Granular Banking Flows and Exchange-Rate Dynamics*

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Abstract

We identify granular financial shocks from data on the external assets and liabilities of global banks based in the UK, the world's largest centre for cross-border banking. Using a new granular international banking model, we show that large banks' idiosyncratic demand flows disproportionately influence exchange-rate dynamics. Empirically, we find that while the supply of US dollars from banks' counterparties is price-elastic, UK-resident global banks' demand for dollars is price-inelastic, which we attribute to their limited risk-bearing capacities. Overall, banks' inelastic demand implies they price most of the exchange-rate response to capital flows, making them 'marginal' investors in currency markets.

JEL Codes: E0, F0, F3.

Key Words: Capital flows; Exchange rates; Financial shocks; Granular instrumental variables; International banking; Inelastic demand.

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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). Recently, 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, 2021a). However, open questions remain, including: From where do these financial (capital-flow) shocks originate? How much do exchange rates respond to these financial shocks? And which agents' financial constraints matter most for the exchange-rate response—i.e., who is the 'marginal investor' in currency markets?

In this paper, we investigate the granular origins and causal effects of capital-flow shocks. We do so using a unique bank-level dataset covering UK-resident global banks' external balance sheets, broken down by asset class and currency denomination. As is well known, financial assets are highly concentrated in a few large International Financial Centres (IFCs). For cross-border banking claims—which comprise over one-quarter of overall cross-border claims from 1997Q1-2019Q3—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, and peaking at around \$7.1 trillion in 2008Q1.[1] Using our dataset, we show that these financial assets are also held by a relatively small number of large financial players. Specifically, 20% of UK-based global banks account for about 80% of banks' overall *gross and net* cross-border US dollar (USD) positions. This provides evidence of granularity in cross-border banking.

Motivated by these stylised fact, we present a new granular banking model of exchange-rate determination, which builds on the 'Gamma model' of Gabaix and Maggiori (2015). Unlike the canonical Gamma model, global banks' risk-bearing capacities are heterogeneous in our setting. This gives rise to variation across banks in the size of their cross-border asset positions and foreign-currency exposures, as in the data. Further, we allow banks to differ in their beliefs about the expected returns from different risky assets and liabilities. These beliefs act as bank-specific financial shocks to Uncovered Interest Parity (UIP), driven by both bank-level and aggregate factors that act as demand shifters for currency. Banks trade these 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 funds supply it. Altogether, the resulting equilibrium expressions capture the realistic feature

[1] See Cesa-Bianchi, Dickinson, Kosem, Lloyd, and Manuel (2021) and Beck, Lloyd, Reinhardt, and Sowerbutts (2023) for recent surveys on the UK's position as an IFC.

[2] We use the term 'fund' generically to refer to any financial player transacting debt and equity instruments cross-border with UK-resident global banks.

that idiosyncratic demand flows by large banks—due to fluctuations in their 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.

Further, we decompose the exchange-rate response to financial shocks into the contributions of banks' demand elasticities and funds' supply elasticities for foreign currency. Importantly, the most *price-inelastic* type of intermediary prices the majority of the exchange-rate response, making them the marginal investors in currency markets. Intuitively, price-inelastic intermediaries with more-limited risk-bearing capacities require larger exchange-rate movements to be willing to adjust the size of their foreign currency exposures.

Using the model as a guide, we identify granular financial shocks by constructing granular instrumental variables (GIVs) (Gabaix and Koijen, 2020) for gross and net cross-border banking flows. Intuitively, our GIVs are a time-series of exogenous capital flows in and out of USD assets by large banks, which we extract 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 USDs, with some banks' positions large enough that their idiosyncratic moves can influence aggregate capital flows—requirements that our dataset fulfils. For identification, the GIV framework helps to partial out (unobserved) aggregate confounders by taking the difference between the size- and equal-weighted sum of banks' cross-border flows. As evidence of this, and unlike many instruments used in the literature, our GIVs are uncorrelated with commonly-used proxies for the global financial cycle.

Our theoretical model also codifies threats to identification for the GIVs. We account for these threats in our empirical setup by controlling for bank-level balance-sheet information (e.g., liquid-asset, deposit and capital ratios), a wide-array of asset return differentials (e.g., government and corporate bond yields and equity returns) and exchange-rate expectations, as well as using, now standard, principal-component analysis to account for potentially heterogeneous exposures of banks to unobserved common shocks. We also carry out a detailed narrative assessment of our instrument, by accessing *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 with bank-specific, non-systemic shocks to large banks such as management changes, mergers or legal penalties, as well as stress-test failings and computer-system failures.

Armed with our granular shocks and testable predictions from theory, we turn to investigate the causal link between capital flows and exchange rates, which reveals 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 USD/GBP exchange rate.[3] We find that a 1% increase in UK-resident banks' net dollar-debt position leads to a 0.4-0.8% 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 2% cumulative USD appreciation after 1 year. Consistent with theory, this effect does not reverse even 2 years after the initial shock. 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 USD/GBP exchange rate. Compared to debt flows, however, equity flows have a significantly smaller effect on exchange rates.[4] 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 dollar-deposit liabilities, mismatched changes in USD-debt positions, for example due to carry trading, will result in economically significant, and persistent, exchange-rate movements.

Second, to understand the structural underpinnings of these multipliers, we use our net dollar-debt GIV to estimate—via two-stage least squares—distinct UK-bank demand and ROW-fund supply elasticities for USDs. On the supply side, we find that the quantity of USDs supplied by banks' ROW counterparties is elastic with respect to the USD/GBP exchange rate: *ceteris paribus*, a 1% change in the exchange rate results in a more than proportional change in the net supply of USD debt by banks' counterparties, about 2% according to our estimates. However, on the demand side, our point estimates suggest that the demand for USDs by UK-resident global banks is inelastic. A 1% change in the USD/GBP exchange rate results in a less than proportional change in net demand for USD debt, about -0.5%.[5] Importantly, that the demand elasticity lies significantly below the supply elasticity implies that UK-resident global banks exert a greater influence over the exchange-rate response to financial shocks compared to (the average of) other financial-market participants, such as the mutual funds studied by Camanho, Hau, and Rey (2022). That is, through the lens of our model, our empirical results suggest that UK-resident banks are 'marginal' in the dollar-sterling market due to their relatively low risk-bearing capacities. A consequence, however, of inelastic currency demand is that external shocks to the supply of dollars—e.g., from US monetary policy and other drivers of the Global Financial Cycle (Rey, 2015; Miranda-Agrippino and Rey, 2020)—may weigh more heavily on the value of sterling when intermediated by banks.

[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.

[4]This may be because the local-currency price of equities reacts more to capital flows than the local-currency price of debt (see Gabaix and Koijen, 2022), such that exchange rates need to react relatively less to equity flows to clear the market.

[5]Of note, inelastic demand is at odds with the micro-foundations of the baseline Gamma model. We propose a simple alteration to the model that can rationalise our inelastic estimates.

Third, to assess the drivers of the inelastic demand for US dollars, we extend our empirical setup to investigate the role of banks' time-varying risk-bearing capacity for exchange-rate dynamics. We focus on banks' Tier-1 capital ratios, which are a function of both regulatory policy and banks' own risk-management preferences. Interacting bank capital with our net dollar-debt GIV suggests that the causal effect of capital flows on exchange rates is twice as large when banks' capital ratios are one standard deviation below average. This provides novel evidence—to support that in Corsetti, Lloyd, and Marin (2020) and Ostry (2023)—highlighting that the link between capital flows and exchange rates is highly state dependent owing to time-variation in intermediaries' risk-bearing capacity. It also implies that a better capitalised banking sector helps to insulate small-open economies, like the UK, from global financial shocks, by flattening banks' demand curves for dollars.

Literature Review. Our paper contributes to the substantial literature discussing the extent to which exchange rates are 'disconnected' with fundamentals (e.g., Meese and Rogoff, 1983; Fama, 1984; Obstfeld and Rogoff, 2000; Jeanne and Rose, 2002; Evans and Lyons, 2002; Lloyd and Marin, 2020; Stavrakeva and Tang, 2020; Chahrour, Cormun, De Leo, Guerron-Quintana, and Valchev, 2021; Lilley, Maggiori, Neiman, and Schreger, 2022; Gourinchas, Ray, and Vayanos, 2022; Greenwood, Hanson, Stein, and Sunderam, 2023; Corsetti, Lloyd, Marin, and Ostry, 2023). Within this body of work, our paper most closely links with the growing theoretical literature that rationalises this disconnect with financial market imperfections (Itskhoki and Mukhin, 2021a,b; Fukui, Nakamura, and Steinsson, 2023; Itskhoki and Mukhin, 2024).[6] Our heterogeneous-bank theoretical framework provides the granular foundations for UIP shocks, highlighting how idiosyncratic 'belief' shocks to banks' cross-border asset demand can influence exchange-rate dynamics. Further, our estimates of banks' and funds' price elasticities of currency demand/supply can be used to calibrate the financial frictions that underpin state-of-the-art international macroeconomics models.[7]

We also contribute to the growing literature that uses granular players in financial markets to estimate macro elasticities. Using their GIV methodology, Gabaix and Koijen (2022) show that US equity demand is price inelastic, which they argue rationalises the considerable volatility of equity prices. While Galaasen, Jamilov, Juelsrud, and Rey (2020) use matched firm-bank loan-level data to construct a GIV for domestic credit risk in the Norwegian banking sector,

[6] This class of models stands in contrast to no-arbitrage ones in which the demand elasticity of exchange rates to capital flows is infinite (Friedman, 1953, see). 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, Massa, and Peress, 2010).

[7] We also show empirically that time-variation in the tightness banks' financial constraints, as measured by their capital ratios, matters for exchange-rate dynamics, contributing to the substantial literature linking bank-level characteristics to cross-border transmission (e.g., Kashyap and Stein, 2000; Cetorelli and Goldberg, 2012a,b).

our paper is one of the first to construct a bank-level GIV for cross-border capital flows.

In related work, Camanho, Hau, and Rey (2022) build a GIV for mutual funds' international equity rebalancing flows.[8] They find that the average elasticity of the counterparties of these mutual funds, of which a subset are global banks, is about 1. Since we estimate UK-based banks' demand elasticities to be about 0.5, their results are consistent with our finding that banks are the primary actor segmenting global financial markets and influencing exchange-rate dynamics.[9] In another related paper, Aldasoro, Beltrán, Grinberg, and Mancini-Griffoli (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. Helpfully for us, they demonstrate how their country-level GIVs improve on existing (non-granular) instruments used in the literature (e.g., Blanchard, Ostry, Ghosh, and Chamon, 2016; Cesa-Bianchi, Ferrero, and Rebucci, 2018; Avdjiev, Hardy, McGuire, and von Peter, 2021). However, our instruments are constructed at the more granular bank level and so require more innocuous identification assumptions than their alternative country-level GIVs.

