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1 Introduction

The extent to which capital flows move exchange rates is a long-standing question in international macroeconomics. A major challenge to addressing it has been the difficulty identifying plausibly exogenous cross-border flows, since capital flows evolve simultaneously with current and expected future macroeconomic conditions and their relationship with exchange rates can be confounded by other factors, such as global risk sentiment. In this paper, we resolve this impasse by using a *bank-level* dataset capturing the external assets and liabilities of UK-resident global intermediaries to construct novel Granular Instrumental Variables (GIVs) (Gabaix and Koijen, 2020) for cross-border flows. We use these instruments to ask: What is the causal effect of international banking flows on the US dollar (USD)? How inelastic are the relationships between exchange rates and the supply and demand for USDs? What role does banks' time-varying risk-bearing capacity play for these links?

Our dataset is sufficiently granular and representative to answer these questions in a robust and general manner. It is well known that currency-market trading is highly concentrated in a few large International Financial Centres (IFCs) and, as we document in detail, amongst a relatively small number of large financial players. Cross-border banking claims comprised, on average, over one-quarter of overall cross-border claims worldwide over the period 1997Q1-2019Q3. Amongst these banking claims, the UK represents by far the largest IFC, with the 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] Our raw dataset contains the external assets and liabilities of 451 UK- and foreign-owned global banks, of which a small number of large institutions explain the majority of overall positions. Moreover, our dataset can be disaggregated by asset class and, most critically for our analysis, currency denomination. Of the cross-border positions taken by global banks, nearly one-half are denominated in USDs.

Motivated by the unique features of our dataset, as well as the stylised facts we uncover within it, 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, banks' risk-bearing capacities are heterogeneous in our setting. This gives rise to variation across banks in the size of their cross-border currency positions, as in the data. Further, we allow banks to differ in their beliefs about the expected returns to different assets. These beliefs can be interpreted generically as bank-specific shocks to Uncovered Interest Parity (UIP), driven by both bank-level and aggregate factors that act as demand shifters for currency. Since our model features multiple financial assets, we solve for the equilibrium of the global demand

[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.

system (Koijen and Yogo, 2019a,b). Altogether, the resulting expressions capture the realistic feature that idiosyncratic 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 financial shocks that resolve traditional exchange-rate puzzles (Itskhoki and Mukhin, 2021a).

Using the model as a guide, we exploit variation in the size of banks' cross-border USD holdings to construct bank-level GIVs as instruments for aggregate capital flows. Intuitively, our GIVs extract idiosyncratic moves in and out of USD assets by large, granular banks by measuring changes in their 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 other 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 instruments and testable predictions from theory, we turn to estimating 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 find that UK-based banks' net cross-border USD flows have a significant causal effect on the USD/GBP exchange rate.[2] 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 two years. When breaking down this

[2]Importantly, we show that our GIVs naturally correct for valuation effects, implying that our results are not driven by mechanical changes in exchange rates that influence portfolio values.

net dollar position, 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. Overall, our results indicate that, while a change in UK-resident banks' dollar-debt positions will not result in significant exchange-rate changes when offset with equal and opposite changes in dollar-liabilities, mismatched changes in USD-debt positions, for example due to carry trading, will result in economically significant, and persistent, exchange-rate changes.

Second, to understand the structural underpinnings of these multipliers, we use our net dollar-debt GIV to estimate—via two-stage least squares—distinct demand and supply elasticities for net USD-debt flows in response to exchange-rate fluctuations. On the supply side, we find that the quantity of USDs supplied by the rest of the world 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. However, on the demand side, our point estimates suggest that the demand for USDs by UK-resident banks is inelastic. A 1% change in the USD/GBP exchange rate results in a less than proportional change in demand for USD debt, about -0.5% according to our estimates. Inelastic demand poses challenges for recent macro-finance models in which asset markets tend to be extremely price elastic owing to the presence of arbitrageurs. Indeed, we discuss how this finding is at odds even with the baseline Gamma model, and propose a simple alteration to the model that can rationalise these inelastic estimates. Moreover, inelastic currency demand makes small open economies like the UK more sensitive to the global financial cycle. In particular, external shocks to the supply of dollars—e.g., from US monetary policy—weigh more heavily on exchange rates and hence on the real economy as well.

Third, to investigate the drivers of the inelastic demand for 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 nearly 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 from global financial shocks, by flattening banks' demand curves for dollars.

Overall, our novel bank-level granular instruments provide robust and representative evidence that sheds light on the causal links between capital flows and exchange rates. While our study is not the first to use GIVs to address related questions, our instruments have a number of advantages over existing alternatives. First, by focusing on cross-border banking, our instruments capture a large share of cross-border flows (over one quarter on average). In contrast, Camanho, Hau, and Rey (2022) use fund-level data to build a GIV for international equity allocations. Their data captures a smaller fraction of overall cross-border flows since they focus only on equity flows. Their implied estimates for the effects of equity flows on exchange rates, like ours, are smaller than those we obtain for debt flows in our more representative dataset of UK-resident banks. Second, our instruments are constructed at the bank level. In contrast, 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 requires more innocuous identification assumptions than their alternative country-level GIVs.

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; Corsetti, Lloyd, Marin, and Ostry, 2023). Within this large 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).[3] In particular, 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.

We also contribute to the growing literature studying granularity in international banking. While Galaasen, Jamilov, Juelsrud, and Rey (2020) use bank-level data to construct a bank-level GIV for domestic credit risk in the Norwegian banking sector, our paper is the first to construct a bank-level GIV for cross-border capital flows. As discussed, other prominent examples of

[3]This class of models stands in contrast to (consumption-based) no-arbitrage ones in which the demand elasticity of exchange rates to capital flows is infinite (see Gabaix and Maggiori (2015) for a discussion). 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).

similar instruments are either focused on a more specialised market (Camanho et al., 2022) or are constructed at the country level (Koijen and Yogo, 2019b; Aldasoro et al., 2023). Our novel GIV provides robust and representative quantitative estimates of foreign-exchange elasticities in the market for USDs. In particular, we estimate that global banks' demand for USDs is price inelastic, analogous to the findings in Gabaix and Koijen (2022) for US funds' equity demand, which can rationalise why exchange rates are so volatile.

Finally, by estimating a global demand system (Koijen and Yogo, 2019a), our empirical results demonstrate that the relationship between exchange rates and capital flows depends crucially on both asset class and the state of the bank sector. In particular, our findings suggest that the multiplier effect on exchange rates from changes in external dollar debt positions is substantially larger than that from external dollar equity. This provides novel evidence of segmentation in international financial markets, suggesting scope to deploy developing international models in this context (e.g., Gourinchas, Ray, and Vayanos, 2022; Greenwood, Hanson, Stein, and Sunderam, 2023). Moreover, we also demonstrate how banks' risk-bearing capacity, measured by bank capital ratios, influences 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).

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.

2 Data

In this section, we describe our dataset, and document stylised facts about aggregate and granular features of UK-resident banks' aggregate portfolio 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.[4] The panel contains detailed data on banks'

[4]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).

cross-border claims.[5] Most importantly for our study, these claims are reported by currency. In addition, the dataset includes information on cross-border claims by asset class, cross-border liabilities, as well as measures of bank capitalisation and liquidity.

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 of other sources 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.

