BEYOND BILATERAL FLOWS: INDIRECT CONNECTIONS AND EXCHANGE RATES*

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Abstract

This paper studies how cross-border financial connections affect the response of exchange rates to trade shocks. Theoretically, we develop a multi-country model whereby a country's exchange rate depends on the financiers' ability to manage capital flows between a country and its counterparties (direct connection) and between its counterparties and their trading partners (indirect connection). Empirically, we quantify the network of financial connections using granular data on cross-border claims and liabilities of globally active banks. Consistent with our theoretical predictions, we find that indirect connection can either amplify or mitigate the impact of trade shocks on future exchange rate returns, depending on the shock's origin and size, while direct connection always dampens these effects.

Keywords: Exchange Rates, Currency Returns, Imperfect Financial Markets, Global Banking.
JEL Classification: F21, F30, F31, G12, G15, G21

1 INTRODUCTION

The ability of financial institutions to intermediate capital flows plays a key role for exchange rate determination both theoretically (e.g., Gabaix and Maggiori, 2015; **?**) and empirically (e.g., Du, Hebert and Wang, 2023; Fang, 2021). Theoretical research, particularly in two-country or small open economy settings, has primarily focused on how elastically capital can flow into a country, emphasizing the role of direct financial connectionsâi.e., the capacity of financial institutions to intermediate capital flows between a country and its immediate counterparties. In these models, greater intermediation capacity typically leads to smaller exchange rate adjustments following external shocks. However, this focus on direct connections overlooks that financial intermediaries operate through a complex network of cross-border interactions. Capital often moves across borders not in simple bilateral flows but through a network of intermediaries. Who a country borrows from and how elastically those lenders can, in turn, obtain capital shape the way capital flows through the financial system. Yet, the role of these indirect financial connections in exchange rate determination remains poorly understood.

This paper explores how both direct and indirect financial connections influence exchange rate dynamics in response to trade shocks. We develop a multi-country model in which the impact of a trade shock depends not only on a countryâs direct financial links but also on the network of intermediation beyond its immediate counterparties. Our empirical analysis, using granular data on cross-border claims and liabilities, demonstrates that while stronger direct financial connections consistently dampen the exchange rate response to trade shocks, indirect financial connections can either amplify or mitigate these effects, depending on the nature of the shock. These findings suggest that understanding global capital flows requires moving beyond bilateral financial relationships and considering the broader network structure of financial intermediation.

In this paper, we unpack direct and indirect effects arising from cross-border financial connections and attempt to understand how they contribute to exchange rate determination, both theoretically and empirically. Ultimately, we show that while the ease with

which a country can attract capital is important, so too is who a country attracts capital from and in turn, where their counterparty gets capital from and so on. While stronger direct financial connections help attenuate the impact of capital flows on exchange rate, indirect financial connections can have an amplifying or dampening effect depending on the source of the shock. We start from a growing literature suggesting that exchange rates react inelastically to capital flows (e.g., Jeanne and Rose, 2002; Froot and Ramadorai, 2005; Bacchetta and Wincoop, 2006; Koijen and Yogo, 2020; Jiang, Richmond and Zhang, 2022), define the strength of financial connection between any pair of countries as how elastically capital can flow between them. Before describing the features of our model, it is useful to provide a simple intuition on how the network of financial connections influences exchange rates. Imagine a world with three countries, say the US, Eurozone, and Japan. All countries trade goods with each other and have initially balanced external accounts, but there are no direct financial flows between the Eurozone and Japan. All capital is channeled through the US. Imagine a scenario where the US experiences a positive shock to its trade balance as displayed in Figure 1. The inelastic response to the resulting capital flows means that the euro and yen should both fall in value against the dollar. Now suppose that Japan has a stronger direct financial connection with the US, meaning that a given capital flow between them has a smaller impact on the dollar-yen exchange rate. From the Eurozone's perspective, its direct financial connection with the US is unchanged but there is an improvement in its indirect connection to Japan. Now in response to a positive shock to the US trade balance, more of this resulting surplus flows to Japan thus leading to a larger Japanese and a smaller Eurozone trade deficit. This smaller Eurozone deficit implies the stronger indirect connection *moderates* the impact of the shock on the euro-dollar exchange rate.

FIGURE 1 AND FIGURE 2 ABOUT HERE

Now consider an alternative second scenario where the Eurozone experiences a negative shock to its trade balance, e.g. due to rise in import demand, as reported in Figure 2. As above, this weakens the euro vis-a-vis the dollar, whereas the yen strengthens as Japan's trade surplus with the Eurozone corresponds to a flow of capital to the US. In turn, this

flow is redirected to the Eurozone to finance its trade deficit. Now imagine, again, that Japan has a stronger direct financial connection with the US (equivalent to an improvement in the Eurozone's indirect connection with Japan). More capital is now able to flow out of Japan increasing its external surplus, in turn more capital must to flow to the Eurozone via the US. The larger capital flow to Europe brings about a sharper depreciation of the euro. The stronger indirect connection *amplifies* the impact of the shock.

We first formalize this intuition in a multi-country version of the Gabaix and Maggiori (2015) model of inelastic exchange rates. We confirm that a stronger, or more elastic, direct financial connection moderates the response of exchange rates to capital flows. However, a stronger indirect financial connection can either amplify or mitigate the response of exchange rates depending on the source of the capital flow: whether it arises due to a change in the trade balance of the domestic economy, portfolio flows or to economic environment in a large trading partner. The model also shows that the intuition extends beyond a three country setting and that the notion of indirect connections extends to measures of centrality used in the network literature.

Our key contribution is to test whether these insights hold in the data. To do so, we need a proxy for the strength of financial connections, the elasticity of the exchange rates with respect to the net capital flows, between countries. We argue that, in theory, this should be related to the gross, not net, bilateral financial exposure between any two countries. Intuitively, an inelastic connection limits large gross positions. To build a network of gross financial positions we use data on bilateral cross-border banking activity from the restricted version of the Locational Banking Statistics by residence (LBSR) compiled by the BIS. This dataset contains data on the country-level cross-border banking positions of banks located in BIS-reporting countries, against all sectors across a broad array of counterparty countries worldwide. This data enables us to measure gross cross-border claims at the quarter-country-pair level for over 70 countries, thereby providing a proxy for the strength of financial connections.[1]

[1] Although the LBSR data contains a larger set of counterparty countries, our results are limited to the 70 countries that are common to both the LBSR and the other datasets that we use to conduct our empirical analysis.

In our empirical analysis, we first validate the use gross banking claims as a proxy for the elasticity of exchange rates to capital flows. To do so, following Camanho, Hau and Rey (2022), we construct idiosyncratic equity portfolio shocks from equity holdings data on international mutual funds and ETFs using a granular instrumental variables (GIV) approach (Gabaix and Koijen, 2024). We estimate the exchange rate response to these plausibly exogenous portfolio shocks and find that the response is negatively related to higher levels of gross claims. Gross banking positions are proxies for the elasticity of the exchange rate with respect to capital flows.

To measure the strength of a country's direct and indirect financial connections, we construct an adjacency matrix that contains the sum of claims and liabilities of counterparty countries against banks in reporting countries. This matrix encompasses a network of gross cross-border banking positions, allowing us to decompose direct and indirect connections from the perspective of a country as a counterparty. The direct connections are simply the sum of a country's claims and liabilities against all banks in reporting countries. The indirect connections are derived from the eigenvector centrality of the network, which captures the importance of a country by considering the strength of its financial connections, both direct and indirect. We then use off-the-shelf techniques to extract the strength of indirect connections from this centrality measure. In particular, we collapse all indirect connections for a given country into a single quarter-country measure, which is crucial for our empirical analysis.

As our main empirical exercise, we employ a battery of panel FX return regressions that use indirect financial connections as key explanatory variables to empirically test our theoretical predictions. Our panel regressions have monthly exchange rate returns (against the US dollar) as the dependent variable, a set of interactions motivated by our theoretical predictions as explanatory variables, a set of controls that are known to predict exchange rates, and time fixed effects to exploit cross-sectional differences within each month. More specifically, each interaction measures the response of exchange rate returns to various sources of trade imbalance variation (namely, a country's own trade balance, trade shocks originating from abroad, and local trade shocks) conditional on different

levels of direct and indirect financial connections.

We find that, conditional on a positive shock to the US trade balance used to proxy a large import demand shock abroad, a stronger indirect financial connection *moderates* the exchange rate movement in line with the first scenario described above. In contrast, and in line with the second scenario, stronger indirect connections *amplifies* the response of a country's exchange rate to idiosyncratic shocks to their own trade balance. As we hinted at above, this amplifying effect depends on how capital flows among other countries react to a trade shock. If the shocked country is small, our theory predicts indirect connections have a minimal role in determining how the exchange rate reacts to a local trade shock as the resulting capital flows in the rest of the world are also small. In line with this logic, we find that this amplifying effect is increasing in the size of the country and thus, empirically, is only present in very large countries (in terms of their share of total trade).

Finally, and importantly, our theory suggests that the relevant measure of financial connectivity is how easily capital can flow in the currency of the counterparty countries and not flows in a vehicle currency such as the US dollar. Intuitively, exchange rates react to capital flows because the financial assets exchanged are denominated in different currencies. A feature of the version of the LBSR we use is that it allows us to measure the denomination of gross financial positions. Hence, we can measure the strength of financial connections both in claims denominated in vehicle currencies and the currency of the counterparties. We then show empirically that the our measured effects of a stronger indirect connection only applies when we measure those connections using gross claims denominated in the currency of the counterparty not in a vehicle currency.

Overall, this paper first provides a simple and intuitive theoretical guide for why indirect financial connections can have a role to play in exchange rate determination. We then find clear empirical evidence for these theoretical predictions in the cross-section of exchange rate returns.

LITERATURE REVIEW. We contribute to the growing literature on the financial intermediation of global imbalances under imperfect markets (e.g., Obstfeld and Rogoff, 1995; Bruno and Shin, 2015; Maggiori, 2017; He, Krishnamurthy and Milbradt, 2019). However, in this context, multi-country settings have received relatively less attention (Maggiori, 2022). Closest to our work is Hou, Sarno and Ye (2024), who also build a multicountry version of Gabaix and Maggiori (2015). They develop a model showing that a network of trade imbalances can be used to generate a factor that predicts currency excess returns. Our focus is different as we consider how cross-border financial connections proxied through a network gross financial positions can mitigate or amplify trade shocks. Richmond (2019) pioneered the use of network analysis in explaining exchange rates in a model with rich heterogeneity in trade flows but without financial market imperfections. That work, alongside Jiang and Richmond (2023), documents the importance of trade centrality in explaining cross-sectional differences in risk premia. Unlike the measures of centrality based on financial networks that we propose in this paper, trade centrality correlates with currency risk premia through interest rate differentials, whereas we find financial centrality to be primarily associated with exchange rate returns. Moreover, we document empirically that the correlation between a country's relative position in trade and financial networks is far from perfect, suggesting that both networks capture different determinants of currency returns. Bahaj, Fuchs and Reis (2024) study the role played by financial networks of liquidity arrangements among central banks and document that indirect connections affect CIP deviations. Our definition of a financial network is broader and we show implications for exchange rates.

Our work also fits into an extensive literature on understanding the factors behind cross-sectional variation in excess returns. Lustig, Roussanov and Verdelhan (2011); Heyerdahl-Larsen (2014); Colacito, Croce, Gavazzoni and Ready (2018) consider currency risk premia in multi-country models with the goal of explaining the moments of exchange rate returns in settings with elastic exchange rates. The financial market imperfection that we consider leads to a breakdown of no-arbitrage and so leads to a different set of predictions. In that sense, this paper is closer to Della Corte, Riddiough and Sarno (2016), who show that currency excess returns are related to countries' external imbalances and the propensity

to issue external liabilities, consistent with models of inelastic exchange rates.

In a similar vein, this paper links to set of studies assessing the sensitivity of exchange rates to capital flows, thereby testing the hypothesis that exchanges react inelastically. Pandolfi and Williams (2019); Camanho, Hau and Rey (2022) study how capital flows from international equity investors rebalancing their portfolios affect exchange rates. Becker, Schmeling and Schrimpf (2024); Bippus, Lloyd and Ostry (2023) follow Camanho, Hau and Rey (2022) and use granular instruments from syndicated loans and bank loans, respectively, to estimate the elasticity of exchange rates to capital flows. We contribute by showing how the cross-border gross financial positions of a country's bank sector is positively correlated with how elastically the exchange rate can adjust to shocks. In terms of data, we are also similar to Correa, Paligorova, Sapriza and Zlate (2021) who use the restricted version of the Locational Banking Statistics dataset from the BIS to analyze the impact of monetary policy on cross-border bank flows.

The remainder of this paper is organized as follows. Section 2 introduces our model and presents our empirical predictions. Section 3 presents a detailed description of our confidential dataset on cross-border banking activity and discuss the construction of network centrality. Section 4 verifies the prediction of the theoretical model of the importance of banking network centrality for future exchange rate returns before we conclude in Section 5. A separate Internet Appendix provides proofs and other supporting analyses.

2 Model

This section extends the exchange rate determination model with imperfect financial markets of Gabaix and Maggiori (2015) to an arbitrary number of countries, while introducing bilateral exchange rate elasticities. This simple extension is sufficient to generate a rich set of predictions showing that indirect financial connections matter for future exchange rate returns.

2.1 Environment

There are two time periods and N countries of different sizes. Each country is populated by households that receive utility in each period from consuming a mix of a domestic nontradable good, a domestic tradable good, and imported tradeable goods. The nontradable good serves as the numéraire in each country, so that exchange rates are the relative price between countries' nontradable goods. Households have an endowment of the domestic goods and do not discount the future. There is no uncertainty and all future variables are known as of today; endowments are such that uncertainty is irrelevant for agents' behavior.

Financial markets are segmented. Households trade only risk-free bonds denominated in their local currency; as there is no discounting, net interest rates are nil in equilibrium. Additionally, households have a deterministic and perfectly inelastic portfolio position in foreign bonds which can be interpreted as noise trading or a policy intervention; we refer to these as portfolio flows. International bond trading occurs exclusively through financiers. Each group of financiers only buys and sells bonds denominated in two unique currencies, profiting from the exchange rate differential. In doing so, financiers intermediate capital flows along a bilateral connection between the corresponding countries. Importantly, financiers face a limited commitment problem that results in a downward-sloping demand curve for bonds in each currency. For simplicity, we assume that financiers' profits are distributed lump-sum to households in proportion to households' own losses from currency movements. To save space, a detailed description of the problems facing households and financiers is presented in Internet Appendix A.1 as they are similar to Gabaix and Maggiori (2015). In the main text, we simply state the resulting balance of payment identities that can be used in pin down the equilibrium.

2.2 Balance of Payments Identities and Equilibrium

In country j, per capita household expenditure on imported good i in local currency is $h_i \iota_{j,t}$, where h_i denotes the normalized ($\sum_i h_i = 1$) size of households in country i and $\iota_{j,t}$ is preference parameter that pins down country j's per capita import demand at time

t. Let $e_{j,t}$ denote the country's exchange rate at time t with currency 1, which we refer to as the dollar. Aggregating across markets and across households while accounting for financiers' profits, we end up with the following dollar-denominated balance of payments identities for country j defined as

$$t=0: \quad \underbrace{h_j \sum_{i \neq j} h_i e_{i,0} \iota_{i,0}}_{\text{export revenues}} - \underbrace{h_j(1-h_j) e_{j,0} \iota_{j,0}}_{\text{import spending}} - \underbrace{f_j}_{\text{net portfolio flows}} + \underbrace{\sum_{i \neq j} \Lambda_{ji} e_{s_{ji},0} \left(\frac{e_{j,1}}{e_{j,0}} - \frac{e_{i,1}}{e_{i,0}} \right)}_{\text{net borrowing from financiers}} = 0 \quad , \tag{1}$$

$$t=1: \quad \underbrace{h_j \sum_{i \neq j} h_i e_{i,1} \iota_{i,1}}_{\text{export revenues}} - \underbrace{h_j(1-h_j) e_{j,1} \iota_{j,1}}_{\text{import spending}} + \underbrace{f_j}_{\text{net portfolio flows}} - \underbrace{\sum_{i \neq j} \Lambda_{ji} e_{s_{ji},0} \left(\frac{e_{j,1}}{e_{j,0}} - \frac{e_{i,1}}{e_{i,0}} \right)}_{\text{net repayments to financiers}} = 0 \quad . \tag{2}$$

The first identity states that the net borrowing from financiers in period 0 must equal to the country's trade deficit plus f_j, the dollar value of j's inelastic portfolio positions abroad net of foreigners' portfolio positions with j (so that $\sum_i f_i = 0$). Financiers lend or borrow with inelastic demand curves. The capital flow from financiers between country i and country j is absorbed by the demand curve $\Lambda_{ji} e_{s_{ji},0} \left(\frac{e_{j,1}}{e_{j,0}} - \frac{e_{i,1}}{e_{i,0}} \right)$. The term $\left(\frac{e_{j,1}}{e_{j,0}} - \frac{e_{i,1}}{e_{i,0}} \right)$ is the dollar return to financiers of purchasing bonds denominated in currency j, financed by borrowing in currency i (recall, net interest rates are nil). This return is converted into an arbitrary currency, s_{ji}, in which financiers value their profits by multiplying by $e_{s_{ji},0}$. More important is the parameter Λ_{ji}. This parameter is symmetric ($\Lambda_{ij} = \Lambda_{ji}$) and it pins down the slope of the demand curve for country j's bond from the financiers between i and j as function of this return. Hence, the parameter determines how elastically capital can flow between these two countries. The lower Λ_{ji}, the greater return on currency j vis-à-vis currency i required by the financiers connecting i and j for them to intermediate a given capital flow from i to j.

The second identity simply states that a country's trade balance plus its net revenue from

its foreign portfolio position in period 1 must be sufficient to repay the financiers the amount the country borrowed in period 0.[2] An equilibrium is a set of exchange rates in period zero and period one that ensure that the balance of payments identities from Equation (1) and Equation (2) are satisfied across all countries.

Direct and Indirect Connections

Because countries can potentially borrow from $N-1$ counterparties, how elastically country j can finance its total external balance needs depends on the complete vector $\{\Lambda_{ji}\}_i$. We refer to these as the country's *direct* financial connections with the rest of the world. The stronger the country's direct connections, the smaller the impact of any given shock to the country's external balance on its exchange rate as financiers demand a small change in the return on country's j exchange rate as compensation to intermediate capital flows.

However, the capital flows to county j depend not just on the return on its own exchange rate ($e_{j,1}/e_{j,0}$) but also on the return on the exchange rate of its counterparty's (i.e the $e_{i,1}/e_{i,0}$ terms in Equation (1) and Equation (2)). The determination of counterparty exchange rates depend not just on their connection to j but also the financial connections to other countries in the global economy. Concretely, a scenario where financiers are borrowing in currency i to lend in currency j. If country i then strengthens its direct financial connection with a third country k, this will impact the exchange rate of currency i and, in turn, this will alter currency j's exchange rate by changing the return financiers operating between i and j receive on their short position. From country j's perspective, we think of this as a change in its *indirect* financial connection to country k. From this logic, indirect connections influence exchange rates through the interconnected nature of capital flows.

However, the exact role of indirect connections is less intuitive and depends on the underlying source of the exchange rate movements. To build further intuition we first conduct

[2] A country that lends to financiers in period-0 will make a capital loss vis-à-vis financiers in dollar terms if its currency depreciates in period 1 (and vice-versa for a borrower). We assume that each household's share of financiers profits just offsets these capital losses. So in the balance of payments identities, revaluation effects coming from the denomination of households' assets and liabilities cancel with the transfer from financiers.

comparative statics over the equilibrium in a three country case, which allows to obtain closed formed solutions. We then turn briefly to how our results extend with an arbitrary number of financially connected countries, where the solution is obtained numerically.

2.3 A Three-Country Example

We now consider a simplified example involving three countries of varying sizes: We label country 1 as the US with size h_1, the Eurozone is country 2 with size h_2, and Japan is country 3 with size h_3, where $h_1 < 1/2$ and $h_1 \geq h_2, h_3$. To sharpen our analysis, assume no financial connection between the Eurozone and Japan (i.e. $\Lambda_{23} = \Lambda_{32} = 0$), so that all capital flows are intermediated through the US. Following Gabaix and Maggiori (2015), we also assume that financiers intermediating flows between the US and Eurozone value their profits in euros, while those operating between the US and Japan value their profits in yen. To facilitate the explanation, we treat the Eurozone as a domestic economy and the US as a foreign economy, while referring to Japan as a third economy.

To explore the role of *direct* and *indirect* connections, we conduct comparative statics on the response of the euro-dollar exchange rate to changes in import demand and portfolio flows at time zero. This exchange rate is denoted as $e_{2,0}$ and an increase indicates a euro appreciation. We assess how the euro-dollar exchange responds to a change in (i) import demand at home, $\iota_{2,0}$; (ii) a portfolio flow out of the Eurozone to the US, f_2; and (iii) foreign (US) import demand, $\iota_{1,0}$. Our interest is in how the euro-dollar exchange rate's response to these changes are affected by strength of the Eurozone's direct and, more importantly, indirect financial connections. The Eurozone's direct financial connection is given by Λ_{12}; capturing how elastically capital can flow between the US and the Eurozone. From the perspective of the Eurozone, the indirect financial connection is given by Λ_{13}; capturing how elastically capital can flow between the US and Japan.