In concurrent work, Becker, Schmeling, and Schrimpf (2023) independently employ a GIV framework to estimate the impact of banks' cross-currency lending on exchange rates. For a range of currencies, they show that when non-US banks extend more syndicated loans in USDs relative to US banks' syndicated loans in foreign currency, the USD appreciates. Like us, they underscore the importance of intermediaries' risk-bearing capacity. In contrast, our study leverages currency mismatches between the lending and borrowing of UK-based global banks to assess the structural underpinnings of UIP deviations. Building on our granular international banking model, our empirical results indicate that UK-based banks' demand for USD is price-inelastic while their counterparties' USD supply is elastic, suggesting banks are the 'marginal' player in the dollar-sterling market. Overall, our GIVs provide robust and representative evidence that sheds new light on the causal links between capital flows and exchange rates and on which types of financial agents segment global financial markets.

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.

[8] Their data captures a smaller fraction of overall cross-border flows than ours since they focus on equity flows.

[9] While the authors do not estimate mutual funds' price elasticity directly, our findings together suggest that the elasticity of mutual-fund flows to exchange-rates is quite high.

2 Data

In this section, we describe our dataset, and document stylised facts about aggregate and granular features of UK-resident global banks' cross-border positions.

2.1 UK-Resident Banks in Global Context

Our main data 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.[10] The panel contains detailed data on banks' cross-border claims and liabilities by asset class.[11] Most importantly for our study, these claims are reported by currency. In addition, the dataset includes information on banks' capitalisations and liquidity buffers, among other controls.

In a global context, the dataset captures a substantial portion of cross-border capital flows, reflecting the UK's position as an IFC. First, over the 1997-2019 period of our analysis, total banking claims (measured using BIS Locational Banking Statistics) comprised, on average, 26% of total cross-border claims for the same set of countries (measured using the External Wealth of Nations Dataset of Lane and Milesi-Ferretti, 2018). In turn, the claims originating from UK-based banks that are captured in our dataset, represent, on average, 18% of overall cross-border banking claims over the same period. So our dataset represents around 5% of overall cross-border asset positions for the 1997Q1-2019Q3 period.

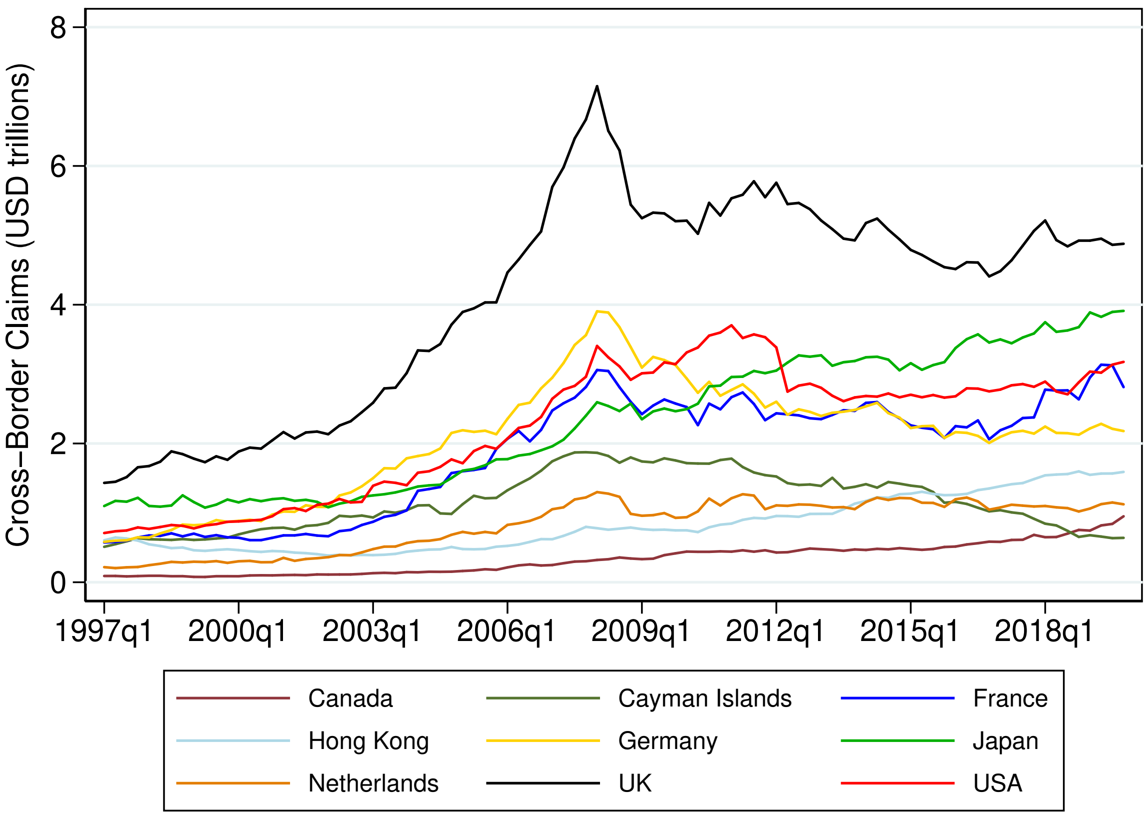
In comparison to other global banking centres, UK-resident banks comprise the largest share of aggregate cross-border claims. Figure 1 puts this in context, plotting the time series of all banking claims originating from the UK alongside those from other source countries of cross-border bank lending. UK-resident banks' cross-border claims are significantly larger than all other countries'. On average over the period, the total claims of UK-resident banks are almost twice as large as those from US-based banks. Similar patterns are present for UK-banks' cross-border liabilities.

Moreover, cross-border banking claims originating from the UK comprise a substantial share of the UK's overall external linkages. The claims originating from UK-based banks in

[10] This dataset has been used for other purposes in a number of previous and ongoing studies, including: Aiyar, Calomiris, Hooley, Korniyenko, and Wieladek (2014), Forbes, Reinhardt, and Wieladek (2017), Bussière, Hills, Lloyd, Meunier, Pedrono, Reinhardt, and Sowerbutts (2021), Andreeva, Coman, Everett, Froemel, Ho, Lloyd, Meunier, Pedrono, Reinhardt, Wong, Wong, and Żochowski (2023), Eguren-Martin, Ossandon Busch, and Reinhardt (2023), and Lloyd, Reinhardt, and Sowerbutts (2023).

[11] 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 rest of the world as a whole, rather than specific nations.

Figure 1: 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 2019Q3. *Source*: BIS Locational Banking Statistics.

our dataset represent, on average over the 1997-2019 period, 38% of the UK's total external asset position (measured with External Wealth of Nations Dataset of Lane and Milesi-Ferretti, 2018).

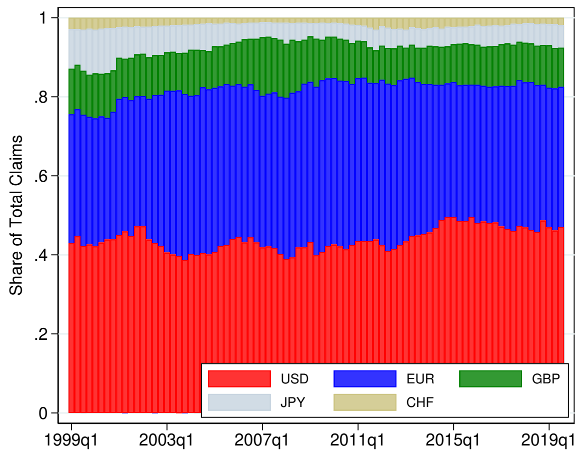
2.2 UK-Resident Banks' Cross-Border Claims

Our raw dataset contains information on 451 banks reporting cross-border claims in at least one quarter over the period 1997Q1-2019Q3. For the purposes of 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.[12] As a consequence, our analysis predominantly focuses on the intensive margin of cross-border USD-denominated lending. Our cleaned quarterly dataset includes 109 global banks, which together engage in the vast majority of cross-

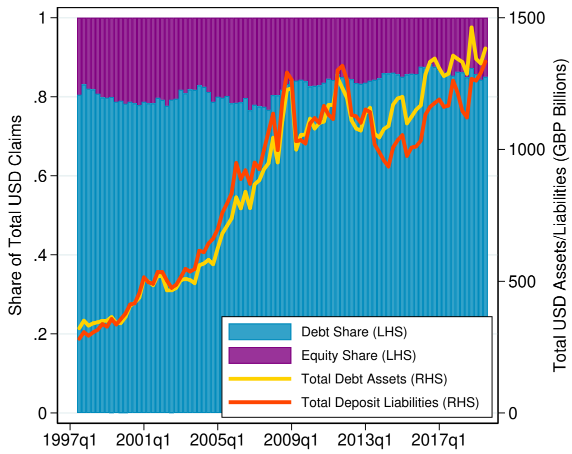
[12]Moreover, as with other studies that use this dataset (e.g., Bussière et al., 2021; Andreeva et al., 2023; Lloyd et al., 2023), we also winsorise our bank-level data to ensure that the quarterly growth of cross-border positions is bounded between -100% and $+100\%$.

Figure 2: Decomposing UK-Based Banks' Cross-Border Claims and Liabilities

(a) Currency Decomposition of Cross-Border Claims



(b) Asset Decomp. (LHS) and Total Positions (RHS)



Notes: Left-hand figure decomposes UK-based banks' total external claims by currency from 1999Q1 (owing to creation of the euro) to 2019Q3. 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 2019Q3.

border UK bank lending.

Our key variable of interest is the quarterly change in the stock of currency-specific cross-border claims (or liabilities) between bank i and the rest of the world at time t. In this paper, we focus on USD-denominated claims, which comprise, on average, 44% of all claims over the sample, as Figure 2a shows.[13] In comparison, euro-denominated claims comprise on average 38% of claims.

Within these dollar-denominated assets, we consider two asset classes, namely: 'loans and advances' (henceforth 'debt') and 'shares, other equity, and securities other than shares' (henceforth 'equity').[14] Figure 2b decomposes these USD claims by type of asset. Debt comprises the lion's share of cross-border dollar claims. As of 2019Q3, the stock of USD-denominated loans was around 5-times larger than the stock of USD-denominated portfolio investments.

Moreover, the counterpart to these dollar debt positions are USD-denominated deposits, liabilities from the perspective of UK banks. As shown in the lines in Figure 2b, both UK banks' dollar-debt and dollar-deposit positions have grown considerably over time. While, unsurprisingly, the path of these asset and liability positions over time have been broadly similar, there are notable mismatches. Specifically, the average absolute net USD debt position

[13] This statistic is calculated over the period 1999Q1-2019Q3 to avoid distortions due to the creation of the euro in 1999.