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 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

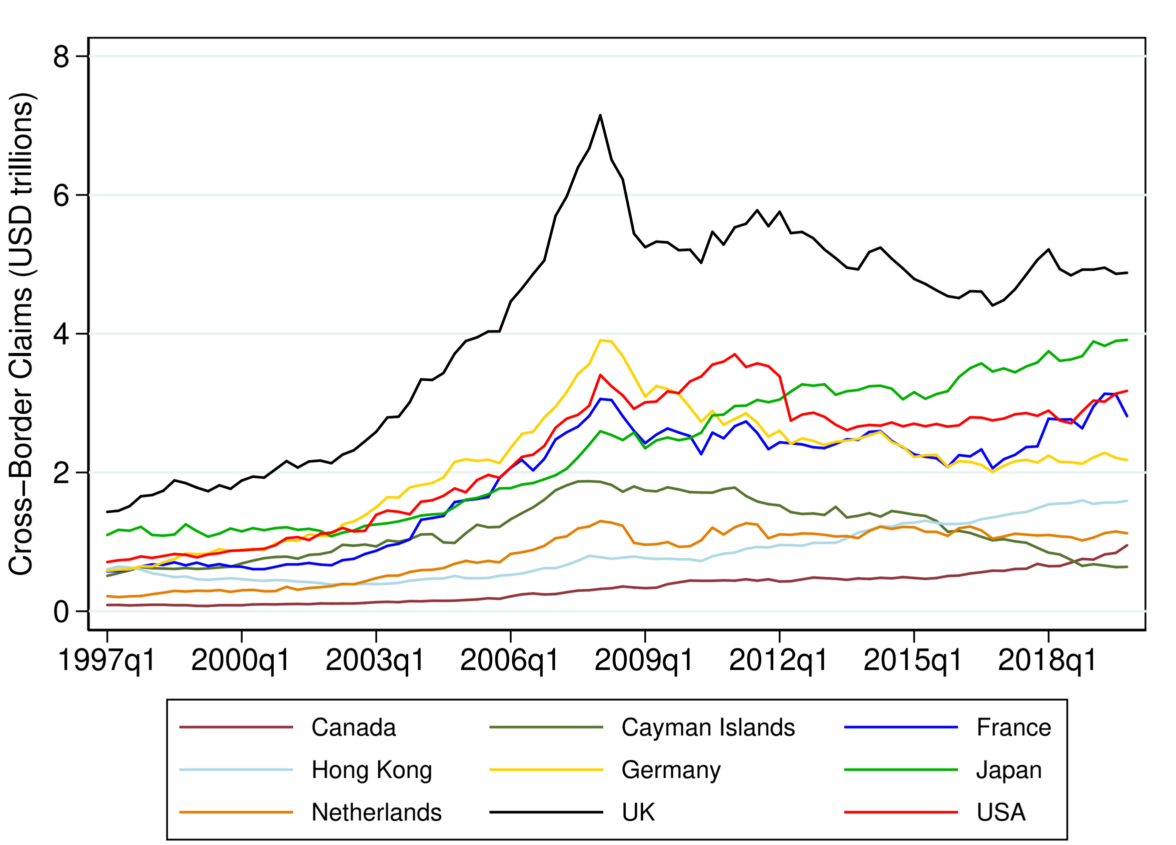
Our raw dataset contains information on 451 banks reporting cross-border claims in at least one quarter over the period 1997Q1-2019Q3. For the purposes of our analysis, we clean our sample to focus on stable bank-currency relationships. We do so by only including banks for which we have at least 80 quarters of data.[6] 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.

Our key variable of interest is the quarterly change in the stock of currency-specific cross-

[5] Within the dataset, cross-border claims can be further disaggregated by recipient country. However, for our baseline 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.

[6] 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 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.

border claims 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.[7] 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').[8] 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.

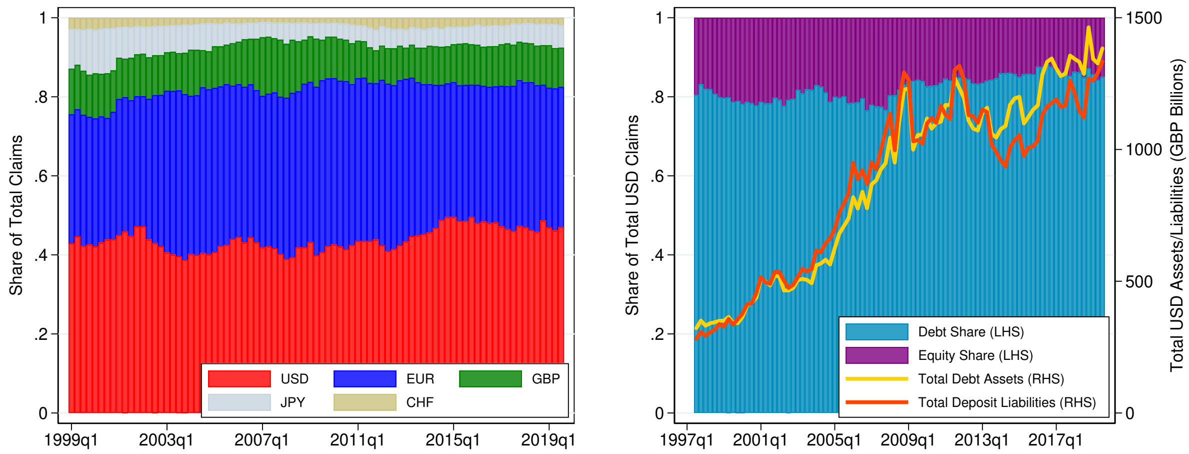
Moreover, the counterpart to these dollar debt positions are USD-denominated deposits, liabilities from the perspective of banks. These dollar-debt and dollar-deposit positions are shown in the lines in Figure 2b. They show how UK-resident banks' USD debt assets and de-

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

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

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.

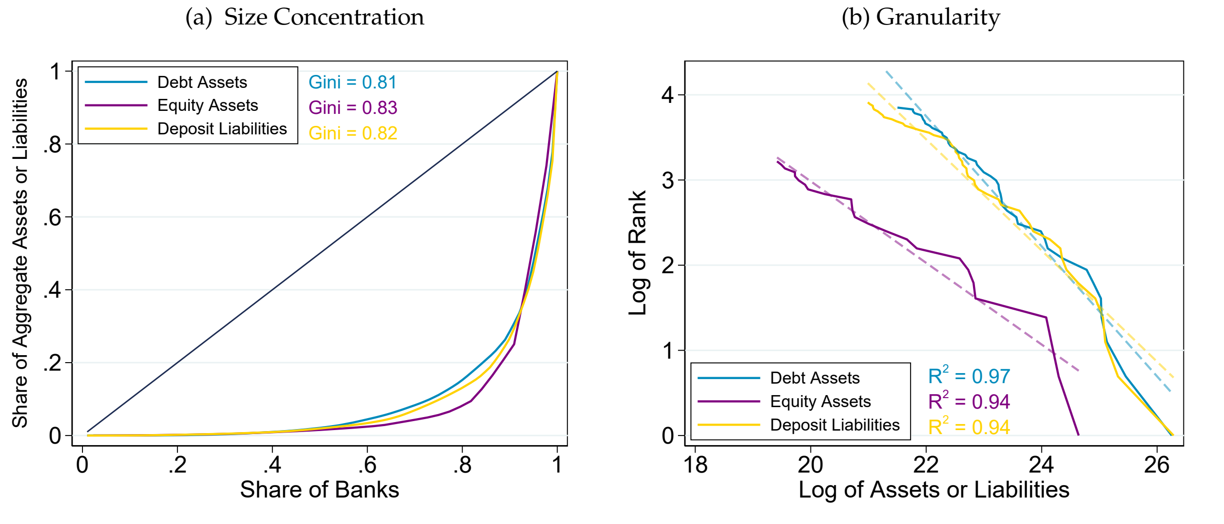
posit liabilities have grown considerably over time. While, unsurprisingly, the path of these asset and liability positions over time have been broadly similar, there are notable mismatches. As a result, there is time-variation in net dollar-debt positions for UK-resident banks over the sample. Specifically, 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 for much of our sample.[9]

2.3 Granularity of UK-Resident Banks

While UK-resident global banks as a whole cover a sizeable portion of overall cross-border claims, individual banks' cross-border positions exhibit considerable heterogeneity. Figure 3a displays Lorenz curves and associated Gini coefficients for UK-resident global banks' debt assets, equity assets, and deposit liabilities in the final period of our sample. Across these three

[9]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 Global Banks' Cross-Border Assets and Liabilities



Notes: Figure 3a presents Lorenz curves and Gini coefficients respectively for global banks' average debt assets, equity assets and deposit liabilities in 2019:Q2. Figure 3b plots log-rank vs log-size, along with linear best fit lines and the associated R^2, separately for debt assets, equity assets and deposit liabilities in 2019:Q2. The sample in Figure 3b is restricted to the 50 largest banks for debt and deposits, and 25 largest for equity.

measures of bank-size concentration, we see clear evidence of the Pareto principle: around 80% of aggregate bank debt, equity and deposits are held by 20% of global 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 size in three ways: banks' cross-border debt assets, equity assets and deposit liabilities, in the final period of our sample. That straight lines can fit this relationship to such a degree—the R^2 are 0.97 for dollar-debt, 0.94 for equity and 0.94 for deposits—is evidence of granularity and in particular is consistent with Zipf's law: the size of the n^{th} largest global bank is proportional to $1/n$.

