; International banking.

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1 Introduction

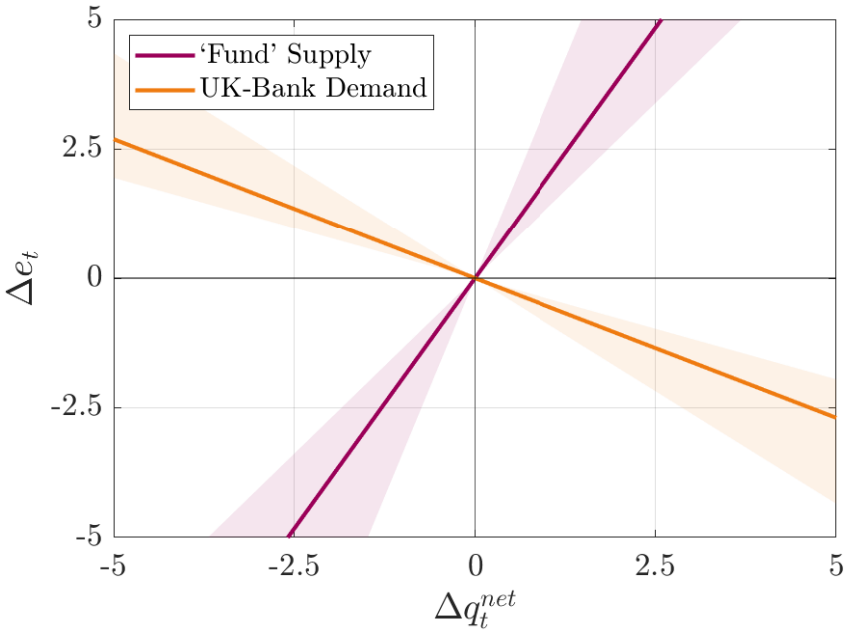
The disconnect between exchange rates and macro fundamentals is a long-standing puzzle in international macroeconomics (Meese and Rogoff, 1983; Obstfeld and Rogoff, 2000). A growing theoretical literature has rationalised this disconnect by incorporating financial shocks and financial frictions into open-economy macroeconomics models (Gabaix and Maggiori, 2015; Itskhoki and Mukhin, 2021). However, open empirical questions remain. From where do these financial (capital-flow) shocks originate? How much do exchange rates respond to these financial shocks? Which agents' financial constraints price most of the exchange rate response? What role do FX derivatives play?

To address these questions, we construct granular capital-flow shocks using data on the external assets and liabilities of UK-resident global banks over the past quarter century. We focus on financial shocks emanating from the banking system since banks are large, highly-connected intermediaries in global financial markets. Cross-border banking corresponds to, on average, 25% of all external assets over our sample. Since the UK represents by far the largest hub for cross-border banking, our dataset is well-suited to our analysis. Guided by a novel granular international-banking model, we first document that net flows into USD debt by UK-resident global banks meaningfully move exchange rates, with a 1% flow estimated to appreciate the USD by 0.5% against GBP. Decomposing this multiplier into structural elasticities, we uncover that banks' demand for USD debt is on-average price-elastic, whereas the USD-debt supply by banks' counterparties, which we label generically as 'funds', is price-inelastic. This relationship is illustrated graphically in Figure 1, with UK banks' demand curve significantly flatter than funds' supply curve. It implies that UK-resident global banks help dampen the exchange rate response to financial shocks. Finally, we document significant time variation in the compensation banks require to intermediate capital flows—shifting from being price-inelastic before the Global Financial Crisis (GFC) to price-elastic afterward. Using 25 years of data on UK-based banks' FX derivatives values, we link this shift to a substantial post-GFC increase in banks' FX hedging. Given banks' central role in currency markets, this finding may help explain the tighter connection between exchange rates and fundamentals in recent years (e.g., Bussiere et al., 2022; Engel et al., 2022; Lilley et al., 2022; Engel and Wu, 2024).

We begin by documenting key stylised facts about our bank-level data. First, as is well known, financial assets are highly concentrated in a few large International Financial Centres (IFCs). In banking, the UK represents by far the largest IFC, with cross-border assets of UK-resident global banks averaging almost twice that of their US counterparts.[1] Furthermore,

[1] See Cesa-Bianchi et al. (2021) and Beck et al. (2023) for recent surveys on the UK's position as an IFC.

Figure 1: Elastic UK-Bank Demand and Inelastic 'Fund' Supply of USD Debt



Notes: Supply and demand relationship between the change in the GBP/USD exchange rate Δe_t (where an increase corresponds to a USD appreciation) and changes in net-USD debt (debt − deposit) quantities Δq_t^{net} implied by elasticity estimates described in Section 5.2. Shaded areas denote 1 standard-deviation error bands.

banks are a key link between the UK and global markets, with cross-border claims originating from UK-based banks constituting, on average, 36% of the UK's entire external asset position over our 1997-2023 sample. Second, while UK-resident banks' USD external debt assets and liabilities closely track one another over time, there are notable mismatches. In particular, UK banks' moved from net-short the USD via debt instruments pre-GFC to net-long afterwards. Third, and most importantly, we show that these financial assets are held by a relatively small number of large players. Around 20% of UK-based global banks account for about 80% of banks' overall *gross and net* cross-border USD positions. This granularity is crucial for our identification strategy.

To inform our empirical analysis, and motivated by these stylised facts, we present a granular banking model of exchange rate determination, which builds on the 'Gamma model' of Gabaix and Maggiori (2015). Unlike the original setup, global banks' risk-bearing capacities are heterogeneous in our 'Granular Gamma model'. This generates variation in the size of banks' cross-border asset positions and foreign-currency exposures, as in the data. Banks trade assets and liabilities across borders with a set of rest-of-the-world (ROW) 'funds' that have their own financial constraints and beliefs.[2] In doing so, banks demand foreign currency while ROW

[2]We use the term 'fund' generically to refer to any agent taking net currency exposures *vis-à-vis* UK-resident global banks. In practice, UK banks' counterparties will include both U.S. dealer banks, who may take small

funds supply it. Banks also differ in their 'beliefs' about expected carry-trade returns. These beliefs, which are driven by both aggregate and bank-specific factors, reflect bank-specific financial shocks to Uncovered Interest Parity (UIP) that act as demand shifters for currency. Altogether, the resulting equilibrium captures the realistic feature that idiosyncratic demand flows by large banks—due to bank-specific beliefs—play a disproportionate role in driving exchange-rate dynamics. This provides a granular foundation for the financial shocks that resolve traditional exchange-rate puzzles.

We then decompose the exchange rate response to financial shocks into the contributions of banks' demand elasticities and funds' supply elasticities for foreign currency. The most *price-inelastic* type of intermediary prices the majority of the exchange rate response. Intuitively, price-inelastic intermediaries require larger exchange rate movements to be willing to adjust the size of their foreign currency exposures. Importantly, we show that intermediaries with greater risk-bearing capacities and who use FX derivatives to hedge exchange-rate risk have more-elastic currency demand, dampening the exchange rate response to capital-flow shocks.

Using the model as a guide, we identify financial shocks empirically by constructing granular instrumental variables (GIVs) (Gabaix and Koijen, 2024) for gross and net cross-border banking flows. Our GIVs are time series of exogenous capital flows into and out of USD assets by large banks, extracted by measuring changes in large banks' positions over and above the changes common to all banks. For relevance, our instruments require a large cross-section of banks taking positions in USD, with some banks' positions large enough that their idiosyncratic moves can influence aggregate capital flows—requirements that our dataset fulfils. For exogeneity, the GIV framework helps to partial out aggregate confounders by taking the difference between the size- and equal-weighted sum of banks' cross-border flows. Importantly, we further residualise these bank-level flows with respect to common factors—estimated via principal-component analysis—and bank-level characteristics that can drive changes in banks' positions over time. The former is particularly important in our setting, since global financial shocks are known to play an important role in banks' cross-border portfolio decisions. Reassuringly, we find that our GIVs are uncorrelated with commonly-used proxies for the Global Financial Cycle (Miranda-Agrippino and Rey, 2020), unlike many instruments used in the literature. To support this further, we also carry out a detailed narrative assessment of our instrument, using AI to access *Financial Times* archives to ensure that its main drivers are plausibly exogenous events. Our analysis reveals that the lion's share of our GIVs' moves are linked

residual exposures (Barbiero et al., 2024; Dao et al., 2025), and importantly also non-banks such as various types of funds (Camanho et al., 2022; Hacioglu-Hoke et al., 2026), even they if do not trade directly with UK banks. Differences in elasticities between UK banks and their counterparties likely reflects the presence of non-banks, however.

with bank-specific, non-systemic shocks to large banks such as mergers, management changes, or legal penalties, as well as stress-test failings and computer-system failures—as opposed to global financial events, which could introduce endogeneity into our instruments.

Armed with our granular shocks and testable predictions from theory, we investigate the causal link between capital flows and exchange rates over time, highlighting the following results. First, by regressing exchange rate movements directly on our net (assets less liabilities) dollar-debt GIV, we estimate the causal multiplier of UK banks' net-USD capital flows on the GBP/USD exchange rate.[3] A 1% increase in UK-resident banks' net dollar-debt position leads to a 0.5% appreciation of the USD against GBP on impact, within the quarter. These effects persist too. Using a local-projections specification, we estimate that this shock results in around a 1.5% cumulative USD appreciation after 1 year, before returning to zero thereafter. This is consistent with flows being reasonably persistent. When breaking down this net-flow multiplier, we find that exogenous changes in USD-denominated debt assets and deposit liabilities result in roughly equal and opposite responses in the GBP/USD exchange rate. Overall, our results indicate that, while a change in UK-resident banks' dollar-debt assets will not result in a significant exchange rate response when offset by an equal change in USD-deposit liabilities, mismatched changes in USD-debt positions, for example due to carry trading, can result in economically significant, and persistent, exchange rate movements.

Second, to understand the structural underpinnings of these multipliers, we use our net-USD debt GIV to estimate, via two-stage least squares, distinct UK-bank demand and ROW-fund supply elasticities for USD. On the supply side, we find that the quantity of USD supplied by banks' ROW counterparties is price-inelastic with respect to the GBP/USD exchange rate: *ceteris paribus*, a 1% change in the exchange rate results in a less than proportional change in the net supply of USD debt by banks' counterparties—about 0.5% according to our estimates. However, on the demand side, point estimates suggest that the USD demand by UK-resident global banks is *on-average* elastic. A 1% change in the GBP/USD exchange rate results in a more than proportional change in net demand for USD debt—of nearly -2%. That the demand elasticity lies significantly above the supply elasticity implies that UK-resident global banks play a role in dampening the exchange rate response to financial shocks compared to (the average of) other financial-market participants, such as various types of funds, non-financials and dealers. A key implication of inelastic USD supply is that UK banks may face difficulties in securing USD without incurring substantial costs through adverse price movements.

Third, to assess time variation in the relationship between capital flows and exchange rates,

[3] Importantly, we show that our GIVs naturally correct for valuation effects, implying that our results are not driven by mechanical changes in portfolio values due to exchange rate movements.

we extend our empirical setup to jointly investigate the role of banks' FX derivatives use, their capitalisation and financial-market volatility. Within our Granular Gamma model, the former of these factors impacts banks' USD exposure and hence the risk-compensation banks demand for a given risk-bearing capacity, whereas the latter two directly affect banks' capacity to bear risk. To measure the extent to which banks use FX derivatives to speculate versus hedge, we complement our asset/liability data with quarterly information on large UK banks' derivatives values over the past quarter century.[4] We proxy banks' FX derivatives hedging activity by the covariance between the values of their FX derivatives and on-balance-sheet net USD positions, where a negative covariance implies FX derivatives mechanically serve as a hedge. Importantly, our proxy displays a structural shift around the GFC, with FX derivatives moving from reinforcing changes in the value of banks' net-USD positions pre-GFC to offsetting them afterwards. Since we show UK-based banks are net-long USD debt on-balance-sheet post-crisis, our proxy implies they are net-short USD via FX derivatives over this period, consistent with the evidence in Hacioglu-Hoke et al. (2026).[5]

Interacting our measure of banks' FX derivative hedging, their average Tier-1 capital ratio, and the VIX (our proxy for financial market volatility) with our net-USD debt GIV points to the first and last of these factors playing the most significant role in generating time variation in banks' USD-demand elasticity. The causal effect of capital flows on exchange rates is twice as large when banks' FX derivatives hedging is 1 standard deviation below and the VIX 1 standard deviation above average, which we show is due to a significant steepening of banks' USD demand curve. By the same token, banks' increased FX hedging post-GFC has significantly dampened the exchange rate response to capital flows, which may help explain tighter post-GFC connection between exchange-rate dynamics and fundamentals, most notably that the UIP cannot be rejected in recent samples (e.g., Bussiere et al., 2022).[6] Overall, these results provide novel evidence highlighting that the link between capital flows and exchange rates is highly state dependent owing to time-variation in intermediaries' risk-bearing capacity and their use of FX derivatives.

Literature Review. Our paper contributes to the substantial literature on the 'disconnect' between exchange rates and fundamentals (e.g., Meese and Rogoff, 1983; Fama, 1984; Obstfeld

[4]UK-resident banks may use FX derivatives (swaps) as a source of USD funding. Importantly, when banks' are net-long USD on-balance-sheet, this USD funding decreases their USD exposure, thereby acting as an FX hedge.

[5]Hacioglu-Hoke et al. (2026) show that the non-dealer arms of UK-resident global banks, the entities that make cross-border loans, are generally net-short USD via FX derivatives over most of the 2015-2020 period. Since we show UK-based banks were net-short USD via on-balance-sheet debt pre-GFC and our proxy suggests banks used FX derivatives to speculate over this period, it suggests banks were also net-short USD via derivatives pre-GFC.

[6]While tighter post-GFC banking regulation could have made UK-banks' USD demand more inelastic, our findings indicate that the impact of their increased FX hedging more than offsets this effect.

and Rogoff, 2000; Jiang et al., 2021; Engel and Wu, 2023; Stavrakeva and Tang, 2024; Chahrour et al., 2024). Within this body of work, our paper closely links with the growing theoretical literature rationalising this disconnect with financial shocks and market imperfections (Jeanne and Rose, 2002; Gabaix and Maggiori, 2015; Greenwood et al., 2023; Gourinchas et al., 2022; Itskhoki and Mukhin, 2021, 2025a,b; Fukui et al., 2025; Kekre and Lenel, 2024; Dao et al., 2025).[7] Our heterogeneous-bank framework provides the granular foundations for UIP shocks, highlighting that idiosyncratic 'belief' shocks, unrelated to fundamentals, emanating from large banks can affect aggregate cross-border asset demand and hence exchange rates. Further, our time-varying empirical estimates of banks' and their counterparties' price elasticities of USD demand/supply can be used to calibrate the financial frictions that underpin international macroeconomics models. In particular, our analysis points a significant increase in banks' demand elasticity post-GFC, which may help explain an exchange-rate 'reconnect' in this period.

We also contribute to the literature relating currency demand to exchange rates. Evans and Lyons (2002) shows that dealer order flow, a measure of net buying pressure for a particular currency pair, explains a large fraction of high-frequency exchange rate movements. The importance of currency demand has been echoed in other studies, including Froot and Ramadorai, 2005; Brunnermeier et al., 2008; Della Corte et al., 2016; Liao and Zhang, 2025; Ostry, 2023; Nenova, 2025; Bahaj et al., 2024. Several papers also study the role of banking flows and funding for exchange rates, often in the context of changes in US monetary policy (see, e.g., Bruno and Shin, 2015; Ivashina et al., 2015; Bräuning and Ivashina, 2020; Adrian and Xie, 2020).

Relatedly, we contribute to the growing literature that uses granular players in financial markets to estimate causal effects and macro elasticities. Using their GIV methodology, Gabaix and Koijen (2021) show that US equity demand is price inelastic, which they argue rationalises the volatility of equity prices.[8] In a similar spirit to our paper, Camanho et al. (2022) build a GIV for mutual funds' international equity rebalancing flows and study their causal effects on exchange rates, providing evidence of an upward sloping currency supply curve. Aldasoro et al. (2023) use data from the BIS Locational Banking Statistics to construct GIVs for cross-border flows at the *country-level*, with a focus on transmission to emerging-market economies.[9]

Concurrent work by Becker et al. (2023) uses a GIV setup for a range of currencies, showing that when non-US banks extend more syndicated loans in USD relative to US banks' syn-

[7] This class of models stands in contrast to no-arbitrage ones in which the demand elasticity of exchange rates to capital flows is very large (see Friedman, 1953). Instead, models with limits to arbitrage (e.g., Shleifer and Vishny, 1997) generate a downward-sloping demand curve for currency (e.g., Kouri, 1981; Hau and Rey, 2004, 2006; Hau et al., 2010).

[8] See also Koijen and Yogo, 2019, 2020 for an alternative 'demand-system' approach to elasticity estimation.

[9] Helpfully for us, they demonstrate how their country-level GIVs improve on existing (non-granular) instruments used in the literature (e.g., Blanchard et al., 2016; Cesa-Bianchi et al., 2018; Avdjiev et al., 2021).

dicated loans in foreign currency, the USD appreciates. In contrast, our study leverages USD mismatches between the lending and borrowing of UK-based global banks to estimate the structural elasticities underpinning GBP/USD UIP deviations. Crucially, while we find that UK-based banks' demand for USD is on-average price-elastic (and their counterparties' USD supply inelastic, we document a substantial increase in banks' demand elasticity post-GFC, which we empirically link to banks' greater FX hedging via derivatives. By combining detailed information on banks' on- and off-balance sheet dollar positions, we shed new light on the causal links between capital flows and exchange rates over time. In complementary work, Barbiero et al. (2024) construct supply-side granular risk-limit shocks based on GIV-identified changes in desk-level VaR constraints at dealer banks. They find that tighter currency-risk limits decrease dealers' net exposures, raise bid-ask spreads, and increase FX volatility.[10]

Finally, our paper contributes to the burgeoning literature studying FX derivatives use. On the supply side, a number of studies link the emergence of deviations from covered interest parity (CIP) post GFC to a decline in dealer-banks' risk bearing capacity, due to tighter regulatory constraints (see, e.g., Du et al., 2018; Avdjiev et al., 2019; Rime et al., 2022). This evidence, alongside other drivers of CIP, has been confirmed using granular FX derivatives data (see, e.g., Cenedese et al., 2021; Moskowitz et al., 2024). While banks' have undoubtedly become more constrained post-GFC, as reflected in CIP deviations, there is little evidence on how banks' adjusted their FX exposures, and the resulting implications for UIP deviations, largely due to data limitations. In particular, while a few recent papers study currency demand via FX derivatives (Czech et al., 2022; Khetan, 2024; Kloks et al., 2024; Kubitza et al., 2024; Hacioglu-Hoke et al., 2026), their underlying data only becomes available in the mid-2010s.[11] By contrast, we leverage 25 years of data on bank-level FX derivatives values, alongside their on-balance-sheet currency positions, to study changes in how banks' manage currency risk over time, finding evidence that banks' began to use FX derivatives as a hedge post-GFC, which we argue contributed to their greater price elasticity and a consequent decline in UIP deviations.

Outline. The remainder of this paper is structured as follows. Section 2 summarises our data, and presents stylised facts. Section 3 presents our theoretical framework, the Granular Gamma model. Section 4 bridges the gap from theory to our empirical strategy, describing the construction of our novel GIVs. Section 5 presents our empirical results. Section 6 concludes.

[10] Lu and Wallen (2024) show that dealer bank trading desks bear little market risk and profit from toll-taking.

[11] One exception is Du et al. (2024), who use use a variety of data sources across countries, mostly at the sector-level, to show that hedge ratios for insurance companies, pension funds and mutual funds rose by about 15 percentage points from pre- to post-GFC. They do not, however, study banks' FX derivatives use.

2 Data

We first describe our data, and document stylised facts about aggregate and granular features of UK-resident global banks' cross-border positions and FX derivatives values.

2.1 UK-Resident Banks in Global Context

Our main source is a confidential quarterly panel of bank balance-sheet data constructed from regulatory filings and statistical data forms submitted to the Bank of England by domestic- and foreign-owned banks operating in the UK.[12] The panel contains detailed data on UK-resident banks' cross-border claims and liabilities by asset class.[13] Most importantly for our study, these claims are reported by currency. In addition, the dataset includes information on banks' capitalisation and liquidity buffers, among other controls.