[14] Other assets include, amongst other things, certificates of deposits.

of the UK banking system over our sample is 66 billion GBP.[15] Thus, UK-resident banks can have significant net exposures to USDs, which we will leverage in our theoretical framework below.[16]

There is also time-variation in the sign of UK banks' USD exposure over the sample. For much of the 2000s, USD deposit liabilities were larger than USD debt assets, implying that UK-resident banks were net-short the USD using fixed-income instruments. Conversely, for much of the 2010s, banks' net currency exposure from fixed-income switched, with UK-resident banks now taking net-long positions in USD debt. Since US interest rates were relatively low (high) compared to the UK's for much of the 2000s (2010s), this provides some evidence to suggest that UK-resident banks performed carry trades during our sample.

2.3 Granularity of UK-Resident Banks

While UK-resident banks as a whole cover a sizeable portion of global cross-border claims, there is significant heterogeneity in individual banks' cross-border positions. Figure 3a displays Lorenz curves and associated Gini coefficients for UK-resident global banks' USD debt assets, equity assets, deposit liabilities and absolute net debt (absolute value of debt assets less deposit liabilites) in the final period of our sample. Across these different measures of gross and net size, we see clear evidence of the Pareto principle: around 80% of total USD banking debt, equity, deposits and net-debt exposures are held by 20% of banks.

We also provide evidence that global banks appear to be granular (Gabaix, 2011), implying that idiosyncratic flows by large global banks can theoretically shape aggregate capital flows. Following Gabaix (2009), we show this in Figure 3b by comparing the log-rank of banks' size to the log of their size, where we measure again size in four ways: banks' cross-border USD debt assets, equity assets, deposit liabilities, and net-debt in the final period of our sample. That straight lines can fit this relationship to such a degree—the R^2 are between 0.94 and 0.96—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 form 1, which is consistent with Zipf's law.

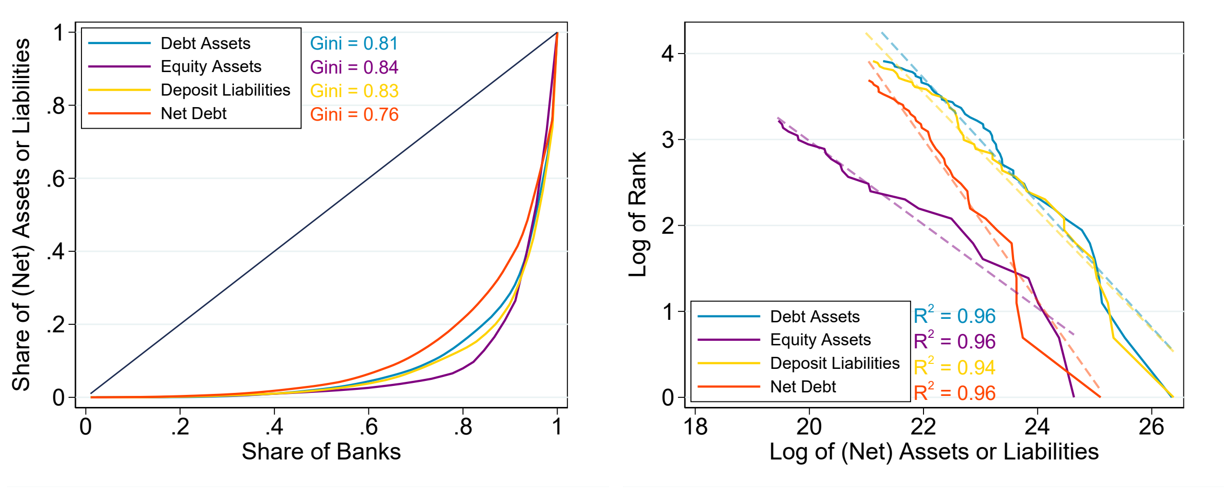
In all, the size concentration—in particular in terms of *net* positions—that we document motivates our granular banking model in Section 3. It suggests that idiosyncratic flows from

[15] The standard deviation of these absolute positions is 51 billion GBP. Banks' largest (smallest) net-dollar position over our sample is 195 billion GBP (1 billion GBP).

[16] While UK-resident banks have been subject to some Pillar 1 and 2 capital requirements on mismatched foreign-exchange positions since the mid-2010s—the last few years of our sample—under Prudential Regulatory Authority regulation, these do not preclude foreign-exchange mismatches on balance sheets. Indeed, when accounting for all USD-denominated assets (debt and equity), not only debt as in Figure 2b, UK-resident banks have net-long positions in USD over the whole sample.

Figure 3: Concentration and Granularity in Banks' Cross-Border (Net) Assets and Liabilities

(a) Size Concentration (b) Granularity



Notes: Figure 3a presents Lorenz curves and Gini coefficients respectively for global banks' average USD debt assets, equity assets, deposit liabilities and absolute net-debt (debt less deposits) in 2019:Q3. Figure 3b plots log-rank vs log-size, along with linear best fit lines and the associated R^2, separately for USD debt assets, equity assets, deposit liabilities and absolute net-debt in 2019:Q3. The sample in Figure 3b is restricted to the 50 largest banks for debt and deposits, 25 largest for equity, and 40 largest for absolute net-debt.

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.

3 Theoretical Framework

In this section, we present a new granular model of exchange-rate determination based on capital flows in imperfect financial markets. The model builds on the Gamma model of Gabaix and Maggiori (2015), but differs from it in several key ways. 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, we allow banks to have heterogeneous and time-varying beliefs about the returns to different assets. Together, these first two extensions imply that the beliefs of the largest banks exert the greatest influence on equilibrium exchange rate dynamics. Third, similar to Koijen and Yogo (2019), we allow banks to trade a range of risky financial assets. Finally, banks trade these assets with a set of 'rest-of-the-world' (ROW) funds (Camanho et al., 2022). Together, these next two differences imply that exchange rates are determined by the supply and demand for financial assets by different financial agents, i.e., banks and funds. While these generalisations allow us to bridge the gap between theory and our data on bank-level cross-border claims, our framework still nests the original Gamma model.

The aim of our model is twofold. First, to guide our search for concrete bank-level evidence on financial UIP shocks, which are increasingly popular in the theoretical literature (e.g., Itskhoki and Mukhin, 2021a). Second, to inform our empirical strategy for identifying the causal effect of capital flows on exchange rates.

3.1 The Granular Gamma Model

Consider a price-taking UK-resident banker i who, at time t, has access to a foreign financial asset j with a risky dollar-denominated time-$(t+1)$ return $R^j_{t+1} = 1 + r^j_{t+1}$ and a known domestic opportunity cost $R_t = 1 + r_t$ expressed in sterling.[17] Banker i's optimal demand $Q^j_{i,t}$ for dollar asset j at time t maximises their expected profits in sterling[18]

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

where the exchange rate $\mathcal{E}_t$ is the price of a dollar in sterling (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 cross-border return from asset-class j, $\frac{R^j_{t+1}}{R_t}\frac{\mathcal{E}_{t+1}}{\mathcal{E}_t} - 1$, earned at time $t+1$.[19] By including the banker-specific belief wedge $b^j_{i,t}$, we allow for time-varying deviations from rational expectations.[20] These time-varying beliefs can be driven by both bank-level and aggregate *demand shifters*, that act as financial shocks to UIP.[21]

Following Gabaix and Maggiori (2015), we assume bankers 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 earlier work, 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-

[17] As in Gabaix and Maggiori (2015), R_t can be interpreted as $R_t = 1/\beta$, where $\beta \in (0,1)$ is the household discount factor.

[18] Both foreign- and UK-owned banks residing in the UK are required to report profits in sterling for regulatory reasons.

[19] 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.

[20] 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).

[21] 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).

compatibility constraint that ensures that banks do not divert resources in equilibrium:

$$V_{i,t}^j \geq \Gamma_i^j Q_{i,t}^j \cdot Q_{i,t}^j, \tag{2}$$

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

In equilibrium, since the maximand (1) is linear in $Q_{i,t}^j$ and the constraint (2) is quadratic, the constraint always binds and the solution to the problem 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 asset class 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 the size of banks' equilibrium cross-border positions $Q_{i,t}^j$. Of note, if $b_{i,t}^j = 0$ and $\Gamma_i^j = \Gamma^j$, equation (3) for asset class j 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 bridge the gap between theory and data, we approximate equation (3) using a first-order Taylor expansion around the model's steady state and then take the difference of the approximate expression over time, which yields

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

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

Equation (4) relates the percentage change in bank i's demand $\Delta q_{i,t}^j$ for asset j to the percentage change in the asset's expected excess returns $\Delta \mathbb{E}_t[r_{t+1}^j] - \Delta r_t + \Delta \mathbb{E}_t[e_{t+1}] - \Delta e_t$ 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 US dollar asset j is downward sloping in the relative price of dollars Δe_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.[22] As a result, price elasticities of demand are the same for all banks around the steady state $\phi_i^j = \phi^j \ \forall i$:

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

This arises because, although banks with greater risk-bearing capacities ($\Gamma_i^j \downarrow$) tend to have more elastic demand ($\phi_i^j \uparrow$), they also take commensurately larger steady-state cross-border positions ($\overline{Q}_i^j \uparrow$), which decreases their demand elasticity until ϕ_i^j is constant across banks. We show in Appendix A.1, by adding more structure, that banks' demand elasticity ϕ^j depends 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 $\phi^j := \frac{1+\overline{Q}^j\Gamma^j}{\overline{Q}^j\Gamma^j}$.

Importantly, while we have thus far remained agnostic as to the distribution of Γ_i^j, we 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 as well. This enables us to consider the implications of granularity in bank size, as observed in the data.

Finally, in the baseline Gamma model of Gabaix and Maggiori (2015), the functional form of the incentive-compatibility constraint (2) does not allow for inelastic demand for currency. For now, note that the same is true in our Granular Gamma model, i.e., ϕ^j cannot be less than 1. However, since estimating equation (5) empirically can in principal deliver any value for the price elasticity ϕ^j, our empirical results in subsequent sections will allow us to discern between specific micro-foundations for the Granular Gamma model. We will therefore return to this when discussing our empirical elasticity estimates in Section 5.

3.2 Global Equilibrium in a Single Asset Market

To derive equilibrium conditions for a specific asset class j, we solve for the aggregate demand of UK-resident bankers for j and specify the behaviour of the ROW with respect to j.

We begin by taking the size-weighted average of equation (5), which gives the dynamics of

[22] 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. Intuitively, for banks to agree on the expected return, banks with greater risk-bearing capacities ($\Gamma_i^j \downarrow$) must take proportionately larger positions ($\overline{Q}_i^j \uparrow$).