In all, this heterogeneity in size motivates our granular banking model in Section 3 and implies that idiosyncratic flows from large banks, which we construct in Section 4, can affect aggregate quantities and hence prices. As shown in Section 5, consistent with the 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 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), extending it three 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 return 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 (2019a) and Camanho et al. (2022), we consider a global demand system in which exchange rates are simultaneously determined by the supply and demand for multiple different financial assets. 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 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 financial asset j with a risky dollar-denominated time-$(t+1)$ return $R^j_{t+1} = 1 + r^j_{t+1}$ and a known opportunity cost $R_t = 1 + r_t$ expressed in sterling.[10] Banker i's optimal demand $Q^j_{i,t}$ for dollar asset j at time t maximises their expected profits

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

where the exchange rate $\mathcal{E}_t$ is the price of a dollar in sterling (so an increase corresponds to a USD appreciation), $b^j_{i,t}$ is bank i's subjective belief at time t about the return R^j_{t+1} earned at time $t+1$, and $\text{sign}(j)$ is a sign function taking the value of 1 when banks have a gross-asset position in asset-class j and -1 for a gross-liability position.[11] By including the banker-specific belief wedge $b^j_{i,t}$, we allow for time-varying deviations from rational expectations.[12] These time-varying beliefs can be driven by both bank-level and aggregate *demand shifters*, that can

[10] 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.

[11] Since our dataset includes separate records for assets and liabilities, we can investigate each individually. In this case, we will not observe instances where the gross position varies in sign, allowing us to consider the sign function as fixed over the sample for each asset-class considered.

[12] 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).

act as shocks to UIP.[13]

Following Gabaix and Maggiori (2015), we assume bankers have limited risk-bearing capacity because they can divert a fraction $\Gamma_i^j Q_{i,t}^j$ of the invested/borrowed quantity $Q_{i,t}^j$ for personal use. To generate differences in bank sizes, we introduce heterogeneity in the severity of this agency friction. In particular, we assume that Γ_i^j is inversely proportional to each banker's relative size in steady state: $\Gamma_i^j = \overline{S}_{ij}^{-1}\Gamma^j$, with $\overline{S}_{ij} := \frac{\overline{Q}_i^j}{\sum_{i=1}^n \overline{Q}_i^j}$ where n is the number of bankers and we use bars to refer to a variable's steady state.

Since creditors are only willing to provide external funding if there is no diversion in equilibrium, the agency problem gives rise to an incentive-compatibility constraint

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

which requires expected profits to weakly exceed the value of divertable resources.

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

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

which states that the optimal investment is proportional to the expected return. 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.[14]

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

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

where we use lower case letters to refer to the natural logarithm of variables $e_t := \ln(\mathcal{E}_t)$ and $q_{i,t}^j := \ln(Q_{i,t}^j)$, 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.

[13]In our empirical analysis, in Section 4, we explain further how $b_{i,t}^j$ 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).

[14]Under our assumptions regarding heterogeneity, the steady state of (3) is $\Gamma^j\overline{Q}^j = \text{sign}(j) \cdot \left(\exp(\overline{b}_i^j)\frac{\overline{R}^j}{\overline{R}} - 1\right)$, which requires $\overline{b}_i^j = \overline{b}^j \; \forall i$.

Equation (4) ties changes in bank i's demand $\Delta q^j_{i,t}$ for asset j to changes in the asset's expected excess returns $\Delta\mathbb{E}_t[r^j_{t+1}] - \Delta r_t + \Delta\mathbb{E}_t[e_{t+1}] - \Delta e_t$ and changes in bank i's beliefs $\Delta b^j_{i,t}$ with a price elasticity $\phi^j := \frac{\text{sign}(j)+\overline{Q}^j\Gamma^j}{\overline{Q}^j\Gamma^j}$ that is constant across bankers.

It is important to point out that 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.[15] However, since estimating equation (4) 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 domestic-resident (UK-resident) bankers for j and specify the behaviour of the rest of the world with respect to j.

We begin by taking the size-weighted average of equation (4), which gives the dynamics of UK-based bankers aggregate demand for asset j:

$$\Delta q^j_{S,t} = \phi^j \left(\Delta b^j_{S,t} + \Delta\mathbb{E}_t[r^j_{t+1}] - \Delta r_t + \Delta\mathbb{E}_t[e_{t+1}] - \Delta e_t\right), \tag{5}$$

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, the aggregate demand by UK-resident banks for asset j evolves according to the weighted average of their individual beliefs, as well as expected excess returns.

To derive dynamics for the rest of the world's aggregate supply of asset j, we assume that the quantity of USDs supplied by the rest of the world is analogously linked to their subjective beliefs and expected excess returns:

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

where the price elasticity of supply is denoted generically as ϕ^j_R and rest-of-the-world beliefs are labelled $b^j_{R,t}$.

[15] Specifically, the elasticity $|\phi^j| \equiv |\frac{\partial Q^j_{i,t}}{\partial \mathcal{E}_t}\frac{\mathcal{E}_t}{Q^j_{i,t}}| = |\frac{\partial q^j_{i,t}}{\partial e_t}|$ cannot be less than 1 as $\phi^j = -\frac{\text{sign}(j)+\overline{Q}^j_i\Gamma^j_i}{\overline{Q}^j_i\Gamma^j_i}$ (see equation (4)). When $\text{sign}(j) = 1$, the restriction $|\phi^j| < 1$ leads to the contradiction: $\frac{1+\overline{Q}^j_i\Gamma^j_i}{\overline{Q}^j_i\Gamma^j_i} < 1$. When $Q^j_i < 0$ and thus $\text{sign}(j) - 1$, there is a similar contradiction. So, this specific micro-foundation rules out inelastic demand.

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 USD with rest-of-the-world supply), we uncover equilibrium expressions. These capture both exchange-rate dynamics and the dynamics of domestic-resident bankers' aggregate holdings of asset class j, and we outline them in the following proposition.

Proposition 1 (Equilibrium in Asset Market j in the Granular Gamma Model) *In the Granular Gamma model, the equilibrium exchange-rate appreciation and change in the stock of cross-border holdings of asset j can be approximated by*

$$\Delta e_t = \frac{\phi^j}{\phi^j + \phi^j_R} \Delta b^j_{S,t} + \frac{\phi^j_R}{\phi^j + \phi^j_R} \Delta b^j_{R,t} + \Delta \mathbb{E}_t[r^j_{t+1}] - \Delta r_t + \Delta \mathbb{E}_t[e_{t+1}], \tag{7}$$

$$\Delta q^j_{S,t} = \frac{\phi^j \phi^j_R}{\phi^j + \phi^j_R} \left(\Delta b^j_{S,t} - \Delta b^j_{R,t} \right). \tag{8}$$

Proof: Combine global market clearing $\Delta q^j_{S,t} = \Delta q^j_{R,t}$ with asset demand, equation (5), and supply, equation (6). See Appendix A.2 for more details. □

This proposition highlights that the equilibrium relationships between exchange rate and quantity dynamics and beliefs are governed by the multipliers $\frac{\phi^j}{\phi^j + \phi^j_R}$ and $\frac{\phi^j_R}{\phi^j + \phi^j_R}$, which capture general-equilibrium feedback effects between prices and quantities. These effects are absent in the partial-equilibrium coefficients, highlighting how direct estimates of equations (5) and (6) would yield biased estimates of true general-equilibrium multipliers.