For simplicity, we set $\iota_{i,1} = 1$ for all i. A negative import demand shock in period one is almost equivalent to a positive import demand shock in period zero so this assumption streamlines the analysis without altering the underlying economics. We also set $f_3 = 0$ so that all portfolio flows are between the Eurozone and the US.

Since borrowing must equal repayments when gross interest rates are one, a trade deficit in period zero must be then offset by a surplus in period one. We can then express the exchange rates in period one in terms of exchange rates in period zero, rewrite the net bond positions of financiers, and substitute them into the period zero balance of payments conditions for both country 2 and country 3. We then obtain the following result.

Lemma 1. *From the perspective of country 2 relative to country 1, we obtain that*

(i) An increase in import demand at home or a portfolio outflow from home causes a depreciation of the domestic currency; that is $de_{2,0}/d\iota_{2,0} < 0$ *and* $de_{2,0}/df_2 < 0$*. An increase import demand abroad causes a current appreciation of the domestic currency; that is* $de_{2,0}/d\iota_{1,0} > 0$*.*

(ii) A stronger direct financial connection mitigates the domestic currency in response to changes in import demand and portfolio flows. That is, the absolute value of the three derivatives in point (i) are decreasing in Λ_{12}*.*

Proof. All proofs in Internet Appendix B. □

The findings and intuition behind Lemma 1 is identical to the standard two-country model of with inelastic exchange rates. Consider the case of an increase in US import demand ($\iota_{1,0} \uparrow$). Starting from balanced trade, this causes a deficit in the US and a surplus in the Euro Area (and in Japan). Financiers will fund this deficit by intermediating a capital flow between the Eurozone and the US – borrowing in euros and lending in dollars through the bond market. The euro appreciates against the dollar in period 0 followed by a depreciation tomorrow of the euro against the dollar, so that the financiers profit sufficiently from the flow. The size of the required exchange rate movement depends of Λ_{12}, the greater this parameter the smaller is financier's required return to intermediate. Similar reasoning applies to Eurozone portfolio outflows ($f_2 \uparrow$) or an increase in Eurozone import demand ($\iota_{2,0} \uparrow$), except that the direction of the capital flow is reversed.

What is less obvious is how the ability of financiers to intermediate funds between the US and Japan country alters the response of the euro to changes in import demand or portfolio flows either at home or abroad. This can be determined by inspecting the cross

derivatives of $de_{2,0}/d\iota_{1,0}$, $de_{2,0}/d\iota_{2,0}$ and $de_{2,0}/df_2$ with respect to Λ_{13}, which captures the effect of the financial connection between the US and Japan on the behaviour of the euro. We can obtain the following result.

Proposition 1. *Starting from the point where $\iota_{i,0} = 1$ for all i and $f_2 = 0$, we obtain that*

(i) A stronger indirect connection mitigates the current appreciation of the domestic currency in response to an increase in import demand abroad as $de_{2,0}/d\iota_{1,0}$ (which is positive) is decreasing in Λ_{13}.

(ii) A stronger indirect connection amplifies the current depreciation of the domestic currency in response to an increase in import demand at home as $de_{2,0}/d\iota_{2,0}$ (which is negative) is decreasing in Λ_{13}.

(iii) A stronger indirect connection mitagates the current depreciation of the domestic currency in response to a portfolio outflow at home since $de_{2,0}/df_{2,0}$ (which is negative) is increasing in Λ_{13}.

(iv) The effect of stronger indirect connections on the response of the domestic currency to domestic import demand shocks or to domestic portfolio flows only occurs when the domestic country is large since the derivatives of $de_{2,0}/d\iota_{2,0}$ and $de_{2,0}/df_2$ with respect to Λ_{13} go to zero h_2 approaches zero.

Proof. All proofs in Internet Appendix B. □

To grasp the intuition behind Proposition 1, it is useful to reexpress the balance of payment condition for country 2 as follows

$$\underbrace{\Lambda_{12}((1+\iota_{1,0}) - (1+\iota_{2,0})e_{2,0})}_{\substack{\text{Net Position of Financiers} \\ \text{between the Eurozone and US}}} = \underbrace{h_1(h_2\iota_{2,0}e_{2,0} + h_3\iota_{3,0}e_{3,0}) - h_1(1-h_1)\iota_{1,0}}_{\text{US Trade Balance}}$$

$$+ \underbrace{\Lambda_{13}((1+\iota_{3,0})\,e_{3,0} - (1+\iota_{1,0}))}_{\substack{\text{Net Position of Financiers} \\ \text{between the US and Japan}}} + f_2, \tag{3}$$

where the left-hand (right-hand) side denotes the demand (supply) curve for international borrowing/lending from the Eurozone's perspective. This identity arises from the fact that capital can only flow to the Eurozone through the US. As a result, the net position of financiers between country 2 and country 1 (demand curve) must be equal in magnitude but opposite in sign to the net position of financiers between country 1 and country 2 (supply curve). The supply of capital available to country 2 is then composed of the country 1 trade balance and the net position of financiers operating between countries 1 and 3.

Using Equation (3), we can further unpack demand curve as

$$\text{Demand} = \underbrace{\Lambda_{12}(1+\iota_{1,0})}_{\text{Demand shift}} - \underbrace{\Lambda_{12}(1+\iota_{2,0})e_{2,0}}_{\text{Demand slope}}$$

and the supply curve as

$$\text{Supply} = \underbrace{h_1\left(h_3\iota_{3,0}e_{3,0} - (1-h_1)\iota_{1,0}\right) + \Lambda_{13}\left((1+\iota_{3,0})e_{3,0} - (1+\iota_{1,0})\right)}_{\text{Supply Shift}} + \underbrace{h_1h_2\iota_{2,0}e_{2,0}}_{\text{Supply Slope}},$$

thus highlighting the intersection between a downward-sloping demand curve and an upward-sloping supply curve, both including their respective shifters.

To clarify the explanation, we will continue treating the Eurozone as the domestic economy, the US as the foreign economy, and Japan as a third economy. Point (i) of Proposition 1 examines a positive import demand shock abroad, which causes a foreign trade deficit, a domestic trade surplus, and an immediate appreciation of the euro against the dollar, as indicated by $de_{2,0}/d\iota_{1,0} > 0$. However, the response of $e_{2,0}$ to an increase in $\iota_{1,0}$ depends on the strength of the financial connection between the US and Japan, as captured by Λ_{13}. By calculating the cross-derivative $d^2e_{2,0}/d\iota_{1,0}d\Lambda_{13} < 0$, we demonstrate that a higher Λ_{13} reduces the sensitivity of $e_{2,0}$ to changes in $\iota_{1,0}$, resulting in a lower $de_{2,0}/d\iota_{1,0}$. From the Eurozone perspective, an increase in Λ_{13} acts as a *supply shifter* that moves the equilibrium down the financiers' demand curve, thus mitigating the appreci-

ation of $e_{2,0}$ in Equation (3). Intuitively, when Λ_{13} rises, Japan's trade surplus finances a greater share of the US trade deficit, while the Eurozone funds a smaller share. As a result, financiers operating between the US and the Eurozone intermediate a smaller amount of capital flows and require lower compensation. This, in turn, dampens the magnitude of the future exchange rate return, specifically reducing the euro's appreciation today and its depreciation tomorrow relative to the dollar.

Point (ii) of Proposition 1 examines a positive import demand shock at home, which causes a domestic trade deficit, a foreign trade surplus, and an immediate depreciation of the euro against the dollar, given that $de_{2,0}/d\iota_{2,0} < 0$. Japan also experiences a trade surplus and since capital can only flow to the US, there is an immediate yen appreciation against the dollar.[3] Now, a higher Λ_{13}, means that for any given $e_{3,0}$, a greater the amount of capital will flow from Japan to the US. This will moderate the yen appreciation (in line with Lemma 1). However, from the Eurozone perspective, a higher Λ_{13} acts a supply shifter that moves the equilibrium in Equation (3) down the financiers' demand curve, thus amplifying the depreciation of $e_{2,0}$. In essence, financiers linking countries 1 and 2 are required to absorb a larger supply of capital as Japan is able to recycle a greater surplus back to the Eurozone via the US. However, given the financier's limited capacity to intermediate capital flows, this requires their compensation to be larger, leading to an increase in the future exchange rate return.

Point (iii) of Proposition 1, finally, points out that higher Λ_{13} no longer amplifies the depreciation of the domestic currency in response to a domestic trade shock when the domestic country becomes small. Intuitively, when country 2 is small, changes in its trade balance cannot meaningfully affect the capital flow between countries 1 and 3, which in turn affects the sensitivity of the domestic currency with respect to $\iota_{2,0}$. As h_2 tends to zero, the right-hand side of Equation (3) does not longer change with $\iota_{2,0}$. This curtails the effect through the shift in supply discussed above and, hence, there is no amplification.

[3]The yen appreciation against the dollar is not a knife edge result arising from the assumption of no capital flows between the Eurozone and Japan. It will occur so long as the Japanese-Eurozone connection are relatively weak compared to the Eurozone-US and Japan-US connections. This means that it is efficient to intermediate some capital flows from Japan to the Eurozone via the US, which requires a yen appreciation in period 0 followed by an depreciation in period 1.

To sum up, Proposition 1 suggests that higher indirect connection mitigates the impact of foreign import demand shock but amplify the effect of domestic import demand shock on the future exchange rate return, as long as the latter economy is sufficiently large. The intuition comes from whether the trade balance of a third country moves in the same or opposite direction compared to the domestic trade balance. If the two balances move in the same direction (when $\iota_{1,0}$ increase), better third country connection takes pressure off the domestic currency as the other country can absorb surplus/finance deficits elsewhere more easily. When trade balances move in opposite directions (when $\iota_{2,0}$ increase), better third country connection mean more foreign surpluses are recycled back to the domestic economy (and foreign deficits drain more finance away from it). The need for financiers to absorb it adds additional pressure on the exchange rate.

MULTI-COUNTRY MODEL. We now consider a scenario with N countries and Λ_{ji} taking arbitrary positive values. We make the assumption that financiers value their business in dollars so that $e_{s_{ji},0} = e_{1,0}$ for any country pair.[4] The model is otherwise unaffected. Let $\underline{\iota}_t = (\iota_{1,t}, \iota_{2,t}, \ldots, \iota_{N,t})'$, $\underline{e}_t = (1, e_{2,t}, \ldots, e_{N,t})'$, while $\oslash$ denotes the Hadamard inverse. By stacking together the balance of payments conditions for all countries, we end up with the following result.

Lemma 2. *If financiers value their net bond positions in dollars, the balance of payments conditions stacked across N countries yield the following system of equations*

$$\Omega_0 \underline{e}_0 + \Lambda \left(\underline{e}_1 \oslash \underline{e}_0 \right) = 0$$

$$\Omega_1 \underline{e}_1 - \Lambda \left(\underline{e}_1 \oslash \underline{e}_0 \right) = 0,$$

where Ω_t and Λ are the matrices of trade and financial connections, respectively. In equilibrium, the vectors $\underline{e}_0$ and $\underline{e}_1$ must satisfy the balance of payments conditions.

[4] In the multi-country model presented in the appendix of Gabaix and Maggiori (2015), a linear combination of currencies is used to value financiers businesses enabling analytical solutions. However, it is difficult to interpret what this means in terms of a financial constraint for the financier. So, we simply use the dollar as a benchmark and solve the model numerically.

Proof. All proofs in Internet Appendix B.3. □

Three points standout from Lemma 2. First, the matrix Λ captures the network of financial connections between countries. Each diagonal element of Λ is equal to $\sum_i \Lambda_{ji}$ and represents the combined capacity of financiers with direct financial connection to country j. Hence, these diagonal terms capture the strength of the direct connections between country j and its immediate counterparties.The off-diagonal elements of Λ can be interpreted as a weighted adjacency matrix tracking the strength of the financial connection between any two countries. Hence, these off-diagonals will capture indirect connections. It then follows that the complete network structure plays a role for exchange rate determination. What matters is not only the total intermediation capacity of financiers connected to country j (direct connections) but also whom those financiers are connected to and beyond that (indirect connections). Since the financial connection matters for exchange rates via an adjacency matrix, it makes sense to estimate the strength of direct and indirect connections through measures of the centrality of that matrix.

Second, the matrix Ω_t refers to the network of trade relationships. As we have written the model, trade weights are just proportional to country size. However, differing trade weights among countries would manifest as richer heterogeneity in Ω_t and, in turn, alter how movements in import demand transmits to the exchange rate through trade flows. This links to existing work on trade networks and exchange rate returns (Richmond, 2019). And to the extent that trade and financial networks are likely correlated, this illustrates that it is important to control for the former when exploring whether the latter plays a role in the data.

Finally, as we shall see next, the moderating and amplifying effects of indirect connections described in Proposition 1 are also present in the N country case. This version of the model does not permit closed form solutions. To show that our model's predictions extend beyond the simple three-county example, we instead perform simulations of the model for $N = 20$ countries (countries 1 and 2 are large, while others are small), and then solve for the equilibrium values of $\underline{e}_0$ and $\underline{e}_1$ in Lemma 2 (see Internet Appendix A.4 for

additional details). We then run least-squares regressions based on the following specification that matches our empirical specification in the next section

$$\begin{aligned} e_{j,1}/e_{j,0} \;=\; & \alpha \texttt{Ind}_j + \beta(\texttt{Ind}_j \times \texttt{Shock}^{+}_{1,0}) + \gamma(\texttt{Ind}_j \times \texttt{Shock}^{-}_{j,0}) + \delta(\texttt{Ind}_j \times \texttt{Shock}^{-}_{j,0} \times \texttt{Large}_j) \\ & + \tilde{\alpha}\texttt{Dir}_j + \tilde{\beta}(\texttt{Dir}_j \times \texttt{Shock}^{+}_{1,0}) + \tilde{\gamma}(\texttt{Dir}_j \times \texttt{Shock}^{-}_{j,0}) + \tilde{\delta}(\texttt{Dir}_j \times \texttt{Deficit}_{j,0}) \\ & + \texttt{Controls}_{j,0} + \texttt{Simulation Fixed Effects} + \varepsilon_{j,t+1}, \end{aligned}$$

where $\texttt{Dir}_j$ and $\texttt{Ind}_j$ represent direct and indirect financial connections of country j, respectively, $\texttt{Shock}^{+}_{1,0}$ denotes a positive shock to country 1 net exports (or a negative import demand shock, i.e. $-\iota_{1,0}$), $\texttt{Shock}^{-}_{j,0}$ refers to a negative shock to country j net exports (or a positive import demand shock, , i.e. $\iota_{j,0}$), $\texttt{Large}_j$ indicates a binary variable that equals one if country j is large and zero otherwise, and $\texttt{Deficit}_j$ is the trade deficit of country j in period zero. Financial connections are computed via eigenvector centrality, explained later in Section 3.2.

TABLE 1 ABOUT HERE

We report the estimates associated to our simulation exercise in Table 1. Focusing on specification (3), we find that the estimate of β is negative, meaning that country j higher indirect financial connection mitigates the impact of an import demand shock abroad on the future exchange rate return. In this case, the import demand shock originates from the central country in the network, i.e., country 1. The estimate of γ is positive, which means that higher indirect financial connection amplifies the impact of an import demand shock at home on the future exchange rate return, conditional on the country being large enough. When the country is small, we record no effect since δ is particularly small. Finally, the estimate of $\tilde{\beta}$ is negative and implies that country j higher direct financial connection dampens the future exchange rate returns required to finance a negative trade balance. Overall, these estimates confirm the intuition from the three period model.

2.4 Empirical Predictions

Guided by our model, we provide a list of empirical predictions. We frame our predictions in terms of *direct* and *indirect* connections and how they affect future exchange rate returns. Recall that according to our theoretical framework, a currency depreciation today is associated with its appreciation tomorrow, which corresponds to a positive future exchange rate return.

Prediction 0. *An increase in a country's direct financial connections mitigates the impact of a shock to its external balance on its future exchange rate return.*

This prediction follows from Lemma 1 and is a standard implication of inelastic exchange rates. A negative shock to a country's external balance today should generate a positive exchange rate return in the future (a depreciation today followed by an appreciation tomorrow), and vice versa. However, stronger direct connection to this country should moderate the magnitude of its future exchange rate return. In other words, *direct connection should negatively predict future exchange rate returns conditional on a trade deficit*.

Prediction 1. *An increase in a country's indirect financial connections mitigates the impact of an import demand shock abroad on its future exchange rate return.*

This prediction arises from the first result of Proposition 1. A country should experience a negative exchange rate return in the future (an appreciation today followed by a depreciation tomorrow) when its current trade balance improves thanks to a positive import demand shock affecting a large trading partner, and vice versa. However, as this country's indirect financial connection strengthens, the magnitude of its future exchange rate return gets smaller. Stated differently, *stronger indirect connections should negatively predict future exchange rate returns conditional on a large import demand shock abroad*.

Prediction 2. *An increase in a country's indirect financial connections amplifies the impact of an import demand shock at home on its future exchange rate return. This effect goes to zero as the home country becomes small.*

This prediction arises from the second and third results of Proposition 1. A country should experience a positive exchange rate return in the future (a depreciation today followed by an appreciation tomorrow) when its current trade balance deteriorates in response to a positive import demand shock at home, and vice versa. However, as this country's indirect financial connection strengthens, the magnitude of its future exchange rate return gets larger. This effect goes to zero as the local economy becomes small. Put differently, *indirect connections should positively predict future exchange rate returns conditional on a large import demand shock at home*.

Prediction 3. *The relevant network of financial intermediation is the one denominated in the currencies of the counterparty countries and not the one denominated in a vehicle currency such as the dollar.*

This prediction is a more subtle outcome of the model. The link between financial connection and the exchange rate arises from financiers adopting long/short strategies in the currencies of the countries they are intermediating between. Exchange rates adjust to allow financiers to make sufficient arbitrage profits to intermediate the necessary capital flow. If financial flows were in a vehicle currency, i.e., if financiers were raising dollars in one country to lend dollars in another, the mechanism would then break down as the exchange rate plays no part in determining financiers profitability.

2.5 From the Model to the Data

Our empirical predictions are about the response of future exchange rate returns to current financial connections, conditional on trade shocks. To test our predictions, we need to measure both financial connections and trade shocks. We use bilateral cross-border banking claims and liabilities for the former, and the residuals of a factor model of trade balances for the latter.

While we describe these proxies in the next section, further discussion is warranted on the use of international *gross banking positions* to construct an empirical proxy for Λ_{ji}, which exogenously determines the elasticity of exchange rates to bilateral capital flows.

In reality, these elasticities are likely to be a function of unobservable variables that affect the capacity of the financial system to intermediate capital flows, either due to regulatory constraints or variation in risk-taking capacity. The underlying assumption is that such elasticities are correlated with the size of bilateral gross banking positions. Hence, we use the latter as a proxy for the former.

This concept can be effectively illustrated through a straightforward extension of our model, which we formally explain in Internet Appendix A.5. Here, we present the underlying intuition: Drawing from Bippus et al. (2023) and Bacchetta and Wincoop (2006), we can introduce heterogeneous intermediaries with different demand curves for the long-short currency trade. This heterogeneity may arise from differences in beliefs or the need to hedge non-asset income. Consequently, for a given currency, some intermediaries may prefer to maintain a net long position, while others opt for a net short position. However, the magnitude of each intermediary's net position remains constrained by Λ_{ji}. As a result, the aggregate gross bilateral position between any two currencies (that is, the sum of the absolute values of all intermediary positions) will be proportional to two factors: the constraint limiting the size of intermediaries' net positions, and the dispersion of beliefs or hedging needs among intermediaries. Importantly, while this dispersion of beliefs or hedging needs does not directly influence the exchange rate, it does affect the gross positions. Therefore, gross positions serve as a valid proxy for Λ_{ji}

Put differently, if the exchange rate is relatively elastic, dispersion among investors will lead to large gross positions. For an inelastic bilateral connection the opposite will be true. In Section 4.1, we will provide further evidence that supports the claim that gross flows proxy Γ_{ji}^{-1} using a granular instrumental variables (GIV) approach of Gabaix and Koijen (2024)

3 Data Description and Network Centrality

In this section, we start with a description of our database on bilateral cross-border banking claims and liabilities. Next, we provide a review of other datasets used in our em-

pirical research, including exchange rates and bilateral trade data. Finally, we measure banking network centrality at the country-level to proxy for the elasticity of exchange rates before turning to preliminary summary statistics.

3.1 Data Description

Cross-Border Banking Data. We source data on cross-border banking activity from the restricted *Locational Banking Statistics by residence* (LBSR) database, compiled by the Bank for International Settlement (BIS) and released on a restricted basis to the central banks of reporting countries. This dataset provides quarterly data by country-pair on cross-border financial claims and liabilities of internationally active banks and institutions located in 45 reporting countries against the counterparties in more than 200 countries.[5]

TABLE 2 ABOUT HERE

The LBSR database is useful to examine the interconnections at the country level since it records aggregate international financial assets and liabilities of banks and institutions on the basis of their residence rather than their nationality. Specifically, banks and institutions report their positions on an unconsolidated basis for each individual entity within their group, including intra-group positions with foreign subsidiaries and foreign branches. The LBSR database will then aggregate these position at the country level using principles that are consistent with balance of payments and international investment position statistics. For example, a loan that originates from an HSBC branch in Germany will be identified as a German claim (as per the location of the bank), rather than a British claim (as per the nationality of the bank). Ultimately, the database embodies the outstanding amount of cross-border financial claims and liabilities between all reporting banks and institutions in the source country and the counterparty sectors in the destination country. The *restricted* version of LBSR database also provides a breakdown by currency (i.e., local currency of the reporting country, British pound, euro, Japanese yen, Swiss

[5]Both claims and liabilities are reported at the country level, adjusted for exchange rate fluctuations across quarters, and revised for breaks-in-series due, for example, to changes in reporting practices and methodologies (BIS, 2019).

franc, US dollar, and other foreign currencies), instrument (i.e., debt securities, loans and deposits, and other instruments), and counterparty sector (i.e., banks, non-bank financial institutions, non-financial corporations, general government, and households).