UK-based bankers aggregate demand for cross-border asset j:

$$\Delta q^j_{S,t} = \phi^j \left(\Delta\mathbb{E}_t[r^j_{t+1}] - \Delta r_t + \Delta\mathbb{E}_t[e_{t+1}] - \Delta e_t\right) + \Delta b^j_{S,t}, \tag{6}$$

where the size-weighted averages (aggregates) are defined as $\Delta q^j_{S,t} := \sum_{i=1}^n S_{i,t-1}\Delta q^j_{i,t}$ and $\Delta b^j_{S,t} := \sum_{i=1}^n S_{i,t-1}\Delta b^j_{i,t}$, using weights $S^j_{i,t-1} := \frac{Q^j_{i,t-1}}{\sum_{i=1}^n Q^j_{i,t-1}}$. Thus, percentage changes in the aggregate demand by UK-resident banks for asset j evolve in proportion to expected excess returns and percentage changes in the size-weighted average of their individual beliefs $\Delta b^j_{S,t}$. Again, since the price elasticity ϕ^j is greater than 0, the aggregate demand curve is downwarding sloping in exchange rates, with aggregate beliefs $\Delta b^j_{S,t}$ 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 rest of the world's aggregate supply of asset j, we assume there exist a set of ROW 'funds'—any financial agent trading debt or equity instruments cross-border with UK-resident global banks—whose cross-border positions are analogously linked to their subjective beliefs, denoted by $b^j_{R,t}$, and expected excess returns:[23]

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

The price elasticity of supply ϕ^j_R, 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 $\Delta q^j_{S,t} = \Delta q^j_{R,t}$—i.e., equating UK-resident banks' demand for asset j with ROW funds' supply for it—we can derive equilibrium expressions. These include both equilibrium exchange-rate dynamics and the dynamics of domestic-resident bankers' aggregate holdings of asset class j, which we outline in the following proposition.

Proposition 1 (Equilibrium in Asset Market j) *In the Granular Gamma model, the equilibrium US dollar appreciation and the percentage change in UK-banks' cross-border holdings of dollar-*

[23]Concretely, ROW funds supply the foreign risky asset j to UK banks and invest cross border in the UK domestic safe asset (opportunity cost).

denominated asset j can be approximated by

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

$$\Delta q^j_{S,t} = \frac{\phi^j_R}{\phi^j + \phi^j_R} \Delta b^j_{S,t} + \frac{\phi^j}{\phi^j + \phi^j_R} \Delta b^j_{R,t}. \tag{9}$$

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

Equation (8) highlights that the equilibrium relationships between exchange-rate dynamics and changes in beliefs are governed by the multiplier $M^j := \frac{1}{\phi^j + \phi^j_R}$, which captures equilibrium feedback effects between prices and quantities. When UK banks become more optimistic about the return to investing in USD-asset j, $\Delta b^j_{S,t} \uparrow$, the USD appreciates against sterling. When ROW funds become more optimistic about the return to selling USD-asset j, $\Delta b^j_{R,t} \uparrow$, the USD depreciates against sterling. In both cases, 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 larger when banks' and funds' price elasticities are lower: $M^j \uparrow$ if ϕ^j, $\phi^j_R \downarrow$. Thus, the set of intermediaries—banks or funds—with more inelastic demand/supply exert greater influence over equilibrium exchange-rate dynamics. Intuitively, this is because more inelastic intermediaries—those with the less capacity to bear risk—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.[24] Which types of intermediary is more price-elastic is an empirical question, which we address in Section 5.

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

3.3 Global Equilibrium Across Asset Markets

In practice, UK-resident banks and ROW funds trade a wide array of different asset classes with each other. Equilibrium in each of these markets is characterised by equations (8) and (9) from Proposition 1, but with (potentially) unique multipliers. As a result, we can tie equi-

[24] Although ϕ^j and ϕ^j_R 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^j and ϕ^j_R since the two types of financiers must intermediate equal and opposite amounts in equilibrium.

librium exchange-rate dynamics to changes in beliefs and excess returns across these different asset classes.

Proposition 2 (Equilibrium Across All Asset Markets) *In the Granular Gamma model with multiple financial assets, the equilibrium US dollar appreciation can be approximated by*

$$\Delta e_t = \frac{1}{m}\sum_{j=1}^{m}\left(\frac{1}{\phi^j+\phi^j_R}\Delta b^j_{S,t} - \frac{1}{\phi^j+\phi^j_R}\Delta b^j_{R,t} + \Delta\mathbb{E}_t[r^j_{t+1}]\right) - \Delta r_t + \Delta\mathbb{E}_t[e_{t+1}]. \tag{10}$$

Proof: Assuming there are m different asset classes, sum over the m different versions of equation (8). □

Proposition 2 demonstrates that it is *net* beliefs and net flows across all asset classes j that determine equilibrium exchange-rate dynamics. This is because net cross-border positions determine banks' and funds' currency exposure, and hence the amount of exchange-rate risk on their respective balance sheets. Mapping to our data, Proposition 2 highlights that it is mismatched changes in banks' cross-border USD asset and liability holdings, due to fluctuations in their net (asset less liability) beliefs, that drive equilibrium exchange-rate dynamics. We will test this result empirically below. Furthermore, the proposition indicates that one must adjust the multiplier estimates for the number of asset classes (m) that UK-resident banks trade.

4 Empirical Strategy

Guided by our theoretical framework, we exploit the significant heterogeneity and concentration in banks' cross-border positions to construct granular financial (capital flow) shocks using the GIV approach of Gabaix and Koijen (2020). 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 our identification strategy and how we mitigate those concerns.

4.1 Granular Instrumental Variables

To estimate the elasticities ϕ^j and ϕ^j_R, we construct GIVs that capture exogenous idiosyncratic beliefs by granular banks. To construct the instruments, we use the subscript ξ to denote the difference between the size- and equal-weighted average of any variable $X^j_{i,t}$ such that $X^j_{\xi,t} := X^j_{S,t} - X^j_{E,t}$ with $X^j_{S,t} := \sum_{i=1}^n S^j_{i,t-1} X^j_{i,t}$ and $X^j_{E,t} := \frac{1}{n}\sum_{i=1}^n X^j_{i,t}$.

We specify the following form for changes in bank-specific beliefs

$$\Delta b^j_{i,t} = u^j_{i,t} + \lambda^j_i \eta^j_t + \theta^j C^j_{i,t-1}, \quad \text{with} \quad \mathbb{E}[u^j_{i,t}(\eta^j_t, \Delta b^j_{R,t})] = 0, \tag{11}$$

for all t, where $u^j_{i,t}$ are exogenous unobserved i.i.d. shocks, η^j_t are vectors of unobserved common factors with unobserved bank-specific loadings λ^j_i, and $C^j_{i,t-1}$ are observed controls with unknown coefficients θ^j.[25] Since the bank-specific belief shocks $u^j_{i,t}$ are i.i.d., they are uncorrelated with aggregate bank factors (η^j_t) and ROW-fund beliefs ($\Delta b^j_{R,t}$): $\mathbb{E}[u^j_{i,t}(\eta^j_t, \Delta b^j_{R,t})] = 0$.

We construct our GIVs for different asset classes j, z^j_t, from observables, by taking the difference between the size- and equal-weighted change in cross-border holdings $z^j_t := \Delta q^j_{\xi,t}$. Using equation (5), we can 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 bank-level beliefs $z^j_t = \Delta b^j_{\xi,t}$, that is:

$$z^j_t = u^j_{\xi,t} + \lambda^j_\xi \eta^j_t + \theta^j C^j_{\xi,t-1}. \tag{12}$$

In the event that banks' loadings on the unobserved common factors are correlated with size ($\lambda^j_\xi \neq 0$), we can account for the common factors η_t by controlling for principal components of bank-level flows in our specifications. We describe this procedure in detail in Section 4.4. Then, given that we control for relevant observables C^j_{t-1} as well, our GIVs reflect the size-minus-equal weighted combination of i.i.d. bank-level belief *shocks*:

$$z^j_t = u^j_{\xi,t}. \tag{13}$$

Consistent with banks' loadings on common factors being *un*correlated with size, we show in Appendix D that our GIVs, unlike other instruments, are unrelated to common proxies of the global financial cycle (see Section 4.4 for further details).

In the subsequent sections, we discuss in detail how these GIVs can be used to estimate the multipliers and elasticities present in the Granular Gamma model. Intuitively, since the GIVs

[25] The unobserved common factors are assumed to take the parametric form: $\lambda^j_i \eta^j_t = \sum_{k=1}^K \lambda^j_{i,k} \eta^j_{k,t}$.

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 the narrative strategy we use to verify the exogeneity of our GIVs, in Section 4.4.

Of note, since we have data on both the assets—debt (D) and equity (E)—and liabilities—deposits (L)—of banks, we can also construct GIVs for banks' *net* positions. In particular, we focus on the effects of net USD-denominated debt flows, which we define as $\Delta q_{i,t}^{net} := \frac{1}{2}\left(\Delta q_{i,t}^D - \Delta q_{i,t}^L\right)$ since $\overline{Q}^D \approx \overline{Q}^L$. Using equation (5), the bank-level net flow is

$$\Delta q_{i,t}^{net} = \phi^{net}\left(\frac{1}{2}\mathbb{E}_t[r_{t+1}^D - r_{t+1}^L] - \Delta r_t + \Delta\mathbb{E}_t[e_{t+1}] - \Delta e_t\right) + \frac{1}{2}\left(\Delta b_{i,t}^D - \Delta b_{i,t}^L\right), \quad (14)$$

where, since $\overline{Q}^D \approx \overline{Q}^L$ we treat $\phi^D \approx \phi^L$, which we label as ϕ^{net}. This equation illustrates that we can treat $j = net$ analogously to the other asset classes with $\Delta b_{i,t}^{net} := \frac{1}{2}\left(\Delta b_{i,t}^D - \Delta b_{i,t}^L\right)$ and $\mathbb{E}_t[r_{t+1}^{net}] := \frac{1}{2}\mathbb{E}_t\left[r_{i,t+1}^D - r_{i,t+1}^L\right]$. We can then construct the net-debt GIV as

$$\Delta z_t^{net} := \frac{1}{2}\left(z_t^D - z_t^L\right). \quad (15)$$

Since it is net flows that matter for exchange-rate dynamics in the Granular Gamma model, 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 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 (11) and (12) to rewrite the equilibrium condition (8) in terms of observables and an error term:

$$\Delta e_t = M^j z_t^j + \left(\Delta\mathbb{E}_t[r_{t+1}^j] - \Delta r_t + \Delta\mathbb{E}_t[e_{t+1}]\right) + M^j\theta^j C_{Ej,t-1} + \epsilon_t^j, \quad (16)$$

where $\epsilon_t^j := M^j\left(u_{E,t}^j + \lambda_E^j\eta_t^j + \Delta\mathbb{E}_t[b_{R,t+1}^j]\right)$ and $M^j := \frac{1}{\phi^j + \phi_R^j}$.