We further highlight the role of belief shocks for exchange-rate determination by providing a decomposition of the *level* of the exchange rate in Appendix A.3.

3.3 Global Demand System

In practice, UK-resident banks and the rest of the world trade a wide array of different asset classes with each other. Equilibrium in each of these markets is characterised by equations (7) and (8) from Proposition 1, but with unique multipliers. As a result, we can tie equilibrium exchange-rate dynamics to changes in beliefs and excess returns across these different asset classes.

Proposition 2 (Global Demand System) *In the Granular Gamma model, the equilibrium exchange-rate appreciation can be approximated by*

$$\Delta e_t = \frac{1}{m} \sum_{j=1}^{m} \left(\Delta \mathbb{E}_t[r^j_{t+1}] + \frac{\phi^j}{\phi^j + \phi^j_R} \Delta b^j_{S,t} + \frac{\phi^j_R}{\phi^j + \phi^j_R} \Delta b^j_{R,t} \right) - \Delta r_t + \Delta \mathbb{E}_t[e_{t+1}]. \tag{9}$$

Proof: Assuming there are m different asset classes, sum over the m different versions of equation (7). $\square$

Proposition 2 is important for our subsequent empirical analysis since it highlights that one must adjust the multiplier estimates for the number of asset classes UK-resident banks trade.

4 Empirical Strategy

Our empirical strategy builds on this theoretical framework and exploits the significant heterogeneity and concentration in the distribution of cross-border holdings present in our data by applying 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 instruments for aggregate capital flows and 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

In order to estimate the elasticities ϕ^j and ϕ^j_R, we construct GIVs that extract exogenous variation in aggregate beliefs $b^j_{S,t}$ from the idiosyncratic beliefs of 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

$$\Delta b^j_{i,t} = u^j_{i,t} + \lambda^j_i \eta^j_t + \theta^j C^j_{i,t-1}, \quad \text{with} \quad \mathbb{E}[u^j_{i,t}(\eta^j_t, \Delta b^j_{R,t})] = 0, \tag{10}$$

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.[16] Importantly, since the bank-specific belief shocks $u^j_{i,t}$

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

are i.i.d., they are uncorrelated with aggregate bank (η_t^j) and rest-of-the-world ($\Delta b_{R,t}^j$) shocks: $\mathbb{E}[u_{i,t}^j(\eta_t^j, \Delta b_{R,t}^j)] = 0$.

We construct our GIVs for different asset classes j, z_t^j, from observables, by taking the difference between the size- and equal-weighted change in cross-border holdings $z_t^j := \Delta q_{\xi,t}^j$. Using equation (4), 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 $z_t^j = \phi^j \Delta b_{\xi,t}^j$, that is:

$$z_t^j = \phi^j \left(u_{\xi,t}^j + \lambda_\xi^j \eta_t^j + \theta^j C_{\xi,t-1}^j \right). \tag{11}$$

In the subsequent sections, we discuss in detail how these GIVs can be used to estimate the multipliers and elasticities implicit within the Granular Gamma model. Intuitively, since the GIVs place a greater weight on the beliefs of large banks, idiosyncratic belief shocks to such large banks affect the banking-sectors' aggregate beliefs and thus exchange rates (relevance). Further, if banks' loadings on the unobserved common factors are uncorrelated with size ($\lambda_\xi^j = 0$), controlling for relevant observables C_{t-1}^j ensures that our GIVs reflect the size-minus-equal weighted combination of i.i.d. bank-level belief *shocks* $z_t^j = \phi^j u_{\xi,t}^j$ (exogeneity). We discuss the steps we take to tighten our identification, including using principal components to proxy for the common factors η_t and a narrative strategy 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 also construct GIVs for *net* positions. In particular, we focus on the effects of net USD-denominated debt positions, 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 $\overline{Q}^D \approx \overline{Q}^L$. Building on equation (4), the bank-level net flow is

$$\Delta q_{i,t}^{net} = \frac{\phi^{net}}{2}\left(\Delta b_{i,t}^D - \Delta b_{i,t}^L + \mathbb{E}_t[r_{t+1}^D - r_{t+1}^L]\right) - \phi^{net}\left(\Delta r_t - \Delta \mathbb{E}_t[e_{t+1}] + \Delta e_t\right), \tag{12}$$

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

$$\Delta z_t^{net} := \frac{1}{2}\left(z_t^D - z_t^L\right). \tag{13}$$

4.2 Multiplier Estimation

We first estimate the causal effect of changes in cross-border asset positions on the exchange rate captured in Proposition 2. To derive an estimable expression for this 'multiplier' M^j, we use equation (10) to rewrite the equilibrium condition (7) in terms of variables and an error term:

$$\begin{aligned}\Delta e_t =& M^j z_t^j + \left(\Delta \mathbb{E}_t[r_{t+1}^j] - \Delta r_t + \Delta \mathbb{E}_t[e_{t+1}]\right) + M^j \phi^j \theta^j C_{Ej,t-1} + \epsilon_t^j, \\ \text{with} \quad & \epsilon_t^j := M^j \phi^j \left(u_{E,t}^j + \lambda_E^j \eta_t^j + \frac{\phi_R^j}{\phi^j} \Delta \mathbb{E}_t[b_{R,t+1}^j] \right). \end{aligned} \tag{14}$$

where $M^j := \frac{1}{\phi^j + \phi_R^j}$.

To identify the multiplier M^j by estimating equation (14) 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.[17]

To satisfy the first requirement, we estimate the regression implied by equation (14) 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 we define in equations (5) and (6), respectively, using our GIVs.

To estimate the supply elasticity ϕ_R^j, we use z_t^j as an instrument for the exchange rate Δe_t in regressions of the size-weighted change in cross-border positions $\Delta q_{S,t}^j$ implied by equations (6) and market clearing:

$$\Delta q_{S,t}^j = \phi_R^j \Delta e_t - \phi_R^j \left(\Delta \mathbb{E}_t[r_{t+1}^j] - \Delta r_t + \Delta \mathbb{E}_t[e_{t+1}]\right) - \phi_R^j \Delta b_{R,t}^j. \tag{15}$$

[17] As shown in Gabaix and Koijen (2020), $u_{\xi,t}^j$ is uncorrelated with $u_{E,t}^j$ when $\lambda_\xi = 0$. Since $u_{i,t}^j$ are i.i.d., $u_{\xi,t}^j$ is uncorrelated with $\Delta b_{R,t}^j$.

The instrument's relevance follows from equation (7), 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 (14) and second stage (15) regressions: $\mathbb{E}[z_t^j(\epsilon_t^j, \Delta b_{R,t}^j)] = 0$.

To estimate the 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 cross-border positions $\Delta q_{E,t}^j$ implied by taking an equal-weighted average of equation (4):

$$\Delta q_{E,t}^j = -\phi^j \Delta e_t + \phi^j \left(\Delta \mathbb{E}_t[r_{t+1}^j] - \Delta r_t + \Delta \mathbb{E}_t[e_{t+1}] + \theta^j C_{E,t-1}^j \right) + \underbrace{\phi^j \left(u_{E,t}^j + \lambda_E^j \eta_t^j \right)}_{:=\nu_t^j}. \tag{16}$$

In this case, the instrument's relevance again follows from equation (7). Similarly, exogeneity requires: $\mathbb{E}[z_t^j(\epsilon_t^j, \nu_t^j)] = 0$.