TABLE 3 ABOUT HERE

We merge the LBSR database with other datasets described below, which in our main specification limits our sample to 70 countries between December 1983 to December 2019 that are counterparties to each of the set of reporting countries in the dataset and also have observations on the other datasets. As we will discuss later in Section 3.2, when computing banking network centrality, we do so from the perspective of a country as a counterparty in the dataset. As a result, the sample of countries that have a measure of centrality corresponds to the set of counterparty countries at each point in time. Table 3 lists the counterparty countries in the dataset, whereas Table 2 lists the reporting countries, which by construction will be the only countries that determine the centrality of other countries in the network. Following the introduction of the euro in January 1999, we aggregate claims and liabilities for all available members of the Euro Area, and only consider bilateral positions with non-Eurozone countries. Armed with quarterly observations on cross-border assets and liabilities, we first construct a measure of network centrality described later in this section, and then retrieve monthly observations by forward filling, i.e., by keeping end-of-period data constant until a new observation becomes available.

EXCHANGE RATE DATA. We source daily spot and one-month forward exchange rates from Barclays Bank and WM Refinitiv via Datastream for a large cross-section of 70 countries. All exchange rates are defined as units of US dollars per unit of foreign currency so that an increase in the exchange rate indicates an appreciation of the foreign currency (or, equivalently, a US dollar depreciation). The analysis uses monthly data obtained by sampling exchange rates on the last business day of each month between December 1983 and January 2020.

EQUITY HOLDINGS DATA. We collect data on mutual fund and ETF's holdings of international equities from S&P Global Capital IQ, with quarterly frequency from 2005 through 2022. Fund's holdings are aggregated at the country level to calculate its portfolio share on each country, and we classify the country origin of the equity flows as per the domicile of the fund. In total, there are around 68 thousand funds in our sample with cross-border equity exposure, resulting in around 37 million observations of quarter×fund×foreign-country equity portfolio exposures, for a total of 17 developed economies. This data will be used to construct granular instrumental variables in Section 4.1 to show causal evidence of the association between cross-border banking positions and the elasticity of exchange rates.

OTHER DATA. Our empirical analysis uses supplementary data, in addition to exchange rates and cross-border financial data. First, we collect quarterly observations on bilateral merchandise exports and imports from the IMF's Direction of Trade Statistics, and annual observations on country-level gross domestic product from the World Bank database between 1983 and 2019. Second, we obtain annual observations on the financial openness index of Chinn and Ito (2006), a *de jure* measure of capital account openness, from Ito's website between 1983 and 2019.

3.2 MEASURING OUR KEY VARIABLES

FX RETURNS AND FORWARD PREMIA. The exchange rate return from purchasing a unit of foreign currency at time t while reversing the position at time $t+1$ in the spot market is then calculated as

$$y_{i,t} = \ln(e_{j,t+1}/e_{j,t}),$$

where $e_{j,t}$ is the spot exchange rate of currency j relative to the dollar at time t and ln denotes the natural log transformation. While the model assumes for tractability that interest rates are zero, our empirical analysis also controls for the possibility that interest rates could endogenously clear the market in response to trade imbalances. To this end, we quantify the interest rate differential between the dollar and the foreign currency j

using the forward premium, $fp_{j,t}$. This is defined as the natural logarithm of the ratio between the forward exchange rate of currency j at time t with delivery date $t+1$ and $e_{j,t}$.

DIRECT FINANCIAL CONNECTIONS. A network can be viewed as a collection of nodes and edges. In our context, countries represent the nodes and their connections denote the edges. As explained in Section 2.5 we construct an empirical proxy for the matrix of financial connections (i.e., Λ in the model) using gross cross-border banking claims and liabilities. We denote this matrix as A_t, where each element in the matrix, $A_{ji,t}$, is the sum of claims and liabilities held by country j against banks in country i at time t.

In our model, direct connections are captured by $\Gamma_j^{-1} 1_N$, which for each country is simply the sum of its direct connections with other countries. Thus, our empirical measure of direct connections is given by:

$$\texttt{Dir}_{j,t} = \frac{1}{x_{j,t}} \sum_{i=1}^{N} A_{ji,t},$$

which is the sum of each element in the j-th row of the adjacency matrix A_t, where 1_N is a vector of ones. As our model is static, we avoid contaminating our empirical analysis with any trend in the data by scaling our measure of direct connections by a deterministic trend $x_{j,t}$ within each country. Hence, direct connections are simply the detrended sum of gross claims and liabilities held by a country against banks in other countries.

INDIRECT FINANCIAL CONNECTIONS. Although our model does not deliver a closed-form representation of indirect connections with an economy with more than three countries, we can characterize them by computing higher-order powers of the adjacency matrix A_t. For example, each cell of the square of the adjacency matrix results in the indirect connections of a given country with other countries in the network through third countries. Specifically, $(A_t^2)_{j,i} = A_{j,k} \sum_{k=1}^{N} A_{k,i}$, which is the indirect connection of country j with country i through all other countries k in the network.

Similarly, we can take the cubic power of the adjacency matrix to obtain the indirect connections of a country with all other countries in the network through the indirect connection of a third country, and so on and so forth. Thus, the ℓ-th power of the adjacency matrix captures the ℓ-th order indirect connections of a country j with all other countries in the network.

Thus, in our empirical analysis our measure of indirect connections will be:

$$\texttt{Ind}_t = \lambda_t^{-2} A_t^2 \, 1_N + \lambda_t^{-3} A_t^3 \, 1_N + \lambda_t^{-4} A_t^4 \, 1_N + \ldots = \sum_{\ell=2}^{\infty} \lambda_t^{-\ell} A_t^{\ell} \, 1_N, \tag{4}$$

where λ_t is a discounting factor that ensures convergence of the sum, and it can be a function of a common trend since indirect connections depend on the entire network of cross-border positions. Following Bonacich (1987) and Bonacich (2007), any λ_t below the largest eigenvalue of the matrix A_t converges to the *Katz Centrality* of the network, whereas setting λ_t equal to the largest eigenvalue leads to the *Eigenvector Centrality*. To avoid conducting an empirical analysis with an arbitraty choice of λ_t, we use the eigenvector centrality that gives the largest possible weight to higher-order indirect connections. Further details on the computation of eigenvector centrality are provided in Section C.1.

Currency Denomination of Networks. In our model, financiers go long the currency of the debtor country and short the currency of the creditor country, and exchange rates have to fluctuate to compensate them for intermediating the necessary capital flows. If capital flows were instead intermediated in a vehicle currency, for example the dollar or the euro, the exchange rate adjustment would play no role in determining the profitability of financiers. According to this process, the network of financial intermediation that matters for exchange rate determination is the one denominated in the currencies of the countries involved. In contrast, a network of financial intermediation handled in a vehicle currency would have no relationship with exchange rates. Since we observe the currency breakdown of cross-border claims and liabilities, we construct a measure of network centrality that is closely aligned with the mechanism unveiled in our model. Specifically,

we compute our centrality measures using only claims and liabilities of country j against banks in country i expressed in the currency of country i (reporting country), thus excluding cross-border positions denominated in other currencies. To test Prediction 3, we also build measures of network centrality based on positions denominated in a vehicle currency like the dollar, and report results in our robustness section.

TRADE SHOCKS. Our model postulates that exchange rates respond to an increase in *indirect* network centrality conditional on import demand shocks. These quantities are not directly observable and we estimate them as follows. First, we construct net exports for each country j using the bilateral value of merchandise exports and imports as percentage of GDP. Second, we apply principal component analysis to our sample of net exports and select all principal components that explain at least one percent of total variability (we pick eleven principal components). Finally, for each country j, we project its net exports on the principal components and save the residual term. For the US, the residual term is named as $\texttt{Shock}^{+}_{us,t}$ (positive shock to net exports), so that an increase indicates an improvement of the US trade balance (or a deterioration of the foreign trade balance). For any other country, the residual term is conveniently multiplied by minus one and named as $\texttt{Shock}^{-}_{j,t}$ (negative shock to net exports), so that an increase means a deterioration of country j trade balance. We will interpret $\texttt{Shock}^{+}_{us,t}$ as a negative import demand shock to a large country abroad and $\texttt{Shock}^{-}_{j,t}$ as a positive import demand shock at home.

TRADE CENTRALITY. A recent study shows that trade network centrality is an important determinant of interest rate differentials and currency risk premia (Richmond, 2019). Following that contribution, we also calculate trade network centrality using bilateral trade intensity coupled with the global share of exports each country j in our sample and use it as a control variable in our empirical analysis.

ACCOUNTING FOR COUNTRY HETEROGENEITY. There exists a certain degree of heterogeneity across countries that may arise, for example, from differences in size, develop-

ment, openness, and regulations. These persistent differences can affect network centrality and make a cross-country comparison challenging. Akin to Richmond (2019), we thus standardize the centrality of each country, including *direct* and *indirect* connections, relative to its sample mean and standard deviation, and work with these measures thorough the rest of this paper. In doing so, we address the question of *which country is becoming more central in the network*, rather than dealing with the question of *who is the most central country in the network*. We also standardize every other variable except interest rate differentials and exchange rate returns, hence the same interpretation follows for these economic quantities.

3.3 Preliminary Analysis

Before turning to our empirical analysis, it is worth to visualize the sample properties of our key variables, i.e., *direct* and *indirect* connections based on cross-border positions denominated in the local currency of the reporting country. In Panel A of Figure 3, we plot the cross-country average of *direct* connections $\texttt{Dir}_{j,t}$. We also include the interquartile range, with shaded areas denoting US recessions based on NBER dates.[6] In Panel B of Figure 3, we move to the *indirect* connection $\texttt{Ind}_{j,t}$ and plot their cross-country averages. They are likely to capture different sources of information since the average of *direct* connection is higher in times of economic expansion and lower during periods of economic contraction, whereas the average *indirect* connection tends to be more volatile during the same periods.

FIGURE 3 ABOUT HERE

Finally, one may wonder whether our measures of centrality are somehow correlated with trade centrality. We address this concern in Figure 3. Here, for each time period,

[6]The *direct* connection of country j is the sum all of cross-border claims and liabilities against banks in other countries. Not surprisingly, this quantity displays an upward trend that may be associated to a period of greater globalization. To better visualize the average dynamics of *direct* connection, we detrend the *direct* connection of each country j using a linear trend. Similarly, we detrend the trade centrality of each country j using a linear trend to better visualize its dynamics. We plot the cross-country average of trade centrality in the Internet Appendix Figure A.1.

we plot the cross-sectional correlation between trade centrality and *direct* connection in Panel A, and between trade centrality and *indirect* connection in Panel B. Both *direct* and *indirect* connections are based on cross-border positions denominated in the local currency of the reporting country. Panel A shows that correlation between *direct* connection and trade centrality varies substantially over time, and it is generally positive with average value close to 16%. Interestingly, the relationship between *direct* connection and trade centrality is not always positive since it is negative in a few occasions like the late 1990s and the late 2010s. Panel B, moreover, displays the correlation between *indirect* connection and trade centrality, and reveals no clear pattern. The average correlation is about -2%, indicating that the latter is fairly distinct from the former. For example, correlation is primarily negative in the 1980s, reverses sign a few times in the 1990s, slightly positive in the 2000s, and then often negative in the last decade of our sample. In absolute terms, moreover, correlation has been substantially decreasing over time, a phenomenon that may be attributed to financial liberalization. For example, correlation reached its lowest value of about -80% in the late 1980s, peaked in the 1990s at about 80% but dropped to roughly -40% in the last decade of our sample. Last but not least, according to NBER data, correlation does not have a clear pattern around US recessions.

FIGURE 4 ABOUT HERE

In addition to cross-sectional correlations, we also compute time-series correlations country by country. The average of these correlations between trade centrality and *direct* connection is close to 41%, whereas between trade centrality and *indirect* connection is about -11%. Taken together, these figures suggests that financial intermediation centrality and trade centrality are likely to capture different determinants of currency returns.

We now move to the next section, where we use panel regressions run at a monthly frequency as a device to test the predictions of our model. For those variables available at a quarterly or annual frequency, we retrieve monthly observations by forward filling, i.e., by keeping end-of-period data constant until a new observation becomes available. Finally, we winsorize exchange rate returns at the 1% level on both tails to remove outliers.

4 EMPIRICAL RESULTS

This section provides empirical evidence in support of our theoretical predictions. First, we evaluate the efficacy of gross banking positions as a reliable proxy for intermediation capacity, a key ingredient for the subsequent analyses. Second, we investigate the role of *direct* and *indirect* connections for future exchange rate returns, conditional on trade shocks. Third, we compare financial connections derived from cross-border intermediation conducted in non-vehicle currencies against those conducted in dollar terms. Finally, we show that our results are not driven by pegged currencies in our sample.

4.1 A PROXY FOR THE ELASTICITY OF EXCHANGE RATES

Our empirical analysis makes use of gross banking positions as a proxy for the elasticity of exchange rates. In addition to theoretical arguments presented in Section 2.5, we now provide empirical evidence on the relationship between gross banking intermediation and the ability of financiers in absorbing portfolio investment flows denominated in local currency. In particular, In particular, in Lemma 2...

This argument provides us with a simple testable hypothesis, i.e., if the elasticity of exchange rates is positively associated with higher levels of gross banking intermediation, the exchange rate multiplier of exogenous portfolio flows declines with higher levels of gross banking intermediation. To test this hypothesis, we run panel regressions subsumed by the following specification

$$y_{j,t} = \alpha \texttt{Dir}_{j,t} + \beta \texttt{Equity}_{j,t} + \delta(\texttt{Equity}_j \times \texttt{Dummy}_{j,\alpha})_t + \texttt{Controls}_{j,t} + fe + \varepsilon_{j,t} \tag{5}$$

where $y_{j,t}$ is the *contemporaneous* exchange rate return of country j in percentage per annum, $\texttt{Dir}_j$ is *direct* connection (or gross banking intermediation) of country j relative to banks located in the reporting countries, $\texttt{Equity}_{j,t}$ is net portfolio equity flow constructed using micro-level equity holdings from international mutual funds and exchange-traded funds, $\texttt{Dummy}_{j,\alpha}$ is a dummy variable that equals one for high level of gross financial intermediation, and $\texttt{Controls}_j$ includes twenty principal components extracted from the country-specific matrix of portfolio shares. The dummy variable kicks in when $\texttt{Dir}_{i,t}$ is

above zero (or its mean), above its half standard deviation, and above its standard deviation. We also include $\texttt{Dummy}_{j,\alpha}$ as a regressor (not displayed to save space), country and time fixed effects.

Since net portfolio equity flows are endogenous to exchange rates, we instrument them with GIV akin to Gabaix and Koijen (2024). To the extent that GIV identifies value-weighted average of idiosyncratic portfolio equity shocks that are exogenous to $\varepsilon_{j,t}$, a negative and statistically significant estimate of δ would be consistent with higher levels of gross intermediation being *causally* associated with a more elastic response of exchange rates to net portfolio equity flows. It is important to emphasize that the direction of this causality is not identified in Equation (5), neither it is crucial for our empirical analysis. For our analysis, it is important that gross banking intermediation and the elasticity of exchange rates are jointly determined. Whether the former causes the latter or vice versa, it is not relevant to our theoretical predictions. We simply exploit their correlation to justify the use of gross banking intermediation as a proxy for the elasticity of exchange rates.

Our implementation of granular instrumental variables to instrument net portfolio equity flows follows closely from Camanho et al. (2022). First, let D_j be the set of domestic funds domiciled in country j, and F_j be the set of foreign funds not domiciled in country j. Second, define as $\Delta w_{ji,t}$ the change in the portfolio weight of fund j on equities in country i at quarter t. Finally, $a^F_{ji,t}$ denotes the dollar market value of equity positions held by the foreign fund j in country i relative to all foreign funds, whereas $a^D_{ji,t}$ indicates the dollar market value of equity positions held by the domestic fund j in country i relative to all domestic funds. We define net portfolio equity flow for country j at time t as

$$\texttt{Equity}_{j,t} = \mu_{j,t}\texttt{Equity}^{out}_{j,t} - (1-\mu_{j,t})\texttt{Equity}^{in}_{j,t},$$

where $\mu_{j,t}$ is the dollar market value of equity positions held by foreign funds in country j relative to both domestic and foreign funds in the same country, $\texttt{Equity}^{out}_{j,t}$ is the equity outflows due to portfolio rebalancing by domestic funds, and $\texttt{Equity}^{in}_{j,t}$ is the equity inflows due to portfolio rebalancing by foreign funds. In other words, the net equity portfolio flow is equivalent to the relative size of outbound and inbound equity investments.

The GIV instrument is then computed as follows

$$z_{j,t} = \mu_{j,t} z^{out}_{j,t} - (1 - \mu_{j,t}) z^{in}_{j,t}, \tag{6}$$

where $z^{out}_{j,t}$ and $z^{out}_{j,t}$ are the difference between the fund-weighted and equal-weighted average of equity outflows and inflows in country j, respectively. It then follows that $z_{j,t}$ captures the idiosyncratic flows of large funds relative to the general rebalancing flows of the average fund relative to country j. Although Equation (6) removes the time-varying country-specific common component of portfolio shares, there could be other time-varying country-specific factors that are correlated with large funds idiosyncratic shocks and thus be endogenous to exchange rates. Akin to Gabaix and Koijen (2024), we then extract principal components from the portfolio shares of all funds invested in a given country and use them as additional controls in Equation (5).[7]

TABLE 4 ABOUT HERE

In Table 4, we report the two-stage least-squares estimates of Equation (5), using $z_{j,t}$ from Equation (6) as an instrument for $\texttt{Equity}_{j,t}$. The first row reports the unconditional multiplier β, which is positive in all specifications. On average, a one standard deviation increase in the net portfolio equity flows is associated with an average contemporaneous appreciation of the local currency ranging between 1.5% and and 2.2% per annum. This is consistent with the idea of imperfect financial markets where portfolio flows must be absorbed by a financial system with limited intermediation capacity, thus making exchange rates inelastic to net capital flows. In other words, an exogenous demand shift (i.e., portfolio shocks) meets an inelastic supply, leading to a contemporaneous appreciation of the local currency. The second row reports estimates of δ, the interaction between net equity portfolio flows and standardized gross banking intermediation (which is equivalent by construction to *direct* connection). Although the coefficient is not significant, the direction is consistent with the above hypothesis. The remaining rows report the interaction of the

[7] We extract twenty principal components, which on average represents all principal components that explain at least one percent of the variation.

net equity portfolio flows with gross intermediation, when gross intermediation is above zero, half standard deviation above zero, one standard deviations above zero. The coefficient of these interaction terms are all negative, which is consistent with the hypothesis that higher levels of gross banking intermediation are associated with higher levels of intermediation capacity, with a corresponding reduction of the exchange rate multiplier of portfolio flows.

4.2 Direct Connection and Future Exchange Rate Returns

While our primary focus is on indirect connections, one may wonder whether future exchange rate returns are also sensitive to *direct* financial connections as indicated by our Prediction 0. We thus run panel regressions summarized by the following specification

$$\begin{aligned} y_{j,t+1} &= \alpha \texttt{Dir}_{j,t} + \beta(\texttt{Dir}_{j,t} \times \texttt{Deficit}_j)_t + \gamma \texttt{TradeCent}_{j,t} \\ &+ \delta(\texttt{TradeCent}_j \times \texttt{Deficit}_j)_t + \texttt{Controls}_{j,t} + fe + \varepsilon_{j,t+1}, \end{aligned} \tag{7}$$

where $y_{j,t+1}$ is the future exchange rate return of country j in percentage per annum, $\texttt{Dir}_j$ is *direct* connection of country j relative to banks located in the reporting countries, $\texttt{Deficit}_j$ is the trade deficit (net exports multiplied by minus one) of country j, $\texttt{TradeCent}_j$ is the trade centrality of Richmond (2019), and $\texttt{Controls}_j$ includes country-specific variables as the capital account openness of Chinn and Ito (2006), forward premium, and the share of world GDP. It is worth mentioning that we use trade deficit of an import demand shock as Prediction 0 applies to any shock that worsens the trade deficit, both within and outside of the country. Finally, all specifications include the regressor $\texttt{Deficit}_{j,t}$ (not displayed to save space) and time fixed-effects fe that absorb unobserved time-variant factors that are common to all countries.

TABLE 5 ABOUT HERE

We report the parameter estimates of Equation (7) in Table 5, with standard errors clustered at the country level in parentheses. Specification (2) focuses on the interaction between direct connection and trade deficit, which is equivalent to assessing the effect of

gross financial intermediation on exchange rates conditional on trade shocks. We uncover a negative and highly statistically significant estimate on β (-1.080 with a standard error of 0.295). Specification (4) adds the interaction between trade centrality and trade deficit as well as the control variables but yields qualitatively similar results. The estimate on β is about -0.865 with a standard error of 0.335. Taken together, these specifications suggests that, in economic terms, a one standard deviation increase in *direct* connection and trade deficit decreases the future exchange rate return approximately by one percent per annum, with and without control variables. This corroborates prediction 0.