Cross-border banking claims originating from the UK comprise a substantial share of the UK's overall external linkages. In particular, claims originating from UK-based banks in our dataset represent, on average over the 1997-2023 period, 36% of the UK's total external asset position (measured with External Wealth of Nations Dataset of Lane and Milesi-Ferretti, 2018).

Compared to other global banking centres, UK-resident banks comprise the largest share of aggregate cross-border claims. Figure 2 shows this, plotting the time series of all banking claims originating from the UK alongside those from other source countries of international bank lending. UK-resident banks' total cross-border claims capture, on average over the period, 18% of overall cross-border banking claims, almost twice the share of the US, and peak at around $7.1 trillion in 2008Q1. Similar patterns are present for cross-border liabilities.

Overall, these facts showcase the scale of UK cross-border banking, both as a share of the UK external account and relative to other international banking hubs.

2.2 Decomposing UK-Resident Banks' Cross-Border Positions

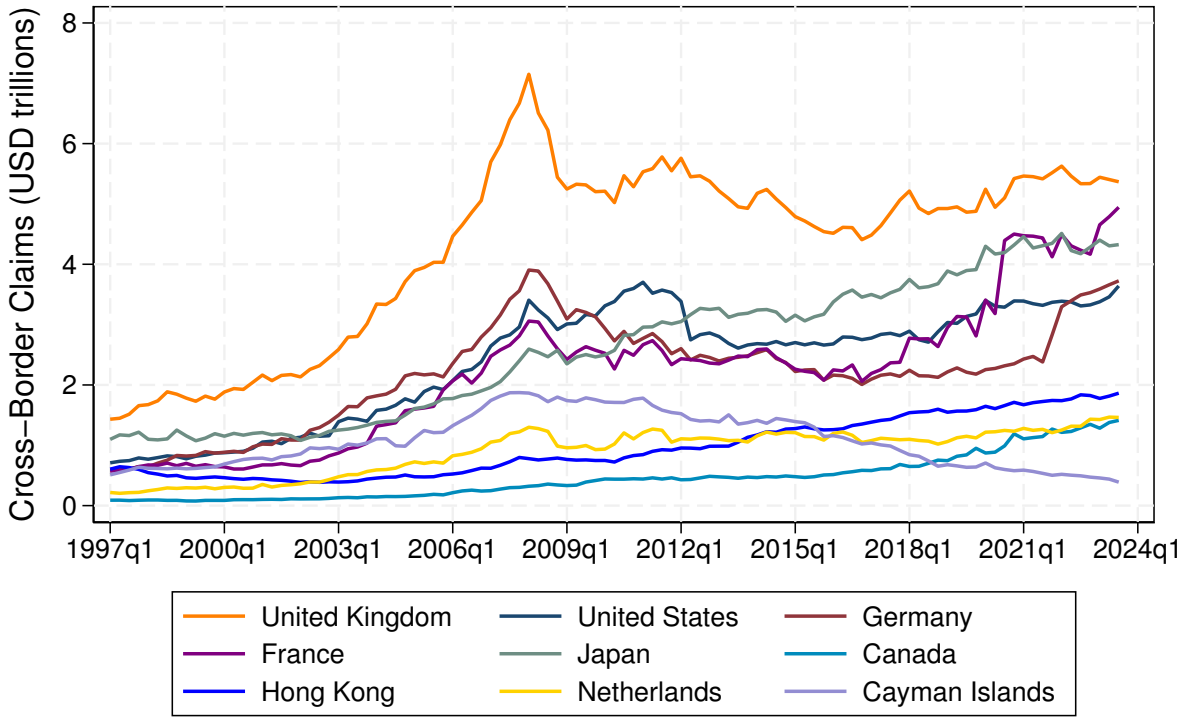
Our raw data contains information on 510 banks reporting cross-border claims in at least one quarter over the period 1997Q3-2023Q3. For our analysis, we clean our sample to focus on stable bank-currency relationships. We do so by only including banks for which we have at least 80 quarters of data.[14] As a consequence, we focus on the intensive margin of cross-border

[12] Specifically, we use the Bank of England 'Country analysis of UK external claims (CC) and liabilities (CL)' forms, which have been used for other purposes in numerous previous studies, including: Aiyar et al. (2014), Forbes et al. (2017), Bussière et al. (2021), Andreeva et al. (2025), Eguren-Martin et al. (2023), and Lloyd et al. (2023).

[13] Within the dataset, cross-border claims and liabilities can be further disaggregated by recipient country. However, for our analysis, we aggregate up recipient-countries to consider UK-resident banks' exposures to the ROW as a whole, rather than specific nations.

[14] Moreover, as with other studies that use this dataset (e.g., Bussière et al., 2021; Andreeva et al., 2025; Lloyd et al., 2023), we also winsorise our bank-level data to ensure that the quarterly growth of cross-border positions is

Figure 2: Cross-Border Banking Claims by Country of Origin



Notes: Aggregate cross-border banking claims, for selected countries of origin (the major sources of cross-border banking claims), from 1997Q1 to 2023Q3. *Source*: BIS Locational Banking Statistics.

lending. The cleaned quarterly dataset includes 129 global banks, which together engage in the vast majority of cross-border bank lending from the UK.

Our key variable of interest is the quarterly change in the stock of currency-specific cross-border claims (and liabilities) between bank i and the ROW at time t. Here, we focus on USD-denominated claims, which comprise, on average, 47% of all claims over the sample (Figure 3a).[15] In comparison, EUR-denominated claims comprise on average 36% of claims.[16]

Within USD-denominated assets, we focus on'loans and advances' (henceforth 'debt'), as opposed to equity, since fixed-income instruments map more directly to UIP. In any case, by decomposing total cross-border USD claims by asset type, Figure 3b demonstrates that debt comprises the lion's share. As of 2023Q3, the stock of USD-denominated debt was around 10-times larger than USD-denominated portfolio investments.

The counterpart to these USD debt positions are USD-denominated deposits, liabilities for UK banks. As the lines in Figure 3b show, UK banks' USD debt and deposit positions have both

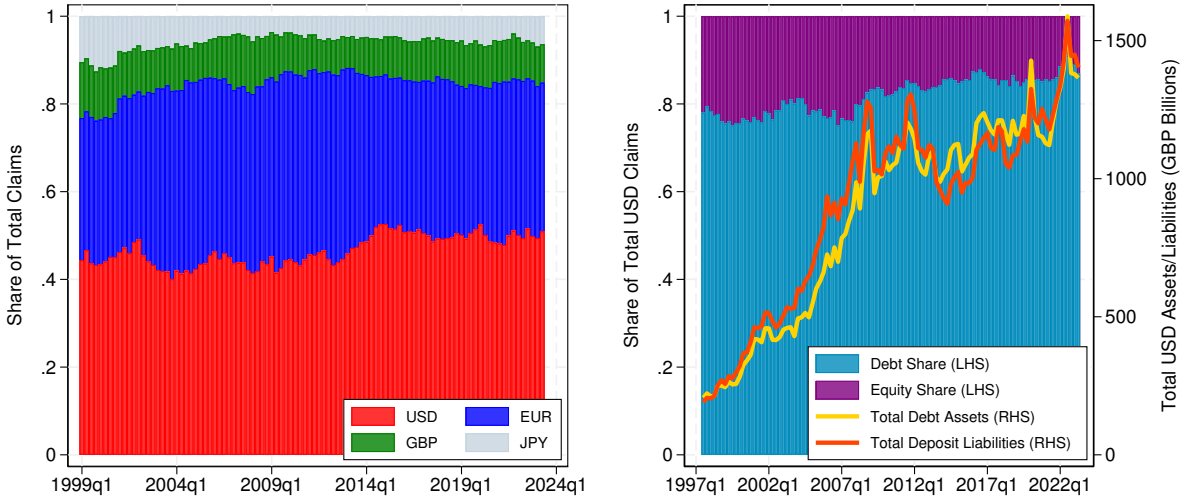
bounded between -100% and $+100\%$.

[15]This statistic is calculated over the period 1999Q1-2023Q3 to avoid distortions due to the creation of the euro.

[16]EUR-denominated positions do not exhibit the same level of concentration as USD positions, rendering them less suitable for our subsequent analysis.

Figure 3: Decomposing UK-Based Banks' Cross-Border Claims and Liabilities

(a) Currency Breakdown of Cross-Border Claims (b) Breakdown of USD Cross-Border Claims & Liabilities



Notes: Left-hand figure decomposes UK-based banks' total external claims by currency from 1999Q1 (owing to creation of the euro) to 2023Q3. Right-hand figure decomposes total USD-denominated external claims by asset class (debt and equity) and additionally presents total USD debt assets and deposit liabilities (in GBP trillions) from 1997Q3 to 2023Q3.

grown considerably over time. While they have, unsurprisingly, grown in a broadly similar manner, there have been notable mismatches, with absolute *net*-USD debt positions averaging 71 billion GBP over our sample.[17] So, UK-resident banks often have significant net exposures to USD on their balance sheets, which we leverage in our theoretical framework below.[18]

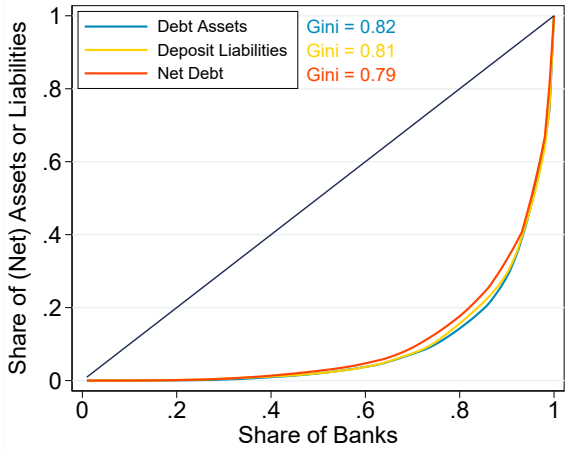
These USD exposures have also varied in sign over time. For much of the 2000s, USD liabilities were larger than USD assets, implying that UK-resident banks were net-short the USD with fixed-income instruments. Conversely, for much of the 2010s, banks' net fixed-income currency exposure switched, with UK-resident banks taking net-long positions in USD debt. Since US interest rates were relatively low (high) compared to the UK's, and the USD depreciated (appreciate) against GBP, for much of the 2000s (2010s), this provides suggestive evidence that the UK banking system performed carry trades during our sample.

[17] The standard deviation of these absolute positions is 48 billion GBP. Banks' largest (smallest) net-USD position over our sample is 210 billion GBP (0.4 billion GBP).

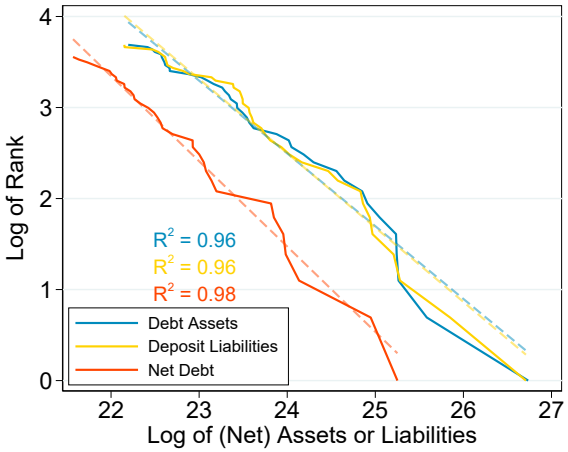
[18] While UK-resident banks have been subject to some Pillar 1 and 2 capital requirements on mismatched currency positions since the mid-2010s under Prudential Regulatory Authority regulation, these do not preclude FX mismatches on balance sheets.

Figure 4: Concentration and Granularity in Banks' Cross-Border (Net) Assets and Liabilities

(a) Size Concentration



(b) Granularity



Notes: Figure 4a presents Lorenz curves and Gini coefficients respectively for global banks' average USD debt assets, deposit liabilities and absolute net-debt (debt less deposits) in 2022Q3. Figure 4b plots log-rank vs log-size, along with linear best fit lines and the associated R^2, separately for USD debt assets, deposit liabilities and absolute net-debt in 2022Q3. The sample in Figure 4b is restricted to the 40 largest banks for debt and deposits and 35 largest for absolute net-debt.

2.3 Granularity of UK-Resident Banks

While UK-resident banks collectively cover a sizeable portion of global cross-border claims, there is significant heterogeneity in individual banks' positions. Figure 4a displays Lorenz curves and associated Gini coefficients for UK-resident global banks' USD-debt assets, deposit liabilities and absolute net positions (debt assets less deposit liabilities) in 2022Q3, near the end of our sample. Across these measures of gross and net size, there is clear evidence of a Pareto principle: around 80% of total USD positions are held by roughly 20% of banks.

Figure 4b also provides evidence that global banks appear granular (Gabaix, 2011), implying that idiosyncratic flows by large global banks can theoretically shape aggregate banking flows. Following Gabaix (2009), this plot compares the log-rank of banks' size to the log of their size—using the same three measures of size as Figure 4a. That straight lines can fit this relationship to such a degree—the R^2 are between 0.96 and 0.98—is evidence of a power law and hence granularity in cross-border banking: the size of the n^{th} largest global bank is proportional to $1/n$. In the case of absolute net debt, the constant of proportionality is statistically indistinguishable from 1, consistent with Zipf's law.

In all, this size concentration—in particular for *net* positions—motivates the granular banking model in Section 3. It suggests that idiosyncratic flows from large banks, which we construct in Section 4, can affect aggregate quantities and prices. As shown in Section 5, consistent

with this granular hypothesis, idiosyncratic capital flows from large banks (i.e., GIVs) indeed have a sizeable impact on exchange rates.

2.4 UK-Resident Banks' FX Derivatives Use

To supplement our dataset covering banks' external asset and liability positions, we leverage unique information on the *value* of the largest UK-resident banks' FX derivatives positions over the past quarter century.[19] FX derivatives, nearly 90% of which involve the USD in one leg of the contract (BIS, 2025), enable banks to adjust their on-balance-sheet net-USD exposures documented in Section 2.2. Although FX-derivative *exposure* data are unavailable for UK banks over most of our sample—precluding construction of their total net exposure—the co-movement between the *values* of banks' on-balance-sheet and FX derivative positions provides a proxy for whether derivatives amplify or dampen FX exposure. Intuitively, if banks are net-long (or net-short) USD both on balance sheet and via FX derivatives, exchange rate movements adjust their values in the same direction; if they are instead net-long in one and net-short the other, valuation effects would offset.[20][21]

Figure 5a traces the value of UK-resident banks' FX derivative 'assets', defined as 'in-the-money' positions, over the past quarter century. These positions are comparable in value to banks' external USD-debt assets, and reach a peak of nearly 1.5 trillion GBP by end-2022. Banks' FX derivative asset values also increase substantially in the run-up to the GFC, and remain elevated thereafter, pointing to greater FX derivatives use in the latter half of our sample. The figure further decomposes the value of these positions into those held by the largest 5 banks (in terms of average value over the sample) and the smaller 10 banks, highlighting significant concentration in banks' derivatives use.[22]

Banks' net FX derivative values are comparatively small, as seen in 5b, since their liability values (out-of-the-money positions) closely track asset values. Net-FX derivative values also change sign over time. For example, aggregating over all banks, net-FX derivative valuations turn sharply negative in the 2010s, a period in which the USD appreciated strongly, which also coincides with the value of banks' on-balance-sheet dollar debt positions turning positive

[19] Specifically, we use the Bank of England's 'Quarterly derivatives (DQ)' forms.

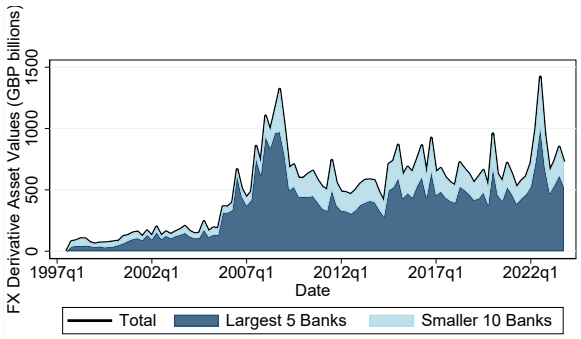
[20] While the value of banks' debt holdings and FX derivatives positions may adjust due to quantity changes, there is evidence that most variation in values at quarterly frequency comes from price changes (Rey et al., 2024).

[21] We refer to bank i being net-long USD via an FX derivative (e.g., an FX swap) if they receive USD in the far leg of the contract. As the USD appreciates (in excess of the fixed forward rate $\mathcal{F}$), such a net-long USD derivative position increases in value, since i can expect to sell the USD it receives at expiry in the spot market at a better rate (greater than $\mathcal{F}$).

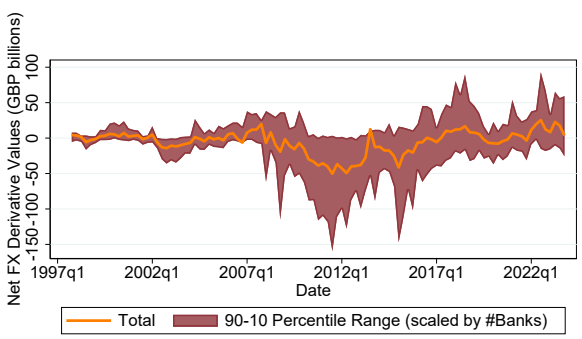
[22] Banks are only required to report derivatives values in a given quarter when their gross values exceed 10 billion GBP. As such, we focus on the 15 banks that report in all quarters. Since the derivatives market is highly concentrated, these 'intensive' banks capture on-average over 90% the entire sector's market value over our sample.

Figure 5: UK-Resident Banks' Total and Net FX Derivative Asset Values

(a) FX Derivative Asset Values



(b) Net FX Derivative Values



Notes: Figure 5a presents the total value of all UK-resident banks' FX derivative assets (i.e., in-the-money contracts) from 1997Q3 to 2023Q3, with dark and light shadings denoting to the values held by the largest 5 banks (on average over the sample) and other 10 smaller banks, respectively. Figure 5b plots the net (assets minus liabilities) value of UK-resident banks FX derivatives holdings over the same period, with the shaded region denoting the range between 90^{th} and 10^{th} percentiles of the distribution (scaled by the number of banks). The sample is restricted to the 15 largest banks that report in each quarter of our sample, and who together hold on-average over 90% the entire sector's market value.

(see Figure 3b). This pattern is consistent with FX derivatives serving, on average, as a hedge against USD-debt exposures in the UK banking sector during this period. In particular, it suggests that the UK banking system, while issuing net dollar loans, were net-short USD via FX derivatives, consistent with the exposure of UK-resident non-dealer banks in Hacioglu-Hoke et al. (2026). Importantly, however, there is substantial cross-sectional heterogeneity in the sign of net FX derivative valuations, as reflected in the shaded 10^{th}–90^{th} percentile range. We therefore focus on the co-movement between the values of banks' net FX derivative and on-balance-sheet net USD positions at the *bank level* in our subsequent empirical analysis.

3 Theoretical Framework

To guide this empirical analysis, in this section, we present a granular model of exchange rate determination, featuring capital flow shocks in imperfect financial markets. The model builds on the Gamma model (Gabaix and Maggiori, 2015), but differs in several key respects. First, since a small number of large banks account for the majority of cross-border activity, we introduce heterogeneity in risk-taking capacity across banks. Second, banks have heterogeneous and time-varying 'beliefs' about cross-border asset returns. Together, these extensions imply that the beliefs of the largest banks exert the greatest influence on equilibrium exchange-rate dynamics. Third, banks trade financial assets with a set of ROW funds, so exchange rates are determined by the supply and demand for assets by different financial agents (i.e., banks and

funds). While these generalisations allow us to bridge the gap between theory and our data, our Granular Gamma model still nests the original model setup.