In both cases, since $\mathbb{E}[u_{\xi,t}^j(u_{E,t}^j, \Delta b_{R,t}^j, \eta_t^j)] = 0$ holds by construction, we can identify both elasticities if $z_t^j = \phi^j u_{\xi,t}^j$, that is, if the loadings on unobserved common factors are uncorrelated with size $\lambda_\xi^j = 0$ and observable controls C_{t-1}^j are included as regressors. Should $\lambda_\xi^j \neq 0$, we achieve identification by including proxies for η_t^j as controls. We also test for $\lambda_\xi^j = 0$ implicitly via a narrative strategy that examines whether the events that compose our GIV seem exogenous.

4.4 Threats to Identification

As discussed, we take additional steps to strengthen our identification, prior to estimating the regressions implied by equations (14), (15) and (16). 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 (10). The final step, using narrative techniques to investigate the sources of large movements in holdings at the bank level, is complementary.

4.4.1 Exchange-Rate Valuation Effects

A general concern when assessing the effects of 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.[18]

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

$$Q^j_{i,t} - Q^j_{i,t-1} := \underbrace{\left(\frac{\mathcal{E}_t}{\mathcal{E}_{t-1}} R^j_t - 1\right)}_{\text{Valuation Effect}} Q^j_{i,t-1} + \underbrace{F^j_{i,t}}_{\text{Capital Flow}} Q^j_{i,t-1}. \tag{17}$$

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

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

$$z^j_t = F^j_{S,t} - F^j_{E,t} \tag{18}$$

Proof: Since $\frac{\mathcal{E}_t}{\mathcal{E}_{t-1}} R^j_t \approx 1$, we can approximate (17) as $F^j_{i,t} = \Delta q^j_{i,t} - \Delta e_t - r^j_t$. This gives the size-weighted capital flow $F^j_{S,t} = \Delta q^j_{S,t} - \Delta e_t - r^j_t$ and the equal-weighted capital flow $F^j_{E,t} = \Delta q^j_{E,t} - \Delta e_t - r^j_t$. Combining these averages with the definition of our instruments $z^j_t := \Delta q^j_{\xi,t}$, we arrive at $z^j_t = F^j_{S,t} - F^j_{E,t}$. $\square$

This corollary implies that our estimates of the exchange-rate multiplier codified in equation (14) 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 (15) and (16): 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 (10), is how we account for time-varying bank-specific factors $C^j_{i,t}$. Our confidential bank-level data set provides a range of control variables 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

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

liquid-asset ratio, to account for potential differences across banks depending on their buffers of liquid assets,[19] 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.

Finally, in addition to controlling for a wide range of local asset returns as well as an index of exchange rate expectations, we also control for the VIX index as a measure of global risk-sentiment and uncertainty that 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 (10) 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 (4) using the definition (10) to get:

$$\Delta q_{i,t}^j = \theta_t^j + \theta_q^j C_{i,t-1}^j + \zeta_{i,t}^j \tag{19}$$

where θ_t^j denotes an asset-time-fixed effect for asset j that accounts for 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, the coefficient $\theta_q^j := \phi^j \theta^j$ reflects loadings on bank-level controls $C_{i,t}^j$, and the error term $\zeta_{i,t}^j := \phi^j(u_{i,t}^j + \lambda_i^j \eta_t^j)$. 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 $\hat{\zeta}_{i,t}^j$. We then use these residuals to obtain estimates of the unobserved common factors $\hat{\eta}_{k,t}^j$ for $k = 1, ..., K$ by performing principle-component analysis on these residuals $\hat{\zeta}_{i,t}^j$ cross-sectionally (i.e., period by period).

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

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 (13), 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 contribution of these 'Large Banks' is summed to deliver the blue bar. In practice, while the exact composition of these 'Large Banks' changes each period, they draw from a small set of institutions in our dataset (< 10). So the plot reveals the granular composition of our GIVs for net USD debt.

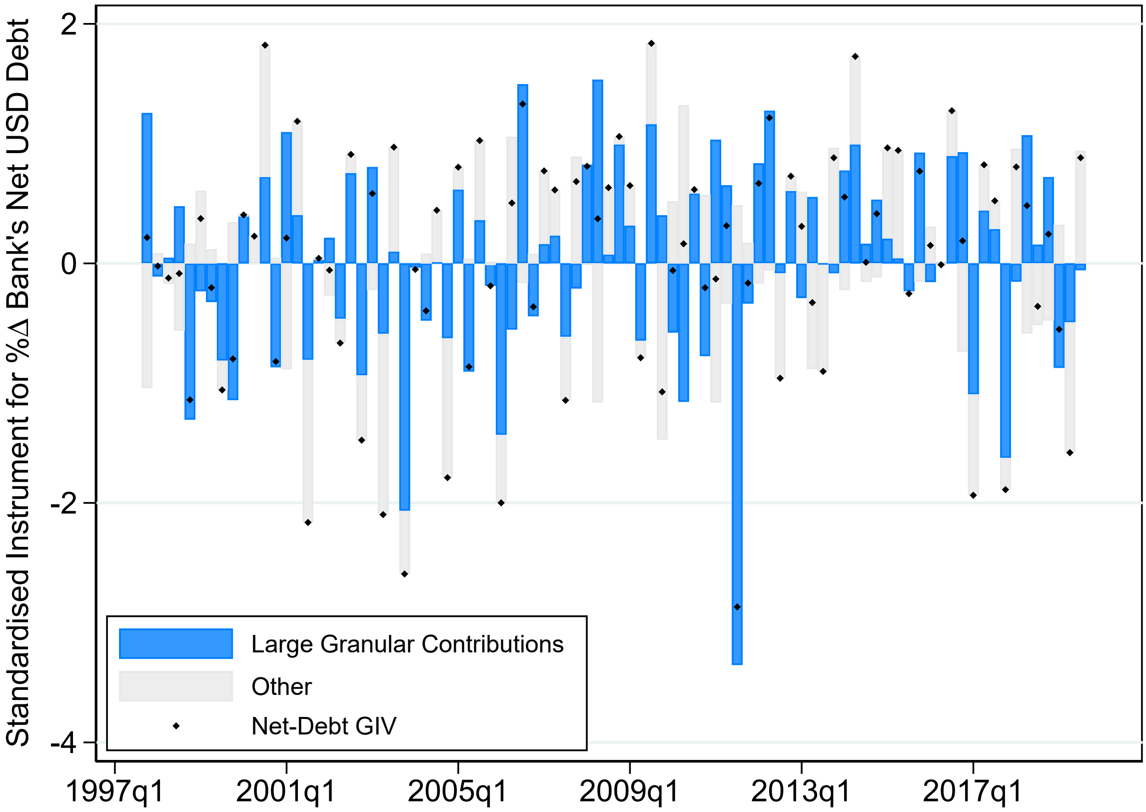
Using information available to us about the identity of these large banks, we then carry out a narrative assessment of key events that occur in periods when a given bank contributes to a substantial portion of the GIV for USD-denominated net-debt positions. To do this, we manually search and analyse 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.3 in Appendix D that the net-debt GIV plotted in Figure 4 is not driven by 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.

Therefore, 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.

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.

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 changes in holdings of different asset classes, captured in Proposition 2, on USD/GBP exchange rates, we build on equation (14) and estimate the following relationship by OLS:

$$\Delta e_t = \sum_{j=1}^{m} M^j \frac{z_t^j}{m} + \beta_M^j C_t + u_t, \tag{20}$$
$$\text{where} \quad C_t = \left[(\Delta r_{t+1}^j - \Delta r_{t+1}^{j,*})_{\forall j}, \Delta \mathbb{E}_t[e_{t+1}], C_{S,t-1}^j, C_{t-1}, \hat{\eta}_t^j \right],$$

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.[20] 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 $C_{S,t-1}^j$. These include for 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 $\hat{\eta}_t^j$ as proxies for unobserved common factors.