4.3 Indirect Connections and Future Exchange Rate Returns

We now move to testing the theoretical predictions 1 and 2 described in Section 2.4 by running panel regressions based on the following specification

$$\begin{aligned} y_{j,t+1} = {} & \alpha \texttt{Ind}_{j,t} + \beta(\texttt{Ind}_j \times \texttt{Shock}^{+}_{us})_t + \gamma(\texttt{Ind}_j \times \texttt{Shock}^{-}_{j})_t + \delta(\texttt{Ind}_j \times \texttt{Shock}^{-}_{j} \times \texttt{Large}_j)_t \\ & + \tilde{\alpha}\texttt{Dir}_{j,t} + \tilde{\beta}(\texttt{Dir}_j \times \texttt{Shock}^{+}_{us})_t + \tilde{\gamma}(\texttt{Dir}_j \times \texttt{Shock}^{-}_{j})_t + \tilde{\delta}(\texttt{Dir}_j \times \texttt{Deficit}_j)_t \\ & + \texttt{Controls}_{j,t} + fe + \varepsilon_{j,t+1}, \end{aligned} \tag{8}$$

where $y_{j,t+1}$ is the future exchange rate return of country j expressed in percentage per annum, $\texttt{Dir}_j$ and $\texttt{Ind}_j$ are the *direct* and *indirect* connections, respectively, of country j relative to banks located in the reporting countries, $\texttt{Shock}^{+}_{us}$ is a positive shock to the US trade surplus, $\texttt{Shock}^{-}_{j}$ is a positive shock to the trade deficit in country j, $\texttt{Deficit}_j$ is the trade deficit of country j, $\texttt{Large}_j$ is a binary variable that selects the top 5% economies in terms of share of global trade (amounting to the largest 8 economies), and $\texttt{Controls}_j$ is as defined for Equation (7). We also include other regressors (e.g., $\texttt{Shock}^{+}_{us}$, $\texttt{Shock}^{-}_{j}$, $\texttt{Large}_j$, and $\texttt{Deficit}_j$) and interactions (e.g., $\texttt{Ind}_j \times \texttt{Large}_j$ and $\texttt{Shock}^{-}_{j} \times \texttt{Large}_j$), which are not displayed to save space. Finally, specifications are saturated with country and time fixed-effects fe.

The first interaction $\texttt{Ind}_j \times \texttt{Shock}^{+}_{us}$ is motivated by Prediction 1, where $\texttt{Shock}^{+}_{us}$ should be interpreted as an import demand shock affecting a large trading partner of the local

country j. According to this prediction, as $\texttt{Ind}_j$ increases, we should expect a lower future exchange rate return for country j in response to an improvement of its current trade balance caused by a positive yet large import demand shock abroad. As a result, Prediction 1 corresponds to a negative estimate of β.

Prediction 2 motivates the second $\texttt{Ind}_j \times \texttt{Shock}_j^-$ and third $\texttt{Ind}_j \times \texttt{Shock}_j^- \times \texttt{Large}_j$ interaction. According to this prediction, as $\texttt{Ind}_{j,t}$ increases, we should anticipate a higher future appreciation of currency j in response to a deterioration in its current trade balance caused by a positive domestic import demand shock. This relationship should disappear as the domestic economy becomes small. To discriminate between large and small economies, we introduce the dummy variable $\texttt{Large}_j$ that selects countries that are sufficiently large in terms of their share of global trade. For our primary exercise, we select the top 5% economies, which corresponds to the largest eight economies. We then explore robustness to this threshold below. Altogether, Prediction 2 corresponds to an estimate of γ that is indistinguishable from zero and a positive estimate of δ.

TABLE 6 ABOUT HERE

Table 6 reports the parameter estimates associated with the previous specification, with standard errors clustered at the country level in parentheses. We uncover a negative and highly statistically significant estimate on β, a positive and highly statistically significant estimate on δ but an insignificant estimate of γ, all as consistent with predictions 1 and 2. These findings suggests that a large foreign demand import shocks (in our case a large increase in the US trade balance unexplained by common trade factors) is associated with lower exchange rate returns for those countries whose counterparties become more central in the global financial network. In economic terms, one standard deviation increase in US net exports and one standard deviation increase in *indirect* centrality is associated with an average of 0.7 percent lower exchange rate returns per annum. These findings are robust to different combinations of fixed effects, to controlling for the strength of direct financial connections including the interactions with the equivalent shocks.

FIGURE 5 ABOUT HERE

For robustness, Figure 5, reports estimates of the fully saturated regression model described in Equation (8) that for different thresholds of country size, and report the estimates of δ. The figure displays the estimated coefficient for each threshold of country share of global trade, along with the 90% confidence interval. The estimated coefficients become larger with the size threshold, suggesting that the amplifying affect of stronger indirect connections of a country-specific trade shock, is monotonically increasing with the size of the country experiencing the shock.

4.4 CURRENCY DENOMINATION OF NETWORKS

Our measures of financial connections are based on cross-border positions denominated in the local currency of the reporting country. However, given the specialness of the US dollar as vehicle currency, it is natural to ask whether cross-border claims and liabilities denominated in US dollars are equally important. Put differently, does it matter whether financiers intermediate trade imbalances in US dollars or in the currencies of the counterparty countries? Prediction 3 claims that the relevant network of financial intermediation is the one denominated in the currencies of the counterparty countries.

To validate our theoretical prediction, we perform a *horse-race* based on the following panel specification:

$$\begin{aligned} y_{j,t+1} \;=\; & \beta(\texttt{Ind}_j \times \texttt{Shock}^{+}_{us})_t + \gamma(\texttt{Ind}_j \times \texttt{Shock}^{-}_{j})_t + \delta(\texttt{Ind}_j \times \texttt{Shock}^{-}_{j} \times \texttt{Large}_i)_t \\ & + \tilde{\beta}(\texttt{Ind}^{\$}_j \times \texttt{Shock}^{+}_{us})_t + \tilde{\gamma}(\texttt{Ind}^{\$}_j \times \texttt{Shock}^{-}_{j})_t + \tilde{\delta}(\texttt{Ind}^{\$}_j \times \texttt{Shock}^{-}_{j} \times \texttt{Large}_j)_t \\ & + \theta(\texttt{Dir}_j \times \texttt{Deficit}_j)_t + \tilde{\theta}(\texttt{Dir}^{\$}_j \times \texttt{Deficit}_j) \\ & + \texttt{Controls}_{j,t} + fe + \varepsilon_{j,t+1}, \end{aligned}$$

where the dollar superscript denotes measures of financial connections based on cross-border claims and liabilities denominated in US dollars. Like the previous specification, we also include the regressors $\texttt{Ind}_j$, $\texttt{Dir}_j$, $\texttt{Ind}^{\$}_j$, $\texttt{Dir}^{\$}_j$, $\texttt{Shock}^{-}_{j}$, $\texttt{Shock}^{+}_{us}$, $\texttt{Large}_j$, and

$\texttt{Deficit}_j$, as well as the interactions $\texttt{Ind}_j \times \texttt{Large}_j$, $\texttt{Shock}_j^- \times \texttt{Large}_j$, and $\texttt{Ind}_j^\$ \times \texttt{Large}_j$ (not displayed to save space).

TABLE 7 ABOUT HERE

Table 7 reports selected parameter estimates. Our results indicate, in line with our model's predictions, that financial connections based on dollar-denominated cross-border positions play no major role for future exchange rate returns. Hence, to the extent that network centrality is an empirical proxy for intermediation capacity, the relevant network is not the one denominated in dollars but the one denominated in the currency of the counterparty country.

4.5 Other Measures of Financial Connections

In our core analysis, we use cross-border claims and liabilities as a proxy for the intermediation capacity of global intermediaries. To ensure the robustness of our findings, we replicate Table 6 using measures of financial connections based either on cross-border claims or cross-border liabilities.

TABLE 8 ABOUT HERE

Specifically, in Table 8, we only use cross-border claims to form the adjacency in Equation (**??**) but find qualitatively similar results, meaning that estimates of β are negative and statistically significant as indicated by Prediction 1, whereas estimates of θ are positive and statistically significant as suggested by Prediction 2.

TABLE 9 ABOUT HERE

In Table 9, moreover, we only use cross-border liabilities to assemble the adjacency in Equation (**??**). We confirm our main findings since estimates of β remain negative and statistically significant as suggested Prediction 1, whereas estimates of θ continue to positive and statistically significant as implied from Prediction 2.

4.6 The Role of Pegged Currencies

Our analysis is based on a broad sample of countries, some of which may be subject to restrictions on cross-border capital flows and/or have pegged exchange rate regimes at various points in time.

TABLE 10 ABOUT HERE

To guard against illiquid and hard-to-trade currencies, we first construct a dummy variable $\texttt{Peg}_{j,t}$ that assigns in each month a value of one if country j operates under a pegged exchange rate regime using the exchange rate classification index of Ilzetzki, Reinhart and Rogoff (2019), and zero otherwise.[8] Hence, we augment the panel regressions described by Equation (8) by interacting the key explanatory variables with the dummy variable $\texttt{Peg}_{j,t}$ as

$$
\begin{aligned}
y_{j,t+1} \;=\; & \alpha \texttt{Ind}_{j,t} + \beta(\texttt{Ind}_j \times \texttt{Shock}_{us}^{+})_t + \gamma(\texttt{Ind}_j \times \texttt{Shock}_j^{-})_t + \delta(\texttt{Ind}_j \times \texttt{Shock}_j^{-} \times \texttt{Large}_j)_t \\
& + \theta(\texttt{Ind}_j \times \texttt{Shock}_{us}^{+} \times \texttt{Peg}_j)_t + \kappa(\texttt{Ind}_{j,t} \times \texttt{Shock}_j^{-} \times \texttt{Peg}_j)_t + \lambda(\texttt{Ind}_j \times \texttt{Shock}_j^{-} \times \texttt{Large}_j \times \texttt{Peg}_j)_t \\
& + \tilde{\alpha}\texttt{Dir}_{j,t} + \tilde{\beta}(\texttt{Dir}_j \times \texttt{Shock}_{us}^{+})_t + \tilde{\gamma}(\texttt{Dir}_j \times \texttt{Shock}_j^{-})_t + \tilde{\delta}(\texttt{Dir}_j \times \texttt{Deficit}_j)_t \\
& + \texttt{Controls}_{j,t} + fe + \varepsilon_{j,t+1},
\end{aligned}
$$

We report our estimates in Table 10 but document no major changes in our estimates of β, γ, and δ. We thus conclude that illiquid and hard-to-trade currencies do not drive the main outcome of our empirical investigation.

5 Conclusions

Understanding the complex interplay underlying global financial intermediation is vital to devise effective policy responses aiming at financial stability in the wake of global

[8] Using the fine exchange rate classification, the dummy variable is equal to zero if a currency belongs to a pre-announced crawling band that is wider than or equal to ±2%, a *de facto* crawling band that is narrower than or equal to ±5%, a moving band that is narrower than or equal to ±2%, a managed float, a free float, or a free-falling regime. These scenarios have a code between 9 and 14.

shocks. This paper illustrates, both theoretically and empirically, the role of financial connections for future exchange rate returns. Using the restricted Locational Banking Statistics by residence database compiled by the BIS, we construct a network of international bank lending and show that a country-level measure of banking centrality is associated with lower future currency returns conditional on higher external financing needs (proxied by trade deficit). This mechanism, moreover, can be attributed to banking positions denominated in the local currency of the counterparty rather than banking positions denominated in a vehicle currency like the dollar or the euro.

Overall, we provide empirical support for the existence of a meaningful link between exchange rate returns and countries' financial connections, a fundamental and theoretically motivated driving force with an amplifying effect stemming from countries' external financing needs. We thus contribute to the recent literature on the role of financiers' intermediation capacity and global imbalances in determining future exchange rates.

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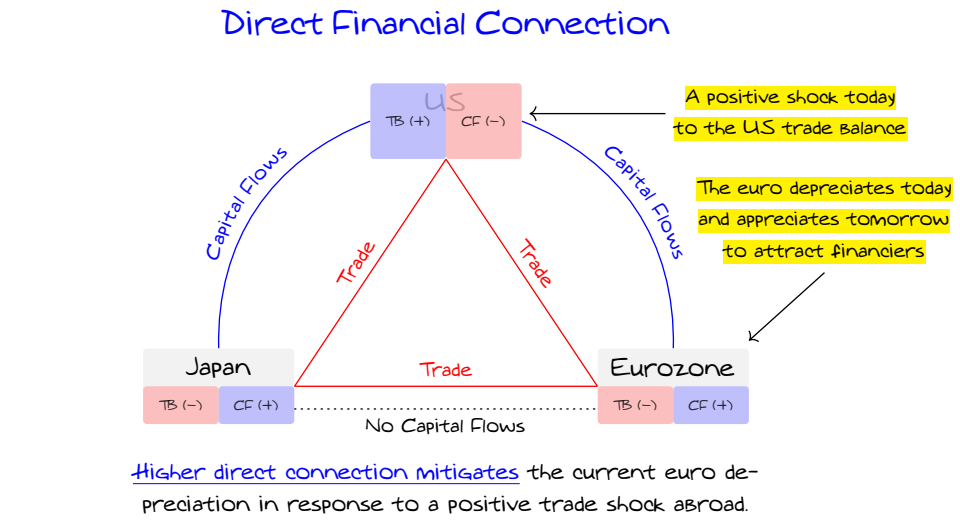
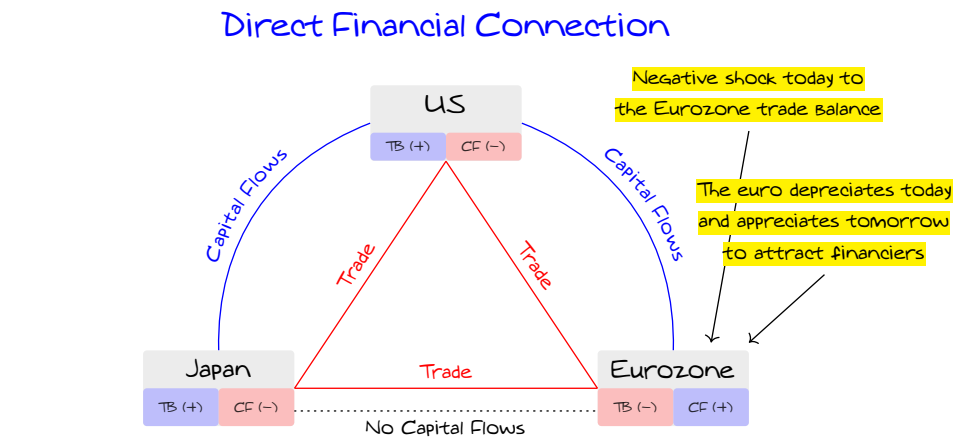


FIGURE 1. FINANCIAL CONNECTIONS: SCENARIO 1

This illustrates a simplified version of our model to fix ideas about the role of direct and indirect financial connections on the response of the euro to a positive shock to the US trade balance. In this scenario, all economies have balanced external accounts, trade goods with each other but the US is the sole country through which capital is channeled. Suppose the US experiences a positive shock to its trade balance, which implies that both euro and yen should both fall in value against the dollar. However, higher direct connection between the US and Eurozone will mitigate the euro depreciation (top panel). Now suppose that Japan has a stronger direct financial connection with the US, meaning that a given capital flow between them has a smaller impact on the dollar-yen exchange rate. From the Eurozone's perspective, its direct financial connection with the US is unchanged but there is an improvement in its indirect connection to Japan. Now in response to a positive shock to the US trade balance, more of this resulting surplus flows to Japan thus leading to a larger Japanese and a smaller Eurozone trade deficit. This smaller Eurozone deficit implies that higher indirect connection moderates the impact of the shock on the euro-dollar exchange rate (bottom panel).



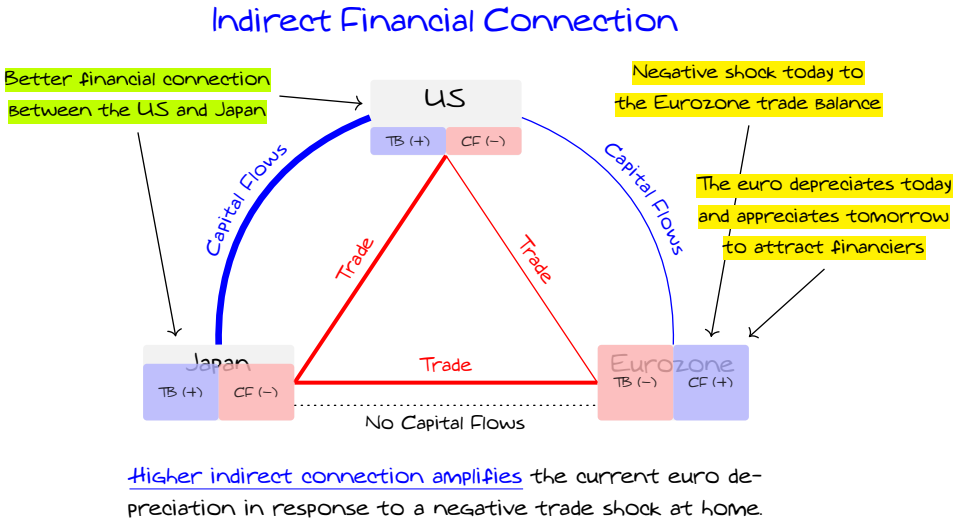


FIGURE 2. FINANCIAL CONNECTIONS: SCENARIO 2

This illustrates a simplified version of our model to fix ideas about the role of direct and indirect financial connections on the response of the euro to a negative shock to the Eurozone trade balance. In this scenario, all economies have balanced external accounts, trade goods with each other but the US is the sole country through which capital is channeled. Suppose the Eurozone experiences a negative shock to its trade balance, which weakens the euro relative to dollar, whereas the yen strengthens as the Japanese trade surplus with the Eurozone corresponds to a flow of capital to the US, which in turn is redirected to the Eurozone to finance its trade deficit. However, higher direct connection between the US and Eurozone will mitigate the euro depreciation (top panel). Now imagine, that Japan has stronger direct financial connection with the US (equivalent to an improvement in the Eurozone's indirect connection). More capital is now able to flow out of Japan increasing its external surplus, in turn more capital must to flow to the Eurozone via the US. The larger capital flow to the Eurozone brings about a sharper depreciation of the euro. Higher indirect connection amplifies the impact of the trade shock (bottom panel).

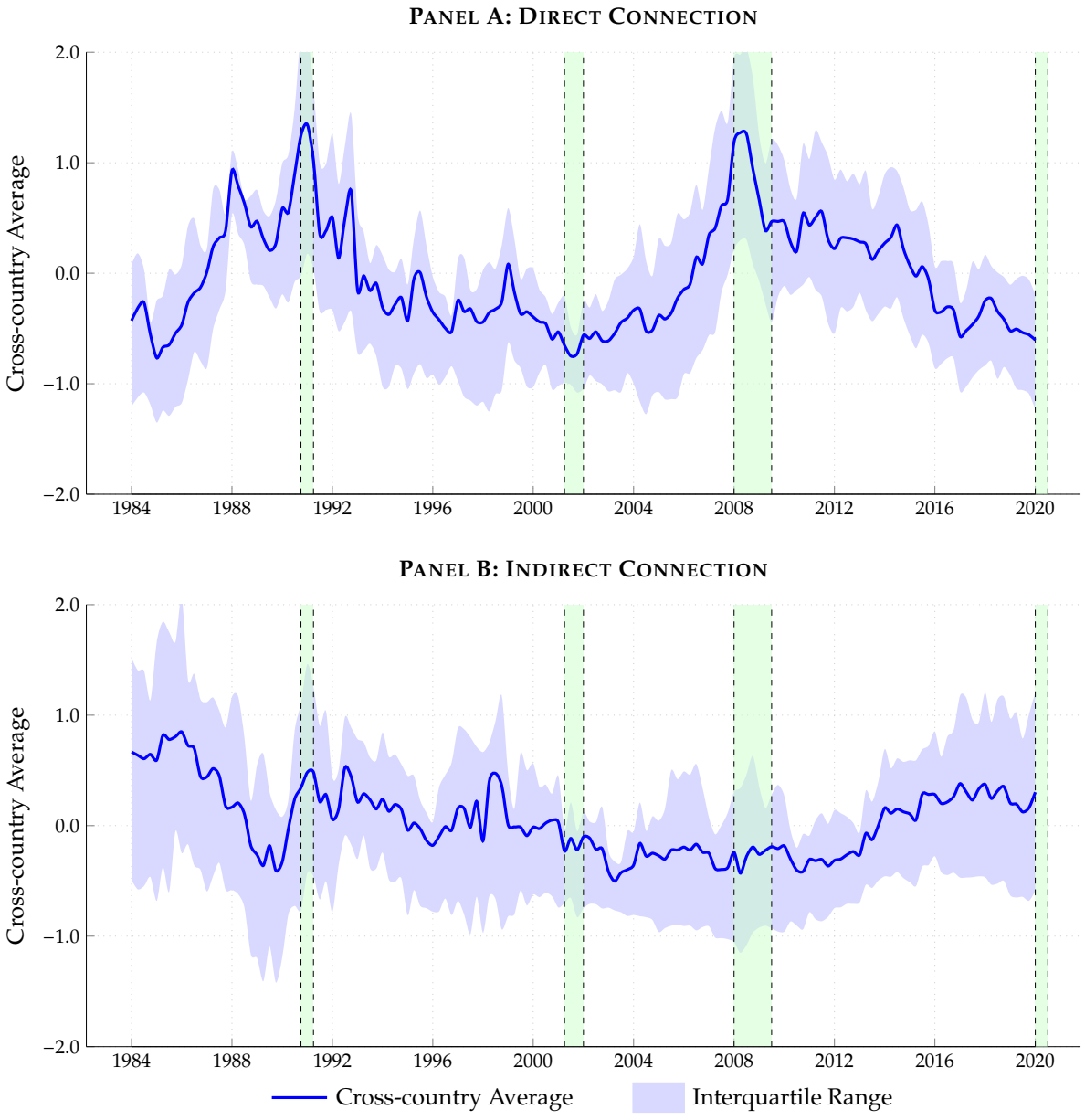


FIGURE 3. DIRECT AND INDIRECT CONNECTIONS

This figure displays, for each time period, the cross-sectional average of the direct (Panel A) and indirect (Panel B) connections of each country j relative to banks located in the reporting countries. Financial connections are based on cross-border claims and liabilities denominated in the local currency of the reporting country. The figure also reports the interquartile range and vertical shaded areas denoting US recessions based on NBER dates. The sample runs at the quarterly frequency between December 1983 and December 2019. Data are collected from the restricted version of the Locational Banking Statistics by Residence held by the BIS.