3.1 The Granular Gamma Model

Consider a price-taking UK-resident bank i who, at time t, has access to a foreign financial asset j with a risky USD-denominated return $R^j_{t+1} = 1 + r^j_{t+1}$ and a known domestic opportunity cost $R_t = 1 + r_t$ expressed in GBP.[23] Bank i's optimal demand $Q^j_{i,t}$ for USD asset j at time t maximises expected profits in GBP:[24]

$$V^j_{i,t} = \max_{Q^j_{i,t}>0} \mathbb{E}_t \left[\exp(b^j_{i,t}) \cdot \left(\frac{R^j_{t+1}}{R_t} \frac{\mathcal{E}_{t+1}}{\mathcal{E}_t} - 1 \right) \right] Q^j_{i,t}, \tag{1}$$

where the exchange rate $\mathcal{E}_t$ is the price of a USD in GBP (so an increase corresponds to a USD appreciation) and $b^j_{i,t}$ is bank i's subjective belief at time t about the excess return from asset j, $\frac{R^j_{t+1}}{R_t} \frac{\mathcal{E}_{t+1}}{\mathcal{E}_t} - 1$, earned at time $t+1$.[25] By including the bank-specific belief wedge $b^j_{i,t}$, we allow for time-varying deviations from rational expectations.[26] These time-varying beliefs can be driven by both bank-level and aggregate *demand shifters*, that act as financial shocks to UIP.[27]

Following Gabaix and Maggiori (2015), we assume banks have limited risk-bearing capacity because they can divert a fraction $\Gamma^j_i Q^j_{i,t}$ of their invested/borrowed quantity $Q^j_{i,t}$ for personal use. Different from the original setup, we allow Γ^j_i to depend on i, implying heterogeneity in risk-bearing capacity across banks. This agency problem gives rise to an incentive-compatibility constraint that ensures that banks do not divert resources in equilibrium:

$$V^j_{i,t} \geq \Gamma^j_i Q^j_{i,t} \cdot Q^j_{i,t}, \tag{2}$$

which requires expected profits to weakly exceed the value of divertable resources. A higher Γ^j_i tightens bank i's constraint, reflecting a reduction in risk-bearing capacity.

In equilibrium, since the maximand (1) is linear in $Q^j_{i,t}$ and the constraint (2) is quadratic,

[23] As in Gabaix and Maggiori (2015), R_t can be equal to $1/\beta$, where $\beta \in (0,1)$ is the household discount factor.

[24] Both foreign- and UK-owned banks residing in the UK must report profits in GBP for regulatory reasons.

[25] Our dataset includes separate records for assets and liabilities, so we can investigate each individually. We present in equation (1) the asset case where $\mathbb{E}_t(\exp(b^j_{i,t}) \cdot (\frac{R^j_{t+1}}{R_t} \frac{\mathcal{E}_{t+1}}{\mathcal{E}_t} - 1)) > 0$ so bank i optimally chooses a long position in asset j, $Q^j_{i,t} > 0$, financed by shorting the domestic safe asset. The liability case ($Q^j_{i,t} < 0$) where bank i invests in the domestic safe asset and shorts asset j is analogous because the problem is symmetric about a zero-excess return.

[26] Similar 'belief' shocks have been used in a large literature studying incomplete information, irrational expectations and heterogeneous beliefs in international macroeconomics (e.g., Evans and Lyons, 2002; Bacchetta and Van Wincoop, 2006; Burnside, Eichenbaum, Kleshchelski, and Rebelo, 2011).

[27] In our empirical analysis, in Section 4, we explain further how $b^j_{i,t}$ can be defined more broadly as a demand shifter. A large literature focuses on such UIP shocks (e.g., Kouri, 1976; Kollmann, 2005; Fahri and Werning, 2014).

the constraint always binds and the solution is:

$$Q_{i,t}^{j} = \frac{1}{\Gamma_i^j} \cdot \mathbb{E}_t \left[\exp(b_{i,t}^{j}) \cdot \left(\frac{R_{t+1}^{j}}{R_t} \frac{\mathcal{E}_{t+1}}{\mathcal{E}_t} - 1 \right) \right], \tag{3}$$

which states that the optimal size of bank i's position in USD asset j is proportional to bank i's beliefs and the expected excess return on j, modulated by their risk-bearing capacity. Equation (3) highlights that differences in risk-bearing capacity Γ_i^j and/or beliefs $b_{i,t}^j$ across banks can generate differences in banks' equilibrium cross-border positions $Q_{i,t}^j$. If $b_{i,t}^j = 0$ and $\Gamma_i^j = \Gamma^j$, (3) collapses to the optimality condition in the baseline Gamma model in Gabaix and Maggiori (2015) with homogeneous banks and rational expectations, but where the return to j is risky.

Approximation. To take this to the data, we approximate equation (3) using a first-order Taylor expansion around the model's steady state and difference the approximate expression over time, to yield:

$$\Delta q_{i,t}^{j} \approx \left(\frac{1 + \overline{Q}_i^j \Gamma_i^j}{\overline{Q}_i^j \Gamma_i^j} \right) \cdot \left(\Delta \mathbb{E}_t[r_{t+1}^j] - \Delta r_t + \Delta \mathbb{E}_t[e_{t+1}] - \Delta e_t \right) + \Delta b_{i,t}^j, \tag{4}$$

where lower-case letters refer to the natural logarithm of variables $e_t := \ln(\mathcal{E}_t)$ and $q_{i,t}^j := \ln(Q_{i,t}^j)$, bars refer to variables in steady state $\overline{Q}_i^j$ and Δ refers to the difference between t and $t-1$ (with $\Delta \mathbb{E}_t[x_{t+1}] := \mathbb{E}_t[x_{t+1}] - \mathbb{E}_{t-1}[x_t]$). Appendix A.1 provides details of this derivation.

Equation (4) relates the percentage change in bank i's demand $\Delta q_{i,t}^j$ for USD-asset j to the percentage change in the asset's expected excess (carry-trade) return $\Delta \mathbb{E}_t[r_{t+1}^j] - \Delta r_t + \Delta \mathbb{E}_t[e_{t+1}] - \Delta e_t$ and the percentage change in bank i's beliefs $\Delta b_{i,t}^j$. The price elasticity of demand $\phi_i^j := \frac{1+\overline{Q}_i^j \Gamma_i^j}{\overline{Q}_i^j \Gamma_i^j}$, which is increasing in bank i's risk-bearing capacity and decreasing in their steady-state amount intermediated, is always greater than 0. Thus, UK bank i's demand curve for USD-asset j is downward sloping in the relative price of USD e_t. Changes in bank i's beliefs serve to shift their demand for asset j and, consequently, for USD.

We consider a symmetric steady state in which beliefs are the same for all banks: $\overline{b}_i^j = \overline{b}^j \, \forall i$. Banks therefore agree on the expected return to asset j in steady state, $\exp(\overline{b}^j)(\frac{\overline{R}^j}{\overline{R}} - 1)$, and so take steady-state cross-border positions $\overline{Q}_i^j$ that are inversely proportional to their risk-bearing capacities Γ_i^j.[28] As a result, price elasticities of demand are the same for all banks around the

[28] That is, in steady state, equation (3) is $\overline{Q}_i^j = \frac{1}{\Gamma_i^j} \left[\exp(\overline{b}^j) \cdot \left(\frac{\overline{R}^j}{\overline{R}} - 1 \right) \right]$ such that $\overline{Q}_i^j \Gamma_i^j$ is independent of i.

steady state $\phi_i^j := \phi_B^j \; \forall i$:

$$\Delta q_{i,t}^j \approx \phi_B^j \cdot \Big(\Delta \mathbb{E}_t[r_{t+1}^j] - \Delta r_t + \Delta \mathbb{E}_t[e_{t+1}] - \Delta e_t \Big) + \Delta b_{i,t}^j. \tag{5}$$

This arises because, although banks with greater risk-bearing capacities (lower Γ_i^j) tend to have more elastic demand (higher ϕ_i^j), they also take commensurately larger steady-state cross-border positions (higher $\overline{Q}_i^j$), which decreases their demand elasticity until ϕ_i^j is constant across banks. Appendix A.1 shows that banks' demand elasticity ϕ_B^j can depend on the *average* risk-bearing capacity across all banks (Γ^j) as well as the *total* amount intermediated in steady state by the banking sector ($\overline{Q}^j$), such that $\phi_B^j := \frac{1+\overline{Q}^j\Gamma^j}{\overline{Q}^j\Gamma^j}$.

Importantly, while we have thus far remained agnostic as to the distribution of Γ_i^j, note that under a symmetric steady state with $\overline{b}_i^j = \overline{b}^j \; \forall i$, the distribution across i of $1/\Gamma_i^j$ maps directly to the distribution of $\overline{Q}_i^j$ (see equation (3) in steady state). Therefore, if $1/\Gamma_i^j$ follows a Pareto distribution across banks, then the steady-state bank-size distribution $\overline{Q}_i^j$ does too. This enables us to consider the implications of granularity in bank size observed in the data.

3.2 Global Financial Market Equilibrium

To derive equilibrium conditions for USD asset j, we solve for the aggregate demand of UK-resident banks for j and specify the behaviour of ROW counterparties with respect to j.

We begin by taking the size-weighted average of equation (5), which gives the dynamics of UK-based banks' aggregate demand for cross-border asset j:

$$\Delta q_{S,t}^j = \phi_B^j \Big(\Delta \mathbb{E}_t[r_{t+1}^j] - \Delta r_t + \Delta \mathbb{E}_t[e_{t+1}] - \Delta e_t \Big) + \Delta b_{S,t}^j, \tag{6}$$

where the size-weighted averages (aggregates) are defined as $\Delta q_{S,t}^j := \sum_{i=1}^n S_{i,t-1} \Delta q_{i,t}^j$ and $\Delta b_{S,t}^j := \sum_{i=1}^n S_{i,t-1} \Delta b_{i,t}^j$, using weights $S_{i,t-1}^j := \frac{Q_{i,t-1}^j}{\sum_{i=1}^n Q_{i,t-1}^j}$. Thus, percentage changes in the aggregate demand by UK-resident banks for USD asset j evolve in proportion to expected excess returns and percentage changes in the size-weighted average of their individual beliefs $\Delta b_{S,t}^j$. Again, since the price elasticity ϕ_B^j is greater than 0, the aggregate demand curve is downward sloping in exchange rates, with aggregate beliefs $\Delta b_{S,t}^j$ serving as a demand shifter for asset j and USD. Importantly, the beliefs of granular banks matter disproportionately for aggregate beliefs due to size weighting, and hence matter most for banks' aggregate demand.

To derive dynamics for the ROW's aggregate supply of dollar asset j, we assume there exist a set of ROW 'funds'—any financial agent trading with and taking net exposure *vis-à-vis* UK-resident global banks—whose cross-border positions are analogously linked to their subjective

beliefs, denoted by $b^j_{F,t}$, and expected excess returns:[29]

$$\Delta q^j_{F,t} = -\phi^j_F \left(\Delta \mathbb{E}_t[r^j_{t+1}] - \Delta r_t + \Delta \mathbb{E}_t[e_{t+1}] - \Delta e_t \right) + \Delta b^j_{F,t}. \tag{7}$$

The price elasticity of supply ϕ^j_F, being analogously tied to ROW funds' financial constraints and positions, is always positive. Therefore, funds' aggregate supply curve of US dollar asset j is upward sloping in the relative price of USD Δe_t, with changes in funds' beliefs acting as a supply shifter for asset j and USD.

Combining these equations with global market clearing $\Delta q^j_{S,t} = \Delta q^j_{F,t}$—i.e., equating UK-resident banks' demand for asset j with ROW funds' supply of it—we derive expressions for equilibrium exchange-rate dynamics and the dynamics of domestic-resident banks' aggregate holdings of asset j, as outlined in the following proposition.

Proposition 1 (Equilibrium in Asset Market j) *In the Granular Gamma model, the equilibrium USD appreciation and the percentage change in UK-banks' cross-border holdings of USD-denominated asset j can be approximated by:*

$$\Delta e_t = \frac{1}{\phi^j_B + \phi^j_F} \Delta b^j_{S,t} - \frac{1}{\phi^j_B + \phi^j_F} \Delta b^j_{F,t} + \left(\Delta \mathbb{E}_t[r^j_{t+1}] - \Delta r_t + \Delta \mathbb{E}_t[e_{t+1}] \right), \tag{8}$$

$$\Delta q^j_{S,t} = \frac{\phi^j_F}{\phi^j_B + \phi^j_F} \Delta b^j_{S,t} + \frac{\phi^j_B}{\phi^j_B + \phi^j_F} \Delta b^j_{F,t}. \tag{9}$$

Proof: Combine global market clearing $\Delta q^j_{S,t} = \Delta q^j_{F,t}$ with asset demand, equation (6), and supply, equation (7). See Appendix A.2 for more details. □

Equation (8) highlights that equilibrium relationships between exchange-rate dynamics and changes in beliefs are governed by the multiplier $M^j := \frac{1}{\phi^j_B + \phi^j_F}$, which captures equilibrium feedback effects between prices and quantities. When UK banks become more optimistic about the return to investing in USD-asset j (higher $\Delta b^j_{S,t}$), the USD appreciates against GBP. When ROW funds become more optimistic about the return to selling USD-asset j, (higher $\Delta b^j_{F,t}$), the USD depreciates against GBP. This is because changes in beliefs increase the quantity of asset j demanded and supplied by banks and funds, respectively (see equation (9)).

The exchange rate response to changes in beliefs is also larger when banks' and funds' price elasticities are lower: $M^j \uparrow$ if $\phi^j_B, \phi^j_F \downarrow$. Thus, the set of intermediaries—banks or funds—with more inelastic demand/supply exert greater influence over equilibrium exchange-rate dynam-

[29] Concretely, ROW funds supply the USD asset j to UK banks, invest cross border in the GBP domestic safe asset and evaluate profits in USD.

ics. Intuitively, this is because more inelastic intermediaries require greater compensation via larger exchange rate movements to be willing to adjust the size of their balance sheets—i.e., their foreign currency exposures.[30] Which types of intermediary is more price-elastic is an empirical question, which we address in Section 5.2.

Equilibrium exchange-rate dynamics in equation (8) also depend on expected exchange rate movements and cross-border asset return differentials. We control for these in our empirical analysis.

3.3 Empirical Considerations

Before turning to our empirical strategy, we briefly outline two considerations for extending our baseline Granular Gamma model when confronted with our data.

Inelastic Intermediaries. As in the Gamma model of Gabaix and Maggiori (2015), the functional form of the incentive-compatibility constraint (2) in our Granular Gamma model does not allow for inelastic currency demand—i.e., ϕ_B^j cannot be less than 1. However, estimating equation (5) empirically can in principal deliver any value for the price elasticity ϕ_B^j. This suggests scope to adapt the Gamma model setup to allow for inelastic demand.

One extension could be to alter the divertable fraction to $(\Gamma_i^j Q_{i,t}^j)^{\gamma_i^j}$, with parameter γ_i^j, such that the incentive-compatibility constraint becomes:

$$V_{i,t}^j \geq (\Gamma_i^j Q_{i,t}^j)^{\gamma_i^j} \cdot Q_{i,t}^j.$$

With this exponential friction, the first-order condition of the bank becomes:

$$Q_{i,t}^j = \frac{1}{\Gamma_i^j} \cdot \mathbb{E}_t \left[\exp(b_{i,t}^j) \cdot \left(\frac{R_{t+1}^j}{R_t} \frac{\mathcal{E}_{t+1}}{\mathcal{E}_t} - 1 \right) \right]^{\frac{1}{\gamma_i^j}},$$

which we can approximate as:

$$\Delta q_{i,t}^j \approx \frac{1}{\gamma_i^j} \frac{1 + (\Gamma_i^j \overline{Q}_i^j)^{\gamma_i^j}}{(\Gamma_i^j \overline{Q}_i^j)^{\gamma_i^j}} \cdot \left(\Delta \mathbb{E}_t[r_{t+1}^j] - \Delta r_t + \Delta \mathbb{E}_t[e_{t+1}] - \Delta e_t \right) + \Delta b_{i,t}^j. \tag{10}$$

By redefining $\phi_i^j := \frac{1}{\gamma_i^j} \frac{1+(\Gamma_i^j \overline{Q}_i^j)^{\gamma_i^j}}{(\Gamma_i^j \overline{Q}_i^j)^{\gamma_i^j}}$, the demand curve in (10) can be seen to be analogous to that in (4). Crucially, however, the parameter governing the severity of the agency friction γ_i^j gives

[30] Although ϕ_B^j and ϕ_F^j depend on both the intermediaries' risk-bearing capacity and the steady-state amount intermediated (see equation (4)), only the former can affect the relative value of ϕ_B^j and ϕ_F^j since the two types of financiers must intermediate equal and opposite amounts in equilibrium.

rise to a demand curve for cross-border positions that can have a price elasticity ϕ_i^j below unity. Our empirical results in Section 5.2 will allow us to discern between specific micro-foundations for the Granular Gamma model.

FX Derivatives. Like the Gamma model, our Granular Gamma model assumes that bank i's position in USD-asset j translates exactly into USD exposure. In practice, however, banks can adjust their USD exposures via FX derivatives (see, e.g., Hacioglu-Hoke et al., 2026). For example, bank i can overlay a USD FX derivative (e.g., swap or forward) exposure, denoted $D_{i,t}^j$, such that their total net-USD exposure from holding USD-asset j is given by:

$$X_{i,t}^j := Q_{i,t}^j + D_{i,t}^j.$$

If bank i is constrained by their USD *exposure* $X_{i,t}^j$, rather than their holdings $Q_{i,t}^j$, then their USD demand curve, equation (5), becomes:

$$\Delta x_{i,t}^j \approx \phi_B^{j,X}\Big(\Delta \mathbb{E}_t[r_{t+1}^j] - \Delta r_t + \Delta E_t[e_{t+1}] - \Delta e_t\Big) + \Delta b_{i,t}^j, \tag{11}$$

where $x_{i,t}^j := \ln(X_{i,t}^j)$ and $\phi_B^{j,X} := \left(\frac{1+\overline{X}_i^j \Gamma_i^j}{\overline{X}_i^j \Gamma_i^j}\right)$ denotes the price elasticity of demand of USD exposure with respect to exchange rates. See Appendix A.3 for further details.

The relationship between the elasticities of banks' USD flows to exchange rates ϕ_B^j and of USD exposures to exchange rates $\phi_B^{j,X}$ depends on how changes in banks' dollar derivatives exposures $\Delta d_{i,t}^j := \Delta \ln(D_{i,t}^j)$ co-move with changes in on-balance-sheet dollar positions $\Delta q_{i,t}^j$. In particular, if $\mathrm{Cov}(\Delta q_{i,t}^j, \Delta d_{i,t}^j) > 0$, such that bank i uses FX derivatives to amplify USD exposure (i.e., to speculate), then $\phi_B^{j,X} > \phi_B^j$ since, in this case, on-balance-sheet dollar flows reflect only part of bank i's total adjustment in net dollar exposure to changes in exchange rates (expected returns). Conversely, if $\mathrm{Cov}(\Delta q_{i,t}^j, \Delta d_{i,t}^j) < 0$, such that bank i uses FX derivatives to dampen currency exposure (i.e., to hedge), then $\phi_B^{j,X} < \phi_B^j$ since, in this case, on-balance-sheet dollar flows overstate the change in bank i's net dollar exposure to changes in exchange rates.

A key implication is that movements in ϕ_B^j over time may not only reflect changes in risk-bearing capacity Γ_i^j, but also changes in the extent to which banks use FX derivatives to hedge or speculate. In particular, greater FX hedging via derivatives would increase ϕ_B^j and therefore decrease the multiplier M^j from flows to exchange rates. We will investigate this in Section 5.3 using a proxy for $\mathrm{Cov}(\Delta q_{i,t}^j, \Delta d_{i,t}^j)$ based on the value of banks' FX derivatives positions.

4 Empirical Strategy

Guided by our theoretical framework, we exploit the significant heterogeneity and concentration in banks' cross-border USD positions to construct granular financial (capital-flow) shocks using the GIV approach of Gabaix and Koijen (2024). As we have illustrated in Section 2, some banks are large enough to impact aggregate quantities and their idiosyncratic behaviour survives aggregation. Through the lens of the model described in Section 3, idiosyncratic moves by banks can arise due to changes in beliefs. GIVs then extract the idiosyncratic moves by large, granular banks by comparing their behaviour (via size-weighted aggregation) with the behaviour of average banks (via equal-weighted aggregation). Since these banks are granular, the GIVs are relevant for aggregate capital flows and hence exchange rates.