To identify the multiplier M^j by estimating equation (16) by OLS, two conditions are required. First, the change in expected excess returns to asset class j, as well as other controls, should be included. Second, the GIV z_t^j must be uncorrelated with the unobserved error term ϵ_t^j, that is, uncorrelated with η_t^j since z_t^j is orthogonal to the other terms by construction.

To satisfy the first requirement, we estimate the regression implied by equation (16) using a wide range of measures of returns—including relative government and corporate bond-yield differentials, relative equity returns and relative interbank interest rates—as control variables alongside survey data capturing changes in expected exchange rates from *Consensus Economics*. We further control for weighted bank-level and aggregate controls (see Section 4.4.2 for details). To satisfy the second requirement, the exogeneity of the GIV, we take a number of steps to tighten our identification in the event that $\lambda_\xi^j \neq 0$, which we explain in Section 4.4. These include accounting for unobserved common shocks η_t^j using principal-components analysis (Section 4.4.3) as well as a narrative check of the GIVs themselves (Section 4.4.4).

4.3 Elasticity Estimation with Two-Stage Least Squares

We then turn to estimate the two price elasticities ϕ^j and ϕ_R^j 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_R^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:

$$\Delta q_{S,t}^j = \phi_R^j \Delta e_t - \phi_R^j \left(\Delta \mathbb{E}_t[r_{t+1}^j] - \Delta r_t + \Delta \mathbb{E}_t[e_{t+1}] \right) + \Delta b_{R,t}^j. \tag{17}$$

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 (16) and second stage (17) regressions: $\mathbb{E}[z_t^j(\epsilon_t^j, \Delta b_{R,t}^j)] = 0$. 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^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):

$$\Delta q_{E,t}^j = -\phi^j \Delta e_t + \phi^j \left(\Delta \mathbb{E}_t[r_{t+1}^j] - \Delta r_t + \Delta \mathbb{E}_t[e_{t+1}] \right) + \theta^j C_{E,t-1}^j + \underbrace{u_{E,t}^j + \lambda_E^j \eta_t^j}_{:=\nu_t^j}. \tag{18}$$

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 (18) 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).[26]

In the next section, we describe in detail the steps we take to ensure the exogeneity restrictions are satisfied in our setup.

4.4 Threats to Identification

As discussed, we take additional steps to strengthen our identification, prior to estimating the regressions implied by equations (16), (17) and (18). 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 aggregate controls and unobserved common factors, are reflected in our specification of bank-level beliefs in equation (11). 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.

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.[27]

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

$$Q^j_{i,t} - Q^j_{i,t-1} := \underbrace{\left(\frac{\mathcal{E}_t}{\mathcal{E}_{t-1}} R^j_t - 1\right)}_{\text{Valuation Effect}} Q^j_{i,t-1} + \underbrace{F^j_{i,t}}_{\text{Capital Flow}} Q^j_{i,t-1}. \tag{19}$$

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

[26] 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 (17) to estimate the supply elasticity. Gabaix and Koijen (2020) show the optimal weighting scheme that smooths noise from estimates of the demand elasticity is equal weights.

[27] In our framework, this applies to valuation effects more broadly since all bankers receive the same *ex post* returns R^j_{t+1}.

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

$$z_t^j = F_{S,t}^j - F_{E,t}^j \tag{20}$$

Proof: Since $\frac{\mathcal{E}_t}{\mathcal{E}_{t-1}} R_t^j \approx 1$, we can approximate (19) as $F_{i,t}^j = \Delta q_{i,t}^j - \Delta e_t - r_t^j$. This gives the size-weighted capital flow $F_{S,t}^j = \Delta q_{S,t}^j - \Delta e_t - r_t^j$ and the equal-weighted capital flow $F_{E,t}^j = \Delta q_{E,t}^j - \Delta e_t - r_t^j$. Combining these averages with the definition of our instruments $z_t^j := \Delta q_{\xi,t}^j$, we arrive at $z_t^j = F_{S,t}^j - F_{E,t}^j$. $\square$

This corollary implies that our estimates of the exchange-rate multiplier codified in equation (16) 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 (17) and (18): they capture the responsiveness of cross-border positions to changes in the exchange rate, excluding valuation effects.

4.4.2 Bank and Macro Controls

A second concern, formalised by equation (11), is how we account for time-varying bank-specific factors $C_{i,t}^j$. Our confidential bank-level data set provides a range of control variables that can account for variation in different banks' cross-border portfolios 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,[28] 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.

[28] Kashyap and Stein (2000) show that monetary policy can have a greater impact on banks with lower liquid-asset buffers.

Finally, in addition to controlling for a wide range of local asset returns as well as a measure of exchange rate expectations from *Consensus Economics*, we also control for global risk-sentiment and uncertainty using the VIX index, which has been shown to affect capital flows and exchange rates (see e.g., Rey, 2015, Bruno and Shin, 2015a,b and Miranda-Agrippino and Rey, 2020). Further details on our controls are discussed in Appendix B.1.

4.4.3 Unobserved Common Factors

Additionally, equation (11) 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 our bank-level controls $C_{i,t}^j$ alongside principal component analysis to obtain estimates of common factors $\hat{\eta}_t^j$. Following Gabaix and Koijen (2020), to do this, we start by rewriting equation (5) using the definition (11) to get:

$$\Delta q_{i,t}^j = \theta_t^j + \theta^j C_{i,t-1}^j + \zeta_{i,t}^j \tag{21}$$

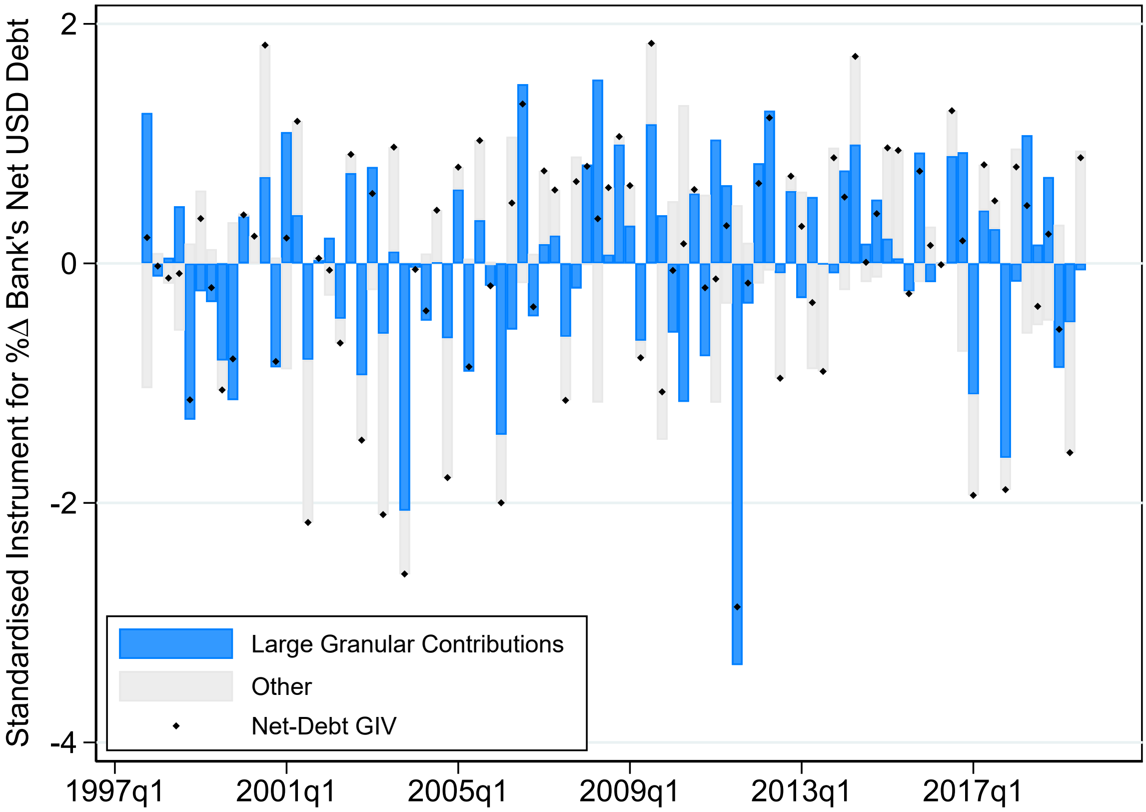
where θ_t^j denotes an asset-time fixed effect for asset j that absorbs the expected returns in $\Delta \mathbb{E}_t[r_{t+1}^j] - \Delta r_t + \Delta \mathbb{E}_t[e_{t+1}] - \Delta e_t$, as well as any other unobserved time-varying object that is the same for all banks i, and the error term is $\zeta_{i,t}^j := u_{i,t}^j + \lambda_i^j \eta_t^j$. 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 time t residuals $\hat{\zeta}_{i,t}^j$ across banks. 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.

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. Unfortunately, a complete discussion of this exercise is limited, owing to confidentiality restrictions on our data. However, in this sub-section we summarise the headline findings from our narrative checks.

To support this, Figure 4 plots a decomposition of the quarterly GIV for USD-denominated net-debt positions (15), 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 over one-fifth of a full-sample standard deviation change. In each period, the con-

Figure 4: 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 1997Q3-2019Q3. 'Large Bank' bar contains total contribution of all banks that explain over 20% of one full-sample standard deviation of the GIV in a given period. In practice, this contains a small number of banks (< 10), although a more granular decomposition is not possible owing to confidentiality restrictions on the date.

tribution 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 manually search and analyse the *Financial Times* archives to identify the key pieces of news pertaining to specific large banks in the quarters in which they move the GIV. 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 most of the key drivers of moves in the GIV are associated with idiosyncratic events, which are unlikely to be systematically related to the macroeconomic outlook or possible confounders (e.g., global risk sentiment). Amongst the news headlines pertaining to large banks in periods in which they explain a large portion of our GIV are: being involved in a merger or acquisition; facing a change in leadership; receiving a legal fine; failing a stress test; or, in one instance, facing a computer failure that limited its ability to process cross-border payments.

In addition, as further evidence that our GIVs are composed of idiosyncratic, non-systemic shocks to large banks, we show in Table D.2 in Appendix D that the net-debt GIV plotted in Figure 4 is not correlated with proxies for the global financial cycle—the VIX index and the global common risky-asset price factor of Miranda-Agrippino and Rey (2020)—nor by the stance of US monetary policy, which has been shown to orchestrate capital flows around the world.

Overall, the steps we have taken to defend ourselves against threats to identification leave us as confident in the exogeneity of our instrument as we can be.