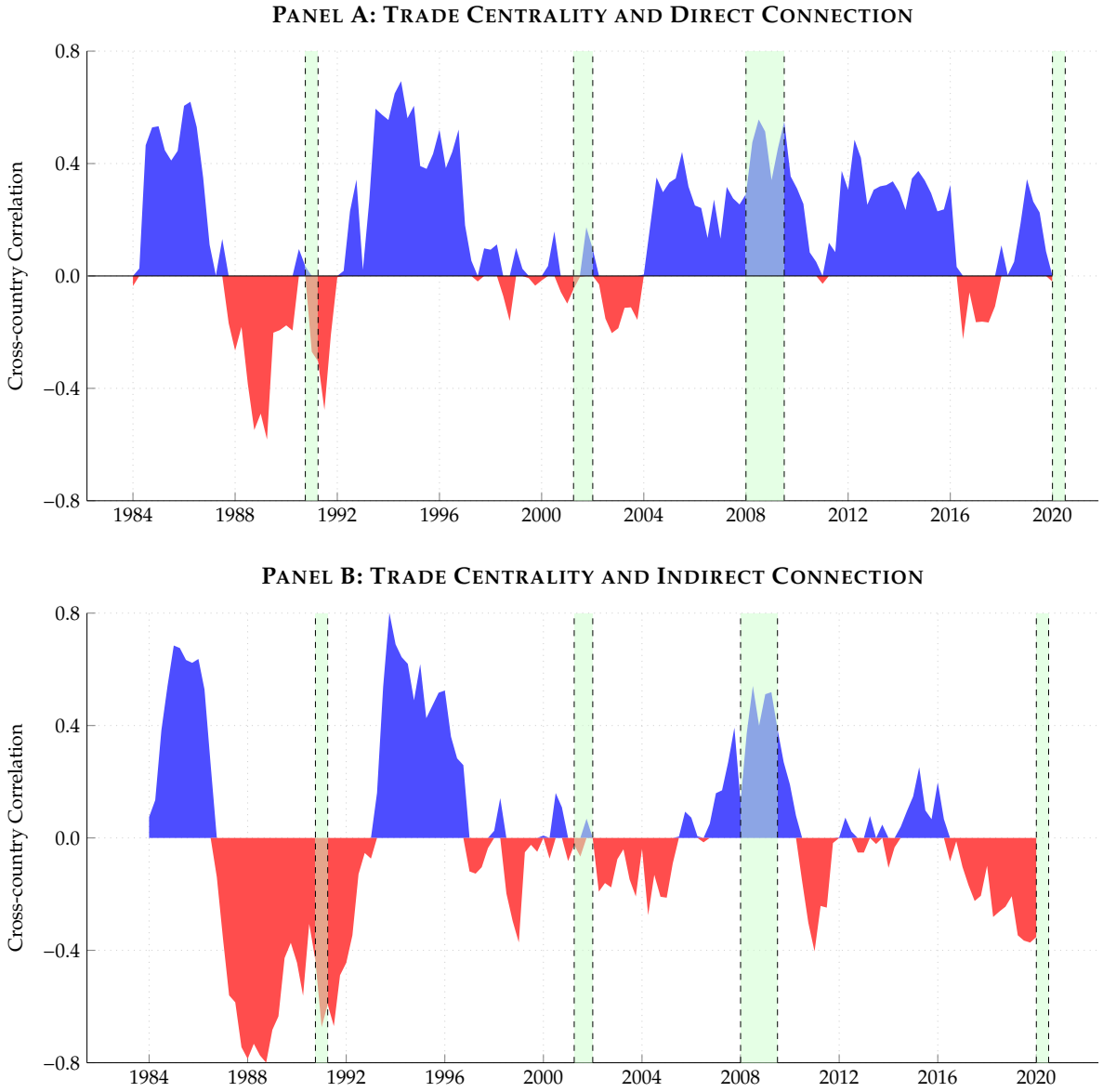


FIGURE 4. CORRELATION WITH TRADE CENTRALITY

This figure displays, for each time period, the cross-sectional correlation between trade centrality and direct (indirect) connection in Panel A (Panel B). Trade centrality is constructed as in Richmond (2019) using bilateral trade intensity and global share of exports. Financial connections are based on cross-border claims and liabilities denominated in the local currency of the reporting country. The figure also reports the interquartile range and vertical shaded areas denoting US recessions based on NBER dates. The sample runs at the quarterly frequency between December 1983 and December 2019. Data are collected from the restricted version of the Locational Banking Statistics by Residence held by the BIS. Other data are the World Bank and IMF.

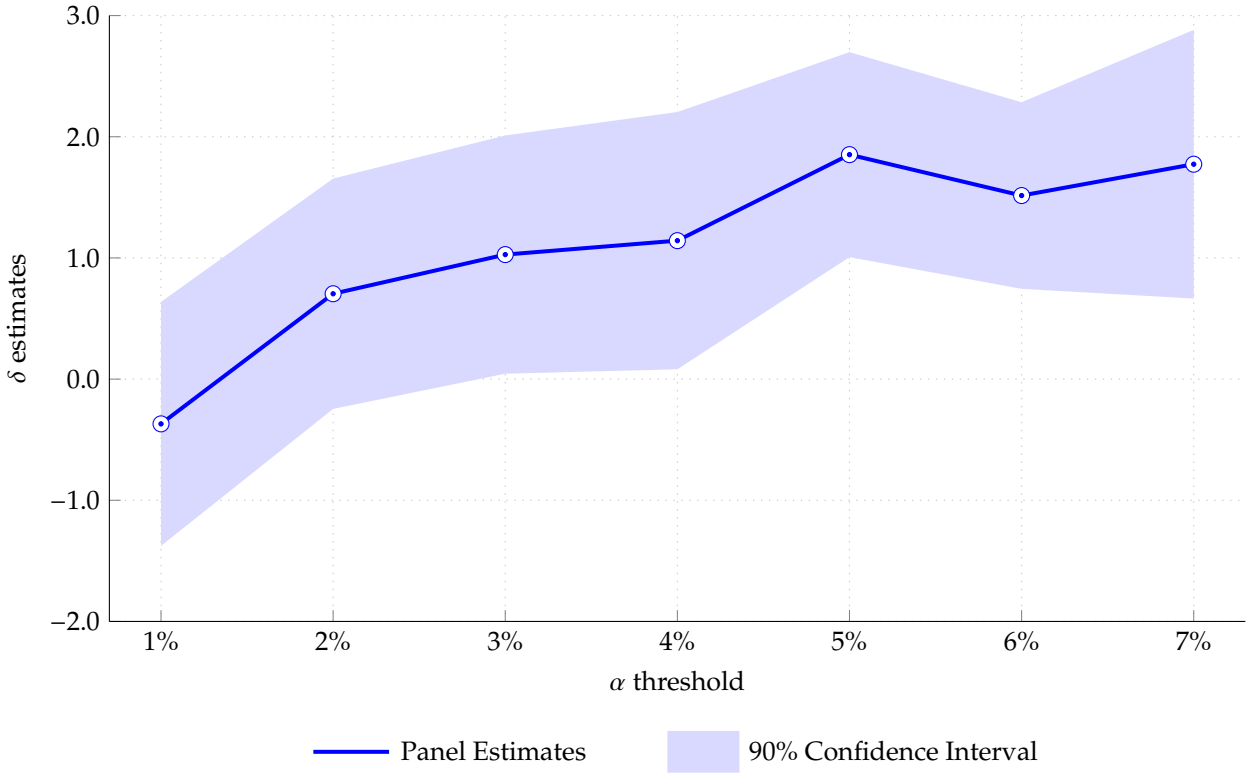


FIGURE 5. COUNTRY SIZE AND CONDITIONAL EXCHANGE RATE RETURNS

This table presents the panel estimates of δ based on the following specification

$$\begin{aligned} y_{j,t} \;=\; & \alpha \texttt{Ind}_{j,t} + \beta(\texttt{Ind}_j \times \texttt{Shock}_{us}^{+})_t + \gamma(\texttt{Ind}_j \times \texttt{Shock}_j^{-})_t + \delta(\texttt{Ind}_j \times \texttt{Shock}_j^{-} \times \texttt{Large}_{j,\alpha})_t \\ & + \tilde{\alpha}\texttt{Dir}_{j,t} + \tilde{\beta}(\texttt{Dir}_i \times \texttt{Shock}_{us}^{+})_t + \tilde{\gamma}(\texttt{Dir}_j \times \texttt{Shock}_j^{-})_t + \tilde{\delta}(\texttt{Dir}_j \times \texttt{Deficit}_j)_t + \texttt{Controls}_{j,t} + fe + \varepsilon_{j,t+1}, \end{aligned}$$

where $y_{j,t+1}$ is the future exchange rate return of country j in percentage per annum, $\texttt{Dir}_j$ and $\texttt{Ind}_j$ are *direct* and *indirect* connections of country j relative to banks located in the reporting countries, respectively, $\texttt{Shock}_{us}^{+}$ is a positive shock to US net exports, $\texttt{Shock}_j^{-}$ is a negative shock to country j net exports, $\texttt{Deficit}_j$ is the trade deficit (net exports multiplied by minus one) of country j, $\texttt{Large}_{i,\alpha}$ is a binary variable that selects the top α percent economies in terms of share of global trade, and $\texttt{Controls}_j$ includes country-specific variables as the capital account openness of Chinn and Ito (2006), forward premium, share of world GDP, and the trade network centrality of Richmond (2019). We also include other regressors (e.g., $\texttt{Shock}_{us}^{+}$, $\texttt{Shock}_j^{-}$, $\texttt{Large}_{i,\alpha}$, and $\texttt{Deficit}_j$) and interactions (e.g., $\texttt{Ind}_j \times \texttt{Large}_j$ and $\texttt{Shock}_j^{-} \times \texttt{Large}_{i,\alpha}$), which are not displayed to save space. Exchange rates are defined as units of dollars per unit of foreign currency, financial connections use cross-border claims and liabilities denominated in the local currency of the reporting country, net exports employ bilateral merchandise exports and imports as percentage of GDP, and trade shocks are computed using a factor model based on principal components. fe denotes the fixed effects. Confidence interval is based on standard errors clustered by country. The sample runs at a monthly frequency between September 1983 and December 2019. Cross-border claims and liabilities are from the restricted version of the Location Banking Statistics by residence held by the BIS, whereas other data are from Datastream, World Bank, and IMF.

TABLE 1. MODEL'S SIMULATION

This table presents panel regression estimates based on following specification

$$
\begin{aligned}
e_{j,1}/e_{j,0} \;=\; & \alpha \texttt{Ind}_j + \beta(\texttt{Ind}_j \times \texttt{Shock}^{+}_{1,0}) + \gamma(\texttt{Ind}_j \times \texttt{Shock}^{-}_{j,0}) + \delta(\texttt{Ind}_j \times \texttt{Shock}^{-}_{j,0} \times \texttt{Large}_j) \\
& + \tilde{\alpha}\texttt{Dir}_j + \tilde{\beta}(\texttt{Dir}_j \times \texttt{Shock}^{+}_{1,0}) + \tilde{\gamma}(\texttt{Dir}_j \times \texttt{Shock}^{-}_{j,0}) + \tilde{\delta}(\texttt{Dir}_j \times \texttt{Deficit}_{j,0}) + \texttt{Controls}_{j,0} + fe + \varepsilon_{j,t+1},
\end{aligned}
$$

where e_j is the exchange rate of country j, $\texttt{Dir}_j$ and $\texttt{Ind}_j$ are *direct* and *indirect* connections of country j, respectively, $\texttt{Shock}^{+}_{1}$ is a positive shock to country 1 net exports, $\texttt{Shock}^{-}_{j}$ is a negative shock to country j net exports, $\texttt{Deficit}_j$ is the trade deficit (net exports multiplied by minus one) of country j, $\texttt{Large}_j$ is a binary variable that selects a large country and $\texttt{Controls}_j$ includes additional regressors (e.g., $\texttt{Large}_j$, $\texttt{Deficit}_j$) and other interactions (e.g., $\texttt{Dir}_j \times \texttt{Large}_j$ and $\texttt{Shock}^{-}_{j,0} \times \texttt{Large}_j$). Exchange rates are defined as units of dollars per unit of foreign currency and financial connections are calculated using eigenvector centrality. Data are generated using 20,000 simulations and 20 countries as described in Section A.4.

	(1)	(2)	(3)
$\texttt{Ind}_j$	0.005	0.000	−0.005
$\texttt{Ind}_j \times \texttt{Shock}^{+}_{1,0}$	−0.007	−0.005	−0.003
$\texttt{Ind}_j \times \texttt{Shock}^{-}_{j,0}$	−0.012	−0.006	0.002
$\texttt{Ind}_j \times \texttt{Shock}^{-}_{j,0} \times \texttt{Large}_j$	−0.088	−0.028	0.036
$\texttt{Dir}_j$		−0.001	0.005
$\texttt{Dir}_j \times \texttt{Shock}^{+}_{1,0}$		0.006	0.004
$\texttt{Dir}_j \times \texttt{Shock}^{-}_{j,0}$		0.007	−0.001
$\texttt{Dir}_j \times \texttt{Deficit}_{j,0}$		−1.149	−0.545
$\texttt{Ind}_j \times \texttt{Deficit}_{j,0}$			−0.554
$\texttt{Dir}_j \times \texttt{Shock}^{-}_{j,0} \times \texttt{Large}_j$			−0.079
R^2	0.98	0.99	0.99
Obs	37,981	37,981	37,981

TABLE 2. CROSS-BORDER BANKING ACTIVITY: LIST OF REPORTING COUNTRIES

This table lists the source countries of bilateral cross-border banking claims and liabilities in our sample. The sample runs at the quarterly frequency between December 1983 and December 2019. Cross-border claims and liabilities are from the restricted version of the Location Banking Statistics by residence held by the BIS.

Year	Reporting Countries
1983	Austria, Bahamas, Belgium, Canada, Cayman Islands, Denmark, Finland, France, Germany, Hong Kong, Ireland, Italy, Japan, Luxembourg, Netherlands, Netherlands Antilles, Spain, Sweden, Switzerland, United Kingdom, United States
1997	Australia, Portugal
2000	Taiwan, Turkey
2001	Guernsey, India, Isle of Man, Jersey
2002	Bermuda, Brazil, Chile, Panama
2003	Greece, Macau, Mexico
2005	South Korea
2007	Malaysia
2008	Cyprus
2009	South Africa
2010	Curacao, Indonesia
2014	Norway
2015	China
2016	Philippines
2017	Saudi Arabia

TABLE 3. CROSS-BORDER BANKING ACTIVITY: LIST OF COUNTERPARTY COUNTRIES

This table lists the destination countries of bilateral cross-border banking claims and liabilities in our sample. The sample runs at the quarterly frequency between December 1983 and December 2019. Cross-border claims and liabilities are from the restricted version of the Location Banking Statistics by residence held by the BIS.

Year	Counterparty Countries
1984	Austria, Australia, Belgium, Canada, Denmark, Germany, Hong Kong, Ireland, Italy, Japan, Liechtenstein, Netherlands, Norway, Nauru, New Zealand, Portugal, Singapore, Spain, South Africa, Sweden, Switzerland, United Kingdom, United States
1990	Kuwait, Saudi Arabia, Tuvalu
1992	Kiribati
1995	United Arab Emirates
1996	Czech Republic, France, Greece, Indonesia, Malaysia, Mexico, Poland, Taiwan
1997	Hungary, India
1998	Andorra, Finland, Greenland, Thailand, Vatican City
1999	Euro Area, San Marino
2000	Bahrain, Philippines, Turkey
2001	Guernsey, Isle of Man, Jersey
2002	South Korea, Slovakia
2004	Argentina, Bulgaria, Brazil, Chile, Colombia, Croatia, Egypt, Iceland, Israel, Jordan, Kazakhstan, Kenya, Lithuania, Latvia, Malta, Morocco, Oman, Peru, Pakistan, Palestinian Authority, Qatar, Russia, Slovenia, Tunisia
2005	China, Romania
2006	Montenegro
2010	Ukraine
2011	Botswana, Serbia, Sri Lanka, Uganda, Vietnam, Zambia

TABLE 4. EQUITY PORTFOLIOS AND EXCHANGE RATES

This table presents panel regression estimates based on the following specification

$$y_{j,t} = \alpha \texttt{Dir}_{j,t} + \beta \texttt{Equity}_{j,t} + \delta(\texttt{Equity}_j \times \texttt{Dummy}_{j,\alpha})_t + \texttt{Controls}_{j,t} + fe + \varepsilon_{j,t}$$

where $y_{j,t}$ is the *contemporaneous* exchange rate return of country j in percentage per annum, $\texttt{Dir}_j$ is *direct* connection (or gross banking intermediation) of country j relative to banks located in the reporting countries, $\texttt{Equity}_{j,t}$ is the net equity portfolio flow instrumented by granular instrumental variables as in Equation (6), $\texttt{Dummy}_{j,\alpha}$ is a dummy variable that equals one for a given level of gross financial intermediation, and $\texttt{Controls}_j$ includes twenty principal components extracted from portfolio shares from the country-specific matrix of portfolio shares. The dummy variable kicks in when $\texttt{Dir}_j$ is above zero (or its mean), above its half standard deviation, and above its standard deviation. We also include $\texttt{Dummy}_\alpha$ as a regressor, which is not displayed to save space. Standard errors (in parentheses) are clustered by country. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% level, respectively. The sample runs at a quarterly frequency between September 2005 and January 2020. Cross-border claims and liabilities are from the restricted version of the Location Banking Statistics by residence held by the BIS. Mutual fund and exchange-trade funds' holdings of international equities are from S&P Global Capital IQ. Other data are from Datastream.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$\texttt{Equity}_{j,t}$	1.477***	1.576***	1.463	1.688*	1.999***	2.169***	1.675***	1.747***
	(0.568)	(0.509)	(1.020)	(0.882)	(0.766)	(0.715)	(0.613)	(0.543)
$\texttt{Dir}_j \times \texttt{Equity}_{j,t}$	−0.580	−0.642						
	(0.531)	(0.411)						
$\texttt{Equity}_{j,t} \times \texttt{Dummy}_{\{\texttt{Dir}_j > 0\}}$			−0.148	−0.376				
			(1.213)	(1.040)				
$\texttt{Equity}_{j,t} \times \texttt{Dummy}_{\{\texttt{Dir}_j > 0.5\sigma\}}$					−1.730**	−1.989**		
					(0.857)	(0.790)		
$\texttt{Equity}_{j,t} \times \texttt{Dummy}_{\{\texttt{Dir}_j > 1\sigma\}}$							−1.531*	−1.472**
							(0.793)	(0.656)
R^2	0.57	0.59	0.57	0.59	0.58	0.59	0.58	0.59
Obs	890	890	890	890	890	890	890	890
Time fe	✓	✓	✓	✓	✓	✓	✓	✓
Country fe	✓	✓	✓	✓	✓	✓	✓	✓
Controls		✓		✓		✓		✓
F-stat (First Stage)	4892.17	543.79	4892.12	524.96	4914.65	526.06	4867.10	520.91

TABLE 5. FINANCIAL CONNECTIONS AND EXCHANGE RATES

This table presents panel regression estimates based on the following specification:

$$y_{j,t+1} = \alpha \texttt{Dir}_{j,t} + \beta(\texttt{Dir}_j \times \texttt{Deficit}_j)_t + \gamma \texttt{TradeCent}_{j,t} + \delta(\texttt{TradeCent}_j \times \texttt{Deficit}_j)_t + \texttt{Controls}_{j,t} + fe + \varepsilon_{j,t+1},$$

where $y_{j,t+1}$ is the future exchange rate return of country j in percentage per annum, $\texttt{Dir}_j$ is *direct* connection of country j relative to banks located in the reporting countries, $\texttt{Deficit}_j$ is the trade deficit (net exports multiplied by minus one) of country j, $\texttt{TradeCent}_j$ is the trade centrality of Richmond (2019), and $\texttt{Controls}_j$ includes country-specific variables as the capital account openness of Chinn and Ito (2006), forward premium, and the share of world GDP. We also include the regressor $\texttt{Deficit}_{j,t}$, which is not displayed to save space. Exchange rates are defined as units of dollars per unit of foreign currency, financial connections use cross-border claims and liabilities denominated in the local currency of the reporting country, net exports employ bilateral merchandise exports and imports as percentage of GDP. fe denotes the fixed effects. Standard errors (in parentheses) are clustered by country. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% level, respectively. The sample runs at a monthly frequency between September 1983 and December 2019. Cross-border claims and liabilities are from the restricted version of the Location Banking Statistics by residence held by the BIS. Other data are from Datastream, World Bank, and IMF.