We proceed by describing our GIV construction and outlining our estimation procedure. Then, we discuss potential threats to identification and how we mitigate those concerns.

4.1 Granular Instrumental Variables

To estimate the elasticities ϕ_B^j and ϕ_F^j, we construct GIVs that capture exogenous idiosyncratic beliefs by granular banks. Using the subscript ξ to denote the difference between the size- and equal-weighted average of any variable $X_{i,t}^j$ such that $X_{\xi,t}^j := X_{S,t}^j - X_{E,t}^j$, with $X_{S,t}^j := \sum_{i=1}^n S_{i,t-1}^j X_{i,t}^j$ and $X_{E,t}^j := \frac{1}{n}\sum_{i=1}^n X_{i,t}^j$, we specify the following form for changes in bank-specific beliefs

$$\Delta b_{i,t}^j = u_{i,t}^j + \lambda_i^j \eta_t^j + \theta^j C_{i,t-1}^j, \quad \text{with} \quad \mathbb{E}[u_{i,t}^j(\eta_t^j, \Delta b_{F,t}^j)] = 0, \tag{12}$$

for all t, where $u_{i,t}^j$ are exogenous unobserved i.i.d. shocks, η_t^j are vectors of unobserved common factors with unobserved bank-specific loadings λ_i^j, and $C_{i,t-1}^j$ are observed controls with unknown coefficients θ^j.[31] Since bank-specific belief shocks $u_{i,t}^j$ are i.i.d., they are uncorrelated with aggregate bank factors (η_t^j) and ROW-fund beliefs ($\Delta b_{F,t}^j$): $\mathbb{E}[u_{i,t}^j(\eta_t^j, \Delta b_{F,t}^j)] = 0$.

We construct our GIV for asset j, z_t^j, from observables, by taking the difference between the size- and equal-weighted change in cross-border holdings $z_t^j := \Delta q_{\xi,t}^j$.[32] Using equation (5), we see that these GIVs admit a structural interpretation through the lens of the Granular Gamma model, being comprised of the size-minus-equal weighted combination of changes in

[31] The unobserved common factors are assumed to take the parametric form: $\lambda_i^j \eta_t^j = \sum_{k=1}^K \lambda_{i,k}^j \eta_{k,t}^j$, where the first factor is a time fixed effect.

[32] Mechanically, this partials out the time fixed effect in the factor structure.

bank-level beliefs $z_t^j = \Delta b_{\xi,t}^j$:

$$z_t^j = u_{\xi,t}^j + \lambda_\xi^j \eta_t^j + \theta^j C_{\xi,t-1}^j. \tag{13}$$

To guard against the possibility that banks' loadings on unobserved common factors are correlated with size ($\lambda_\xi^j \neq 0$), we construct estimates for the common factors η_t^j from principal components of bank-level flows to use as controls.[33] We describe this procedure in detail in Section 4.4. Given that we control for relevant observables $C_{i,t-1}^j$ as well, our GIVs reflect the size-minus-equal weighted combination of i.i.d. bank-level belief *shocks*:

$$z_t^j = u_{\xi,t}^j. \tag{14}$$

Consistent with the GIV procedure removing common shocks, we show in Appendix D that our GIVs, unlike many other instruments in the literature, are unrelated to common proxies of the global financial cycle (see Section 4.4 for further details).

In the subsequent sections, we discuss how these GIVs can be used to estimate the multipliers and elasticities present in the Granular Gamma model. Intuitively, since the GIVs place a greater weight on the beliefs of large banks, idiosyncratic belief shocks to such large banks affect the banking-sectors' aggregate beliefs and are thus *relevant* for exchange rates. Further, when our GIVs reflect the size-minus-equal weighted combination of i.i.d. bank-level belief shocks $z_t^j = u_{\xi,t}^j$, they are *exogenous* as well. We discuss the steps we take to tighten our identification, including a narrative strategy to verify the exogeneity of our GIVs, in Section 4.4.

Since we have data on banks' debt assets (A) and deposit liabilities (L), we can also construct GIVs for banks' *net* debt positions. In particular, we define bank i's net USD-denominated debt flow as $\Delta q_{i,t}^{net} := \frac{1}{2}\left(\Delta q_{i,t}^A - \Delta q_{i,t}^L\right)$ since $\overline{Q}^A \approx \overline{Q}^L$. Using equation (5), the bank-level net flow reflects

$$\Delta q_{i,t}^{net} = \phi_B^{net}\left(\frac{1}{2}\mathbb{E}_t[r_{t+1}^A - r_{t+1}^L] - \Delta r_t + \Delta \mathbb{E}_t[e_{t+1}] - \Delta e_t\right) + \frac{1}{2}\left(\Delta b_{i,t}^A - \Delta b_{i,t}^L\right), \tag{15}$$

where, since $\overline{Q}^A \approx \overline{Q}^L$, we treat $\phi_B^A \approx \phi_B^L$, which we label as ϕ_B^{net}. This equation illustrates that we can treat $j = net$ analogously to both $j = \{A, L\}$ with $\Delta b_{i,t}^{net} := \frac{1}{2}\left(\Delta b_{i,t}^A - \Delta b_{i,t}^L\right)$ and

[33] Specifically, we residualise $\Delta q_{i,t}^j$ with respect to our estimates of the common factors η_t^j (alongside $C_{i,t-1}^j$) prior to constructing $z_t^j := \Delta q_{\xi,t}^j$. We also control for η_t^j (and $C_{i,t-1}^j$) in our regression specifications for inference.

$\mathbb{E}_t[r^{net}_{t+1}] := \frac{1}{2}\mathbb{E}_t\left[r^A_{i,t+1} - r^L_{i,t+1}\right]$. We can then construct the net-debt GIV as

$$\Delta z^{net}_t := \frac{1}{2}\left(z^{A^D}_t - z^{L^D}_t\right). \tag{16}$$

Since it is net flows that matter for exchange-rate dynamics, we are particularly interested in the effects of our net-debt GIV.

4.2 Multiplier Estimation

We first estimate the causal effect of changes in banks' cross-border USD asset and liability positions on exchange rates, as outlined in Proposition 2. To derive an estimable expression for this 'multiplier' M^j, we use equations (12) and (13) to rewrite the equilibrium condition (8) in terms of observables and an error term:

$$\Delta e_t = M^j z^j_t + \left(\Delta\mathbb{E}_t[r^j_{t+1}] - \Delta r_t + \Delta\mathbb{E}_t[e_{t+1}]\right) + \epsilon^j_t, \tag{17}$$

where $\epsilon^j_t := M^j\left(u^j_{E,t} + \lambda^j_E\eta^j_t + \theta^j C_{Ej,t-1} + \Delta\mathbb{E}_t[b^j_{F,t+1}]\right)$ and $M^j := \frac{1}{\phi^j_B+\phi^j_F}$.

To identify the multiplier M^j with OLS estimation of equation (17), two conditions are required. First, the change in expected excess returns to asset j should be included. Second, the GIV z^j_t must be uncorrelated with the unobserved error term ϵ^j_t, that is, uncorrelated with η^j_t and $C_{Ej,t-1}$ since $u^j_{\xi,t}$ is uncorrelated with the other terms by construction.

To satisfy the first requirement, we estimate the regression implied by equation (17) while including realised changes in short- and long-maturity government bond-yield differentials as control variables, alongside survey data capturing changes in expected exchange rates from *Consensus Economics* (as in Stavrakeva and Tang, 2024) and lags of realised exchange-rate movements. To satisfy the second requirement, the exogeneity of the GIV, we take a number of steps to tighten our identification, which we explain in Section 4.4. These include controlling for weighted bank-level controls (Section 4.4.2), accounting for unobserved common shocks η^j_t using principal-components analysis (Section 4.4.3), a narrative check of the GIVs themselves (Section 4.4.4), and analysing the correlation between our GIV and proxies for the Global Financial Cycle (Section 4.4.5).

4.3 Elasticity Estimation with Two-Stage Least Squares

We then turn to estimate the two price elasticities ϕ^j_B and ϕ^j_F that compose the multiplier, which are defined in equations (6) and (7), respectively, using our GIVs. As we detail below, the same GIV 'bank demand shock' can be used to identify both banks' demand elasticity and

funds' supply elasticity with respect to exchange rates.

To estimate ROW funds' aggregate supply elasticity ϕ_F^j, we use z_t^j as an instrument for the exchange rate Δe_t in regressions for the *size-weighted* change in banks' cross-border positions $\Delta q_{S,t}^j$, as implied by combining equations (7) and market clearing:

$$\Delta q_{S,t}^j = \phi_F^j \Delta e_t - \phi_F^j \left(\Delta \mathbb{E}_t[r_{t+1}^j] - \Delta r_t + \Delta \mathbb{E}_t[e_{t+1}] \right) + \Delta b_{F,t}^j. \tag{18}$$

The instrument's relevance follows from equation (8), which defines the relationship between size-weighted changes in beliefs and exchange-rate dynamics, since belief shocks by large banks survive aggregation. For exogeneity, we need the instrument to be uncorrelated with the error terms in both the first-stage (17) and second-stage (18) regressions: $\mathbb{E}[z_t^j(\epsilon_t^j, \Delta b_{F,t}^j)] = 0$. This corresponds to the classic case of using a demand shock to estimate the supply elasticity.

To estimate UK-resident banks' aggregate demand elasticity ϕ_B^j, we use z_t^j as an instrument for the exchange rate Δe_t in regressions for the *equal-weighted* change in banks' cross-border positions $\Delta q_{E,t}^j$, as implied by taking an equal-weighted average of equation (5):

$$\Delta q_{E,t}^j = -\phi_B^j \Delta e_t + \phi_B^j \left(\Delta \mathbb{E}_t[r_{t+1}^j] - \Delta r_t + \Delta \mathbb{E}_t[e_{t+1}] \right) + \underbrace{u_{E,t}^j + \lambda_E^j \eta_t^j + \theta^j C_{E,t-1}^j}_{:=\nu_t^j}. \tag{19}$$

In this case, the instrument's relevance again follows from equation (8). Similarly, exogeneity requires: $\mathbb{E}[z_t^j(\epsilon_t^j, \nu_t^j)] = 0$. Intuitively, equation (19) builds on the fact that individual banks' currency demands also react to the exchange rate movements induced by granular banks' demand shocks. As a result, we can identify banks' demand elasticity by regressing any weighted sum of banks' idiosyncratic demand flows on our instrumented exchange rate changes, provided these weights are uncorrelated with banks' size (else we recover the supply elasticity).[34]

4.4 Threats to Identification

Here, we describe the additional steps we take to strengthen our identification, prior to estimating the regressions implied by equations (17), (18) and (19). The first of these, the potential presence of exchange-rate valuation effects, are accounted for by the GIV methodology. The next two of these, accounting for bank-level and unobserved common factors, are reflected in our specification of bank-level beliefs in equation (12). The final steps, using narrative techniques to investigate the sources of large movements in our GIV and showing that our GIV is uncorrelated with the global financial cycle, are complementary.

[34] On the other hand, since funds' supply is only affected by granular demand shocks via market clearing, we use banks' size-weighted flows in regression (18) to estimate the supply elasticity.

4.4.1 Exchange-Rate Valuation Effects

A general concern when assessing the relationship between exchange rate changes on quantities of cross-border assets and liabilities is the presence of exchange-rate valuation effects. In principle, these can create a mechanical link between exchange rate changes and quantities that influence any assessment of causal linkages. However, since exchange-rate valuation effects are common across banks, they are accounted for in the construction of our instruments.

To see this, we decompose the change in a bank i's asset-j position, $Q^j_{i,t} - Q^j_{i,t-1}$ into a valuation-effect and capital-flow component according to

$$Q^j_{i,t} - Q^j_{i,t-1} := \underbrace{\left(\frac{\mathcal{E}_t}{\mathcal{E}_{t-1}} R^j_t - 1\right)}_{\text{Valuation Effect}} Q^j_{i,t-1} + \underbrace{F^j_{i,t}}_{\text{Capital Flow}} Q^j_{i,t-1}. \tag{20}$$

With this, the following corollary clarifies how the GIV approach controls for exchange-rate valuation effects.

Corollary 1 (Exchange-Rate Valuation Effects) *In the Granular Gamma model, granular instrumental variables are unaffected by exchange-rate valuation effects:*

$$z^j_t = F^j_{S,t} - F^j_{E,t} \tag{21}$$

Proof: Since $\frac{\mathcal{E}_t}{\mathcal{E}_{t-1}} R^j_t \approx 1$, we can approximate (20) as $F^j_{i,t} = \Delta q^j_{i,t} - \Delta e_t - r^j_t$. This gives the size-weighted capital flow $F^j_{S,t} = \Delta q^j_{S,t} - \Delta e_t - r^j_t$ and the equal-weighted capital flow $F^j_{E,t} = \Delta q^j_{E,t} - \Delta e_t - r^j_t$. Combining these averages with the definition of our instruments $z^j_t := \Delta q^j_{\xi,t}$, we arrive at $z^j_t = F^j_{S,t} - F^j_{E,t}$. □

This corollary implies that our estimates of the exchange-rate multiplier codified in equation (17) will not be affected by valuation effects. Since these correspond also to the multipliers in our first-stage regressions, the same is true of our estimated supply and demand elasticities in equations (18) and (19): they capture the responsiveness of cross-border positions to exchange rate changes, excluding valuation effects.

4.4.2 Bank Controls

A second concern, formalised by equation (12), is how we account for time-varying bank-specific factors $C^j_{i,t}$. Our confidential bank-level data set provides a range of control variables (listed in Appendix B.1) that can account for variation in different banks' cross-border portfo-

lios across time that might not be plausibly exogenous. We use controls for both the asset and liabilities-side of UK-based banks' balance sheets and, using the quarterly bank-level information at our disposal, we construct size- and equal-weighted aggregates of each.

On the asset-side of the balance sheet, we control for the overall size of each bank using a measure of their (log) total assets, deflated by the GDP deflator. In addition, we control for their liquid-asset ratio, to account for potential differences across banks depending on their buffers of liquid assets,[35] as well as the share of banks' foreign assets over total assets to account for *ex ante* differences in the degree of internationalisation across banks.

On the liability-side, we construct controls for banks' core-deposits ratio, to capture the extent to which banks have access to alternative funding sources in the face of shocks, and the commitment share (defined as the percentage of unused commitments over assets). We also control for banks' capital ratio. Our measure is defined as the percentage of a banking organisation's regulatory Tier 1 risk-based capital-to-asset ratio.

4.4.3 Unobserved Common Factors

Additionally, equation (12) highlights a potential role for common shocks to bank-level beliefs η_t^j that have heterogeneous effects across banks λ_i^j. To control for unobserved common shocks η_t^j, we use principal component analysis to obtain estimates of common factors $\hat{\eta}_t^j$. Following Gabaix and Koijen (2024), to do this, we start by rewriting equation (5) using the definition (12) to get:

$$\Delta q_{i,t}^j = \theta_t^j + \theta^j C_{i,t-1}^j + \zeta_{i,t}^j \tag{22}$$

where θ_t^j denotes a time fixed effect for asset j that absorbs the expected returns in $\Delta\mathbb{E}_t[r_{t+1}^j] - \Delta r_t + \Delta\mathbb{E}_t[e_{t+1}] - \Delta e_t$, as well as any other time-varying object that is the same for all banks i, and the error term is $\zeta_{i,t}^j := u_{i,t}^j + \lambda_i^j \eta_t^j$. We denote the residual from a panel regression of $\Delta q_{i,t}^j$ on our bank-level controls $C_{i,t-1}^j$ and a time fixed-effect θ_i^j as $\hat{\zeta}_{i,t}^j$. For each period, we then obtain estimates of the unobserved common factors at time t, $\hat{\eta}_{k,t}^j$ for $k = 1, ..., K$, by performing principle-component analysis on the residuals $\hat{\zeta}_{i,t}^j$ across banks.[36] Intuitively, our estimates $\hat{\eta}_{k,t}^j$ capture factors that explain common movements across banks' capital flows, but which banks load on heterogeneously since we include time fixed effects.

We then construct our GIVs $z_t^j := \Delta q_{\xi,t}^j$ using $\Delta q_{i,t}^j$s that have been residualised with re-

[35] Kashyap and Stein (2000) show that monetary policy can have a greater impact on banks with lower liquid-asset buffers. Cetorelli and Goldberg (2012) show that global banks access liquidity via internal capital markets.

[36] In practice, we keep the first 20 principle components.

spect to our estimates of the common factors $\hat{\eta}^j_{k,t}$ and bank controls $C^j_{i,t-1}$.[37] If our estimates $\hat{\eta}^j_{k,t}$ span the set of unobserved common factors for which banks' loadings correlate with size, then the GIV procedure will recover the exogenous granular belief shocks: $z^j_t = u^j_{\xi,t}$.

4.4.4 Narrative Checks

Finally, we carry out a narrative inspection of our GIVs to assess the extent to which they are driven by plausibly exogenous events. We summarise the headline results from our narrative checks in this subsection. Unfortunately, a complete discussion of this exercise is limited, owing to confidentiality restrictions on our data.

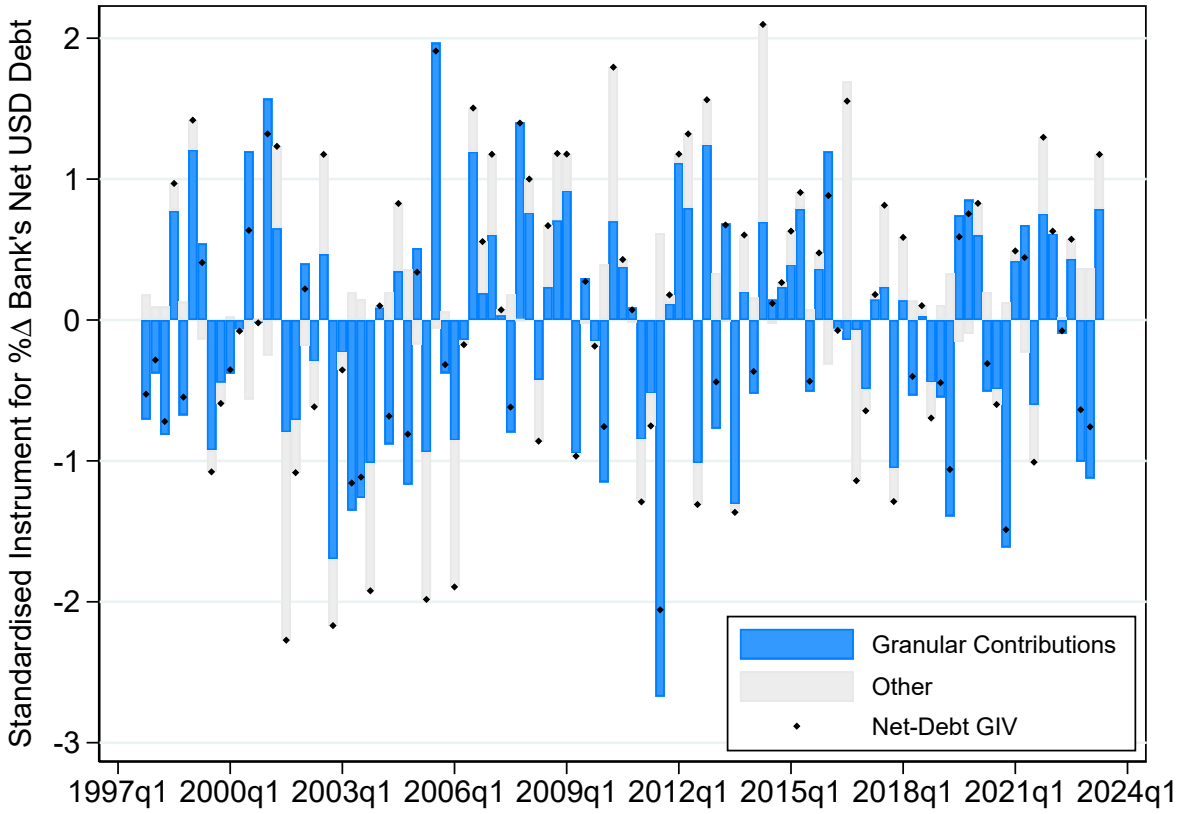
To support our narrative assessment, Figure 6 plots a decomposition of the quarterly GIV for USD-denominated net-debt positions (16), which are normalised to reflect standard-deviation changes relative to the mean. The Figure isolates 'Large Banks' who, in a given period, each individually contribute to at least 10% of the GIV in that period. In each period, the contribution of these 'Large Banks' is summed to deliver the blue bar. In practice, while the exact composition of these 'Large Banks' changes each period, they draw from a small set of institutions in our dataset (< 10). So the plot reveals the granular composition of our GIVs for net USD debt.