Table 1 presents our baseline results. The coefficients on z_t^j/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 1.5 and 2, in comparison to the portfolio-flow multiplier of around 0.2-0.4. Accounting for the fact that cross-border debt

[20] 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 $t+1$.

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 Assets and Liabilities				
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: 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 Dollar-Debt Positions				
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 (20) 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.

Table 2: Appreciation per Unit of GDP Implied by Asset and Liability Multipliers

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%	1.59	2.64
Equity (Assets)	0.18	12%	0.27	2.21
Liabilities	0.92	61%	-0.61	-1.00

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 Table 1 from estimating specification (20). Column 4 puts estimates in units of UK GDP.

positions represent, on average, 80% of total assets, these estimates suggest that the multiplier for total assets is around 1.2-1.7, a figure that is not statistically distinguishable (at the 1% level) from the magnitude of our estimates for cross-border liabilities (-0.6 to -1.1).

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.

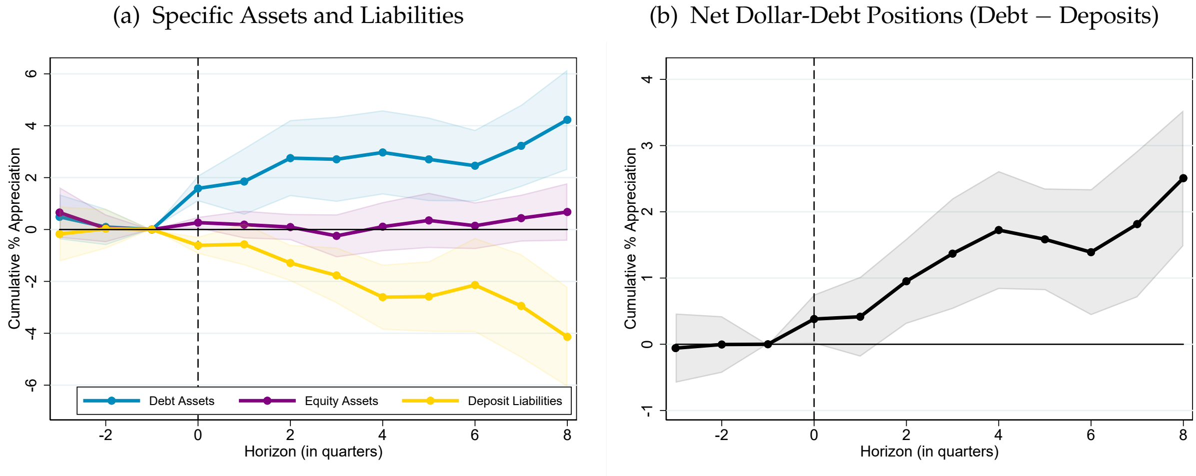
Since the multipliers are given by $M^j = \frac{1}{\phi^j + \phi_R^j}$, our estimates already hint at a fairly inelastic market. This is noteworthy because no-arbitrage theory would predict these elasticities to be significantly higher and multipliers to be close to zero.

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 within the quarter. 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 2.64%.

Finally, we extend regression (20) 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 contemporaneous 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 are particularly 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 4% in the two years after the shock. Estimates for the other side of the carry trade, banks' liabilities, reveal a largely equal and opposite story. A 1% exogenous increase in UK-resident banks' USD deposit liabilities is associated with around a 4% depreciation of the USD in the two years after the shock. So, these estimates suggest that equal-and-opposite changes in UK-resident banks' USD debt-asset and liability positions are associated with near-

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



Notes: Multiplier estimates from local-projection estimation of equation (20) 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.

zero overall effects on the exchange rate.

Figure 5b, however, shows how mismatches in banks' USD debt-asset vs. USD 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), estimates reveal 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 in the two years after the shock.

5.2 Inelastic Intermediaries

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 estimator informed by equations (15) and (16).

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 (15):

$$\Delta q_{S,t}^{net} = \phi_R^{net} \Delta e_t + \beta_{\phi_R}^{net} C_t + u_t, \tag{21}$$

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

Panel A of Table 3 presents estimates of the supply elasticity from our second-stage regression 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.[21] 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 foreigners ϕ_R^{net} ranging from 1.8 to 2.

These elastic estimates imply that the quantity of dollars supplied to UK-resident financial intermediaries responds more than proportionally to changes in price. Or, in other words, they imply that, for a given change in the quantity of USDs supplied, the price of dollars responds less than proportionally—by around 0.2%.

To estimate the corresponding demand elasticity for net dollar-debt by UK-resident banks ϕ^{net}, we build on equation (16) and use z_t^{net} as an instrument for Δe_t in the following regression:

$$\Delta q_{E,t}^{net} = -\phi^{net}\Delta e_t + \beta_\phi^{net} C_t + u_t, \tag{22}$$

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 of (22). Since the first-stage regressions for both (21) and (22) 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. In other words, these 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.

Figure 6 plots the dollar supply and demand relationships implied by the coefficient estimates in column (4) of Table 3. The fact we find that the supply of dollars from the rest of the world is somewhat unsurprising, given the presence of arbitrageurs in the market for dollars. On its own, this implies that shifts in the demand for USDs will disproportionately in-

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

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

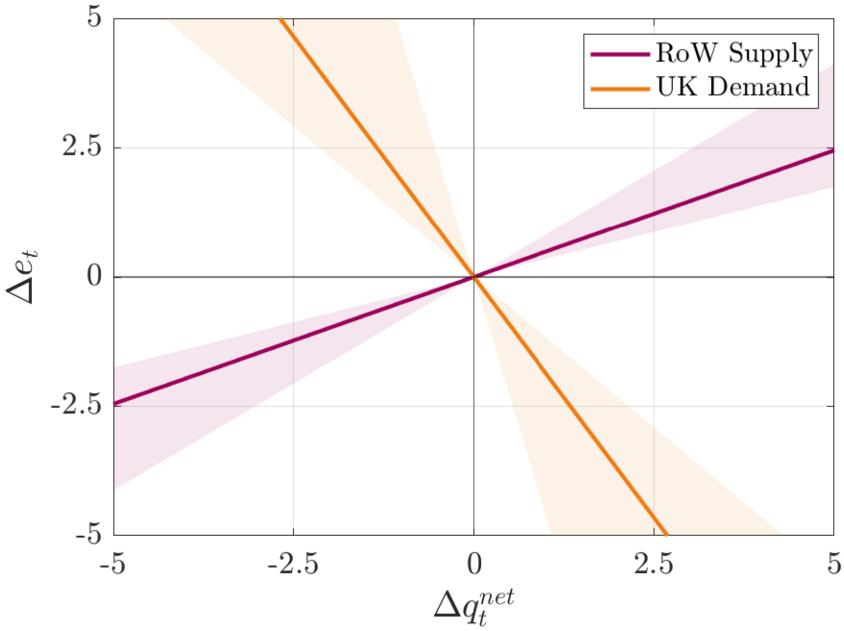
	(1)	(2)	(3)	(4)
PANEL A: 2nd Stage for Supply Elasticity (ϕ_R^{net})				
DEP. VAR.: $\Delta q_{S,t}^{net}$				
Δe_t	0.821***	1.793**	1.804**	2.037**
	(0.294)	(0.719)	(0.767)	(0.824)
Observations	88	88	87	87
1st-Stage F-stat.	8.85	34.22	30.94	32.66
Macro Controls	No	Yes	Yes	Yes
Bank Controls	No	No	Yes	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 (21). PANEL B: Coefficient estimates from regression (22). 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.

fluence quantities *vis-à-vis* prices in the dollar market. On the other hand, the fact we find that UK-resident banks' demand for USDs in cross-border positions is price inelastic is somewhat surprising, given both the role of arbitrageurs and the perception of the USD market as one of the most liquid in the world. Because of this, our results imply that shifts in the supply of dollars from the rest of the world will disproportionately influence prices *vis-à-vis* quantities. This excessive exchange-rate volatility leaves small open economies particularly sensitive to external shocks to the supply of USDs coming from the global financial cycle.