	(1)	(2)	(3)	(4)
$\texttt{Dir}_j$	−0.827***	−0.729***	−0.757***	−0.771***
	(0.275)	(0.254)	(0.263)	(0.259)
$\texttt{Dir}_j \times \texttt{Deficit}_j$		−1.080***	−0.980***	−0.890***
		(0.295)	(0.268)	(0.269)
$\texttt{TradeCent}_j$			−0.826**	−0.865***
			(0.336)	(0.335)
$\texttt{TradeCent}_j \times \texttt{Deficit}_j$				−0.264
				(0.205)
R^2	0.41	0.41	0.41	0.41
Obs	14,981	14,981	14,981	14,981
Time fe	✓	✓	✓	✓
Controls			✓	✓

TABLE 6. FINANCIAL CONNECTIONS, TRADE SHOCKS, AND EXCHANGE RATES

This table presents panel regression estimates based on the following specification

$$y_{j,t+1} = \alpha \texttt{Ind}_{j,t} + \beta(\texttt{Ind}_j \times \texttt{Shock}^+_{us})_t + \gamma(\texttt{Ind}_j \times \texttt{Shock}^-_j)_t + \delta(\texttt{Ind}_j \times \texttt{Shock}^-_j \times \texttt{Large}_j)_t$$
$$+ \tilde{\alpha}\texttt{Dir}_{j,t} + \tilde{\beta}(\texttt{Dir}_j \times \texttt{Shock}^+_{us})_t + \tilde{\gamma}(\texttt{Dir}_j \times \texttt{Shock}^-_j)_t + \tilde{\delta}(\texttt{Dir}_j \times \texttt{Deficit}_j)_t + \texttt{Controls}_{j,t} + fe + \varepsilon_{j,t+1},$$

where $y_{j,t+1}$ is the future exchange rate return of country j in percentage per annum, $\texttt{Dir}_j$ and $\texttt{Ind}_j$ are *direct* and *indirect* connections of country j relative to banks located in the reporting countries, respectively, $\texttt{Shock}^+_{us}$ is a positive shock to US net exports, $\texttt{Shock}^-_j$ is a negative shock to country j net exports, $\texttt{Deficit}_j$ is the trade deficit (net exports multiplied by minus one) of country j, $\texttt{Large}_j$ is a binary variable that selects the top 5% economies in terms of share of global trade (amounting to the largest 8 economies), and $\texttt{Controls}_j$ includes country-specific variables as the capital account openness of Chinn and Ito (2006), forward premium, share of world GDP, and the trade network centrality of Richmond (2019). We also include other regressors (e.g., $\texttt{Shock}^+_{us}$, $\texttt{Shock}^-_j$, $\texttt{Large}_j$, and $\texttt{Deficit}_j$) and interactions (e.g., $\texttt{Ind}_j \times \texttt{Large}_j$ and $\texttt{Shock}^-_j \times \texttt{Large}_j$), which are not displayed to save space. Exchange rates are defined as units of dollars per unit of foreign currency, financial connections use cross-border claims and liabilities denominated in the local currency of the reporting country, net exports employ bilateral merchandise exports and imports as percentage of GDP, and trade shocks are computed using a factor model based on principal components. *fe* denotes the fixed effects. Standard errors (in parentheses) are clustered by country. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% level, respectively. The sample runs at a monthly frequency between September 1983 and December 2019. Cross-border claims and liabilities are from the restricted version of the Location Banking Statistics by residence held by the BIS, whereas other data are from Datastream, World Bank, and IMF.

	(1)	(2)	(3)	(4)	(5)
$\texttt{Ind}_j$	−1.000***	−1.058***	−1.023***	−0.977***	−0.897***
	(0.275)	(0.299)	(0.298)	(0.334)	(0.296)
$\texttt{Ind}_j \times \texttt{Shock}^+_{us}$	−0.631***	−0.643***	−0.651***	−0.484**	−0.531**
	(0.216)	(0.221)	(0.217)	(0.211)	(0.217)
$\texttt{Ind}_j \times \texttt{Shock}^-_j$	−0.281	−0.419	−0.449	−0.314	−0.240
	(0.277)	(0.289)	(0.299)	(0.298)	(0.294)
$\texttt{Ind}_j \times \texttt{Shock}^-_j \times \texttt{Large}_j$		1.886***	1.843***	1.607***	1.409**
		(0.551)	(0.579)	(0.606)	(0.605)
$\texttt{Dir}_j$				−0.097	−0.112
				(0.338)	(0.337)
$\texttt{Dir}_j \times \texttt{Shock}^+_{us}$				−0.298	−0.211
				(0.307)	(0.311)
$\texttt{Dir}_j \times \texttt{Shock}^-_j$				0.099	0.059
				(0.327)	(0.324)
$\texttt{Dir}_j \times \texttt{Deficit}_j$				−0.863***	−0.776***
				(0.270)	(0.284)
R^2	0.41	0.41	0.42	0.42	0.42
Obs	14,981	14,981	14,981	14,981	14,981
Time fe	✓	✓	✓	✓	✓
Country fe			✓		✓
Controls				✓	✓

TABLE 7. FINANCIAL CONNECTIONS AND CURRENCY DENOMINATION

This table presents panel regression estimates based on the following specification

$$
\begin{aligned}
y_{j,t+1} \;=\; & \beta(\texttt{Ind}_j \times \texttt{Shock}^{+}_{us})_t + \gamma(\texttt{Ind}_j \times \texttt{Shock}^{-}_{j})_t + \delta(\texttt{Ind}_j \times \texttt{Shock}^{-}_{j} \times \texttt{Large}_i)_t + \theta(\texttt{Dir}_j \times \texttt{Deficit}_j)_t \\
& + \tilde{\beta}(\texttt{Ind}^{\$}_j \times \texttt{Shock}^{+}_{us})_t + \tilde{\gamma}(\texttt{Ind}^{\$}_j \times \texttt{Shock}^{-}_{j})_t + \tilde{\delta}(\texttt{Ind}^{\$}_j \times \texttt{Shock}^{-}_{j} \times \texttt{Large}_j)_t + \tilde{\theta}(\texttt{Dir}^{\$}_j \times \texttt{Deficit}_j) \\
& + \texttt{Controls}_{j,t} + fe + \varepsilon_{j,t+1},
\end{aligned}
$$

where $y_{j,t+1}$ is the future exchange rate return of country j in percentage per annum, $\texttt{Dir}_j$ and $\texttt{Ind}_j$ are *direct* and *indirect* connections of country j relative to banks located in the reporting countries, respectively, $\texttt{Shock}^{+}_{us}$ is a positive shock to US net exports, $\texttt{Shock}^{-}_{j}$ is a negative shock to country j net exports, $\texttt{Deficit}_j$ is the trade deficit (net exports multiplied by minus one) of country j, $\texttt{Large}_j$ is a binary variable that selects the top 5% economies in terms of share of global trade (amounting to the largest 8 economies), and $\texttt{Controls}_j$ includes country-specific variables as the capital account openness of Chinn and Ito (2006), forward premium, share of world GDP, and the trade network centrality of Richmond (2019). We also include other regressors (e.g., $\texttt{Ind}_j$, $\texttt{Dir}_j$, $\texttt{Ind}^{\$}_j$, $\texttt{Dir}^{\$}_j$, $\texttt{Shock}^{-}_{j}$, $\texttt{Shock}^{+}_{us}$, $\texttt{Large}_j$, and $\texttt{Deficit}_j$) and interactions (e.g., $\texttt{Ind}_j \times \texttt{Large}_j$, $\texttt{Shock}^{-}_{j} \times \texttt{Large}_j$, and $\texttt{Ind}^{\$}_j \times \texttt{Large}_j$), which are not displayed to save space. Exchange rates are defined as units of dollars per unit of foreign currency, financial connections use cross-border claims and liabilities denominated in the local currency of the reporting country (or in US dollars with the superscript \$), net exports employ bilateral merchandise exports and imports as percentage of GDP, and trade shocks are computed using a factor model based on principal components. fe denotes the fixed effects. Standard errors (in parentheses) are clustered by country. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% level, respectively. The sample runs at a monthly frequency between September 1983 and December 2019. Cross-border claims and liabilities are from the restricted version of the Location Banking Statistics by residence held by the BIS. Other data are from Datastream, World Bank, and IMF.

	(1)	(2)	(3)	(4)
$\texttt{Ind}_j \times \texttt{Shock}^{+}_{us}$	−0.417**	−0.438**	−0.454**	−0.435**
	(0.207)	(0.215)	(0.207)	(0.214)
$\texttt{Ind}_j \times \texttt{Shock}^{-}_{j}$	−0.034	−0.127	−0.068	−0.064
	(0.321)	(0.326)	(0.335)	(0.341)
$\texttt{Ind}_j \times \texttt{Shock}^{-}_{j} \times \texttt{Large}_j$	1.756***	1.761***	1.154**	1.089*
	(0.663)	(0.656)	(0.541)	(0.575)
$\texttt{Dir}_j \times \texttt{Deficit}_j$	−1.129***	−1.036***	−1.013***	−0.913***
	(0.318)	(0.338)	(0.289)	(0.311)
$\texttt{Ind}^{\$}_j \times \texttt{Shock}^{+}_{us}$	−0.398	−0.371	−0.392	−0.378
	(0.267)	(0.274)	(0.275)	(0.280)
$\texttt{Ind}^{\$}_j \times \texttt{Shock}^{-}_{j}$	−0.123	−0.140	−0.126	−0.133
	(0.301)	(0.300)	(0.296)	(0.290)
$\texttt{Ind}^{\$}_j \times \texttt{Shock}^{-}_{j} \times \texttt{Large}_j$	2.179*	2.078*	1.926**	1.648*
	(1.219)	(1.229)	(0.874)	(0.860)
$\texttt{Dir}^{\$}_j \times \texttt{Deficit}_j$	0.117	0.081	0.077	0.118
	(0.243)	(0.309)	(0.237)	(0.305)
R^2	0.41	0.42	0.42	0.42
N	14,957	14,957	14,957	14,957
Time fe	✓	✓	✓	✓
Country fe		✓		✓
Controls			✓	✓

TABLE 8. CROSS-BORDER CLAIMS AND FINANCIAL CONNECTIONS

This table presents panel regression estimates based on the following specification

$$y_{j,t+1} = \alpha \texttt{Ind}_{j,t} + \beta(\texttt{Ind}_j \times \texttt{Shock}^{+}_{us})_t + \gamma(\texttt{Ind}_j \times \texttt{Shock}^{-}_{j})_t + \delta(\texttt{Ind}_j \times \texttt{Shock}^{-}_{j} \times \texttt{Large}_j)_t$$
$$+ \tilde{\alpha}\texttt{Dir}_{j,t} + \tilde{\beta}(\texttt{Dir}_j \times \texttt{Shock}^{+}_{us})_t + \tilde{\gamma}(\texttt{Dir}_j \times \texttt{Shock}^{-}_{j})_t + \tilde{\delta}(\texttt{Dir}_j \times \texttt{Deficit}_j)_t + \texttt{Controls}_{j,t} + fe + \varepsilon_{j,t+1},$$

where $y_{j,t+1}$ is the future exchange rate return of country j in percentage per annum, $\texttt{Dir}_j$ and $\texttt{Ind}_j$ are *direct* and *indirect* connections of country j relative to banks located in the reporting countries, respectively, $\texttt{Shock}^{+}_{us}$ is a positive shock to US net exports, $\texttt{Shock}^{-}_{j}$ is a negative shock to country j net exports, $\texttt{Deficit}_j$ is the trade deficit (net exports multiplied by minus one) of country j, $\texttt{Large}_j$ is a binary variable that selects the top 5% economies in terms of share of global trade (amounting to the largest 8 economies), and $\texttt{Controls}_j$ includes country-specific variables as the capital account openness of Chinn and Ito (2006), forward premium, share of world GDP, and the trade network centrality of Richmond (2019). We also include other regressors (e.g., $\texttt{Shock}^{+}_{us}$, $\texttt{Shock}^{-}_{j}$, $\texttt{Large}_j$, and $\texttt{Deficit}_j$) and interactions (e.g., $\texttt{Ind}_j \times \texttt{Large}_j$, and $\texttt{Shock}^{-}_{j} \times \texttt{Large}_j$), which are not displayed to save space. Exchange rates are defined as units of dollars per unit of foreign currency, financial connections use cross-border claims denominated in the local currency of the reporting country (or in US dollars with the superscript \$), net exports employ bilateral merchandise exports and imports as percentage of GDP, and trade shocks are computed using a factor model based on principal components. *fe* denotes the fixed effects. Standard errors (in parentheses) are clustered by country. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% level, respectively. The sample runs at a monthly frequency between September 1983 and December 2019. Cross-border claims are from the restricted version of the Location Banking Statistics by residence held by the BIS. Other data are from Datastream, World Bank, and IMF.

	(1)	(2)	(3)	(4)	(5)
$\texttt{Ind}_j$	−0.769***	−0.761***	−0.729***	−0.573**	−0.470*
	(0.233)	(0.244)	(0.243)	(0.261)	(0.240)
$\texttt{Ind}_j \times \texttt{Shock}^{+}_{us}$	−0.677***	−0.721***	−0.677***	−0.431*	−0.458*
	(0.232)	(0.237)	(0.239)	(0.241)	(0.238)
$\texttt{Ind}_j \times \texttt{Shock}^{-}_{j}$	−0.112	−0.241	−0.296	−0.150	−0.131
	(0.270)	(0.283)	(0.297)	(0.289)	(0.290)
$\texttt{Ind}_j \times \texttt{Shock}^{-}_{j} \times \texttt{Large}_j$		1.767***	1.800***	1.536**	1.478**
		(0.624)	(0.639)	(0.672)	(0.662)
$\texttt{Dir}_j$				−0.408	−0.416
				(0.306)	(0.321)
$\texttt{Dir}_j \times \texttt{Shock}^{+}_{us}$				−0.387	−0.296
				(0.319)	(0.320)
$\texttt{Dir}_j \times \texttt{Shock}^{-}_{j}$				−0.006	−0.013
				(0.305)	(0.304)
$\texttt{Dir}_j \times \texttt{Deficit}_j$				−0.967***	−0.852***
				(0.265)	(0.282)
R^2	0.41	0.41	0.42	0.42	0.42
Obs	14,981	14,981	14,981	14,981	14,981
Time fe	✓	✓	✓	✓	✓
Country fe			✓		✓
Controls				✓	✓

TABLE 9. CROSS-BORDER LIABILITIES AND FINANCIAL CONNECTIONS

This table presents panel regression estimates based on the following specification

$$y_{j,t+1} = \alpha \texttt{Ind}_{j,t} + \beta(\texttt{Ind}_j \times \texttt{Shock}^{+}_{us})_t + \gamma(\texttt{Ind}_j \times \texttt{Shock}^{-}_{j})_t + \delta(\texttt{Ind}_j \times \texttt{Shock}^{-}_{j} \times \texttt{Large}_j)_t$$
$$+ \tilde{\alpha}\texttt{Dir}_{j,t} + \tilde{\beta}(\texttt{Dir}_j \times \texttt{Shock}^{+}_{us})_t + \tilde{\gamma}(\texttt{Dir}_j \times \texttt{Shock}^{-}_{j})_t + \tilde{\delta}(\texttt{Dir}_j \times \texttt{Deficit}_j)_t + \texttt{Controls}_{j,t} + fe + \varepsilon_{j,t+1},$$

where $y_{j,t+1}$ is the future exchange rate return of country j in percentage per annum, $\texttt{Dir}_j$ and $\texttt{Ind}_j$ are *direct* and *indirect* connections of country j relative to banks located in the reporting countries, respectively, $\texttt{Shock}^{+}_{us}$ is a positive shock to US net exports, $\texttt{Shock}^{-}_{j}$ is a negative shock to country j net exports, $\texttt{Deficit}_j$ is the trade deficit (net exports multiplied by minus one) of country j, $\texttt{Large}_j$ is a binary variable that selects the top 5% economies in terms of share of global trade (amounting to the largest 8 economies), and $\texttt{Controls}_j$ includes country-specific variables as the capital account openness of Chinn and Ito (2006), forward premium, share of world GDP, and the trade network centrality of Richmond (2019). We also include other regressors (e.g., $\texttt{Shock}^{+}_{us}$, $\texttt{Shock}^{-}_{j}$, $\texttt{Large}_j$, and $\texttt{Deficit}_j$) and interactions (e.g., $\texttt{Ind}_j \times \texttt{Large}_j$, and $\texttt{Shock}^{-}_{j} \times \texttt{Large}_j$), which are not displayed to save space. Exchange rates are defined as units of dollars per unit of foreign currency, financial connections use cross-border liabilities denominated in the local currency of the reporting country (or in US dollars with the superscript \$), net exports employ bilateral merchandise exports and imports as percentage of GDP, and trade shocks are computed using a factor model based on principal components. fe denotes the fixed effects. Standard errors (in parentheses) are clustered by country. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% level, respectively. The sample runs at a monthly frequency between September 1983 and December 2019. Cross-border liabilities are from the restricted version of the Location Banking Statistics by residence held by the BIS. Other data are from Datastream, World Bank, and IMF.

	(1)	(2)	(3)	(4)	(5)
$\texttt{Ind}_i$	−0.756***	−0.809***	−0.839***	−0.614**	−0.592**
	(0.279)	(0.307)	(0.303)	(0.293)	(0.278)
$\texttt{Ind}_i \times \texttt{Shock}^{+}_{us}$	−0.655***	−0.679***	−0.669***	−0.538**	−0.562**
	(0.241)	(0.251)	(0.235)	(0.228)	(0.224)
$\texttt{Ind}_i \times \texttt{Shock}^{-}_{j}$	−0.287	−0.381	−0.354	−0.260	−0.140
	(0.247)	(0.254)	(0.253)	(0.234)	(0.231)
$\texttt{Ind}_i \times \texttt{Shock}^{-}_{j} \times \texttt{Large}_j$		1.578***	1.453***	1.178**	0.921*
		(0.477)	(0.502)	(0.530)	(0.537)
$\texttt{Dir}_j$				−0.386	−0.366
				(0.297)	(0.302)
$\texttt{Dir}_j \times \texttt{Shock}^{+}_{us}$				−0.345	−0.246
				(0.299)	(0.307)
$\texttt{Dir}_j \times \texttt{Shock}^{-}_{j}$				0.017	−0.032
				(0.312)	(0.311)
$\texttt{Dir}_j \times \texttt{Deficit}_j$				−0.891***	−0.764***
				(0.253)	(0.264)
R^2	0.41	0.41	0.42	0.42	0.42
Obs	14,981	14,981	14,981	14,981	14,981
Time fe	✓	✓	✓	✓	✓
Country fe			✓		✓
Controls				✓	✓

TABLE 10. FINANCIAL CONNECTIONS AND PEGGED CURRENCIES

This table presents panel regression estimates based on the following specification:

$$
\begin{aligned}
y_{j,t+1} \;=\; & \alpha \texttt{Ind}_{j,t} + \beta(\texttt{Ind}_j \times \texttt{Shock}^{+}_{us})_t + \gamma(\texttt{Ind}_j \times \texttt{Shock}^{-}_{j})_t + \delta(\texttt{Ind}_j \times \texttt{Shock}^{-}_{j} \times \texttt{Large}_j)_t \\
& + \theta(\texttt{Ind}_j \times \texttt{Shock}^{+}_{us} \times \texttt{Peg}_j)_t + \kappa(\texttt{Ind}_j \times \texttt{Shock}^{-}_{j} \times \texttt{Peg}_j)_t + \lambda(\texttt{Ind}_j \times \texttt{Shock}^{-}_{j} \times \texttt{Large}_j \times \texttt{Peg}_j)_t \\
& + \tilde{\alpha}\texttt{Dir}_{j,t} + \tilde{\beta}(\texttt{Dir}_j \times \texttt{Shock}^{+}_{us})_t + \tilde{\gamma}(\texttt{Dir}_j \times \texttt{Shock}^{-}_{j})_t + \tilde{\delta}(\texttt{Dir}_j \times \texttt{Deficit}_j)_t + \texttt{Controls}_{j,t} + fe + \varepsilon_{j,t+1},
\end{aligned}
$$

where $y_{j,t+1}$ is the future exchange rate return of country i in percentage per annum, $\texttt{Dir}_j$ and $\texttt{Ind}_j$ are *direct* and *indirect* connections of country i relative to banks located in the reporting countries, , respectively, $\texttt{Shock}^{+}_{us}$ is a positive shock to US net exports, $\texttt{Shock}^{-}_{j}$ is a negative shock to country j net exports, $\texttt{Deficit}_j$ is the trade deficit (net exports multiplied by minus one) of country j, $\texttt{Large}_j$ is a binary variable that selects the top 5% economies in terms of share of global trade (amounting to the largest 8 economies), $\texttt{Peg}_j$ is a dummy variable that selects pegged currencies using the classification of Ilzetzki et al. (2019) and $\texttt{Controls}_j$ includes country-specific variables as the capital account openness of Chinn and Ito (2006), forward premium, share of world GDP, and the trade network centrality of Richmond (2019). We also include other regressors (e.g., $\texttt{Shock}^{+}_{us}$, $\texttt{Shock}^{-}_{j}$, $\texttt{Large}_j$, $\texttt{Peg}_j$, and $\texttt{Deficit}_j$) and interactions (e.g., $\texttt{Ind}_j \times \texttt{Large}_j$ and $\texttt{Shock}^{-}_{j} \times \texttt{Large}_j$)which are not displayed to save space. Exchange rates are defined as units of dollars per unit of foreign currency, financial connections use cross-border liabilities denominated in the local currency of the reporting country (or in US dollars with the superscript \$), net exports employ bilateral merchandise exports and imports as percentage of GDP, and trade shocks are computed using a factor model based on principal components. fe denotes the fixed effects. Standard errors (in parentheses) are clustered by country. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% level, respectively. The sample runs at a monthly frequency between September 1983 and December 2019. Cross-border claims and liabilities are from the restricted version of the Location Banking Statistics by residence held by the BIS. The exchange rate classification is from Ilzetzki's website. Other data are from Datastream, World Bank, and IMF.