Using information available to us about the identity of these large banks, we then carry out a narrative assessment of key events that occur in periods when a given bank contributes to a substantial portion of the GIV for USD-denominated net-debt positions. To do this, we use Open AI's GPT 5 architecture to search and analyse the *Financial Times* archives to identify the key pieces of news pertaining to the large banks which move the GIV in each quarter. Further details of these narrative checks, including sources, are listed in Appendix C.

While this exercise is unlikely to ever fully confirm the exogeneity of the instrument, these checks do reassuringly reveal that the key drivers of moves in the GIV appear associated with idiosyncratic events, which are unlikely to be systematically related to the macroeconomic outlook or possible confounders (e.g., global risk sentiment). Common headlines associated with the bank that moves the GIV the most in a given period are: being involved in a merger or acquisition; governance issues (e.g., fines); adjusting the structure of their operations (e.g., cost cutting); or, in one instance, facing a computer failure that limited its ability to process cross-border payments. The word cloud in Appendix C summarises the key themes from these narrative checks, while preserving the anonymity of the specific large banks that drive variation in our GIV.

[37] We also control for $\hat{\eta}^j_{k,t}$ and $C^j_{i,t-1}$ in our regression specifications for inference.

Figure 6: Granular Bank Contributions to GIV for Net USD Cross-Border Debt Claims



Notes: Decomposition of standardised quarterly granular instrument for net USD-denominated cross-border debt claims over the period 1997Q4-2023Q3. 'Granular Contributions' bar contains total contribution of all banks that explain over 10% of the GIV in a given period. Over the whole sample, this contains a small number of banks (< 10), although a more granular decomposition is not possible owing to confidentiality restrictions on the data.

4.4.5 GIV and the Global Financial Cycle

In addition, as further evidence that our GIVs are composed of idiosyncratic, non-systemic shocks to large banks, we show in Table D.1 in Appendix D that the net-debt GIV plotted in Figure 6 is not correlated with proxies for the Global Financial Cycle. Amongst these proxies, we use the VIX index and the global common risky-asset price factor of Miranda-Agrippino and Rey (2020). Similarly, we also show that our GIV is uncorrelated with the stance of US monetary policy, which has been shown to play a major role in explaining global capital flows.

5 Evidence on Exchange Rates and Banking Flows

We now apply our theoretically-founded empirical framework and present our empirical results for the relationship between cross-border banking flows and exchange rates.

5.1 The Granular Origins of Exchange Rate Fluctuations

To measure the causal multiplier for UK-resident banks' flows into USD assets on the GBP/USD exchange rate, as captured in Proposition 2, we build on equation (17) and estimate the following relationship by OLS:

$$\Delta e_t = \sum_{j=1}^{m} M^j z_t^j + \beta_M' C_t + u_t, \tag{23}$$
$$\text{where} \quad C_t = \left[(\Delta r_{t+1} - \Delta r_{t+1}^*), \Delta \mathbb{E}_t[e_{t+1}], \Delta e_{t-1}, \Delta e_{t-2}, C_{S,t-1}, \hat{\eta}_t^j \right],$$

where we are primarily interested in estimates for the multipliers M^j for $j = \{A, L\}$ and $j = \{net\}$, C_t is a vector of controls with a corresponding vector of coefficients β_M, asterisks (*) denote UK returns, and u_t is a disturbance. Our first set of controls are changes in US-minus-UK local currency return differentials $\Delta r_{t+1}^j - \Delta r_{t+1}^{j,*}$, which we proxy with relative short- (6 month) and long- (10 year) maturity government bond yields.[38] We additionally use *Consensus Economics* forecasts of exchange rates to control for changes in exchange-rate expectations $\mathbb{E}_t[\Delta e_{t+1}]$, as well as two lags of the dependent variable ($\{\Delta e_{t-1}, \Delta e_{t-2}\}$). Next, we include size-weighted, by banks' net debt position, averages of lagged bank-level controls $C_{S,t-1}$, namely banks' total assets, international-asset shares, liquid-asset ratios, core-deposit ratios, commitment shares, and capital ratios. Finally, we include the first twenty principal components extracted from changes in banks' net debt flows $\hat{\eta}_t$ as proxies for unobserved common factors. The sample runs from 1997Q4 to 2022Q4.

Table 1 presents our first set of results. The coefficients on z_t^j represent the causal effect of a 1% increase in UK-resident banks' aggregate holdings of USD instruments on the nominal price of USD in GBP expressed in percent. In Panel A, we report multipliers for USD debt assets and deposit liabilities, estimated jointly. Quantitatively, a 1% flow into USD debt by UK banks appreciates the USD by nearly 0.5% on impact against GBP, within the quarter, while a 1% increase in USD-denominated deposits depreciates the USD by a similar amount. The magnitudes of the estimated multipliers for debt assets and deposit liabilities are remarkably similar to one another—consistent with theory—and are little changed when including controls, although confidence bands are tightened.[39]

In Panel B, we focus in on the multiplier for net-USD debt positions—i.e., USD debt assets minus deposit liabilities. Point estimates imply that a 1% increase in UK banks' net-USD debt position leads to a 0.45% appreciation of the USD *vis-à-vis* GBP on impact. The R^2 in column

[38] We assume that these debt instruments are held to maturity, and so use changes in yields from time $t-1$ to t as our measure of changes in returns.

[39] Coefficients on many of the additional controls are significant, and come with the expected sign.

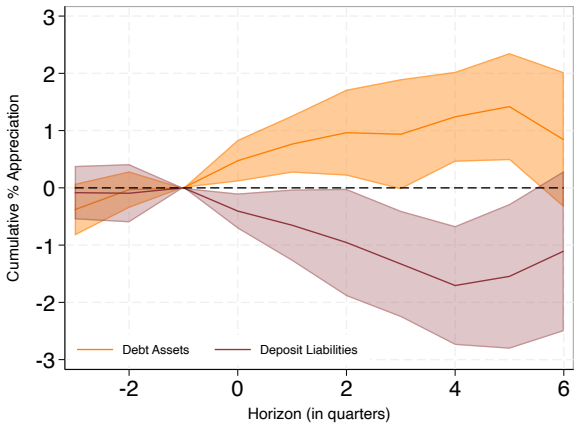
Table 1: Multiplier Estimates for External Asset, Liability and Net Flows on Exchange Rates

	(1)	(2)
	DEP. VAR.: % change nominal GBP/USD (Δe_t)	
PANEL A: Multipliers for USD Debt-Asset and Deposit-Liability Flows		
z_t^A (Debt Assets)	0.42*	0.47**
	(0.21)	(0.22)
z_t^L (Deposits Liabilities)	-0.47*	-0.40**
	(0.26)	(0.19)
$\Delta \mathbb{E}_t[e_{t+1}]$		0.77***
		(0.12)
Δe_{t-1}		-0.29***
		(0.07)
Δe_{t-2}		-0.08*
		(0.04)
$\Delta(r^{us}_{6M,t} - r^{uk}_{6M,t})$		0.02***
		(0.01)
$\Delta(r^{us}_{10Y,t} - r^{uk}_{10Y,t})$		-0.01
		(0.02)
Observations	101	101
Macro Controls	No	Yes
Bank Controls	No	Yes
Components	No	20
R^2	0.04	0.70
PANEL B: Multipliers for Net USD-Debt Flows		
z_t^{net} (Net Debt)	0.44**	0.45**
	(0.22)	(0.20)
Observations	101	101
Macro Controls	No	Yes
Bank Controls	No	Yes
Components	No	20
R^2	0.04	0.69

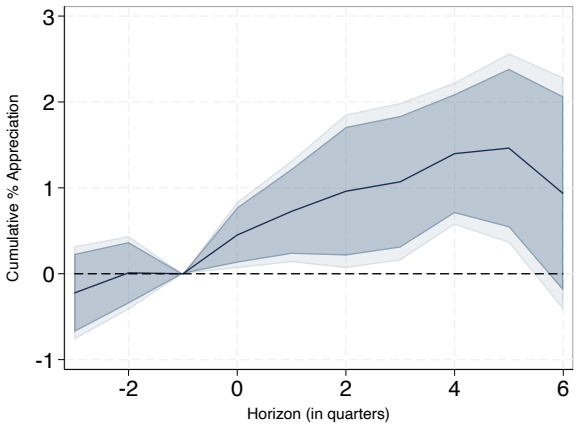
Notes: Coefficient estimates from equation (23) using data for 1997Q4-2022Q4. Panel A presents multiplier estimates for USD debt assets and deposit liabilities (estimated jointly). Panel B presents estimates for net positions, with coefficients on control variables suppressed for presentational purposes. Macro controls: changes in expectations for the GBP/USD exchange rate $\mathbb{E}_t[e_{t+1}]$; two lags of realised GBP/USD exchange rate movements Δe_{t-1} and Δe_{t-2}, 6-month government bond yields $(r^{us}_{6M} - r^{uk}_{6M})$, 10-year government bond yields $(r^{us}_{10Y} - r^{uk}_{10Y})$. Bank controls are (net) size-weighted: total assets, international-asset shares, liquid-asset ratios, core-deposit ratios, commitment shares, capital ratios. Principal components are extracted from changes in net assets. Newey and West (1987) standard errors with 12 lags are in parentheses. Significance at 10%, 5% and 1% denoted by $*$, $**$, and $***$, respectively.

Figure 7: Dynamic Multipliers for Assets, Liabilities and Net Flows on Exchange Rates

(a) Dollar Debt Assets and Deposit Liabilities



(b) Net Dollar-Debt Positions (Debt − Deposits)



Notes: Multiplier estimates from local-projection estimation of equation (23) using data for 1997Q4-2022Q4. Figure 7a presents multiplier estimates for specific assets and liabilities (estimated jointly). Figure 7b presents multiplier estimates for net-debt positions. Shaded areas denote 90% (Panels a and b) and 95% (Panel b) confidence intervals from Newey and West (1987) standard errors with 12 lags. All local projections include the same control variables used in column (4) of Table 1.

(1) from the regression that includes only the net-USD debt GIV is 4%, which is high compared to, e.g., the explanatory power of monetary policy shocks for exchange rates, showcasing the relevance of our granular financial shock for exchange-rate dynamics. Since the multipliers are given by $M^j = \frac{1}{\phi_B^j + \phi_F^j}$, our estimates hint at a fairly inelastic market. This is noteworthy because no-arbitrage theory would predict elasticities to be significantly higher and multipliers to be close to zero.

Next, we extend regression (23) to estimate the dynamic effects of cross-border USD banking flows on the GBP/USD exchange rate. To do this, we estimate the regression as a local projection (Jordà, 2005), directly projecting the h-period-ahead exchange-rate change, $\Delta^h e_{t+h} := e_{t+h} - e_{t-1}$, on the same variables included in the on-impact results in Table 1.

Figure 7a reveals that the causal effects of UK banking flows into USD debt assets and deposit liabilities are persistent. Subsequent to the on-impact multiplier of around 0.45 from column (2) of Table 1, a 1% flow into USD debt assets is associated with a cumulative USD appreciation of around 1.5% one year after the shock. Estimates for the other side of the carry trade, banks' deposit liabilities, reveal a roughly equal and opposite story. Consistent with our model where a persistent increase in demand generates a persistent shift in the level of the exchange rate, these multipliers take 6 quarters to revert back to zero after the initial shock, which may reflect the maturity of the modal debt asset being purchased. Overall, these estimates suggest that equal-and-opposite changes in UK-resident banks' USD debt-asset and

liability positions are associated with near-zero overall effects on the exchange rate.

Figure 7b, however, shows how mismatches in banks' USD-debt asset vs. liability positions can have substantial exchange rate effects. Plotting the impulse response of the GBP/USD exchange rate to exogenous changes in banks' net-USD debt position reveals that a 1% change in banks' net carry-trade position in USD is associated with around a 1.5% appreciation of the USD *vis-à-vis* GBP one year after the shock.

Finally, to put our multiplier estimates for nominal exchange rates into perspective, we translate them into different units to demonstrate how exogenous cross-border banking flows per unit of UK GDP influence the nominal GBP/USD exchange rate one-year ahead. Our results imply that a net flow into USD-denominated debt by UK banks equivalent to 1% of UK GDP appreciates the USD by about 2.5% one year after the shock.

5.2 Elastic Banks and Inelastic Funds

Motivated by these causal effects, we next estimate the supply and demand elasticities for net USD-debt using two-stage least squares. These structural elasticities, which were summarised in Figure 1, underpin the equilibrium exchange-rate dynamics from Section 5.1.

To estimate the supply elasticity for net dollar-debt from ROW 'funds' ϕ_F^{net}, we use the following regression that builds on equation (18):

$$\Delta q_{S,t}^{net} = \phi_F^{net} \Delta e_t + \beta_{\phi_F}^{net} C_t + u_t, \tag{24}$$

where we use z_t^{net} as an instrument for Δe_t, along with the same macroeconomic and size-weighted bank controls C_t from regression (23) which have coefficients denoted by $\beta_{\phi_F}^{net}$.

Panel A of Table 2 presents estimates of the supply elasticity from our second-stage regression. The first-stage F-statistic is significantly above the critical values in Stock and Yogo (2002) and Olea and Pflueger (2013), supporting the relevance of our GIV.[40] The coefficient estimates reveal a significant positive supply relationship between exchange-rate dynamics and cross-border net USD-debt flows, with point estimates for the price elasticity of USD supply from ROW financial players ϕ_F^{net} sitting around 0.5. These inelastic estimates imply that, on average over our sample, ROW funds' flows respond less than proportionately to exchange rate movements—by about a factor of half. This provides evidence in favour of our extended Granular Gamma model with inelastic intermediaries, as outlined in Section 3.3.

To estimate the corresponding demand elasticity for net-USD debt by UK-resident banks

[40] The first-stage results are provided in Appendix D.

Table 2: Supply and Demand Elasticity Estimates for Net Flows *vis-à-vis* Exchange Rates

PANEL A: 2nd Stage for Supply Elasticity (ϕ_F^{net})	
DEP. VAR.: $\Delta q_{S,t}^{net}$	
Δe_t	0.518**
	(0.221)
Observations	101
1st-Stage F-stat.	34.62
Macro Controls	Yes
Bank Controls	Yes
Components	20
PANEL B: 2nd Stage for Demand Elasticity ($-\phi_B^{net}$)	
DEP. VAR.: $\Delta q_{E,t}^{net}$	
Δe_t	-1.856***
	(0.706)
Observations	101
1st-Stage F-stat.	46.75
Macro Controls	Yes
Bank Controls	Yes
Components	20

Notes: PANEL A: Coefficient estimates from regression (24). PANEL B: Coefficient estimates from regression (25). All regressions estimated with data for 1997Q4-2022Q4. Corresponding first-stage regression coefficients reported in Appendix D. Coefficients on macro and bank controls suppressed for presentational purposes. Bank controls are size-weighted (PANEL A) and equal-weighted (PANEL B). The remaining notes from Table 1 concerning the macro controls, bank controls and principle components apply. Newey and West (1987) standard errors with 12 lags are in parentheses. Significance at 10%, 5% and 1% denoted by $*$, $**$, and $***$, respectively.

ϕ_B^{net}, we build on equation (19) using z_t^{net} as an instrument for Δe_t in the following regression:

$$\Delta q_{E,t}^{net} = -\phi_B^{net} \Delta e_t + \beta_{\phi_B}^{net} C_t + u_t, \tag{25}$$

where we now use equal-weighted averages as bank-level controls in C_t, which have coefficients $\beta_{\phi_B}^{net}$.

Panel B of Table 2 presents estimates of the demand elasticity from the second-stage regression (25). Once again, the first-stage F statistics show that our GIV is relevant. In this case, point estimates imply that (the negative of) UK-resident banks' price elasticity of demand for USD debt $-\phi_B^{net}$ is about -1.9. Reassuringly, combining these estimated demand and supply elasticities according to $M^{net} = \frac{1}{\phi_B^{net}+\phi_F^{net}}$ produces multiplier values very similar to those reported in Panel B of Table 1. Interestingly, these estimates indicate that, while the elasticity of USD supply from ROW funds is inelastic with respect to exchange rates, the elasticity of demand by UK-resident banks is elastic on average over our sample—with point estimates lying

significantly above unity. That is, our estimates imply that a 1% appreciation of the USD is associated with a more than proportional increase in USD demand by UK-resident banks—by nearly double.

In decomposing the multiplier $M^{net} = \frac{1}{\phi_B^{net}+\phi_F^{net}}$, the fact that the demand elasticity ϕ_B^{net} lies significantly above the supply elasticity ϕ_F^{net} implies that UK-resident banks help dampen the exchange rate response to financial shocks compared to the average of other market participants, such as various types of non-bank financial institutions. A key implication of funds' inelastic USD supply is that UK banks may face difficulties in securing USD without incurring substantial costs through adverse exchange rate movements.

5.3 Time-Varying Multipliers and Elasticities

In this section, we extend our empirical framework to test for time variation in the banking systems' willingness and ability to absorb capital flows. In particular, we jointly investigate three potential drivers of time-variation in the multiplier from banking flows to exchange rates: (i) bank hedging via FX derivatives; (ii) bank capital; and (iii) financial market volatility. Changes in both bank capital and financial market volatility may directly influence the agency friction at the heart of the Granular Gamma model and hence price elasticities. FX hedging using derivatives, on the other hand, dampens the extent to which net-USD debt flows translate into USD exposures, and so decreases the compensation banks demand for a given agency friction.

Our metric for UK-resident banks' FX hedging via derivatives $Hedge$, informed by our discussion in Section 3.3, is constructed as:

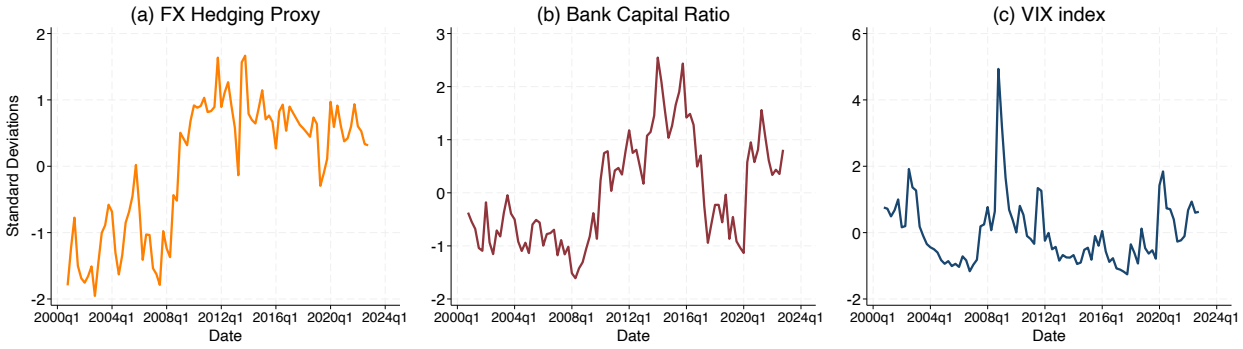
$$Hedge_t := \frac{-1}{N} \sum_{i=1}^{N} \rho_{i,t}^{(12)}[\Delta q_i^{net}, \Delta d_i^{net}], \tag{26}$$

where $\rho_{i,t}^{(12)}[\Delta q_i^{net}, \Delta d_i^{net}]$ refers to the correlation between changes in the value of bank i's on-balance-sheet net-USD debt position and off-balance-sheet FX derivatives position over the preceding 12 quarters. Intuitively, $Hedge_t$ captures the notion that if the value of banks' FX derivative holdings fall when the value of their net-USD debt holdings improves, then FX derivatives are mechanically serving as a hedge ($Hedge_t > 0$). If instead they co-move positively ($Hedge_t < 0$), FX derivatives act as a speculative instrument.