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 investigate the causal multiplier for banks' flows into different asset classes on the USD/GBP exchange rate, as captured in Proposition 2, we build on equation (16) and estimate the following relationship by OLS:

$$\Delta e_t = \sum_{j=1}^{m} M^j \frac{z_t^j}{m} + \beta_M^j C_t + u_t, \qquad (22)$$
$$\text{where} \quad C_t = \left[(\Delta r_{t+1}^j - \Delta r_{t+1}^{j,*})_{\forall j}, \Delta \mathbb{E}_t[e_{t+1}], C_{S,t-1}^j, C_{t-1}, \hat{\eta}_t^j \right],$$

where we are primarily interested in estimates for the multipliers M^j for all j, C_t^j is a vector of controls with a corresponding vector of coefficients β_M^j, asterisks (*) denote UK returns, and u_t is a disturbance. Our first set of controls are a wide range of changes in US-minus-UK local currency return differentials $\Delta r_{t+1}^j - \Delta r_{t+1}^{j,*}$: relative 3-month interbank deposits rates, relative short- and long-maturity government bond yields, relative corporate bond index yields and relative realized equity returns.[29] We additionally use *Consensus Economics* forecasts of exchange rates to control for changes in exchange-rate expectations $\mathbb{E}_t[\Delta e_{t+1}]$, akin to those used by Stavrakeva and Tang (2020), as well as log-changes in the lagged VIX as a control for broader macro-financial conditions in C_{t-1}. Next, we include size-weighted, by total assets, averages of lagged bank-level controls $C^j_{S,t-1}$, namely banks' total assets, international-asset shares, liquid-asset ratios, core-deposit ratios, commitment shares, and capital ratios. Finally, we include the first five principal components extracted from changes in total assets $\hat{\eta}^j_t$ as proxies for unobserved common factors.

Table 1 presents our baseline results. The coefficients on z^j_t/m represent the causal effect of a 1% increase in UK-resident banks' aggregate holdings of USD instruments on the nominal price of dollar in pounds expressed in percent.

In Panel A, we report multipliers for specific assets and liabilities, estimated jointly. The positive coefficients in the first two rows indicate that both asset-side measures, debt and equity positions, have significant effects on the dollar, pushing it to appreciate on impact. The effect is particularly strong for dollar-debt positions. Significant negative coefficients in the third row also imply that increases in cross-border borrowing in dollar are associated with a USD depreciation.

These effects are robust to the inclusion of bank and macro controls (columns 2 and 3), as well as to accounting for unobserved common factors (column 4), and quantitative estimates are similar across specifications. Coefficients on many of the additional controls are significant, and come with the expected sign. On the asset-side, cross-border debt positions have a significantly higher multiplier, which we estimate to be between 1.2 and 2, in comparison to the portfolio-flow multiplier of around 0.2-0.4. These differences may be because the local-currency price of equities reacts more to capital flows than the local-currency price of debt (see Gabaix and Koijen, 2022), such that exchange rates need to react less to clear the market.[30] While we find that the *on-impact* multiplier for deposit liabilities (-0.6 to -1.1) is slightly lower than for dollar debt, we show below that their causal effects in subsequent periods are about equal and opposite.

In Panel B, we focus in on the multiplier for the net debt positions—i.e., USD debt assets minus deposit liabilities. Our point estimates imply that a 1% increase in net dollar-debt positions is associated with between a 0.4 and 0.8% appreciation of the dollar on impact. Of note, the R^2 in column (1) coming from the regression that includes only the net-dollar debt GIV is

[29] For debt instruments, we use changes in returns from time $t-1$ to t since these yields are known at time t. For equities, we instead use changes in *realized* equity returns from t to $t+1$.

[30] Another possibility is that banks' counterparties in equity markets have more elastic demand than their counterparties in debt markets.

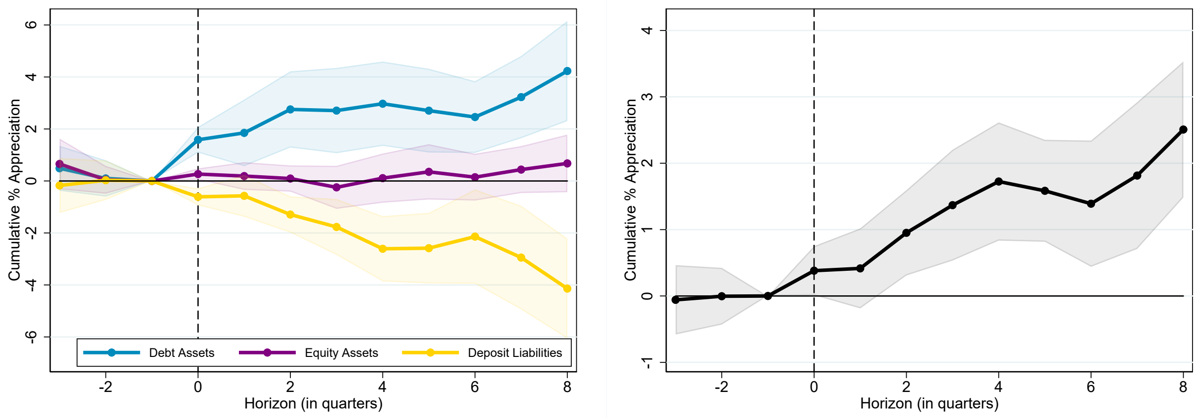
Table 1: Multiplier Estimates for External Asset, Liability and Net Flows on Exchange Rates

	(1)	(2)	(3)	(4)
	DEP. VAR.: % change nominal USD/GDP			
PANEL A: Multipliers for Specific USD Asset and Liability Flows				
z_t^j/m: Debt (Assets)	2.000***	1.231***	1.190***	1.585***
	(0.358)	(0.198)	(0.208)	(0.253)
z_t^j/m: Equity (Assets)	0.423***	0.251*	0.277**	0.265**
	(0.142)	(0.139)	(0.136)	(0.112)
z_t^j/m: Deposits (Liabilities)	-1.135***	-0.485***	-0.443**	-0.610***
	(0.346)	(0.168)	(0.175)	(0.167)
$\Delta\mathbb{E}_t[e_{t+1}]$		0.453***	0.445***	0.445***
		(0.099)	(0.095)	(0.094)
$\Delta(r^{us}_{eq,t+1} - r^{uk}_{eq,t+1})$		0.037***	0.040***	0.043***
		(0.013)	(0.012)	(0.013)
$\Delta(r^{us}_{6M,t} - r^{uk}_{6M,t})$		0.036***	0.029**	0.035***
		(0.013)	(0.013)	(0.012)
$\Delta(r^{us}_{10Y,t} - r^{uk}_{10Y,t})$		0.028	0.027*	0.028
		(0.018)	(0.016)	(0.018)
$\Delta(r^{us}_{ib,t} - r^{uk}_{ib})$		-0.021**	-0.016	-0.022*
		(0.010)	(0.011)	(0.011)
$\Delta(r^{us}_{corp,t} - r^{uk}_{corp,t})$		-0.015*	-0.018**	-0.014**
		(0.008)	(0.008)	(0.007)
Δvix_{t-1}		-0.013	-0.013	-0.018
		(0.015)	(0.015)	(0.014)
Observations	88	88	87	87
Macro Controls	No	Yes	Yes	Yes
Bank Controls	No	No	Yes	Yes
Components	No	No	No	5
Adjusted R^2	0.201	0.657	0.648	0.682
PANEL B: Multipliers for Net USD-Debt Flows				
z_t^{net}: Net-Debt	0.818***	0.378**	0.367**	0.381**
(Debt – Deposits)	(0.275)	(0.159)	(0.169)	(0.189)
Observations	88	88	87	87
Macro Controls	No	Yes	Yes	Yes
Bank Controls	No	No	Yes	Yes
Components	No	No	No	5
Adjusted R^2	0.069	0.573	0.557	0.570

Notes: Coefficient estimates from equation (22) using data for 1997Q1-2019Q3. Panel A presents multiplier estimates for specific assets/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 USD/GBP exchange rate $\mathbb{E}_t[e_{t+1}]$; relative equity returns $(r^{us}_{eq} - r^{uk}_{eq})$, 6-month government bond yields $(r^{us}_{6M} - r^{uk}_{6M})$, 10-year government bond yields $(r^{us}_{10Y} - r^{uk}_{10Y})$, 3-month interbank deposit rates $(r^{us}_{ib} - r^{uk}_{ib})$, corporate bond yields for US and UK $(r^{us}_{corp} - r^{uk}_{corp})$; and lagged VIX. Bank controls are size-weighted: total assets, international-asset shares, liquid-asset ratios, core-deposit ratios, commitment shares, capital ratios. Principal components are extracted from changes in total assets. Newey and West (1987) standard errors with 12 lags are in parentheses. Significance at 10%, 5% and 1% denoted by $*$, $**$, and $***$, respectively.

Figure 5: Dynamic Multipliers for Assets, Liabilities and Net Flows on Exchange Rates

(a) Specific Assets and Liabilities (b) Net Dollar-Debt Positions (Debt − Deposits)



Notes: Multiplier estimates from local-projection estimation of equation (22) using data for 1997Q1-2019Q3. Figure 5a presents multiplier estimates for specific assets and liabilities (estimated jointly). Figure 5b presents multiplier estimates for net-debt positions. Shaded bars denote 95% 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.

7%, which demonstrates the salience of granular financial shocks for exchange-rate dynamics.

Since the multipliers are given by $M^j = \frac{1}{\phi^j + \phi_R^j}$, our estimates already 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 (22) to estimate the dynamic effects of cross-border banking flows on the USD/GBP 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.

While Figure 5a suggests that the causal effects of cross-border banking flows into USD equity assets on the USD exchange rate are short-lived, the local projections reveal that the causal effects of flows into USD debt assets and liabilities are very persistent. Figure 5a shows that, subsequent to the on-impact multiplier of around 1.6, from column (4) of Table 1, a 1% change in size-minus-equal-weighted debt-asset flows is associated with a cumulative USD appreciation of around 3% one year after the shock. Estimates for the other side of the carry trade, banks' liabilities, reveal a roughly equal and opposite story. A 1% exogenous increase in UK-resident banks' USD deposit liabilities is associated with around a 3% depreciation of the USD one year after the shock. Consistent with our model, where a permanent increase in demand generates a permanent shift in the level of the exchange rate, these multipliers do not revert even two years after the initial shock. Overall, these estimates suggest that equal-and-

Table 2: Appreciation per Unit of GDP Implied by Multiplier Estimates at 1-Year Horizon

Asset Class j	$\overline{Q}^j$	$\overline{Q}^j/\overline{GDP}$	$\hat{M}^j$	$\hat{M}^j \cdot \overline{GDP}/\overline{Q}^j$
Debt (Assets)	0.90	60%	2.97	4.93
Equity (Assets)	0.18	12%	0.11	0.90
Liabilities	0.92	61%	-2.61	-4.28

Notes: Average cross-border positions in GBP (trillions) $\overline{Q}^j$ and as a share of UK GDP (approx. 1.5 trillion GBP) $\overline{Q}^j/\overline{GDP}$ over period 1997Q1-2019Q3 in columns 1 and 2. Column 3 restates multipliers from Panel A of Figure 5 at 1-year horizon from the local projection adaptation of specification (22). Column 4 puts estimates in units of UK GDP.

opposite changes in UK-resident banks' USD debt-asset and liability positions are associated with near-zero overall effects on the exchange rate.