	(1)	(2)	(3)	(4)	(5)
$\texttt{Ind}_j$	−1.000***	−1.058***	−1.023***	−2.228***	−2.210***
	(0.275)	(0.299)	(0.298)	(0.598)	(0.570)
$\texttt{Ind}_j \times \texttt{Shock}^{+}_{us}$	−0.631***	−0.643***	−0.651***	−1.090***	−1.151***
	(0.216)	(0.221)	(0.217)	(0.421)	(0.428)
$\texttt{Ind}_j \times \texttt{Shock}^{-}_{j}$	−0.281	−0.419	−0.449	−0.640	−0.503
	(0.277)	(0.289)	(0.299)	(0.525)	(0.500)
$\texttt{Ind}_j \times \texttt{Shock}^{-}_{j} \times \texttt{Large}_j$		1.886***	1.843***	2.397***	2.252**
		(0.551)	(0.579)	(0.890)	(0.916)
$\texttt{Dir}_j$				−0.051	−0.076
				(0.348)	(0.349)
$\texttt{Dir}_j \times \texttt{Shock}^{+}_{us}$				−0.330	−0.251
				(0.310)	(0.314)
$\texttt{Dir}_j \times \texttt{Shock}^{-}_{j}$				0.032	−0.003
				(0.321)	(0.317)
$\texttt{Dir}_j \times \texttt{Deficit}_j$				−0.878***	−0.802***
				(0.253)	(0.274)
R^2	0.41	0.41	0.42	0.42	0.42
Obs	14,981	14,981	14,981	14,981	14,981
Time fe	✓	✓	✓	✓	✓
Country fe			✓		✓
Controls				✓	✓

Internet Appendix to

BEYOND BILATERAL FLOWS: INDIRECT CONNECTIONS AND EXCHANGE RATES

(not for publication)

Abstract

This appendix presents additional derivations and results not included in the main body of the paper.

A Model Appendix

We first provide details on the model setup before laying out the household maximisation problem in full. We then discuss the model when there are N countries. We then simulate the N country model and show that (i) our predictions from the three country model are born out in the simulation and (ii) running the regression we use in our main empirical specification on simulated data generates the same signs as with actual data.

A.1 Model Setup

Households. Each country j is populated by a mass of households of size h_j. We normalise global population so that $\sum_j h_j = 1$. Households in country j have a per capita endowment of country-specific tradable and nontradable goods denoted as $Y_{j,t}^T$ and $Y_{j,t}^{NT}$, respectively. They do not discount the future and derive their period utility according to $\theta_{j,t} \ln\left(C_{j,t}\right)$, where $C_{j,t}$ is a per capita consumption basket. The latter is defined as

$$C_{j,t} = \left((C_{j,t}^{NT})^{\chi_{j,t}} (C_{j,t}^{T})^{a_{j,t}} \prod_{i \neq j} (C_{ji,t}^{T})^{h_i \iota_{j,t}} \right)^{\frac{1}{\theta_{j,t}}}, \tag{A.1}$$

where $C_{j,t}^{NT}$ is a per capita consumption of the local nontradable good, $C_{j,t}^{T}$ is a per capita consumption of the local tradable good, and $C_{ji,t}^{T}$ is a per capita consumption of the imported tradable good from country i. The preference parameters $\{\chi_{j,t}, a_{j,t}, \iota_{j,t}\}$ are defined such that $\chi_{j,t} + a_{j,t} + \sum_{i \neq j} h_i \iota_{j,t} = \theta_{j,t}$.

The nontradable good is the numéraire in each economy and its price is one in local currency, or simply $p_{j,t}^{NT} = 1$. The exchange rate $e_{j,t}$ is then the relative price of nontradable goods between country j and country 1. As in the main text, we refer to the currency issued by country 1 as the dollar and an increase in $e_{j,t}$ indicates a dollar depreciation vis-à-vis currency j. This gives the nontradable good an interpretation as a money-like good and the exchange rate the classic, and empirically relevant, interpretation as the relative price of two moneys (Mussa, 1977). There are no frictions to trade in goods and the law of one price holds as $e_{j,t} p_{ji,t}^{T} = p_{1i,t}^{T}$, where $p_{ji,t}^{T}$ is the price of the imported tradeable good

from country i in currency j and $p^T_{j,t}$ is the price of the local tradable good in currency j.

Turning to financial assets, households only optimise over their holdings of a risk-free bond denominated in local currency either locally or with financiers with a connection to the country. In addition, the households have in period-0 an exogenous, weakly positive and perfectly inelastic demand for foreign currency bonds. This demand can be interpreted as a policy intervention or as a noise trading. For households in country j we denote f_{ji} as the period-0 value *in dollars* of the household's demand for bonds denominated in the currency i. These portfolio positions are only positive if the country is connected to a financier who trades the relevant bond.

As in Gabaix and Maggiori (2015), we make the assumption that the endowment of non-tradable goods is $Y^{NT}_{j,t} = \chi_{j,t}$. We lay out the solution to the household problem in the full below. However, it suffices to say that this assumption ensures that the marginal utility of an additional unit of expenditure in any period t is always unity. This means that the equilibrium gross interest rate on local currency bonds is equal unity given no discounting, and household expenditure on the imported tradable good i in local currency j is given by $p^T_{ji,t}C^T_{ji,t} = h_i\iota_{j,t}$, hence $\iota_{j,t}$ pins down per capita import demand.

FINANCIERS. Financiers are randomly selected from the population, start penniless, act as price takers, and intermediate bond flows across a country pair. Each group of financiers is randomly assigned to carry out a long-short strategy that borrows in bonds denominated in currency i and lends in bonds denominated in currency j or vice versa, while engaging in no other trades. The profits of financiers operating between countries j and i in dollar terms are given by

$$V_{ji} = \left(R_j \frac{e_{j,1}}{e_{j,0}} - R_i \frac{e_{i,1}}{e_{i,0}} \right) Q_{ji},$$

where R_j and R_i are the interest rates on the two bonds, Q_{ji} denotes the dollar value of financier's net position, which is long bonds in currency j and short bonds in currency i. We also assume that these financiers arbitrarily value their profits in any one of the

currencies involved (e.g., investment currency j, funding currency i, or dollars), which we denote as $e_{s_{ji}}$.

Financiers can choose to divert a fraction $(1 - \Lambda_{ji}^{-1}|Q_{ji}|e_{s_{ji},0}^{-1})$ of their short position and default on their borrowing. This limited commitment problem leads to the following incentive compatibility constraint

$$\left|Q_{ji}\right| \leq e_{s_{ji},0}\Lambda_{ji}\left|R_j\frac{e_{j,1}}{e_{j,0}} - R_i\frac{e_{i,1}}{e_{i,0}}\right|, \tag{A.2}$$

where Λ_{ji} determines the ability of financiers to intermediate bilateral capital flows between countries j and i, and pins down the slope of their demand curve for bonds in currency j relative to bonds in currency i. Financiers are defined by their country-pair and values are defined symmetrically so that $Q_{ji} = -Q_{ij}$, $\Lambda_{ji} = \Lambda_{ij}$, and $V_{ij} = V_{ji}$. A lower Λ_{ji} means a lower intermediation capacity, a steeper demand curve, and a larger exchange rate adjustment between currency j and i to generate equivalent movements in the corresponding capital flows. Hence, Λ_{ji} can be interpreted as the strength of the direct financial connection between countries j and i. A country's indirect financial connections depend on the strength of the direct financial connections of its counterparties. So, for a third country k, Λ_{ik}, will determine the indirect connection between country j and k through country i.

If financiers were unconstrained, they would compete away all profits so that interest parity holds: $R_j e_{j,1}/e_{j,0} = R_i e_{i,1}/e_{i,0}$. Hence, Equation (A.2) will bind. This means that if the financiers intermediate positive capital flows between countries, interest parity does not hold and financiers must make positive profits in period one. The total profits of all financiers in period one are distributed back to households such that the dollar value of a country's net borrowing in period zero is equal to the dollar value of its net repayments in period one such that no household makes a capital gain or loss on its external financial position in dollar terms. This assumption follows the multi-country set up in the Appendix of Gabaix and Maggiori (2015). We denote Π_j the profit transfer received by household j in period 1 in dollar terms.

A.2 Household Maximization Problem

The maximization problem of households in country j is described by

$$\max_{\{C_{j,t}^T, C_{j,t}^{NT}, C_{ji,t}^T\}} \quad \theta_{j,0} \ln C_{j,0} + \theta_{j,1} \ln C_{j,1}, \tag{A.3}$$

subject to Equation (A.1) and the household resource constraint

$$\begin{aligned} \sum_{t=0}^{1} R_j^{-t} \left(Y_{j,t}^{NT} + p_{j,t}^T Y_{j,t}^T \right) + (h_j R_j e_{j,1})^{-1} \left[\Pi_j + \sum_{i \neq j} \left(R_i \frac{e_{i,1}}{e_{i,0}} - R_j \frac{e_{j,1}}{e_{j,0}} \right) f_{ji} \right] = \\ \sum_{t=0}^{1} R_j^{-t} \left(C_{j,t}^{NT} + p_{j,t}^T C_{j,t}^T + \sum_{i \neq j}^{N} p_{ji,t}^T C_{ji,t}^T \right). \end{aligned} \tag{A.4}$$

where the left hand side is the present value of households' endowments plus profits received from financiers and the net return on households' exogenous portfolio position, and the right hand side is the present value of consumption spending all in local currency terms.

This optimization problem can be divided into two separate problems. The first is a static problem, whereby households choose their optimal consumption allocation across different goods given their total consumption expenditure for a given period. The second one is a dynamic intertemporal optimization problem, whereby households decide how much to save and consume in each period.

The static utility maximization problem is given by

$$\begin{aligned} \max_{\{C_{j,t}^T, C_{j,t}^{NT}, C_{ji,t}^T\}} \quad & \chi_{j,t} \ln C_{j,t}^{NT} + a_{j,t} \ln C_{j,t}^T + \iota_{j,t} \sum_{i \neq j}^{N} h_i \ln C_{ji,t}^T \\ & + \lambda_{j,t} \left(CE_{j,t} - C_{j,t}^{NT} - p_{j,t}^T C_{j,t}^T - \sum_{i \neq j}^{N} p_{ji,t}^T C_{ji,t}^T \right) \end{aligned} \tag{A.5}$$

where $\lambda_{j,t}$ is the Lagrange multiplier on the budget constraint, and $CE_{j,t}$ is the household's total consumption expenditure in period t, which is taken as exogenous in this static

problem. The first order conditions for this problem are

$$\begin{aligned}
\frac{\chi_{j,t}}{C_{j,t}^{NT}} &= \lambda_{j,t} \\
\frac{a_{j,t}}{C_{j,t}^{T}} &= \lambda_{j,t} p_{j,t}^{T} \\
\frac{h_i \iota_{j,t}}{C_{ji,t}^{T}} &= \lambda_{j,t} p_{ji,t}^{T} \quad \forall i \neq j
\end{aligned}$$

Imposing that nontradable goods are produced by an endowment process as $Y_{j,t}^{NT} = \chi_{j,t}$, we obtain $\lambda_{j,t} = 1$. Therefore, per capita spending on import from country i by households in country j is $p_{ji,t}^{T} C_{ji,t}^{T} = h_i \iota_{j,t}$.

Next, we turn to the intertemporal optimization problem. Since the risk-free bond pays one unit of nontradable good in all states of the world by assumption, the household's intertemporal budget constraint is given by

$$1 = R_j \frac{U'_{j,1,C^{NT}}}{U'_{j,0,C^{NT}}} = R_j \frac{\left(\frac{\chi_{j,1}}{C_{j,1}^{NT}}\right)}{\left(\frac{\chi_{j,0}}{C_{j,0}^{NT}}\right)} = R_j$$

where $U'_{j,1,C^{NT}}$ is the marginal utility of consumption of the nontradable good at time t, and the last equality follows from assuming that $C_{j,t}^{NT} = \chi_{j,t}$. Note that $R_j = R_i = 1$ given the assumption that all households are assumed to not discount the future. As a result, there will be no interest rate differential between countries and the gross interest rate is one throughout the economy as assumed in Section 2.

A.3 Derivation of the Balance of Payment's Conditions

Given we have described household optimal behaviour, we now derive the balance of payment conditions used in Section 2.2. Let $NX_{j,t}$ be the dollar value of net exports of country j at time t and NB_j be the dollar value of net borrowing from foreigners in period

0 accounting for the country's trade surplus and its inelastic portfolio position. From the standard balance of payments identity, we can write

$$NX_{j,0} - \sum_{i \neq j} f_{ji} + NB_j = 0 \tag{A.6}$$

In period 1, the dollar denominated balance of payment identity is given by

$$NX_{j,1} + \sum_{i \neq j} \frac{e_{i,1}}{e_{i,0}} f_{ji} - \frac{e_{j,1}}{e_{j,0}} NB_j + \Pi_j = 0, \tag{A.7}$$

which follows from gross interest rates being unity and the fact that, once portfolio positions are taken into account, the household only trades in local currency bonds. Hence, NB_j denotes households' net issuance of local currency debt. As a result, the household experiences a capital loss/gain on its net borrowing/lending of $\left(\frac{e_{j,1}}{e_{j,0}} - 1\right)$ in dollar terms if its currency appreciates vis-à-vis the dollar in period 1. Likewise, it experiences capital gains on its foreign portfolio holdings if those currency's appreciate vis-à-vis the dollar.

As described, households trade bonds internationally with financiers. Across all financiers connected to country j, their net purchases of the bonds of currency j are given by

$$\sum_{i \neq j} Q_{ji} = NB_j - \sum_{i \neq j} f_{ij}. \tag{A.8}$$

Households in country j issue NB_j of local currency bonds to financiers, those financiers then sell on $\sum_{i \neq j} f_{ij}$ of those bonds on to foreign households to meet their exogenous portfolio demand.

Using the fact equation Equation (A.2) binds we can rewrite the period-0 balance of payments constraint as

$$NX_{j,0} - \sum_{i \neq j} (f_{ji} - f_{ij}) + \sum_{i \neq j} e_{s_{ji},0} \Lambda_{ji} \left(\frac{e_{j,1}}{e_{j,0}} - \frac{e_{i,1}}{e_{i,0}} \right) = 0. \tag{A.9}$$

Recognising that $NX_{j,t} = h_j \sum_{i \neq j} h_i e_{i,t} \iota_{i,t} - h_j (1 - h_j) e_{j,t} \iota_{j,t}$ from household import demand derived above and that we can define $f_j = \sum_{i \neq j} (f_{ji} - f_{ij})$, we recover equation Equation (1) in the main text. The term f_j denotes the net portfolio flow out of country j. From its definition it follows that, summing across all countries it must be that $\sum_i f_i = 0$.

Turning now to period 1. As described, financiers profits are such that they offset all households' capital gains and losses in dollar terms in period 1. That is

$$\Pi_j = \left(\frac{e_{j,1}}{e_{j,0}} - 1 \right) \left(\sum_{i \neq j} (Q_{ji} + f_{ij}) \right) - \sum_{i \neq j} \left(\frac{e_{i,1}}{e_{i,0}} - 1 \right) f_{ji}. \tag{A.10}$$

Since the capital gains and losses on portfolio positions must net out across households, these transfers sum to the total profit of all financiers. Combining Equation (A.2), Equation (A.8) and Equation (A.10) with the period 1 balance of payment constraint we obtain

$$NX_{j,1} + f_j - \sum_{i \neq j} e_{s_{ji},0} \Lambda_{ji} \left(\frac{e_{j,1}}{e_{j,0}} - \frac{e_{i,1}}{e_{i,0}} \right) = 0. \tag{A.11}$$

where f_j is the net portfolio flow defined above. Solving for net-exports recovers Equation (2).

A.4 Model's Simulation

To obtain simulation results presented in table 1, we run 2000 simulations by drawing $\iota_{j,0} \sim \mathcal{N}(1, 0.1)$ and $\Lambda_{ji} \sim \text{Pareto}(1,1)$ for $i, j = 1, \ldots, N$, while setting $\iota_{j,1} = 1, \forall j$ and $N = 20$. The first country acts as a central country, has an exchange rate fixed to one, and a weight $h_1 = 1/3$. The second country is equally large with a weight $h_2 = 1/3$, whereas the remaining $N - 2$ countries have weights $h_j = 1/(3(N-2))$ for $j > 2$. For each sim-

ulated path, we compute the following variables: (i) the vector of trade deficits in period zero as $-\Omega_0 \underline{e}_0$, (ii) the vector of *direct connections* as $\left\{\sum_i \Lambda_{ij}\right\}_j$, (iii) the vector of *indirect connections* based on the eigenvector centrality of Λ as defined in proposition 1, (iv) the future gross exchange rate return $e_{j,1}/e_{j,0}$, and (v) and an indicator variable that equals one if country j is large (i.e., $h_j = 1/3$) and zero otherwise. We also include simulation fixed effects and all the unconditional variables that are part of each interaction, which we loosely label as controls.

A.5 From the Model to the Data

In this appendix we present a a straightforward extension of our model, where we introduce heterogeneous intermediaries with different demand curves for the long-short currency trade. This heterogeneity generates a theoretical link between gross financial claims that we use as an proxy for financial connections in our empirical analysis.

Following Bippus et al. (2023) and Bacchetta and Wincoop (2006), we assume that each cross is occupied by a mass of intermediaries indexed by a and period 1 outcomes are now uncertain. Each intermediary has a stochastic heterogeneous valuation of the forward position in peripheral currency given by b_{ji}^a, with CDF $F(\cdot)$ and expectation $\int b_{ji}^a da = 1$. This could represent heterogeneity in beliefs or a need to hedge non-asset income.

Consider now the perceived dollar value of an intermediary between countries 1 and 2 as

$$V_{21}^a = \mathbb{E}\left[\left(b_{21}^a \frac{e_{2,1}}{e_{2,0}} - 1\right)\right] Q_{21}^a,$$

and assuming that V_{21}^a enters the financial constraint, we obtain a demand curve at the intermediary level as

$$Q_{21}^a = \Lambda_{ji} \mathbb{E}\left[b_{21}^a e_{2,1} - e_{2,0}\right].$$

However, we also have that

$$Q_{21} = \int Q_{21}^a da = \Lambda_{ji} \mathbb{E}\left[e_{2,1} - e_{2,0}\right],$$

thus showing that the introduction of heterogeneity has no impact on the equations that pin down the overall level of the exchange rate. Even if intermediaries disagree, when summing across intermediaries the exchange rate needs to still clear the market. We can now define the total gross position between countries 1 and 2 as $\int \left|Q_{21}^a\right| da$. In the vicinity of $Q_{21}^a \approx 0$, meaning that net flows are small compared to gross flows (as in the data), we have that

$$\int |Q_{21}^a| \, da = \Lambda_{ji} e_{2,0} \left(\int_1^\infty (b_{21}^a - 1) \, dF(b_{12}^a) + \int_{-\infty}^1 (1 - b_{21}^a) \, dF(b_{21}^a) \right).$$

Hence, the gross position, in local currency terms, is a function of Λ_{ji} and the dispersion of b_{12}^a. Since the dispersion of b_{12}^a does not otherwise matter for the exchange rate, the gross flow is a valid proxy for Λ_{ji}.

B PROOFS

B.1 PROOF OF LEMMA 1

We start by imposing the simplifying assumption that financiers intermediating capital flows between country 1 and country 2 value their profits in euros so that $e_{s_{12},0} = e_{2,0}$, while financiers operating between country 1 and country 3 value their profits in yen so that $e_{s_{13},0} = e_{3,0}$. The net bond positions between country 1 and country 2 is then given by $Q_{21} = \Lambda_{21} (e_{2,1} - e_{2,0})$, whereas the net bond position between country 1 and country 3 corresponds to $Q_{31} = \Lambda_{31} (e_{3,1} - e_{3,0})$.