We measure the UK banking system's capitalisation using a size-weighted average of their Tier-1 capital ratios Cap_S, which are a function of both regulatory policy and banks' internal risk-management preferences. We proxy financial market volatility using the VIX index.

Figure 8 plots time series for bank FX hedging activity, bank capital and financial market

Figure 8: Candidate Drivers of Banks' Demand Elasticity



Notes: Time series of FX hedging proxy $Hedge_t$ (Panel a) constructed according to equation (26), size-weighted bank Tier-1 capital ratio $Cap_{S,t}$ (Panel b), and the VIX_t index (Panel c). Variables are z-scored to have zero mean and unit variance. Sample runs from 2000Q4-2022Q4, since we require 12 quarters of data to construct $Hedge_t$. These variables are used as state variables in regression (27) to test for non-linearities in the multiplier from banking flows to exchange rates.

volatility as standardised variables—i.e., as deviations from mean in units of standard deviations. A key observation is our proxy for banks' hedging via FX derivatives sharply increased at the onset of the GFC and remained elevated thereafter (Panel a). This sharp increase reflects a jump in correlation from about -10%—suggesting FX derivatives, on average, served as a speculative tool in the pre-GFC period—to +20%—suggesting they acted more as hedge during and post-GFC. Since we have shown that UK-resident banks were net-short (net-long) USD debt pre- (post-) GFC, these correlations suggest that UK banks were net-short USD via derivatives over our sample, in line with the evidence in Hacioglu-Hoke et al. (2026). By comparison, banks' capital ratios (Panel b) increased later, in the lead-up to the Basel II reforms, fell sharply at the onset of the Fed tightening cycle in 2016, before rebounding when the Fed returned to the ZLB during the Covid-19 pandemic. The VIX index in Panel c displays notable spikes during the dot-com crash, the global financial crisis, the euro-area sovereign debt crisis, and the Covid-19 pandemic.

To test for non-linearities linked to FX derivatives use, bank capital and financial market volatility jointly, we extend regression (23) by interacting our net-USD debt GIV z_t^{net} with each of these standardised state variables $State_t^s = \{VIX_t, Cap_{S,t}, Hedge_t\}$, lagged one period:

$$\Delta e_t = M z_t^{net} + \sum_s \delta^s \left(z_t^{net} \times State_{t-1}^s \right) + \sum_s \vartheta^s State_{t-1}^s + \beta_M^j C_t^j + u_t \tag{27}$$

where M represents the multiplier when banks' FX hedging, capital ratios and financial volatility are at their long-run average and δ^s represents how this multiplier changes when a state

Table 3: Time-Varying Multiplier of Net Flows on Exchange Rates

	(1)	(2)	(3)	(4)
	DEP. VAR.: % change nominal GBP/USD (Δe_t)			
z_t^{net}	0.418*	0.432*	0.429**	0.442**
	(0.248)	(0.232)	(0.189)	(0.196)
$z_t^{net} \times Hedge_{t-1}$	-0.527***			-0.402**
	(0.175)			(0.182)
$z_t^{net} \times Cap_{S,t-1}$		-0.425**		0.067
		(0.180)		(0.246)
$z_t^{net} \times VIX_{t-1}$			0.541***	0.446***
			(0.162)	(0.150)
Observations	89	89	89	89
Macro Controls	Yes	Yes	Yes	Yes
Bank Controls	Yes	Yes	Yes	Yes
Components	20	20	20	20
R^2	0.742	0.734	0.753	0.772

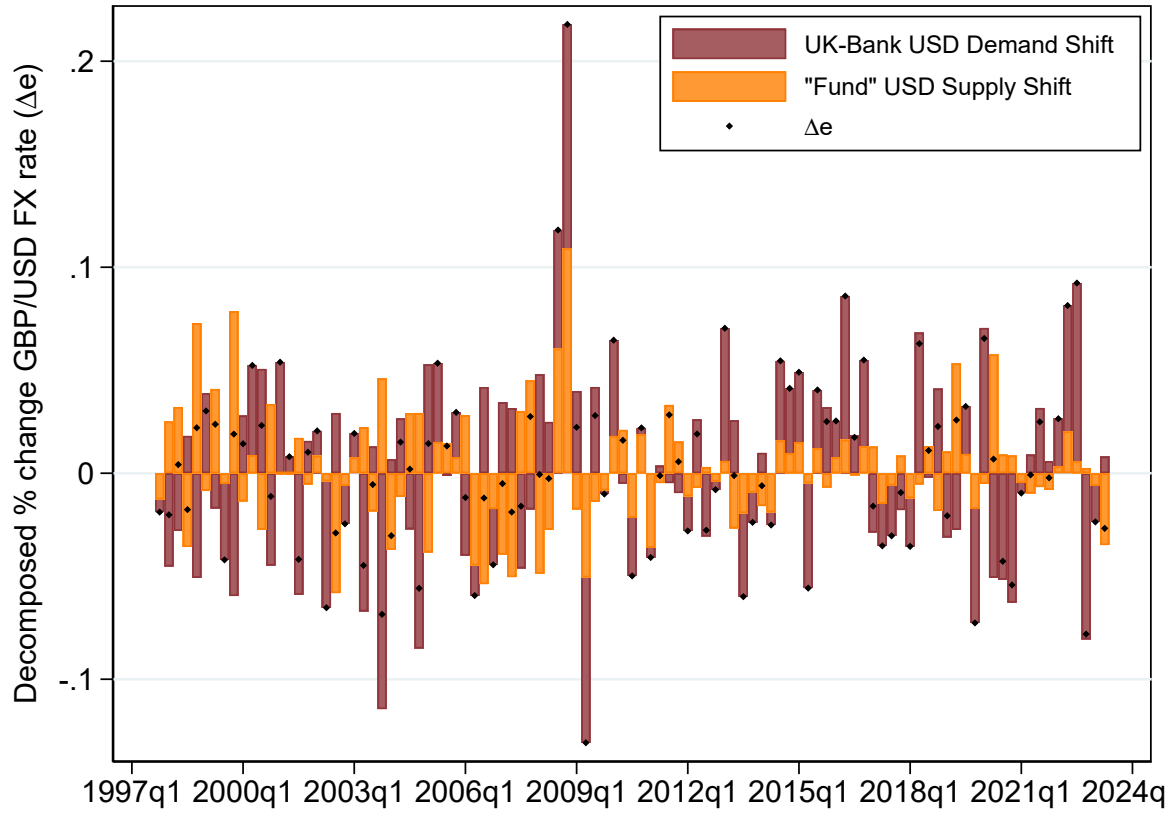
Notes: Coefficient estimates from equation (27) using data from 2000Q4-2022Q4. Coefficients on macro and size-weighted bank controls suppressed for presentational purposes. The remaining notes from Table 1 concerning the macro controls, bank controls and principle components apply. Newey and West (1987) standard errors with 12 lags are in parentheses. Significance at 10%, 5% and 1% denoted by $*$, $**$, and $***$, respectively.

variable s increases by 1 standard deviation.

Table 3 presents our results. In each column, the multiplier M for net-USD debt when the state variables are at their historical averages is about 0.43 and significant, in line with the results from Section 5.1. More importantly, we see that greater bank FX derivative hedging, a lower VIX index and greater bank capital ratios are associated with a lower multiplier from banking flows to exchange rates, although only the former two are significant when all three are included in our preferred regression together, in column (4). Quantitatively, the multiplier can be about fully offset when banks' FX derivative hedging activity is 1 standard deviation above average or the VIX index is 1 standard deviation below, and roughly doubled when these metrics are, respectively, 1 standard deviation below and above average.

These findings highlight that FX derivatives use and financial volatility carry important implications for the relationship between cross-border banking flows and currency markets. In particular, they suggest that increased FX hedging via derivatives—especially in times of low volatility, by flattening banks' demand curves for USDs—significantly dampens the relationship between capital flows and exchange rates. This may help explain the stronger relationship between exchange rates and fundamentals post GFC, especially that UIP cannot be rejected over this period (see, e.g., Bussiere et al., 2022). We test this by separately estimating demand elasticities in 2 distinct states: (i) when banks' hedging via FX derivatives is above

Figure 9: Exchange Rate Decomposition into UK-Bank Demand and Fund Supply Shifts



Notes: Decomposed GBP/USD exchange-rate movements from 1997Q4-2023Q3 into shifts in UK-bank dollar demand (in maroon) and 'fund' dollar supply (in yellow) based on estimated time-varying bank elasticities in Table D.3 and the constant fund supply elasticity in Table 2. Black diamonds refer to realised exchange rate change.

average and financial volatility is not spiking, defined as the VIX being below 1.5 standard deviations above its historical average; and (ii) when banks' hedging is below average and/or the VIX is spiking. The results are presented in Table D.3 and highlight, indeed, that banks are significantly more elastic in state (i) than state (ii).[41]

Finally, armed with our time-varying bank demand, as well as fund supply, elasticities, we decompose realised GBP/USD exchange rate movements into shifts in bank demand and fund supply elasticities for USD debt. Figure 9 presents the results. This decomposition highlights that most exchange rate movements post-GFC reflect demand shifts by UK-resident banks, since their greater FX hedging leads them to be more willing to move into and out of USD debt. Pre-crisis, supply and demand shifts were roughly equally important drivers of exchange rates. Important episodes of heightened market volatility, such as the significant USD appreci-

[41] While in principle time-variation in the multiplier could be due to time-variation in funds' USD supply elasticity, we do not find evidence for this in the data.

ations during the GFC (2008) and euro area debt crisis (2010Q1) as well as following the Brexit Referendum vote (2016Q2) and UK gilt market turbulence (2022Q3), reflect increases in USD demand by both UK banks and their counterparties in a scramble for the safe-haven currency.

Robustness. In Appendix D, we show that our empirical results are robust to: (i) excluding the GFC from our sample; (ii) splitting the sample around the GFC; and (iii) using changes in ex-ante UIP deviations (constructed from survey expectations of exchanges rates from *Consensus Economics*), rather than exchange rate movements, as the dependent variable.

6 Conclusion

In this paper, we have used data on the external assets and liabilities of banks based in the world's largest IFC, the UK, to investigate the granular origins and causal effects of capital-flow shocks. These UK banking positions, which comprise 18% of overall cross-border bank claims and 36% of the UK's total external position, revealed important granularity across banks in relation to their foreign-exchange positions. A small number of large banks account for a large fraction of UK-based banks' net USD debt positions over time.

Motivated by this granularity, we developed a new granular model of exchange rate determination. To test the model's predictions, we identified granular financial shocks by constructing GIVs, which reflect exogenous cross-border banking flows in and out of USD assets by large banks. Using these GIVs, we have shown that cross-border banking flows have a significant causal impact on exchange rates. A 1% increase in UK-resident banks' net-USD debt positions leads to a USD appreciation of 0.5% against GBP on-impact. We have also shown that these effects are highly state dependent, with effects nearly twice as large when banks' FX derivatives hedging is one standard deviation below average and the VIX one standard deviation above. This highlights the importance of banks' time-varying FX derivatives use and risk-bearing capacity for the relationship between capital flows and exchange rates.

Moreover, we have used our granular financial shocks to estimate distinct bank demand and 'fund' supply elasticities in currency markets. Interestingly, our estimates reveal that USD demand by UK-resident banks is price-elastic, on average, with respect to exogenous changes in the exchange rate, whereas the USD supply by ROW financial players is price-inelastic. These findings suggest that banks dampen the exchange-rate response to global financial shocks, especially post-GFC, when banks' greater FX hedging via derivatives flattened their demand curves. In turn, policies that improve banks' and funds' risk-bearing capacities may help mitigate vulnerabilities and improve welfare by further flattening their demand

curves for currency. We defer a deeper investigation of the macroeconomic consequences and policy considerations of our findings to future work.

References

ADRIAN, T. AND P. XIE (2020): "The Non-US bank demand for US dollar assets," Tech. rep., International Monetary Fund.

AIYAR, S., C. CALOMIRIS, J. HOOLEY, Y. KORNIYENKO, AND T. WIELADEK (2014): "The international transmission of bank capital requirements: Evidence from the UK," *Journal of Financial Economics*, 113, 368–382.

ALDASORO, I., P. BELTRÁN, F. GRINBERG, AND T. MANCINI-GRIFFOLI (2023): "The macro-financial effects of international bank lending on emerging markets," *Journal of International Economics*, 142, 103733.

ANDREEVA, D., A. COMAN, M. EVERETT, M. FROEMEL, K. HO, S. LLOYD, B. MEUNIER, J. PEDRONO, D. REINHARDT, A. WONG, E. WONG, AND D. ZOCHOWSKI (2025): "Negative rates, monetary policy transmission and cross-border lending via international financial centers," *Journal of Financial Stability*, 81.

AVDJIEV, S., W. DU, C. KOCH, AND H. S. SHIN (2019): "The dollar, bank leverage, and deviations from covered interest parity," *American Economic Review: Insights*, 1, 193–208.

AVDJIEV, S., B. HARDY, P. MCGUIRE, AND G. VON PETER (2021): "Home sweet host: A cross-country perspective on prudential and monetary policy spillovers through global banks," *Review of International Economics*, 29, 20–36.

BACCHETTA, P. AND E. VAN WINCOOP (2006): "Can Information Heterogeneity Explain the Exchange Rate Determination Puzzle?" *American Economic Review*, 96, 552–576.

BAHAJ, S., P. DELLA CORTE, D. MASSACCI, AND E. SEYDE (2024): "Beyond bilateral flows: indirect connections and exchange rates," Tech. rep., Available at SSRN 4951075.

BARBIERO, O., F. BRAUNING, G. JOAQUIM, AND H. STEIN (2024): "Dealer Risk Limits and Currency Returns," Working Papers 24-11, Federal Reserve Bank of Boston.

BECK, T., S. P. LLOYD, D. REINHARDT, AND R. SOWERBUTTS (2023): "Macro-Financial Policy in an International Financial Centre: The UK Experience Since the Global Financial Crisis," in *Macro-Financial Stability Policy in a Globalised World: Lessons from International Experience*, ed. by C. Borio, E. S. Robinson, and H. S. Shin, World Scientific Publishing Co. Pte. Ltd., World Scientific Book Chapters, chap. 10, 184–223.

BECKER, J., M. SCHMELING, AND A. SCHRIMPF (2023): "Global Bank Lending and Exchange Rates," Working paper, Bank for International Settlements.

BIS (2025): "Triennial Central Bank Survey of Foreign Exchange and OTC Derivatives Markets," Tech. rep., BIS.

BLANCHARD, O., J. D. OSTRY, A. R. GHOSH, AND M. CHAMON (2016): "Capital Flows: Expansionary or Contractionary?" *American Economic Review*, 106, 565–569.

BRÄUNING, F. AND V. IVASHINA (2020): "Monetary policy and global banking," *The Journal of Finance*, 75, 3055–3095.

BRUNNERMEIER, M. K., S. NAGEL, AND L. H. PEDERSEN (2008): "Carry trades and currency crashes," *NBER macroeconomics annual*, 23, 313–348.

BRUNO, V. AND H. S. SHIN (2015): "Cross-border banking and global liquidity," *The Review of Economic Studies*, 82, 535–564.

BURNSIDE, C., M. EICHENBAUM, I. KLESHCHELSKI, AND S. REBELO (2011): "Do Peso Problems Explain the Returns to the Carry Trade?" *The Review of Financial Studies*, 24, 853–891.

BUSSIERE, M., M. CHINN, L. FERRARA, AND J. HEIPERTZ (2022): "The New Fama Puzzle," *IMF Economic Review*, 70, 451–486.

BUSSIÈRE, M., R. HILLS, S. P. LLOYD, B. MEUNIER, J. PEDRONO, D. REINHARDT, AND R. SOWERBUTTS (2021): "Le Pont de Londres: Interactions between monetary and prudential policies in cross-border lending," *Review of International Economics*, 29, 61–86.

CAMANHO, N., H. HAU, AND H. REY (2022): "Global Portfolio Rebalancing and Exchange Rates," *The Review of Financial Studies*, 35, 5228–5274.

CENEDESE, G., P. DELLA CORTE, AND T. WANG (2021): "Currency mispricing and dealer balance sheets," *The Journal of Finance*, 76, 2763–2803.

CESA-BIANCHI, A., R. DICKINSON, S. KOSEM, S. P. LLOYD, AND E. MANUEL (2021): "No economy is an island: how foreign shocks affect UK macrofinancial stability," *Bank of England Quarterly Bulletin*, 61, 1–1.

CESA-BIANCHI, A., A. FERRERO, AND A. REBUCCI (2018): "International credit supply shocks," *Journal of International Economics*, 112, 219–237.

CETORELLI, N. AND L. S. GOLDBERG (2012): "Banking globalization and monetary transmission," *The Journal of Finance*, 67, 1811–1843.

CHAHROUR, R., V. CORMUN, P. DE LEO, P. GUERRON, AND R. VALCHEV (2024): "Exchange Rate Disconnect Revisited," NBER Working Papers 32596, National Bureau of Economic Research, Inc.

CZECH, R., P. DELLA CORTE, S. HUANG, AND T. WANG (2022): "FX option volume," Tech. rep., Bank of England.

DAO, M. C., P.-O. GOURINCHAS, AND O. ITSKHOKI (2025): "Breaking Parity: Equilibrium Exchange Rates and Currency Premia," Tech. rep., National Bureau of Economic Research.

DELLA CORTE, P., S. J. RIDDIOUGH, AND L. SARNO (2016): "Currency premia and global imbalances," *The Review of Financial Studies*, 29, 2161–2193.

DU, W., A. W. HUBER, ET AL. (2024): "Dollar asset holdings and hedging around the globe," Tech. rep., National Bureau of Economic Research.

DU, W., A. TEPPER, AND A. VERDELHAN (2018): "Deviations from covered interest rate parity," *The Journal of Finance*, 73, 915–957.

EGUREN-MARTIN, F., M. OSSANDON BUSCH, AND D. REINHARDT (2023): "Global Banks and Synthetic Funding: The Benefits of Foreign Relatives," *Journal of Money, Credit and Banking*.

ENGEL, C., K. KAZAKOVA, M. WANG, AND N. XIANG (2022): "A reconsideration of the failure of uncovered interest parity for the US dollar," *Journal of International Economics*, 136, 103602.

ENGEL, C. AND S. P. Y. WU (2023): "Liquidity and exchange rates: An empirical investigation," *The Review of Economic Studies*, 90, 2395–2438.

——— (2024): "Exchange Rate Models are Better than You Think, and Why They Didn't Work in the Old Days," Tech. rep., National Bureau of Economic Research.

EVANS, M. D. D. AND R. K. LYONS (2002): "Order Flow and Exchange Rate Dynamics," *Journal of Political Economy*, 110, 170–180.

FAHRI, E. AND I. WERNING (2014): "Dilemma Not Trilemma? Capital Controls and Exchange Rates with Volatile Capital Flows," *IMF Economic Review*, 62, 569–605.

FAMA, E. F. (1984): "Forward and spot exchange rates," *Journal of Monetary Economics*, 14, 319–338.

FORBES, K., D. REINHARDT, AND T. WIELADEK (2017): "The spillovers, interactions, and (un)intended consequences of monetary and regulatory policies," *Journal of Monetary Economics*, 85, 1–22.

FRIEDMAN, M. (1953): "The case for flexible exchange rates," *Essays in Positive Economics*, 157, 33.

FROOT, K. A. AND T. RAMADORAI (2005): "Currency returns, intrinsic value, and institutional-investor flows," *The Journal of Finance*, 60, 1535–1566.

FUKUI, M., E. NAKAMURA, AND J. STEINSSON (2025): "The Macroeconomic Consequences of Exchange Rate Depreciations," *The Quarterly Journal of Economics*, 140, 3015–3065.

GABAIX, X. (2009): "Power Laws in Economics and Finance," *Annual Review of Economics*, 1, 255–294.

——— (2011): "The Granular Origins of Aggregate Fluctuations," *Econometrica*, 79, 733–772.