Inelastic Elasticities in the Granular Gamma Model. As well as being surprising in and of itself, the fact our point estimates imply *inelastic* price-elasticities of demand for USDs is at odds with the micro-foundations underpinning the Gamma model of Gabaix and Maggiori (2015), as well as our novel Granular Gamma model from Section 3. This is due to the form of

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.

the incentive-compatibility constraint (2), which requires the market for dollars to be elastic—i.e., with elasticities above unity—for divertable fractions to be non-negative. This suggests some scope to adapt the Gamma model setup to account for inelastic demand elasticities.

One such 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:

$$V_{i,t}^j \geq (\Gamma_i^j Q_{i,t}^j)^{\gamma_i^j} \cdot Q_{i,t}^j. \tag{23}$$

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

$$Q_{i,t}^j = \frac{\text{sign}(j)}{\Gamma_i^j} \cdot \mathbb{E}_t \left[\exp(b_{i,t}^j) \frac{R_{t+1}^j}{R_t} \frac{\mathcal{E}_{t+1}}{\mathcal{E}_t} - 1 \right]^{\frac{1}{\gamma_i^j}}, \tag{24}$$

which we can approximate as:

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

This expression yields analogous regressions to those described above, providing a new lens through which to interpret our results. Most importantly, it gives rise to a non-linear relationship between cross-border positions and exchange rates through the parameter governing the severity of the agency friction γ_i^j for each bank i in asset class j, raising 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—which is 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 (20) by interacting our net dollar-debt GIV z_t^{net} with the lagged size-weighted average of UK-based banks' Tier-1 capital ratios $Cap_{S,t-1}$:

$$\Delta e_t = M z_t^{net} + \delta \left(z_t^{net} \times Cap_{S,t-1} \right) + \vartheta Cap_{S,t-1} + \beta_M^j C_t^j + u_t \tag{25}$$

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 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)
$z_t^{net} \times Caps_{S,t-1}$	-0.598*	-0.480**	-0.488**	-0.413**
	(0.319)	(0.207)	(0.212)	(0.188)
$Caps_{S,t-1}$	-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 (25) 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 confidential data on the external assets and liabilities of banks based in the world's largest IFC, the UK. These banking flows comprise around one-fifth of cross-border banking flows and our bank-level data revealed important granularity across banks, especially in relation to their foreign-exchange exposure. A small number of large banks account for a large fraction of UK-based banks' USD exposures over time.

We have leveraged this granularity to build a novel GIV that captures exogenous idiosyncratic cross-border banking flows into USDs. While our paper is not the first to build such an instrument for cross-border flows, there are two novelties to our analysis. First, we have focused on *banks'* positions which capture the lion's share of cross-border links, as opposed to specific intermediaries (e.g., hedge funds). Second, we have utilised *bank-level* data to construct our granular instrument and so, in comparison to studies using country-level banking data, our identification does not rely on exogeneity of size-minus-equal-weighted country-level flows, but rather the more innocuous assumption that size-minus-equal-weighted bank-level flows are exogenous. Moreover, we have verified the plausible exogeneity of the instrument by carrying out narrative checks to show that large moves were not driven by systematic (endogenous) events, but rather bank-specific factors like mergers, management changes, stress-test failings and computer-system failures.

Building a Granular Gamma model, we have derived model-based testable predictions. Taking these to the data, we have shown that exogenous granular 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 instruments and our Granular Gamma model to separately estimate demand and supply elasticities in the foreign-exchange market. Surprisingly, our estimates reveal that demand for USDs by UK-resident banks is price inelastic with respect to exogenous changes in the exchange rate. This prediction is at odds with the baseline Gamma model of Gabaix and Maggiori (2015), which restricts elasticities to be greater than 1, although we show that a simple change to the agency friction can rationalise our empirical results.

While our finding of inelastic dollar demand by UK-based banks suggests that small open economies are particularly sensitive to the global financial cycle, policies that ensure banks are well-capitalised can help to mitigate these vulnerabilities. We defer a deeper investigation of the macroeconomic consequences of our findings to future work.

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Appendix

A Model Appendix

A.1 Details on Approxmation

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

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

around the steady state $\overline{Q}_i^j = \frac{\text{sign}(j)}{\Gamma_i^j} \left(\overline{B}_i^j \frac{\overline{R}^j}{\overline{R}} \frac{\overline{\mathcal{E}}}{\overline{\mathcal{E}}} - 1 \right)$ 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{\text{sign}(j)}{\Gamma_i^j} \cdot \mathbb{E}_t \Bigg[\overline{B}_i^j \frac{\overline{R}^j}{\overline{R}} \frac{\overline{\mathcal{E}}}{\overline{\mathcal{E}}} - 1 + \frac{\overline{R}^j}{\overline{R}} \frac{\overline{\mathcal{E}}}{\overline{\mathcal{E}}} (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{\text{sign}(j)}{\Gamma_i^j} \cdot \left(\overline{B}_i^j \frac{\overline{R}^j}{\overline{R}} \frac{\overline{\mathcal{E}}}{\overline{\mathcal{E}}} \right) \cdot \mathbb{E}_t \Bigg[\frac{(B_{i,t}^j - \overline{B}_i^j)}{\overline{B}_i^j} + \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}}} \Bigg] \\
(Q_{i,t}^j - \overline{Q}_i^j) \approx & \frac{\text{sign}(j)}{\Gamma_i^j} \cdot \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{b}_{i,t}^j + \tilde{r}_{t+1}^j - \tilde{r}_t + \tilde{e}_{t+1} - \tilde{e}_t \right] \\
(Q_{i,t}^j - \overline{Q}_i^j) \approx & \frac{\text{sign}(j)}{\Gamma_i^j} \cdot \left(\frac{\overline{Q}_i^j \Gamma_i^j}{\text{sign}(j)} + 1 \right) \cdot \mathbb{E}_t \left[\tilde{b}_{i,t}^j + \tilde{r}_{t+1}^j - \tilde{r}_t + \tilde{e}_{t+1} - \tilde{e}_t \right] \\
(Q_{i,t}^j - \overline{Q}_i^j) \approx & \left(\frac{\text{sign}(j) + \overline{Q}_i^j \Gamma_i^j}{\Gamma_i^j} \right) \cdot \mathbb{E}_t \left[\tilde{b}_{i,t}^j + \tilde{r}_{t+1}^j - \tilde{r}_t + \tilde{e}_{t+1} - \tilde{e}_t \right] \\
\frac{(Q_{i,t}^j - \overline{Q}_i^j)}{\overline{Q}_i^j} \approx & \left(\frac{\text{sign}(j) + \overline{Q}_i^j \Gamma_i^j}{\overline{Q}_i^j \Gamma_i^j} \right) \cdot \mathbb{E}_t \left[\tilde{b}_{i,t}^j + \tilde{r}_{t+1}^j - \tilde{r}_t + \tilde{e}_{t+1} - \tilde{e}_t \right] \\
\tilde{q}_{i,t}^j \approx & \left(\frac{\text{sign}(j) + \overline{Q}_i^j \Gamma_i^j}{\overline{Q}_i^j \Gamma_i^j} \right) \cdot \left(\tilde{b}_{i,t}^j + \mathbb{E}_t[\tilde{r}_{t+1}^j] - \tilde{r}_t + \mathbb{E}_t[\tilde{e}_{t+1}] - \tilde{e}_t \right),
\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 percentage deviations from steady state, line 4 uses the steady-state identity $\overline{Q}_i^j = \frac{\text{sign}(j)}{\Gamma_i^j} \left(\overline{B}_i^j \frac{\overline{R}^j}{\overline{R}} \frac{\overline{\mathcal{E}}}{\overline{\mathcal{E}}} - 1 \right)$, line 5 rearranges, 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