Figure 5b, however, shows how mismatches in banks' USD debt-asset vs. USD deposit liability positions can have substantial exchange rate effects. Plotting the impulse response of the USD/GBP exchange rate to exogenous changes in banks' net dollar-debt position (i.e., debt-assets minus deposit-liabilities) reveals that a 1% change in banks' net carry-trade position in USD is associated with around a 2% appreciation of the dollar *vis-à-vis* sterling one year after the shock. And, once again, this effect is persistent.

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 USD/GBP exchange rate one-year ahead. We report these estimates in Table 2. For example, a flow into dollar-denominated debt by UK banks equivalent to 1% of UK GDP appreciates the dollar by about 5% one year after the shock.

5.2 Inelastic Banks

Motivated by our discussion of Table 1, we next estimate the supply and demand elasticities for net dollar-debt positions using a two-stage least squares estimation procedure informed by equations (17) and (18).

To estimate the supply elasticity for net dollar-debt from the rest of the world ϕ_R^{net}, we use the following regression building on equation (17):

$$\Delta q_{S,t}^{net} = \phi_R^{net} \Delta e_t + \beta_{\phi_R}^{net} C_t + u_t, \tag{23}$$

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 (22) which have coefficients denoted by $\beta_{\phi_R}^{net}$.

Panel A of Table 3 presents estimates of the supply elasticity from our second-stage regres-

Table 3: Supply and Demand Elasticity Estimates for Net Flows *vis-à-vis* Exchange Rates

	(1)	(2)	(3)	(4)
PANEL A: 2nd Stage for Supply Elasticity (ϕ_R^{net}) DEP. VAR.: $\Delta q_{S,t}^{net}$				
Δe_t	0.821***	1.793**	1.804**	2.037**
	(0.294)	(0.719)	(0.767)	(0.824)
Observations	88	88	87	87
1st-Stage F-stat.	8.85	34.22	30.94	32.66
Macro Controls	No	Yes	Yes	Yes
Bank Controls	No	No	Yes	Yes
Components	No	No	No	5
PANEL B: 2nd Stage for Demand Elasticity ($-\phi^{net}$) DEP. VAR.: $\Delta q_{E,t}^{net}$				
Δe_t	-0.402***	-0.854**	-0.888**	-0.538*
	(0.138)	(0.377)	(0.368)	(0.321)
Observations	88	88	87	87
1st-Stage F-stat.	8.85	34.22	27.81	33.71
Macro Controls	No	Yes	Yes	Yes
Bank Controls	No	No	Yes	Yes
Components	No	No	No	5

Notes: PANEL A: Coefficient estimates from regression (23). PANEL B: Coefficient estimates from regression (24). All regressions estimated with data for 1997Q1-2019Q3. Corresponding first-stage regression coefficients reported in Appendix D. Coefficients on macro and bank controls suppressed for presentational purposes. Macro controls: changes in expectations for the USD/GBP exchange rate, relative equity returns, 6-month government bond yields, 10-year government bond yields, 3-month interbank deposit rates, corporate bond yields for US and UK, and lagged VIX. Bank controls are size-weighted (PANEL A) and equal-weighted (PANEL B): total assets, international-asset shares, liquid-asset ratios, core-deposit ratios, commitment shares, capital ratios. Principal components are extracted from changes in total assets. Newey and West (1987) standard errors with 12 lags are in parentheses. Significance at 10%, 5% and 1% denoted by $*$, $**$, and $***$, respectively.

sion for four specifications: without controls, adding macro controls, adding bank controls, and adding further controls for unobserved components. For the final three of these specifications in columns (2)-(4) our first-stage F-statistic is significantly above 10, supporting the relevance of our GIV.[31] In these columns, our coefficient estimates robustly reveal a significant positive supply relationship between exchange rates and cross-border net dollar-debt positions, with point estimates for the price elasticity of USD supply from ROW financial players ϕ_R^{net} ranging from 1.8 to 2. These elastic estimates imply that non-UK bank intermediaries' positions respond more than proportionately to exchange-rate movements—by about a factor of 2.

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

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

ϕ^{net}, we build on equation (18) and use z_t^{net} as an instrument for Δe_t in the following regression:

$$\Delta q_{E,t}^{net} = -\phi^{net} \Delta e_t + \beta_\phi^{net} C_t + u_t, \tag{24}$$

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

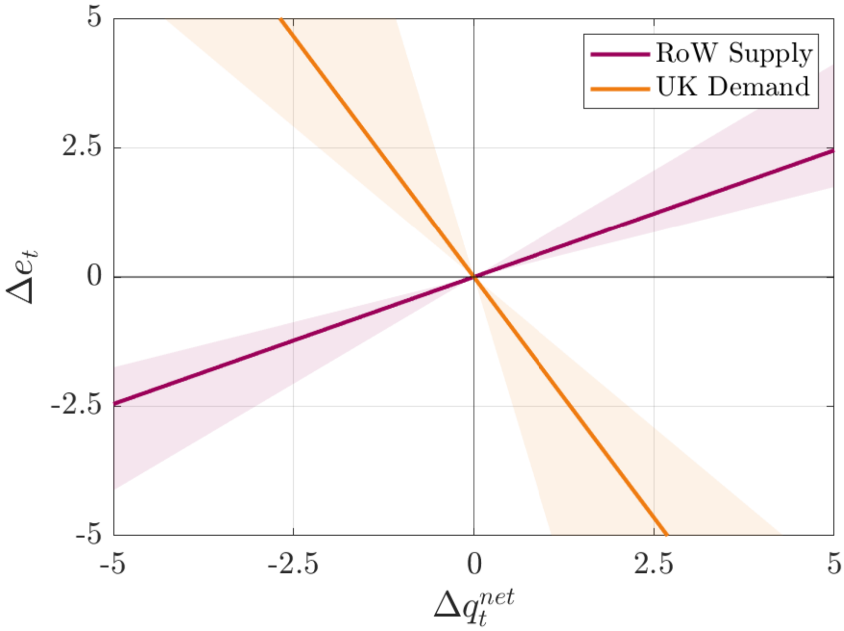
Panel B of Table 3 presents estimates of the demand elasticity from the second stage regression (24). Since the first-stage regressions for both (23) and (24) are nearly identical, our first-stage F statistics continue to suggest that our GIV is relevant in columns (2)-(4). In these columns, point estimates imply that (the negative of) UK-resident banks' price elasticity of demand for USDs $-\phi^{net}$ lies between -0.5 and -0.9. Reassuringly, combining these estimated demand and supply elasticities according to $M^{net} = \frac{1}{\phi^{net}+\phi_R^{net}}$ produces multiplier values very similar to those reported in Panel B of Table 1 (column 4).

Interestingly, these estimates indicate that, while the elasticity of dollar supply from the rest of the world is elastic with respect to prices, the elasticity of demand by UK-resident banks is inelastic—with point estimates lying below unity. That is, our estimates imply that a 1% appreciation of the USD is associated with a less than proportional increase in demand for USDs by UK-resident banks—by about half.

Figure 6 plots the dollar supply and demand relationships implied by the coefficient estimates in column (4) of Table 3. It highlights graphically that UK banks' demand curve (in yellow) is significantly steeper than their foreign counterparties' supply curve (in red). In decomposing the multiplier $M^{net} = \frac{1}{\phi^{net}+\phi_R^{net}}$, the fact that the demand elasticity ϕ^{net} lies significantly below the supply elasticity ϕ_R^{net} implies that UK-resident banks exert a greater influence over the exchange-rate response to financial shocks compared to (the average of) the other market participants, such as various types of non-bank financial institutions. That is, UK-based banks are the marginal traders in the USD-GBP market. Through the lens of our model, this can be attributed to banks' lower capacity (or willingness) to bear risk. An implication of banks' inelastic demand, however, is that global financial shocks that affect the supply of dollars from abroad will weigh heavily on the value of sterling when intermediated by banks, which may carry consequences for the real economy through export and import prices.

Inelastic Elasticities in the Granular Gamma Model. As well as being significant in and of itself, the fact our point estimates imply *inelastic* price-elasticities of USD demand by banks is at odds with the micro-foundations underpinning the Gamma model of Gabaix and Maggiori

Figure 6: Inelastic UK-Bank Demand for and Elastic Rest of the World Supply of USDs



Notes: Supply and demand relationships between the change in the exchange rate Δe_t and changes in net-debt (debt $-$ deposit) quantities Δq_t^{net} implied by elasticity estimates in column (4) of Table 3. Shaded areas denote 1 standard-deviation error bands implied by the Newey and West (1987) standard errors, with 12 lags.

(2015), as well as our Granular Gamma model from Section 3. This is due to the form of the incentive-compatibility constraint (2), which requires the market for dollars to be elastic—i.e., with elasticities above unity—to ensure banks do not divert funds in equilibrium. This suggests there is scope to adapt the Gamma model setup to account for inelastic demand.

One alternative 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:

$$V_{i,t}^j \geq (\Gamma_i^j Q_{i,t}^j)^{\gamma_i^j} \cdot Q_{i,t}^j. \tag{25}$$

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

$$Q_{i,t}^j = \frac{1}{\Gamma_i^j} \cdot \mathbb{E}_t \left[\exp(b_{i,t}^j) \cdot \left(\frac{R_{t+1}^j}{R_t} \frac{\mathcal{E}_{t+1}}{\mathcal{E}_t} - 1 \right) \right]^{\frac{1}{\gamma_i^j}}, \tag{26}$$

which we can approximate as:

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

This expression yields identical regressions to those described above, providing a new lens through which to interpret our results. Most importantly, the parameter governing the severity of the agency friction γ_i^j gives rise to a demand curve for cross-border positions that can have a price elasticity below unity, which raises the question: what influences this agency friction in practice?

5.3 The Role of Banks' Constraints

To answer this question and analyse the drivers of inelastic dollar demand, in this sub-section, we extend our empirical framework to test for time variation in the banking systems' ability to absorb capital flows. To do this, we focus on the role of banks' constraints, in particular their capital ratios—which are a function of regulatory policy and banks' internal risk-management preferences. Bank capital can alleviate the agency friction at the heart of the Granular Gamma model, ensuring that banks have funds to repay depositors and, as a result, can impact dynamics arising from cross-border flows.