GABAIX, X. AND R. S. J. KOIJEN (2021): "In Search of the Origins of Financial Fluctuations: The Inelastic Markets Hypothesis," NBER Working Papers 28967, National Bureau of Economic Research, Inc.

——— (2024): "Granular Instrumental Variables," *Journal of Political Economy*, 132, 2274–2303.

GABAIX, X. AND M. MAGGIORI (2015): "International Liquidity and Exchange Rate Dynamics," *The Quarterly Journal of Economics*, 130, 1369–1420.

GOURINCHAS, P.-O., W. D. RAY, AND D. VAYANOS (2022): "A Preferred-Habitat Model of Term Premia, Exchange Rates, and Monetary Policy Spillovers," NBER Working Papers 29875, National Bureau of Economic Research, Inc.

GREENWOOD, R., S. HANSON, J. C. STEIN, AND A. SUNDERAM (2023): "A Quantity-Driven Theory of Term Premia and Exchange Rates," *The Quarterly Journal of Economics*.

GÜRKAYNAK, R. S., B. SACK, AND J. H. WRIGHT (2007): "The US Treasury yield curve: 1961 to the present," *Journal of Monetary Economics*, 54, 2291–2304.

HACIOGLU-HOKE, S., D. A. OSTRY, H. REY, A. R. PLANAT, V. STAVRAKEVA, AND J. TANG (2026): "Topography of the FX Derivatives Market: A View from London," Tech. rep., National Bureau of Economic Research.

HAU, H., M. MASSA, AND J. PERESS (2010): "Do Demand Curves for Currencies Slope Down? Evidence from the MSCI Global Index Change," *The Review of Financial Studies*, 4, 1681–1717.

HAU, H. AND H. REY (2004): "Can portfolio rebalancing explain the dynamics of equity returns, equity flows, and exchange rates?" *American Economic Review*, 94, 126–133.

——— (2006): "Exchange rates, equity prices, and capital flows," *The Review of Financial Studies*, 19, 273–317.

ITSKHOKI, O. AND D. MUKHIN (2021): "Exchange Rate Disconnect in General Equilibrium," *Journal of Political Economy*, 129, 2183–2232.

——— (2025a): "Mussa Puzzle Redux," *Econometrica*, 93, 1–39.

——— (2025b): "What Drives the Exchange Rate?" *IMF Economic Review*, 73, 86–117.

IVASHINA, V., D. S. SCHARFSTEIN, AND J. C. STEIN (2015): "Dollar funding and the lending behavior of global banks," *The Quarterly Journal of Economics*, 130, 1241–1281.

JEANNE, O. AND A. K. ROSE (2002): "Noise trading and exchange rate regimes," *The Quarterly Journal of Economics*, 117, 537–569.

JIANG, Z., A. KRISHNAMURTHY, AND H. LUSTIG (2021): "Foreign safe asset demand and the dollar exchange rate," *The Journal of Finance*, 76, 1049–1089.

JORDÀ, O. (2005): "Estimation and Inference of Impulse Responses by Local Projections," *American Economic Review*, 95, 161–182.

KASHYAP, A. AND J. STEIN (2000): "What Do a Million Observations on Banks Say about the Transmission of Monetary Policy?" *American Economic Review*, 90, 407–428.

KEKRE, R. AND M. LENEL (2024): "Exchange rates, natural rates, and the price of risk," Tech. Rep. 2024-114, University of Chicago, Becker Friedman Institute for Economics Working Paper.

KHETAN, U. (2024): "Synthetic dollar funding," Tech. rep., Available at SSRN.

KLOKS, P., E. MATTILLE, AND A. RANALDO (2024): "Hunting for dollars," Tech. Rep. 24-52, Swiss Finance Institute Research Paper.

KOIJEN, R. S. J. AND M. YOGO (2019): "A Demand System Approach to Asset Pricing," *Journal of Political Economy*, 127, 1475–1515.

——— (2020): "Exchange Rates and Asset Prices in a Global Demand System," NBER Working Papers 27342, National Bureau of Economic Research, Inc.

KOLLMANN, R. (2005): "Macroeconomic effects of nominal exchange rate regimes: new insights into the role of price dynamics," *Journal of International Money and Finance*, 24, 275–292.

KOURI, P. J. K. (1976): "The Exchange Rate and the Balance of Payments in the Short Run and in the Long Run: A Monetary Approach," *Scandinavian Journal of Economics*, 78, 280–304.

——— (1981): "Balance of payments and the foreign exchange market: A dynamic partial equilibrium model," Tech. rep., National Bureau of Economic Research.

KUBITZA, C., J.-D. SIGAUX, AND Q. VANDEWEYER (2024): "The implications of CIP deviations for international capital flows," Tech. Rep. 24-18, Fama-Miller Working Paper, Chicago Booth Research Paper.

LANE, P. R. AND G. M. MILESI-FERRETTI (2018): "The External Wealth of Nations Revisited: International Financial Integration in the Aftermath of the Global Financial Crisis," *IMF Economic Review*, 66, 189–222.

LIAO, G. Y. AND T. ZHANG (2025): "The hedging channel of exchange rate determination," *The Review of Financial Studies*, 38, 1–38.

LILLEY, A., M. MAGGIORI, B. NEIMAN, AND J. SCHREGER (2022): "Exchange rate reconnect," *Review of Economics and Statistics*, 104, 845–855.

LLOYD, S. P., D. REINHARDT, AND R. SOWERBUTTS (2023): "Financial services trade restrictions and lending from an international financial centre," Bank of England working papers 1022, Bank of England.

LU, L. AND J. WALLEN (2024): "What Do Bank Trading Desks Do?" Tech. rep., Available at SSRN 4898830.

MEESE, R. A. AND K. ROGOFF (1983): "Empirical exchange rate models of the seventies : Do they fit out of sample?" *Journal of International Economics*, 14, 3–24.

MIRANDA-AGRIPPINO, S. AND H. REY (2020): "US monetary policy and the global financial cycle," *The Review of Economic Studies*, 87, 2754–2776.

MOSKOWITZ, T. J., C. P. ROSS, S. Y. ROSS, AND K. VASUDEVAN (2024): "Quantities and covered-interest parity," Tech. rep., National Bureau of Economic Research.

NENOVA, T. (2025): "Global or regional safe assets: evidence from bond substitution patterns," Tech. rep., ECB Working Paper.

NEWEY, W. AND K. WEST (1987): "A Simple, Positive Semi-definite, Heteroskedasticity and Autocorrelation Consistent Covariance Matrix," *Econometrica*, 55, 703–08.

OBSTFELD, M. AND K. ROGOFF (2000): "The Six Major Puzzles in International Macroeconomics: Is There a Common Cause?" in *NBER Macroeconomics Annual 2000, Volume 15*, National Bureau of Economic Research, Inc, NBER Chapters, 339–412.

OLEA, J. L. M. AND C. PFLUEGER (2013): "A robust test for weak instruments," *Journal of Business & Economic Statistics*, 31, 358–369.

OSTRY, D. A. (2023): "Tails of Foreign Exchange-at-Risk (FEaR)," Cambridge Working Papers in Economics 2343, Faculty of Economics, University of Cambridge.

REY, H., A. ROUSSET PLANAT, V. STAVRAKEVA, AND J. TANG (2024): "Elephants in Equity Markets," Working Paper 32756, National Bureau of Economic Research.

RIME, D., A. SCHRIMPF, AND O. SYRSTAD (2022): "Covered interest parity arbitrage," *The Review of Financial Studies*, 35, 5185–5227.

SHLEIFER, A. AND R. W. VISHNY (1997): "The Limits of Arbitrage," *The Journal of Finance*, 52, 35–55.

STAVRAKEVA, V. AND J. TANG (2024): "A Fundamental Connection: Exchange Rates and Macroeconomic Expectations," *Review of Economics and Statistics*.

STOCK, J. H. AND M. YOGO (2002): "Testing for weak instruments in linear IV regression," .

Appendix

A Model Appendix

A.1 Details on Approximation

We approximate the model using a first-order Taylor expansion of the bank's optimality condition:

$$Q_{i,t}^j = \frac{1}{\Gamma_i^j} \cdot \mathbb{E}_t \left[B_{i,t}^j \left(\frac{R_{t+1}^j}{R_t} \frac{\mathcal{E}_{t+1}}{\mathcal{E}_t} - 1 \right) \right] \tag{A.1}$$

around the steady state $\overline{Q}_i^j = \frac{1}{\Gamma_i^j} \left(\overline{B}_i^j \left(\frac{\overline{R}^j}{\overline{R}} \frac{\overline{\mathcal{E}}}{\overline{\mathcal{E}}} - 1 \right) \right)$ where we used $B_{i,t}^j := \exp(b_{i,t}^j)$. We derive the approximation in the following steps:

$$\begin{aligned}
\overline{Q}_i^j + (Q_{i,t}^j - \overline{Q}_i^j) \approx & \frac{1}{\Gamma_i^j} \cdot \mathbb{E}_t \left[\overline{B}_i^j \left(\frac{\overline{R}^j}{\overline{R}} \frac{\overline{\mathcal{E}}}{\overline{\mathcal{E}}} - 1 \right) + \left(\frac{\overline{R}^j}{\overline{R}} \frac{\overline{\mathcal{E}}}{\overline{\mathcal{E}}} - 1 \right) (B_{i,t}^j - \overline{B}_i^j) + \overline{B}_i^j \frac{1}{\overline{R}} \frac{\overline{\mathcal{E}}}{\overline{\mathcal{E}}} (R_{t+1}^j - \overline{R}^j) \right. \\
& \left. - \overline{B}_i^j \frac{\overline{R}^j}{\overline{R}^2} \frac{\overline{\mathcal{E}}}{\overline{\mathcal{E}}} (R_t - \overline{R}) + \overline{B}_i^j \frac{\overline{R}^j}{\overline{R}} \frac{1}{\overline{\mathcal{E}}} (\mathcal{E}_{t+1} - \overline{\mathcal{E}}) - \overline{B}_i^j \frac{\overline{R}^j}{\overline{R}} \frac{\overline{\mathcal{E}}}{\overline{\mathcal{E}}^2} (\mathcal{E}_t - \overline{\mathcal{E}}) \right] \\
(Q_{i,t}^j - \overline{Q}_i^j) \approx & \frac{1}{\Gamma_i^j} \cdot \left\{ \left(\overline{B}_i^j \frac{\overline{R}^j}{\overline{R}} \frac{\overline{\mathcal{E}}}{\overline{\mathcal{E}}} \right) \cdot \mathbb{E}_t \left[\frac{(R_{t+1}^j - \overline{R}^j)}{\overline{R}^j} - \frac{(R_t - \overline{R})}{\overline{R}} + \frac{(\mathcal{E}_{t+1} - \overline{\mathcal{E}})}{\overline{\mathcal{E}}} - \frac{(\mathcal{E}_t - \overline{\mathcal{E}})}{\overline{\mathcal{E}}} \right] \right. \\
& \left. + \left[\overline{B}_i^j \left(\frac{\overline{R}^j}{\overline{R}} \frac{\overline{\mathcal{E}}}{\overline{\mathcal{E}}} - 1 \right) \right] \cdot \frac{(B_{i,t}^j - \overline{B}_i^j)}{\overline{B}_i^j} \right\} \\
(Q_{i,t}^j - \overline{Q}_i^j) \approx & \frac{1}{\Gamma_i^j} \cdot \left\{ \left(\overline{B}_i^j \frac{\overline{R}^j}{\overline{R}} \frac{\overline{\mathcal{E}}}{\overline{\mathcal{E}}} \right) \cdot \mathbb{E}_t \left[\tilde{r}_{t+1}^j - \tilde{r}_t + \tilde{e}_{t+1} - \tilde{e}_t \right] + \left[\overline{B}_i^j \left(\frac{\overline{R}^j}{\overline{R}} \frac{\overline{\mathcal{E}}}{\overline{\mathcal{E}}} - 1 \right) \right] \cdot \tilde{b}_{i,t}^j \right\} \\
(Q_{i,t}^j - \overline{Q}_i^j) \approx & \frac{1}{\Gamma_i^j} \cdot \left\{ \left(\overline{Q}_i^j \Gamma_i^j + 1 \right) \cdot \mathbb{E}_t \left[\tilde{r}_{t+1}^j - \tilde{r}_t + \tilde{e}_{t+1} - \tilde{e}_t \right] + \left(\overline{Q}_i^j \Gamma_i^j \right) \cdot \tilde{b}_{i,t}^j \right\} \\
(Q_{i,t}^j - \overline{Q}_i^j) \approx & \left(\frac{1 + \overline{Q}_i^j \Gamma_i^j}{\Gamma_i^j} \right) \cdot \mathbb{E}_t \left[\tilde{r}_{t+1}^j - \tilde{r}_t + \tilde{e}_{t+1} - \tilde{e}_t \right] + \overline{Q}_i^j \cdot \tilde{b}_{i,t}^j \\
\frac{(Q_{i,t}^j - \overline{Q}_i^j)}{\overline{Q}_i^j} \approx & \left(\frac{1 + \overline{Q}_i^j \Gamma_i^j}{\overline{Q}_i^j \Gamma_i^j} \right) \cdot \mathbb{E}_t \left[\tilde{r}_{t+1}^j - \tilde{r}_t + \tilde{e}_{t+1} - \tilde{e}_t \right] + \tilde{b}_{i,t}^j \\
\tilde{q}_{i,t}^j \approx & \left(\frac{1 + \overline{Q}_i^j \Gamma_i^j}{\overline{Q}_i^j \Gamma_i^j} \right) \cdot \left(\mathbb{E}_t[\tilde{r}_{t+1}^j] - \tilde{r}_t + \mathbb{E}_t[\tilde{e}_{t+1}] - \tilde{e}_t \right) + \tilde{b}_{i,t}^j,
\end{aligned}$$

where line 1 writes out the full first-order Taylor expansion of equation (A.1), line 2 cancels terms, line 3 uses lower-case tildes to denote percent deviations from steady state, line 4 uses the steady-state identity $\overline{Q}_i^j = \frac{1}{\Gamma_i^j} \left(\overline{B}_i^j \left(\frac{\overline{R}^j}{\overline{R}} \frac{\overline{\mathcal{E}}}{\overline{\mathcal{E}}} - 1 \right) \right)$, line 5 simplifies, line 6 divides both sides by $\overline{Q}_i^j$ and line 7 expresses the left-hand side in terms of percent deviations from steady state.

To derive equation (4), take the difference of this expression between time $t-1$ and t, using the law of iterated expectations to ensure that expectations are taken conditional on time t

$$\Delta\tilde{q}^j_{i,t} \approx \left(\frac{1+\overline{Q}^j_i\Gamma^j_i}{\overline{Q}^j_i\Gamma^j_i}\right)\cdot\left(\Delta\mathbb{E}_t[\tilde{r}^j_{t+1}] - \Delta\tilde{r}_t + \Delta\mathbb{E}_t[\tilde{e}_{t+1}] - \Delta\tilde{e}_t\right) + \Delta\tilde{b}^j_{i,t}$$

Since lower-case tildes denote percent deviation from steady state and are approximately equal to log deviations from steady state (i.e., $\tilde{x}_t = \frac{X_t - \overline{X}}{\overline{X}} \approx x_t - \overline{x}$, where $x \equiv \log(X)$), then steady-states cancel out in first difference, so we arrive at equation (4)

$$\Delta q^j_{i,t} \approx \left(\frac{1+\overline{Q}^j_i\Gamma^j_i}{\overline{Q}^j_i\Gamma^j_i}\right)\cdot\left(\Delta\mathbb{E}_t[r^j_{t+1}] - \Delta r_t + \Delta\mathbb{E}_t[e_{t+1}] - \Delta e_t\right) + \Delta b^j_{i,t},$$

where we denote price elasticity of demand as $\phi^j_i = \left(\frac{1+\overline{Q}^j_i\Gamma^j_i}{\overline{Q}^j_i\Gamma^j_i}\right)$.

In a symmetric steady state in which all banks have the same beliefs $\overline{B}^j_i = \overline{B}^j$, we have that $\overline{Q}^j_i\Gamma^j_i = \left(\overline{B}^j\left(\frac{\overline{R}^j}{\overline{R}} - 1\right)\right)$ so that $\phi^j_{B,i} = \phi^j_B\ \forall i$, specifically, $\phi^j_B = \frac{1+\left(\overline{B}^j\left(\frac{\overline{R}^j}{\overline{R}}-1\right)\right)}{\left(\overline{B}^j\left(\frac{\overline{R}^j}{\overline{R}}-1\right)\right)}$. Thus, the price elasticity of demand is a function of the steady state (subjective) cross-border excess return or UIP deviation.

We can add more structure to this steady state to gain intuition for the determinants of this steady state UIP deviation. For example, consider the case where $\overline{B}^j = 1$ for simplicity and $\Gamma^j_i = \overline{S}^{-1}_{ij}\Gamma^j$, with $\overline{S}_{ij} := \frac{\overline{Q}^j_i}{\sum_{i=1}^n \overline{Q}^j_i}$ and n is the number of banks, such that banks' risk-bearing capacities are inversely proportional to their relative steady-state size. In this case, $\left(\overline{B}^j\left(\frac{\overline{R}^j}{\overline{R}} - 1\right)\right) = \overline{Q}^j\Gamma^j$, where $\overline{Q}^j = \sum_{i=1}^n \overline{Q}^j_i$. Thus, $\phi^j_B = \left(\frac{1+\overline{Q}^j\Gamma^j}{\overline{Q}^j\Gamma^j}\right)$, i.e., banks' price elasticity of demand is a function of the average risk-bearing capacity of the banking sector as a whole and the total amount intermediated by the banking sector in steady state.

A.2 Proof of Proposition 1

To find the equilibrium, we use equations (6) and (7) together with $\Delta q^j_{S,t} = \Delta q^j_{F,t}$. This gives

$$\begin{aligned}\phi^j_B\left(\Delta\mathbb{E}_t[r^j_{t+1}] - \Delta r_t + \Delta\mathbb{E}_t[e_{t+1}] - \Delta e_t\right) + \Delta b^j_{S,t} = \\ -\phi^j_F\left(\Delta\mathbb{E}_t[r^j_{t+1}] - \Delta r_t + \Delta\mathbb{E}_t[e_{t+1}] - \Delta e_t\right) + \Delta b^j_{F,t},\end{aligned} \tag{A.2}$$

which simplifies to

$$\Delta e_t = \frac{1}{\phi_B^j + \phi_F^j}\Delta b_{S,t}^j - \frac{1}{\phi_B^j + \phi_F^j}\Delta b_{F,t}^j + \left(\Delta \mathbb{E}_t[r_{t+1}^j] - \Delta r_t + \Delta \mathbb{E}_t[e_{t+1}]\right). \tag{A.3}$$

To find the equilibrium change in quantities, we plug this expression back into equation (6) and obtain

$$\Delta q_{S,t}^j = \frac{\phi_F^j}{\phi_B^j + \phi_F^j}\Delta b_{S,t}^j + \frac{\phi_B^j}{\phi_B^j + \phi_F^j}\Delta b_{F,t}^j. \tag{A.4}$$

A.3 FX Derivatives Extension

Assume that a price-taking UK-resident bank i takes an uncovered position $X_{i,t}^j$ in USD-denominated asset j with return R_{t+1}^j as well as an FX covered position $D_{i,t}^j$ in the same asset, where $X_{i,t}^j = Q_{i,t}^j + D_{i,t}^j$, by borrowing a domestic opportunity cost R_t in GBP. Further, assume that the return R_{t+1}^j is known and safe and that covered interest parity approximately holds. Then, bank i's optimal demand for USD exposure $X_{i,t}^j$ from asset j is given by:

$$\begin{aligned} V_{i,t}^j &= \max_{X_{i,t}^j > 0} \mathbb{E}_t\left[\exp(b_{i,t}^j)\cdot\left(\frac{R_{t+1}^j}{R_t}\frac{\mathcal{E}_{t+1}}{\mathcal{E}_t} - 1\right)\right] X_{i,t}^j - \mathbb{E}_t\left[\exp(b_{i,t}^j)\cdot\underbrace{\left(\frac{R_{t+1}^j}{R_t}\frac{\mathcal{F}_t}{\mathcal{E}_t} - 1\right)}_{=0 \text{ under CIP}}\right] D_{i,t}^j, \\ V_{i,t}^j &= \max_{X_{i,t}^j > 0} \mathbb{E}_t\left[\exp(b_{i,t}^j)\cdot\left(\frac{R_{t+1}^j}{R_t}\frac{\mathcal{E}_{t+1}}{\mathcal{E}_t} - 1\right)\right] X_{i,t}^j. \end{aligned} \tag{A.5}$$

where $\mathcal{F}_t$ is the forward exchange rate.