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

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)

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

A.2 Proof of Proposition 1

To find the global equilibrium, we use equations (5) and (6) together with $\Delta q^j_{S,t} = \Delta q^j_{R,t}$. This gives

$$\begin{aligned} 0 =& \phi^j \left(\Delta b^j_{S,t} + \Delta\mathbb{E}_t[r^j_{t+1}] - \Delta r_t + \Delta\mathbb{E}_t[e_{t+1}] - \Delta e_t\right) \\ &+ \phi^j_R \left(\Delta b^j_{R,t} + \Delta\mathbb{E}_t[r^j_{t+1}] - \Delta r_t + \Delta\mathbb{E}_t[e_{t+1}] - \Delta e_t\right), \end{aligned} \tag{A.2}$$

which simplifies to

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

To find the equilibrium change in quantities, we plug this expression back into equation (5) and obtain

$$\Delta q^j_{S,t} = \frac{\phi^j_R \phi^j}{\phi^j + \phi^j_R} \left(\Delta b^j_{S,t} - \Delta b^j_{R,t}\right). \tag{A.4}$$

A.3 Exchange-Rate Decomposition

To further build intuition on the relationship between beliefs and exchange rates in the Granular Gamma model, we can decompose equilibrium exchange rates into different components. For this, we directly use market clearing on equation (3) and a symmetric rest-of-the-world equation to find the exact equilibrium without relying on approximations. To streamline the analysis, we treat the USD return as risk-free.

Corollary 2 (Exchange-Rate Decomposition) *If the exchange rate is conditionally log-normally distributed, the equilibrium level of the exchange rate in the Granular Gamma model can be expressed as:*

$$e_t = \mathbb{E}_t \sum_{s=t}^{\infty} \left[\ln \left(\frac{\Gamma_R^j}{\Gamma^j + \Gamma_R^j} B_{S,s}^j + \frac{\Gamma^j}{\Gamma^j + \Gamma_R^j} B_{R,s}^j \right) + r_s^j - r_s + \frac{\mathrm{Var}_s(e_{s+1})}{2} \right] + \overline{e}, \tag{A.5}$$

with the long-run exchange rate $\lim_{s\to\infty} \mathbb{E}_t [e_s] = \overline{e}$.

Proof: Sum over equation (3) and use $\Gamma_i^j = \Gamma^j \overline{Q}_i^j / (\sum_{i=1}^n \overline{Q}_i^j)$ to get the aggregate demand by UK banks

$$Q_t^j = \frac{\mathrm{sign}(j)}{\Gamma^j} \left[B_{S,t}^j \frac{R_t^j}{R_t} \frac{\mathcal{E}_{t+1}}{\mathcal{E}_t} - 1 \right]. \tag{A.6}$$

Assuming an analogous equation for the rest-of-the-world supply, market clearing $Q_t^j = Q_{R,t}^j$ gives

$$\mathcal{E}_t = \left(\frac{\Gamma_R^j}{\Gamma^j + \Gamma_R^j} B_{S,t}^j + \frac{\Gamma^j}{\Gamma^j + \Gamma_R^j} B_{R,t}^j \right) \frac{R_t^j}{R_t} \mathbb{E}_t \left[\mathcal{E}_{t+1} \right]. \tag{A.7}$$

Taking the natural logarithm and assuming exchange rates are conditionally 'log-normal' distributed, this becomes

$$e_t = \ln \left(\frac{\Gamma_R^j}{\Gamma^j + \Gamma_R^j} B_{S,t}^j + \frac{\Gamma^j}{\Gamma^j + \Gamma_R^j} B_{R,t}^j \right) + r_t^j - r_t + \frac{\mathrm{Var_t(e_{t+1})}}{2} + \mathbb{E}_t \left[e_{t+1} \right]. \tag{A.8}$$

Solving forward we obtain the expression in the corollary.

□

This corollary shows how the exchange rate depends on expectations about future fundamentals $r_s^j - r_s$, and the weighted average of UK and rest-of-the-world beliefs. The relative weight on UK beliefs is decreasing in the relative severity of the agency friction for UK-based bankers. Intuitively, the UK beliefs are more important the larger is the relative size of the UK banking system.

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(Total Assets), measuring assets deflated by GDP deflator. It controls for the overall size of the bank, an important control variable across banking literature since size can imply preferential access to external funding due to 'too big to fail' status.
- Capital Ratio, measuring the percentage of each banking organisation's regulatory Tier-1 risk-based capital-to-asset ratio. This is a potentially important to control by the capital 'quality' because the adjustment of loans in response to change in deposits could be impaired by capital constraints.
- Liquid-Asset Ratio, measuring the percentage of a bank's asset portfolio that is liquid; a key control as it reflects a bank's ability to adjust its asset side. In Kashyap and Stein (2000), monetary policy has a greater impact on banks with lower buffers of liquid assets.
- Core Deposits Ratio, measuring the percentage of the banking organisation's balance sheet financed with core deposits. This variable captures the *ex ante* extent to which banks access alternative sources of funding outside of deposit taking. A bank with a high ratio can build on a more stable and more reliant funding source.
- Commitment share, measuring the percentage of unused commitments over assets. As a substantial amount of loans is made under commitments, this is an essential control.
- International share, measuring the share of bank's foreign assets over total assets which measures the degree of internationalisation of the bank.

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.[22] 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.

[22] 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

In Table D.1 we break down our multiplier estimates for nominal exchange rates by differentiating between bank and non-bank recipients of cross-border lending and sources of cross-border borrowing. To do this, we construct different GIVs for each lending/borrowing class by recipient/source. Strikingly, while these non-bank- and bank-recepient GIVs are largely uncorrelated, they both play a significant role exchange-rate dynamics. In particular, both debt flows to banks and non-banks have a statistically significant causal effects on exchange rates. Interestingly, deposit liability banking flows matter for exchange rates only if the counterparty is another bank, whereas portfolio flows drive exchange rates only if the counterparty is a non-bank. We plan to investigate these differences in future work.

Table D.1: Exchange-Rate Multipliers for External Assets, Liabilities to Banks vs Non-Banks

Dep. Var.: Δe_t	(1)	(2)	(3)	(4)
z_t^{debt}/m, to Bank	2.837***	1.500***	1.332***	1.532***
	(0.662)	(0.452)	(0.418)	(0.372)
z_t^{port}/m, to Bank	0.220	0.182	0.207	-0.0973
	(0.567)	(0.258)	(0.239)	(0.252)
z_t^{dept}/m, to Bank	-1.296**	-0.686**	-0.564*	-0.646**
	(0.498)	(0.323)	(0.301)	(0.289)
z_t^{debt}/m, to Non-Bank	1.303***	0.950***	0.982***	1.110***
	(0.493)	(0.290)	(0.316)	(0.384)
z_t^{port}/m, to Non-Bank	0.812*	0.324	0.342	0.427**
	(0.466)	(0.267)	(0.246)	(0.193)
z_t^{dept}/m, to Non-Bank	-0.971*	0.0308	0.121	0.389
	(0.559)	(0.432)	(0.497)	(0.540)
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	0.205	0.670	0.671	0.712

Notes: Coefficient estimates from equation (20) using data from 1997Q1-2019Q3. 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.

Table D.2 presents the first stage regression results used to compute our estimates for the demand and supply elasticities displayed in Table 3.

Table D.2: 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 (21). PANEL B: Coefficient estimates from 1st stage regression (22). 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.3 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.3: 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)
$r^{us}_{6M,t}$			-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)
$\Delta r^{us}_{6M,t}$			-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.