To test for non-linearities linked to bank capital, we extend regression (22) by interacting our net dollar-debt GIV z_t^{net} with the lagged size-weighted average of UK-based banks' Tier-1 capital ratios $Cap_{S,t-1}$:

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

where M represents the multiplier when banks' size-weighted capital ratios are at their long-run average and δ represents how this changes with respect to size-weighted bank capital, which is normalised such that the coefficient represents the effect of a 1 standard deviation change.

Table 4 presents our results for this regression. For the average size-weighted bank capital ratio, our multiplier estimate is around 0.3-0.8%. However, this multiplier is decreasing in bank capitalisation, as the significant interaction terms reveal. They indicate that the multiplier can be about fully offset when bank capital ratios are 1 standard deviation above their average, and nearly doubled when ratios are 1 standard deviation below their average. These findings therefore highlight that bank capital regulation has important implications for the relationship between cross-border banking flows and foreign-exchange markets. Furthermore, it suggests that a better capitalised banking sector, by flattening banks' demand curves for USDs, helps to insulate the domestic economy from the global financial cycle.

Table 4: Time-Varying Multiplier of Net Flows on Exchange Rates from Bank Capitalisation

	(1)	(2)	(3)	(4)
	DEP. VAR.: % change nominal USD/GBP			
z_t^{net}	0.760***	0.350**	0.337**	0.363**
	(0.219)	(0.144)	(0.145)	(0.167)
$z_t^{net} \times Cap_{S,t-1}$	-0.598*	-0.480**	-0.488**	-0.413**
	(0.319)	(0.207)	(0.212)	(0.188)
$Cap_{S,t-1}$	-0.001	-0.000	-0.005	-0.004
	(0.004)	(0.003)	(0.005)	(0.004)
Observations	87	87	87	87
Macro Controls	No	Yes	Yes	Yes
Bank Controls	No	No	Yes	Yes
Components	No	No	No	5
Adjusted R^2	0.084	0.587	0.578	0.584

Notes: Coefficient estimates from equation (27) using data from 1997Q1-2019Q3. Coefficients on macro and bank controls are suppressed for presentational purposes. Macro controls: changes in expectations for the USD/GBP exchange rate, relative equity returns, 6-month government bond yields, 10-year government bond yields, 3-month interbank deposit rates, corporate bond yields for US and UK, and lagged VIX. Bank controls are size-weighted: total assets, international-asset shares, liquid-asset ratios, core-deposit ratios, commitment shares, capital ratios. Principal components are extracted from changes in total assets. Newey and West (1987) standard errors with 12 lags are in parentheses. Significance at 10%, 5% and 1% denoted by $*$, $**$, and $***$, respectively.

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 banking positions, which comprise around one-fifth of cross-border banking flows and 38% 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' USD positions over time.

Motivated by this granularity, we developed a new granular model of exchange-rate determination. To test the model's predictions, we idenfitied 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 dollar-debt positions leads to a persistent dollar appreciation of around 2% against sterling. We have also shown that these effects are highly state dependent, with effects nearly twice as large when banks' capital ratios are one standard deviation below average. This highlights the importance of banks' time-varying risk-bearing capacity for exchange-rate dynamics.

Moreover, we have used our granular financial shocks to estimate distinct bank demand

and ‘fund’ supply elasticities in the foreign-exchange market. Interestingly, our estimates reveal that demand for USDs by UK-resident banks is price inelastic with respect to exogenous changes in the exchange rate, whereas the supply of USDs by rest-of-the-world financial players is price elastic. This finding of inelastic demand is at odds with state-of-the-art international macroeconomics models, which restricts elasticities to be greater than 1, although we show that a simple change to the agency friction can rationalise our empirical results. Most importantly, our results suggest that UK-based banks’ relative price-insensitivity makes them the ‘marginal’ player in the dollar-sterling market.

While our finding of inelastic dollar demand by UK-based banks suggests that global financial shocks weigh heavily on the value of the sterling, policies that ensure banks are well-capitalised can help to mitigate these vulnerabilities by flattening their demand curves for currency. We defer a deeper investigation of the macroeconomic consequences and policy considerations of our findings to future work.

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Appendix

A Model Appendix

A.1 Details on Approximation

We approximate the model using a first-order Taylor expansion of the banker'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 \Bigg[\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) \\
& - \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}}) \Bigg] \\
(Q_{i,t}^j - \overline{Q}_i^j) \approx & \frac{1}{\Gamma_i^j} \cdot \Bigg\{ \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] \\
& + \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} \Bigg\} \\
(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 $\phi^j_i = \left(\frac{1+\overline{Q}^j_i\Gamma^j_i}{\overline{Q}^j_i\Gamma^j_i}\right)$.

Of note, 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 $\phi^j_i = \phi^j \; \forall i$, specifically, $\phi^j = \frac{1+\left(\overline{B}^j\left(\frac{\overline{R}^j}{\overline{R}}-1\right)\right)}{\left(\overline{B}^j\left(\frac{\overline{R}^j}{\overline{R}}-1\right)\right)}$. 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, $\phi^j = \left(\frac{1+\overline{Q}^j\Gamma^j}{\overline{Q}^j\Gamma^j}\right)$, 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 $\Delta q^j_{S,t} = \Delta q^j_{R,t}$. This gives

$$\phi^j\left(\Delta\mathbb{E}_t[r^j_{t+1}] - \Delta r_t + \Delta\mathbb{E}_t[e_{t+1}] - \Delta e_t\right) + \Delta b^j_{S,t} = \\ -\phi^j_R\left(\Delta\mathbb{E}_t[r^j_{t+1}] - \Delta r_t + \Delta\mathbb{E}_t[e_{t+1}] - \Delta e_t\right) + \Delta b^j_{R,t}, \tag{A.2}$$

which simplifies to

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

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

$$\Delta q_{S,t}^j = \frac{\phi_R^j}{\phi^j + \phi_R^j}\Delta b_{S,t}^j + \frac{\phi^j}{\phi^j + \phi_R^j}\Delta b_{R,t}^j. \tag{A.4}$$

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*.
- 3-month interbank interest rates, in the US and UK, from *Global Financial Data*.
- 6-month and 10-year government bond yields, in the US and UK, from Gürkaynak et al. (2007) and the Bank of England, respectively.
- 3-month realised equity returns, in the US and UK, from *MSCI*.
- Corporate bond index yields, in the US and UK, from *Global Financial Data*.
- Mean survey forecasts for 3-month-ahead USD/GBP 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 4. However, within our dataset, we are able to further decompose 'Large Banks', which reflects banks explaining at least one-fifth of a full-sample standard deviation of our GIV, into individual banks (the specific composition of which is confidential). As a consequence, we can see period-by-period which entities 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 then conduct a narrative search by manually accessing the Financial Times (FT) archives. We access the FT Historical Archives for the period 1997 to 2016 through the Bank of England Information Centre access to Gale Source.[32] For the 2017-2019 period, we use the FT search function.

For each quarter, we search for news articles pertaining to the specific bank(s) that explain a significant portion of the variation within the period. We use search terms that capture the banks' names, 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 whether it is of relevance to the banks' international operations. Since these articles reveal the name of the bank, we cannot share the links.

Nevertheless, to summarise the results of the narrative checks, we manually classify the events that we find into different key terms. These terms are presented visually in a word cloud in Figure C.1. 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 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, management changes and fines for the different institutions. In addition, stress-test results and computer failures also show up.

[32]See https://www.gale.com/intl/c/financial-times-historical-archive.

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

Notes: Key terms from manual narrative checks of granular instruments. Terms come from searching historical Financial Times archives 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.

D Additional Empirical Results

Table D.1 presents the first stage regression results used to compute our estimates for the demand and supply elasticities displayed in Table 3.

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

	(1)	(2)	(3)	(4)
PANEL A: 1st Stage for Supply Elasticity (ϕ_R^{net})				
DEP. VAR.: Δe_t				
Δz_t^{net}	0.818***	0.378**	0.367**	0.381**
	(0.275)	(0.159)	(0.169)	(0.189)
Observations	88	88	87	87
1st-Stage F-stat.	8.85	34.22	30.94	32.66
Macro Controls	No	Yes	Yes	Yes
Bank Controls	No	No	Yes	Yes
Components	No	No	No	5
PANEL B: 1st Stage for Demand Elasticity ($-\phi^{net}$)				
DEP. VAR.: Δe_t				
z_t^{net}	0.818***	0.378**	0.367**	0.397**
	(0.275)	(0.159)	(0.156)	(0.185)
Observations	88	88	87	87
1st-Stage F-stat.	8.85	34.22	27.81	33.71
Macro Controls	No	Yes	Yes	Yes
Bank Controls	No	No	Yes	Yes
Components	No	No	No	5

Notes: PANEL A: Coefficient estimates from 1st stage regression (23). PANEL B: Coefficient estimates from 1st stage regression (24). Coefficients on macro and bank controls suppressed for presentational purposes. Macro controls: changes in expectations for the USD/GBP exchange rate, relative equity returns, 6-month government bond yields, 10-year government bond yields, 3-month interbank deposit rates, corporate bond yields for US and UK, and lagged VIX. Bank controls are size-weighted (Panel A) and equal-weighted (Panel B): total assets, international-asset shares, liquid-asset ratios, core-deposit ratios, commitment shares, capital ratios. Principal components are extracted from changes in total assets. Newey and West (1987) standard errors with 12 lags are in parentheses. Significance at 10%, 5% and 1% denoted by $*$, $**$, and $***$, respectively.

Table D.2 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 monetary policy rate in levels 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 insigificantly and have no explanatory power (see the adjusted 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.2: GIV for Net-Debt Flows Not Related to Global Financial Cycle

PANEL A DEP. VAR.: Δz_t^{net}	(1)	(2)	(3)	(4)
vix_t	-0.000			-0.000
	(0.000)			(0.000)
GFC_t		0.001		0.001
		(0.001)		(0.002)
$r_{6M,t}^{us}$			-0.000	-0.000
			(0.001)	(0.001)
Observations	88	86	88	86
Adjusted R^2	-0.01	-0.01	-0.01	-0.03
PANEL B DEP. VAR.: Δz_t^{net}	(1)	(2)	(3)	(4)
Δvix_t	0.001			-0.006
	(0.008)			(0.008)
ΔGFC_t		-0.004		0.006
		(0.004)		(0.004)
$\Delta r_{6M,t}^{us}$			-0.002	-0.000
			(0.004)	(0.005)
Observations	88	86	88	86
Adjusted R^2	-0.01	0.01	-0.01	-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 monetary policy rate in levels (Panel A) and in changes (Panel B), with the VIX index in log-changes. Newey and West (1987) standard errors with 12 lags are in parentheses. Significance at 10%, 5% and 1% denoted by $*$, $**$, and $***$, respectively.