Further, assume that banks' face a constraint on the size of their FX exposures only of the form:

$$V_{i,t}^j \geq \Gamma_i^j X_{i,t}^j \cdot X_{i,t}^j. \tag{A.6}$$

Then, banks' optimal USD exposure using asset j has the form:

$$X_{i,t}^j = \frac{1}{\Gamma_i^j}\cdot\mathbb{E}_t\left[\exp(b_{i,t}^j)\cdot\left(\frac{R_{t+1}^j}{R_t}\frac{\mathcal{E}_{t+1}}{\mathcal{E}_t} - 1\right)\right]. \tag{A.7}$$

Following the same steps outlined in Appendix A.1 gives equation (11) from the main text:

$$\Delta x_{i,t}^j \approx \phi_B^{j,X}\left(\Delta \mathbb{E}_t[r_{t+1}^j] - \Delta r_t + \Delta E_t[e_{t+1}] - \Delta e_t\right) + \Delta b_{i,t}^j. \tag{A.8}$$

B Data Appendix

B.1 Bank-Level Controls

Within our regressions we use size- and/or equal-weighted bank-level controls from our bank-level dataset. These bank-level controls include:

- log(Real Total Assets), deflated by GDP deflator.
- Capital Ratio, defined as each banking organisation's regulatory Tier-1 risk-based capital-to-asset ratio, in percent.
- Liquid-Asset Ratio, defined as the ratio of the banking organisation's liquid assets to total assets, in percent.
- Core Deposits Ratio, defined the ratio of the banking organisation's core deposits to total assets, in percent.
- Commitment share, defined as the ratio of unused commitments to total assets, in percent.
- International share, defined as the ratio of bank's foreign assets to total assets, in percent.

B.2 Macro Controls

Our macro controls include:

- VIX index from *CBOE*.
- 6-month and 10-year government bond yields, in the US and UK, from Gürkaynak et al. (2007) and the Bank of England, respectively.
- Mean survey forecasts for 3-month-ahead GBP/USD exchange rate from *Consensus Economics*.

C Narrative Checks of Granular Instrument

As discussed in Section 4.4.4, we carry out a narrative inspection of our granular instrument series to assess the extent to which the main changes in our GIVs are driven by plausibly exogenous events. In this Appendix, we describe our approach to the narrative checks, including documenting the sources we use to carry out the checks and presenting high-level conclusions from the analysis. Unfortunately, a complete discussion of our findings is precluded by confidentiality restrictions on our data.

To conduct the narrative inspection, we first decompose our granular instrument by bank. An aggregated example of this decomposition is presented in Figure 6. However, within our dataset, we are able to further decompose 'Large Banks', which reflects banks explaining over 10% of the GIV in a given period, into individual banks (the specific composition of which is confidential). As a consequence, we can see period-by-period which entity accounted for the most substantial moves in the size-minus-equal-weighted instrument.

Having observed which banks explain these large moves in each period, we use Open AI's GPT 5 architecture to conduct a narrative search by accessing the Financial Times (FT) archives. We provide the agent with the following instructions:[42]

- **Context.** We provide the agent with the following context: "I am conducting a rigorous academic research project looking at changes in UK-resident banks' USD positions over time, at quarterly frequency (from 1997Q4–2023Q3). As part of that analysis, I can see the specific bank that explains the largest move in a granular instrumental variable in each period."

- **Data.** We provide a document containing the names of the bank ('Bank 1') that explains the largest move in our GIV each quarter.

- **Task 1.** For this most important bank each quarter, we ask the agent the following: "In each quarter, I would like to know the main themes that arose in news articles about this bank. Specifically, I would like to focus on UK Financial Times articles in each period. Imagine you have a Ph.D. in finance and summarise the key themes in FT articles for Bank 1 in each quarter from the spreadsheet. Summarise the most important facts, decisions or news about that bank in the FT articles. In each quarter, summarise in ten bullet points, ranking from most to least important to you. Use as few words as possible

[42] In a previous version of this paper, we carried out these narrative checks manually. However, given advances in AI since then and inspiration from the work of Barbiero et al. (2024), we now carry out our primary narrative checks via this approach, complemented with manual searches.

without sacrificing meaning. Put a bullet point title at the beginning. Do not make up any information and be truthful to what is contained in FT articles."

- **Task 2.** Based on the outcome of this task, we then ask the agent to "convert these themes and reporting into a word cloud, with larger words in the cloud representing topics and themes that are more frequent amongst Bank 1 in each time period."

We complement this AI-based test with a manual search, where we access FT Historical Archives for the period 1997 to 2016 through the Bank of England Information Centre access to Gale Source. For each quarter, we search for news articles pertaining to 'Bank 1' within the period. We use search terms that capture the bank's name, and allow variants thereof. We limit the date-range of each search to the first and last days of each quarter. Having accessed the search results, we then manually read through all relevant articles (excluding advertisements for each bank), and assess the key themes to check whether these mirror those captured by the agent. That check reveals strong concordance.

Figure C.1: Key Terms from Narrative Checks of Large-Bank Moves in Granular Instruments



Notes: Key terms from narrative checks of granular instruments. Terms come from using Open AI's GPT 5 architecture to search historical Financial Times articles for news stories pertaining to specific banks that drive our granular instrument in each period. Relative size of terms denotes the relative frequency of the key terms in our narrative-check results.

Figure C.1 presents a world cloud of the key themes arising from those narrative checks. In the cloud, the relative size of the terms denotes the relative frequency with which the terms

arise from our narrative checks. Reassuringly, many of the key terms pertain to bank-specific features, which are unlikely to be tightly linked to systemic factors, such as the financial cycle. Common terms include those relating to mergers and acquisitions, governance issues ("litigation", "governance", "supervision", "misconduct", "accountability", "transparency", "compliance"), banks' structure ("restructuring", "layoffs", "integration", "cost cutting", "asset management", "retail", "private banking") and technology ("digital", "technology", "digitalisation", "fintech").[43] While some words such as "capital", "regulation", "dividends", "liquidity" and "funding" could in principle be aggregate in nature, further analysis shows this is unlikely to be the case, with these words referring largely to idiosyncratic bank-specific managerial decisions, such as adjusting internal risk limits.

[43] In one instance, "technology" refers to a bank's computer systems failing, which limited its ability to process cross-border payment.

D Additional Empirical Results

D.1 Correlation Between GIV and Other Factors

Table D.1 presents coefficient estimates from a regression of our net-debt GIV Δz_t^{net} on the VIX index, the Global Financial Cycle factor of Miranda-Agrippino and Rey (2020), and the 6-month US zero-coupon bond rate in levels (a measure of the US monetary policy stance) in Panel A and in changes (log-changes for the VIX) in Panel B. In both cases, we see that these proxies for the Global Financial Cycle enter statistically insignificantly and have no explanatory power (see the R^2) for our GIV. This stands in contrast to other prominent instruments for capital flows used previously in the literature, as discussed in Aldasoro et al. (2023).

Table D.1: GIV for Net-Debt Flows Not Related to Global Financial Cycle

PANEL A DEP. VAR.: Δz_t^{net}	(1)	(2)	(3)
vix_t	.0001		
	(.0002)		
GFC_t		-.0000	
		(.0000)	
$r_{6M,t}^{us}$			-.0002
			(.0006)
Observations	101	101	101
R^2	0.00	0.00	0.00
PANEL B DEP. VAR.: Δz_t^{net}	(1)	(2)	(3)
Δvix_t	.0003		
	(.0003)		
ΔGFC_t		-.0001	
		(.0001)	
$\Delta r_{6M,t}^{us}$			.0036
			(.0040)
Observations	101	101	101
R^2	0.01	0.02	0.01

Notes: Coefficient estimates from a regression of our net-debt GIV Δz_t^{net} on the VIX index, the global financial cycle factor of Miranda-Agrippino and Rey (2020), and the 6-month US zero-coupon rate in levels (Panel A) and in changes (Panel B), with the VIX index in log-changes. Sample is from 1997Q4-2022Q4. Newey and West (1987) standard errors with 12 lags are in parentheses. Significance at 10%, 5% and 1% denoted by $*$, $**$, and $***$, respectively.

D.2 First-Stage Regression Results

Table D.2 presents the first-stage regression results referenced in Section 5.2. These underpin our estimates for the demand and supply elasticities displayed in Table 2.

Table D.2: 1st Stage Regressions of Exchange Rates on GIV for Net-Flows

PANEL A: 1st Stage for Supply Elasticity (ϕ_R^{net})	
DEP. VAR.: Δe_t	
z_t^{net}	0.450**
	(0.197)
Observations	101
1st-Stage F-stat.	34.62
Macro Controls	Yes
Bank Controls	Yes
Components	20
PANEL B: 1st Stage for Demand Elasticity ($-\phi^{net}$)	
DEP. VAR.: Δe_t	
z_t^{net}	0.416**
	(0.193)
Observations	101
1st-Stage F-stat.	46.75
Macro Controls	Yes
Bank Controls	Yes
Components	20

Notes: PANEL A: Coefficient estimates from first-stage regression accompanying (24). PANEL B: Coefficient estimates from first-stage regression accompanying (25). All regressions estimated with data for 1997Q4-2022Q4. Coefficients on macro and bank controls suppressed for presentational purposes. Bank controls are size-weighted (PANEL A) and equal-weighted (PANEL B). The remaining notes from Table 1 concerning the macro controls, bank controls and principle components apply. Newey and West (1987) standard errors with 12 lags are in parentheses. Significance at 10%, 5% and 1% denoted by $*$, $**$, and $***$, respectively.

D.3 State Dependency of Banks' USD Demand Elasticity

Table D.3 provides results on the state dependency of UK-resident banks' USD demand elasticity, referenced in Section 5.3. We test this by separately estimating demand elasticities using regression (25) in 2 distinct states: (i) when banks' hedging via FX derivatives is above average and financial volatility is not spiking, defined as the VIX is below 1.5 standard deviations above its historical average; and (ii) when banks' hedging is below average and/or the VIX is spiking.

Table D.3: UK-Bank Demand Elasticities by Bank Hedging and VIX States

2nd Stage for Demand Elasticity ($-\phi^{net}$) DEP. VAR.: $\Delta q_{E,t}^{net}$	High Bank Hedging and Low VIX	Low Bank Hedging and/or High VIX
Δe_t	-2.38*	-0.52***
	(1.45)	(0.11)
Observations	51	39
1st-Stage F-stat.	7.65	17.90
Macro Controls	No	No
Bank Controls	No	No
Components	20	20

Notes: Coefficient estimates from regression (25) in 2 distinct states: (i) when banks' hedging via FX derivatives is above average and financial volatility is not spiking, defined as the VIX is below 1.5 standard deviations above its historical average; and (ii) when banks' hedging is below average and/or the VIX is spiking. Regressions sampled from data over 2000Q4-2022Q4. Newey and West (1987) standard errors with 12 lags are in parentheses. Significance at 10%, 5% and 1% denoted by $*$, $**$, and $***$, respectively.

D.4 UIP Returns

Table D.4 demonstrates the robustness of our key results from Section 5.1 (column (1)) and 5.3 (column (2)) when, instead of the exchange rate, ex-ante deviations from UIP—constructed using survey expectations for exchange rates from *Consensus Economics*—are used as the dependent variable.

Table D.4: (Time-Varying) Multiplier of Net Flows on Ex-Ante UIP Deviations

	(1)	(2)
DEP. VAR.: % change UIP ($\Delta\mathbb{E}_t[e_{t+1}] - \Delta e_t + \Delta r_t^{US} - \Delta r_t^{UK}$)		
z_t^{net}	-0.369*	-0.399*
	(0.201)	(0.229)
$z_t^{net} \times Hedge_{S,t-1}$		0.392*
		(0.182)
$z_t^{net} \times Cap_{S,t-1}$		0.009
		(0.212)
$z_t^{net} \times VIX_{t-1}$		-0.429***
		(0.159)
Observations	101	89
Macro Controls	Yes	Yes
Bank Controls	Yes	Yes
Components	20	20
R^2	0.458	0.590

Notes: Coefficient estimates from equations (23) and (27) using data from 1997Q4-2022Q4 and 2000Q4-2022Q4, respectively. Since we move $(\Delta r_{t+1} - \Delta r_{t+1}^*)$ and $\Delta\mathbb{E}_t[e_{t+1}]$ from right-side of regression to left to construct changes in UIP, we drop these macro controls. Coefficients on macro and size-weighted bank controls suppressed for presentational purposes. The remaining notes from Table 1 concerning the macro controls, bank controls and principle components apply. Newey and West (1987) standard errors with 12 lags are in parentheses. Significance at 10%, 5% and 1% denoted by $*$, $**$, and $***$, respectively.

Table D.5 presents the corresponding robustness check for the demand and supply elasticities from Section 5.2.

Table D.5: Supply and Demand Elasticity Estimates for Net Flows *vis-à-vis* Ex-Ante UIP Deviations

PANEL A: 2nd Stage for Supply Elasticity (ϕ_R^{net})	
DEP. VAR.: $\Delta q_{S,t}^{net}$	
ΔUIP_t	-0.691**
	(0.328)
Observations	101
1st-Stage F-stat.	46.12
Macro Controls	Yes
Bank Controls	Yes
Components	20
PANEL B: 2nd Stage for Demand Elasticity ($-\phi^{net}$)	
DEP. VAR.: $\Delta q_{E,t}^{net}$	
ΔUIP_t	2.136**
	(0.998)
Observations	101
1st-Stage F-stat.	39.69
Macro Controls	Yes
Bank Controls	Yes
Components	20

Notes: PANEL A: Coefficient estimates from regression (24). PANEL B: Coefficient estimates from regression (25). All regressions estimated with data for 1997Q4-2022Q4. Since we move $(\Delta r_{t+1} - \Delta r_{t+1}^*)$ and $\Delta \mathbb{E}_t[e_{t+1}]$ from right-side of regression to left to construct changes in UIP, we drop these macro controls. Coefficients on macro and bank controls suppressed for presentational purposes. Bank controls are size-weighted (PANEL A) and equal-weighted (PANEL B). The remaining notes from Table 1 concerning the macro controls, bank controls and principle components apply. Newey and West (1987) standard errors with 12 lags are in parentheses. Significance at 10%, 5% and 1% denoted by $*$, $**$, and $***$, respectively.

D.5 Sub-Sample Splits

Table D.6 demonstrates the robustness of our key results from Section 5.1 (column (1)) and 5.3 (column (2)) when we drop the GFC (i.e., 2008) from our sample.

Table D.6: (Time-Varying) Multiplier of Net Flows on Exchange Changes when Excluding GFC from Sample

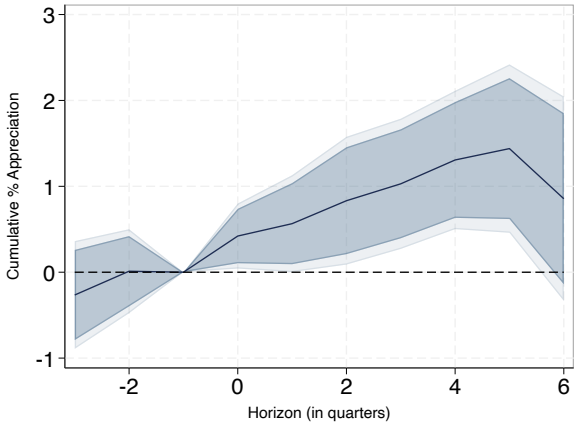
	(1)	(2)
DEP. VAR.: % change nominal GBP/USD exchange rate (Δe_t)		
z_t^{net}	0.421**	0.412**
	(0.193)	(0.204)
$z_t^{net} \times Hedge_{S,t-1}$		-0.351**
		(0.165)
$z_t^{net} \times Cap_{S,t-1}$		0.080
		(0.200)
$z_t^{net} \times VIX_{t-1}$		0.442***
		(0.154)
Observations	97	85
Macro Controls	Yes	Yes
Bank Controls	Yes	Yes
Components	20	20
R^2	0.617	0.708

Notes: Coefficient estimates from equations (23) and (27) using data from 1997Q4-2022Q4 and 2000Q4-2022Q4, respectively, but excluding the GFC (2008) from the sample. Coefficients on macro and size-weighted bank controls suppressed for presentational purposes. The remaining notes from Table 1 concerning the macro controls, bank controls and principle components apply. Newey and West (1987) standard errors with 12 lags are in parentheses. Significance at 10%, 5% and 1% denoted by $*$, $**$, and $***$, respectively.

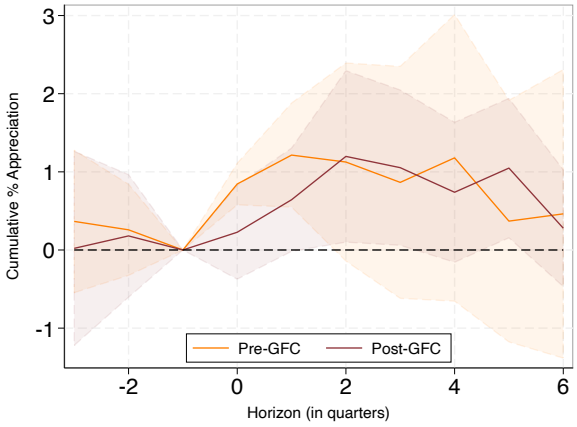
Figure D.1a plots the corresponding impulse response function when the ex-GFC from column (1) of Table D.6 is extended to a local projection setting. Figure D.1b plots the impulse response functions from the local projection when using two subsamples: pre-GFC (2008 and earlier) and post-GFC (after 2008).

Figure D.1: Dynamic Multipliers for Net Flows on Exchange Rates (a) Excluding GFC and (b) Pre-/Post-GFC

(a) Excluding GFC



(b) Pre-/Post-GFC



Notes: Multiplier estimates from local-projection estimation of equation (23) using net-debt positions. Figure D.1a excludes GFC period from 1997Q4-2022Q4 sample. Figure D.1b uses pre- (2008 and earlier) and post-GFC (after 2008) sub-samples. Shaded areas denote 90% (Panels a and b) and 95% (Panel a) confidence intervals from Newey and West (1987) standard errors with 12 lags. All local projections include the same control variables used in column (4) of Table 1.

Table D.7 presents the corresponding robustness check for the demand and supply elasticities from Section 5.2, when excluding the GFC (2008) from our sample.

Table D.7: Supply and Demand Elasticity Estimates for Net Flows *vis-à-vis* Exchange Rates when Excluding GFC from Sample

PANEL A: 2nd Stage for Supply Elasticity (ϕ_R^{net})	
DEP. VAR.: $\Delta q_{S,t}^{net}$	
Δe_t	0.511**
	(0.255)
Observations	97
1st-Stage F-stat.	44.37
Macro Controls	Yes
Bank Controls	Yes
Components	20
PANEL B: 2nd Stage for Demand Elasticity ($-\phi^{net}$)	
DEP. VAR.: $\Delta q_{E,t}^{net}$	
Δe_t	-1.841***
	(0.687)
Observations	97
1st-Stage F-stat.	44.37
Macro Controls	Yes
Bank Controls	Yes
Components	20

Notes: PANEL A: Coefficient estimates from regression (24). PANEL B: Coefficient estimates from regression (25). All regressions estimated with data for 1997Q4-2022Q4, but excluding the GFC (2008) from the sample. Coefficients on macro and bank controls suppressed for presentational purposes. Bank controls are size-weighted (PANEL A) and equal-weighted (PANEL B). The remaining notes from Table 1 concerning the macro controls, bank controls and principle components apply. Newey and West (1987) standard errors with 12 lags are in parentheses. Significance at 10%, 5% and 1% denoted by $*$, $**$, and $***$, respectively.