Since borrowing equals repayments when the , a trade deficit in period 0 must be offset by a surplus in period 1. Formally, this implies that

$$\Omega_1 e_1 = -\Omega_0 e_0$$

where

$$\Omega_t = \begin{pmatrix} -h_1(1-h_1)\iota_{1,t} & h_1h_2\iota_{2,t} & h_1h_3\iota_{3,t} \\ h_1h_2\iota_{1,t} & -h_2(1-h_2)\iota_{2,t} & h_2h_3\iota_{3,t} \\ h_1h_3\iota_{1,t} & h_2h_3\iota_{2,t} & -h_3(1-h_3)\iota_{3,t} \end{pmatrix}$$

so that

$$\begin{pmatrix} -h_1(1-h_1)\iota_{1,1} & h_1h_2\iota_{2,1} & h_1h_3\iota_{3,1} \\ h_1h_2\iota_{1,1} & -h_2(1-h_2)\iota_{2,1} & h_2h_3\iota_{3,1} \\ h_1h_3\iota_{1,1} & h_2h_3\iota_{2,1} & -h_3(1-h_3)\iota_{3,1} \end{pmatrix} \begin{pmatrix} 1 \\ e_{2,1} \\ e_{3,1} \end{pmatrix} =$$
$$-\begin{pmatrix} -h_1(1-h_1)\iota_{1,0} & h_1h_2\iota_{2,0} & h_1h_3\iota_{3,0} \\ h_1h_2\iota_{1,0} & -h_2(1-h_2)\iota_{2,0} & h_2h_3\iota_{3,0} \\ h_1h_3\iota_{1,0} & h_2h_3\iota_{2,0} & -h_3(1-h_3)\iota_{3,0} \end{pmatrix} \begin{pmatrix} 1 \\ e_{2,0} \\ e_{3,0} \end{pmatrix}.$$

Dropping the first row (which is redundant) gives

$$\begin{pmatrix} -h_2(1-h_2)\iota_{2,1} & h_2h_3\iota_{3,1} \\ h_2h_3\iota_{2,1} & -h_3(1-h_3)\iota_{3,1} \end{pmatrix} \begin{pmatrix} e_{2,1} \\ e_{3,1} \end{pmatrix} =$$
$$-\begin{pmatrix} h_1h_2(\iota_{1,1}+\iota_{1,0}) \\ h_1h_3(\iota_{1,1}+\iota_{1,0}) \end{pmatrix} - \begin{pmatrix} -h_2(1-h_2)\iota_{2,0} & h_2h_3\iota_{3,0} \\ h_2h_3\iota_{2,0} & -h_3(1-h_3)\iota_{3,0} \end{pmatrix} \begin{pmatrix} e_{2,0} \\ e_{3,0} \end{pmatrix}$$

and solving for $e_{2,1}$ and $e_{3,1}$ results in

$$e_{2,1} = \frac{\iota_{1,1}+\iota_{1,0}}{\iota_{2,1}} - \frac{\iota_{2,0}}{\iota_{2,1}} e_{2,0}$$

$$e_{3,1} = \frac{\iota_{1,1}+\iota_{1,0}}{\iota_{3,1}} - \frac{\iota_{3,0}}{\iota_{3,1}} e_{3,0}.$$

By setting $\iota_{1,1} = \iota_{2,1} = \iota_{3,1} = 1$, we obtain the exchange rates $e_{2,1}$ and $e_{3,1}$ in period 1 as

$$e_{2,1} = 1 + \iota_{1,0} - \iota_{2,0} e_{2,0}$$

$$e_{3,1} = 1 + \iota_{1,0} - \iota_{3,0} e_{3,0}.$$

We can then rewrite the net bond positions of financiers between countries 1 and 2 and countries 1 and 3 as

$$Q_{21} = \Lambda_{21}\left[(1+\iota_{1,0}) - (1+\iota_{2,0})\, e_{2,0}\right]$$

$$Q_{31} = \Lambda_{31}\left[(1+\iota_{1,0}) - (1+\iota_{3,0})\, e_{3,0}\right].$$

Write the balance of payment identities for period zero as

$$\begin{pmatrix} -h_1(1-h_1)\iota_{1,0} & h_1h_2\iota_{2,0} & h_1h_3\iota_{3,0} \\ h_1h_2\iota_{1,0} & -h_2(1-h_2)\iota_{2,0} & h_2h_3\iota_{3,0} \\ h_1h_3\iota_{1,0} & h_2h_3\iota_{2,0} & -h_3(1-h_3)\iota_{3,0} \end{pmatrix} \begin{pmatrix} 1 \\ e_{2,0} \\ e_{3,0} \end{pmatrix} + \begin{pmatrix} -Q_{21}-Q_{31} \\ Q_{21} \\ Q_{31} \end{pmatrix} - \begin{pmatrix} -f_2 \\ f_2 \\ 0 \end{pmatrix} = 0.$$

Drop the top row (which is redundant), and substitute $Q_{2,1}$ and $Q_{3,1}$ to obtain

$$\begin{pmatrix} h_1h_2\iota_{1,0} - f_2 \\ h_1h_3\iota_{1,0} \end{pmatrix} + \begin{pmatrix} -h_2(1-h_2)\iota_{2,0} & h_2h_3\iota_{3,0} \\ h_2h_3\iota_{2,0} & -h_3(1-h_3)\iota_{3,0} \end{pmatrix} \begin{pmatrix} e_{2,0} \\ e_{3,0} \end{pmatrix} = - \begin{pmatrix} \Lambda_{21}\left[(1+\iota_{1,0}) - (1+\iota_{2,0})\, e_{2,0}\right] \\ \Lambda_{31}\left[(1+\iota_{1,0}) - (1+\iota_{3,0})\, e_{3,0}\right] \end{pmatrix}.$$

Rearrange as

$$\begin{pmatrix} e_{2,0} \\ e_{3,0} \end{pmatrix} = \frac{1}{\left(\Lambda_{31}(\iota_{3,0}+1) + h_3(1-h_3)\iota_{3,0}\right)\left(\Lambda_{21}(\iota_{2,0}+1) + h_2(1-h_2)\iota_{2,0}\right) - \left(h_2h_3\right)^2\iota_{2,0}\iota_{3,0}}$$

$$\times \begin{pmatrix} \Lambda_{31}(\iota_{3,0}+1) + h_3(1-h_3)\iota_{3,0} & h_2h_3\iota_{3,0} \\ h_2h_3\iota_{2,0} & \Lambda_{21}(\iota_{2,0}+1) + h_2(1-h_2)\iota_{2,0} \end{pmatrix} \begin{pmatrix} \Lambda_{21}(1+\iota_{1,0}) + h_1h_2\iota_{1,0} - f_2 \\ \Lambda_{31}(1+\iota_{1,0}) + h_1h_3\iota_{1,0} \end{pmatrix},$$

and solve for $e_{2,0}$ since we take the perspective of country 2 as

$$e_{2,0} = \frac{\left(\Lambda_{21}(1+\iota_{1,0}) + h_1h_2\iota_{1,0} - f_2\right)\left(\Lambda_{31}(\iota_{3,0}+1) + h_3(1-h_3)\iota_{3,0}\right) + h_2h_3\iota_{3,0}\left(\Lambda_{31}(1+\iota_{1,0}) + h_1h_3\iota_{1,0}\right)}{\left(\Lambda_{31}(\iota_{3,0}+1) + h_3(1-h_3)\iota_{3,0}\right)\left(\Lambda_{21}(\iota_{2,0}+1) + h_2(1-h_2)\iota_{2,0}\right) - \left(h_2h_3\right)^2\iota_{2,0}\iota_{3,0}}.$$

This provides the expression for the equilibrium value of $e_{2,0}$.

We then move to point (i) of Lemma 1. First, we demonstrate that the currency of country 2 appreciates against the currency of country 1 whenever the latter economy experiences an increase in its import demand by showing that

$$\frac{de_{2,0}}{d\iota_{1,0}} > 0.$$

Specifically, the derivative of $e_{2,0}$ with respect to $\iota_{1,0}$ is given by

$$\frac{de_{2,0}}{d\iota_{1,0}} = \frac{(\Lambda_{21} + h_1h_2)\left(\Lambda_{31}(\iota_{3,0}+1) + h_3(1-h_3)\iota_{3,0}\right) + h_2h_3\iota_{3,0}\left(\Lambda_{31} + h_1h_3\right)}{\left(\Lambda_{31}(\iota_{3,0}+1) + h_3(1-h_3)\iota_{3,0}\right)\left(\Lambda_{21}(\iota_{2,0}+1) + h_2(1-h_2)\iota_{2,0}\right) - \left(h_2h_3\right)^2\iota_{2,0}\iota_{3,0}}, \tag{B.12}$$

which is positive as $h_3(1-h_3)h_2(1-h_2)\iota_{2,0}\iota_{3,0} > \left(h_2h_3\right)^2\iota_{2,0}\iota_{3,0}$ (since $0 < h_2, h_3 < 1/2$) and all other terms are positive. Second, we prove that the currency of country 2 depreciates against the currency of country 1 whenever the former economy experiences an increase in its import demand by showing that

$$\frac{de_{2,0}}{d\iota_{2,0}} < 0.$$

In particular, the derivative of $e_{2,0}$ with respect to $\iota_{2,0}$ is given by

$$\frac{de_{2,0}}{d\iota_{2,0}} = -\frac{\left(\Lambda_{31}(\iota_{3,0}+1) + h_3(1-h_3)\iota_{3,0}\right)\left(\Lambda_{21} + h_2(1-h_2)\right) - \left(h_2h_3\right)^2\iota_{3,0}}{\left(\Lambda_{31}(\iota_{3,0}+1) + h_3(1-h_3)\iota_{3,0}\right)\left(\Lambda_{21}(\iota_{2,0}+1) + h_2(1-h_2)\iota_{2,0}\right) - \left(h_2h_3\right)^2\iota_{2,0}\iota_{3,0}}e_{2,0}, \tag{B.13}$$

which is negative as $h_3(1-h_3)h_2(1-h_2)\iota_{2,0}\iota_{3,0} > \left(h_2h_3\right)^2\iota_{2,0}\iota_{3,0}$ and all other terms entering the quotient are positive.

Third, we prove that the currency of country 2 depreciates against the currency of country 1 whenever the former economy experiences a portfolio outflow by showing that

$$\frac{de_{2,0}}{df_2} < 0.$$

In particular, the derivative of $e_{2,0}$ with respect to f_2 is given by

$$\frac{de_{2,0}}{df_2} = \frac{-\left(\Lambda_{31}(\iota_{3,0}+1)+h_3(1-h_3)\iota_{3,0}\right)}{\left(\Lambda_{31}(\iota_{3,0}+1)+h_3(1-h_3)\iota_{3,0}\right)\left(\Lambda_{21}(\iota_{2,0}+1)+h_2(1-h_2)\iota_{2,0}\right)-\left(h_2h_3\right)^2\iota_{2,0}\iota_{3,0}}. \tag{B.14}$$

This is negative following the similar reasoning as above.

This completes the proof of point (i) of Lemma 1.

Then, we derive point (ii) of Lemma 1. We show that a stronger financial connection between countries 1 and 2 moderates the impact of an import demand shock in country 1 by proving that

$$\frac{d^2e_{2,0}}{d\iota_{1,0}d\Lambda_{21}} < 0 \tag{B.15}$$

In particular, by setting $\iota_{i,0} = 1$ for any country i and $f_2 = 0$, Equation (B.12) simplifies to

$$\frac{de_{2,0}}{d\iota_{1,0}} = \frac{\left(\Lambda_{21}+h_1h_2\right)\left(2\Lambda_{31}+h_3(1-h_3)\right)+h_2h_3\left(\Lambda_{31}+h_1h_3\right)}{\left(2\Lambda_{31}+h_3(1-h_3)\right)\left(2\Lambda_{21}+h_2(1-h_2)\right)-\left(h_2h_3\right)^2}. \tag{B.16}$$

Compute then the derivative with respect to Λ_{21} for both numerator and denominator as

$$2\Lambda_{31}+h_3(1-h_3),$$

$$2\left(2\Lambda_{31}+h_3(1-h_3)\right).$$

The necessary condition to satisfy Equation (B.15) is that

$$\left(2\Lambda_{31}+h_3(1-h_3)\right)\left[\left(2\Lambda_{31}+h_3(1-h_3)\right)\left(2\Lambda_{21}+h_2(1-h_2)\right)-\left(h_2h_3\right)^2\right] <$$
$$2\left(2\Lambda_{31}+h_3(1-h_3)\right)\left[\left(\Lambda_{21}+h_1h_2\right)\left(2\Lambda_{31}+h_3(1-h_3)\right)+h_2h_3\left(\Lambda_{31}+h_1h_3\right)\right],$$

which simplifies to

$$0 < 2h_2\Lambda_{31}+h_2h_3.$$

We next show that a stronger financial connection between countries 1 and 2 attenuates the impact of an import demand shock in country 2 by proving that

$$\frac{d^2 e_{2,0}}{d\iota_{2,0} d\Lambda_{21}} > 0. \tag{B.17}$$

By imposing $\iota_{i,0} = 1$ for any country i and $f_2 = 0$ in Equation (B.13), and noting $e_{2,0} = 1$ at this point, we obtain

$$\frac{de_{2,0}}{d\iota_{2,0}} = -\frac{(2\Lambda_{31} + h_3(1-h_3))(\Lambda_{21} + h_2(1-h_2)) - (h_2 h_3)^2}{(2\Lambda_{31} + h_3(1-h_3))(2\Lambda_{21} + h_2(1-h_2)) - (h_2 h_3)^2}. \tag{B.18}$$

The necessary condition to satisfy Equation (B.17) is that

$$\begin{aligned}(2\Lambda_{31} + h_3(1-h_3))\left[(2\Lambda_{31} + h_3(1-h_3))(2\Lambda_{21} + h_2(1-h_2)) - (h_2 h_3)^2\right] < \\ 2(2\Lambda_{31} + h_3(1-h_3))\left[(2\Lambda_{31} + h_3(1-h_3))(\Lambda_{21} + h_2(1-h_2)) - (h_2 h_3)^2\right],\end{aligned}$$

which reduces to

$$0 < \left[(2\Lambda_{31} + h_3(1-h_3))\, h_2(1-h_2) - (h_2 h_3)^2\right].$$

To complete the proof next show that a stronger financial connection between countries 1 and 2 attenuates the impact of a portfolio flow in country 2 by proving that

$$\frac{d^2 e_{2,0}}{df_2 d\Lambda_{21}} > 0. \tag{B.19}$$

This follows directly from inspection of Equation (B.13) as the expression is a negative quotient, and an increase in Λ_{21} only increases the denominator.

This completes the proof of point (ii) of Lemma 1.

B.2 PROOF OF PROPOSITION 1

We start by proving point (i) of Proposition 1. Recall Equation (B.16) and compute the derivative of the numerator with respect to Λ_{31} as

$$2\left(\Lambda_{21}+h_1h_2\right)+h_2h_3,$$

and the derivative of the denominator with respect to Λ_{31} as

$$2\left(2\Lambda_{21}+h_2(1-h_2)\right).$$

The condition

$$\frac{d^2e_{2,0}}{d\iota_{1,0}d\Lambda_{31}}<0$$

is obtained by showing that

$$\begin{aligned}&\left[2\left(\Lambda_{21}+h_1h_2\right)+h_2h_3\right]\left[\left(2\Lambda_{31}+h_3(1-h_3)\right)\left(2\Lambda_{21}+h_2(1-h_2)\right)-\left(h_2h_3\right)^2\right]<\\&2\left(2\Lambda_{21}+h_2(1-h_2)\right)\left[\left(\Lambda_{21}+h_1h_2\right)\left(2\Lambda_{31}+h_3(1-h_3)\right)+h_2h_3\left(\Lambda_{31}+h_1h_3\right)\right].\end{aligned}$$

Let $A=\left(2\Lambda_{21}+h_2(1-h_2)\right)$ and rewrite the above condition as

$$\left[\left(2\Lambda_{31}+h_3(1-h_3)\right)A-\left(h_2h_3\right)^2\right]-\left[2\left(\Lambda_{21}+h_1h_2\right)+h_2h_3\right]\left(h_2h_3\right)<2\left(\Lambda_{31}+h_1h_3\right)A,$$

which reduces to

$$h_3(1-h_3)A<2h_1h_3A+\left(h_2h_3\right)^2+\left[2\left(\Lambda_{21}+h_1h_2\right)\right]\left(h_2h_3\right),$$

or equivalently to

$$0<\left(h_1-h_2\right)h_3A+\left(h_2h_3\right)^2+\left[2\left(\Lambda_{21}+h_1h_2\right)\right]\left(h_2h_3\right),$$

since $(1-h_3)=h_1+h_2$. The above condition is always true under the assumption that $h_1\geq h_2$. This completes the proof of point (i) Proposition 1.

We then move to proving point (ii) of Proposition 1. Recall Equation (B.18) and compute the derivative of the numerator with respect to Λ_{31} is

$$2\left(\Lambda_{21}+h_2(1-h_2)\right),$$

and the denominator with respect to Λ_{31} as

$$2\left(2\Lambda_{21}+h_2(1-h_2)\right).$$

The condition for having

$$\frac{d^2 e_{2,0}}{d\iota_{2,0} d\Lambda_{31}} < 0$$

is given by

$$\begin{aligned} &2\left(2\Lambda_{21}+h_2(1-h_2)\right)\left(\left(2\Lambda_{31}+h_3(1-h_3)\right)\left(\Lambda_{21}+h_2(1-h_2)\right)-\left(h_2h_3\right)^2\right) < \\ &2\left(\Lambda_{21}+h_2(1-h_2)\right)\left(\left(2\Lambda_{31}+h_3(1-h_3)\right)\left(2\Lambda_{21}+h_2(1-h_2)\right)-\left(h_2h_3\right)^2\right), \end{aligned} \tag{B.20}$$

which reduces to an always true condition

$$-\left(2\Lambda_{21}+h_2(1-h_2)\right)\left(h_2h_3\right)^2 \leq -\left(\Lambda_{21}+h_2(1-h_2)\right)\left(h_2h_3\right)^2.$$

This completes the proof of point (ii) Proposition 1.

To prove point (iii) of Proposition 1 recall Equation (B.14) and evaluate it at the point where $\iota_{i,0}=1$ for any country i and $f_2=0$ to obtain:

$$\frac{de_{2,0}}{df_2} = \frac{-\left(2\Lambda_{31}+h_3(1-h_3)\right)}{\left(2\Lambda_{31}+h_3(1-h_3)\right)\left(2\Lambda_{21}+h_2(1-h_2)\right)-\left(h_2h_3\right)^2}. \tag{B.21}$$

The derivative of the numerator in Equation (B.21) with respect to Λ_{31} is -2, the derivative of the denominator with respect to Λ_{31} is $2\left(2\Lambda_{21}+h_2(1-h_2)\right)$. Therefore, the condition

for having

$$\frac{d^2 e_{2,0}}{df_2 d\Lambda_{31}} > 0$$

is given by

$$2\left(2\Lambda_{13}+h_3(1-h_3)\right)\left(2\Lambda_{13}+h_2(1-h_2)\right) > 2\left(\left(2\Lambda_{13}+h_3(1-h_3)\right)\left(2\Lambda_{12}+h_2(1-h_2)\right)-\left(h_2h_3\right)^2\right), \tag{B.22}$$

which reduces to the always true condition

$$2\left(h_2h_3\right)^2 > 0.$$

To prove point (iv) of Proposition 1, it is sufficient to show that Equation (B.20) and Equation (B.22) hold with equality as $h_2 \to 0$. This is obvious from inspection. This completes the proof of Proposition 1.

B.3 Proof of Lemma 2

The balance of payments condition for country j in period zero can be written as

$$h_j \sum_i h_i e_{i,0}\iota_{i,0} - \sum_{i\neq j}\Lambda_{ji}\frac{e_{i,1}}{e_{i,0}} = h_j e_{j,0}\iota_{j,0} - \sum_{i\neq j}\Lambda_{ji}\frac{e_{j,1}}{e_{j,0}} + f_j. \tag{B.23}$$

In vector notation, this condition amounts to

$$h_j \underline{\iota}_0' H \underline{e}_0 - \tilde{\Lambda}_j\left(\underline{e}_1 \oslash \underline{e}_0\right) = h_j e_{j,0}\iota_{j,0} + \tilde{\Lambda}_j\left(\frac{e_{j,1}}{e_{j,0}} \otimes 1_N\right) + f_j, \tag{B.24}$$

where $\underline{\iota}_t = (\iota_{1,t}, \iota_{2,t}, \ldots, \iota_{N,t})'$, $\underline{e}_t = (1, e_{2,t}, \ldots, e_{N,t})'$, $H = diag\{h_1, h_2, \ldots, h_N\}$, 1_N is a vector of ones, and $\tilde{\Lambda}_j$ denotes the j-th row of the matrix $\tilde{\Lambda}$, whose off-diagonal elements equal to Λ_{ji} and zeroes on the main diagonal. Also, $\odot$ denotes the Hadamard product, $\oslash$ indicates the Hadamard inverse, and $\otimes$ refers to the Kronecker product.

By stacking Equation (B.24) across N countries, we obtain

$$H\left(1_N \otimes \underline{\iota}_0' H\right) \underline{e}_0 - \tilde{\Lambda}\left(\underline{e}_1 \oslash \underline{e}_0\right) = H\left(\underline{\iota}_0 \odot \underline{e}_0\right) - \left(\tilde{\Lambda} 1_N\right) \odot \left(\underline{e}_1 \oslash \underline{e}_0\right) + \underline{f}, \tag{B.25}$$

where $\underline{f} = (f_1, f_2, \ldots, f_N)'$. The above equation can be simplified to

$$\Omega_0 \underline{e}_0 + \Lambda\left(\underline{e}_1 \oslash \underline{e}_0\right) - \underline{f} = 0, \tag{B.26}$$

by setting

$$\Omega_t = H\left(1_N \otimes \underline{\iota}_t' H\right) - \operatorname{diag}\{H \underline{\iota}_t\}, \quad t = 0, 1,$$

$$\Lambda = \operatorname{diag}\{\tilde{\Lambda} 1_N\} - \tilde{\Lambda}.$$

The parallel condition for period one is

$$\Omega_1 \underline{e}_1 - \Lambda\left(\underline{e}_1 \oslash \underline{e}_0\right) + \underline{f} = 0. \tag{B.27}$$

This concludes the proof of Lemma 2.

C EMPIRICS

C.1 EIGENVECTOR CENTRALITY

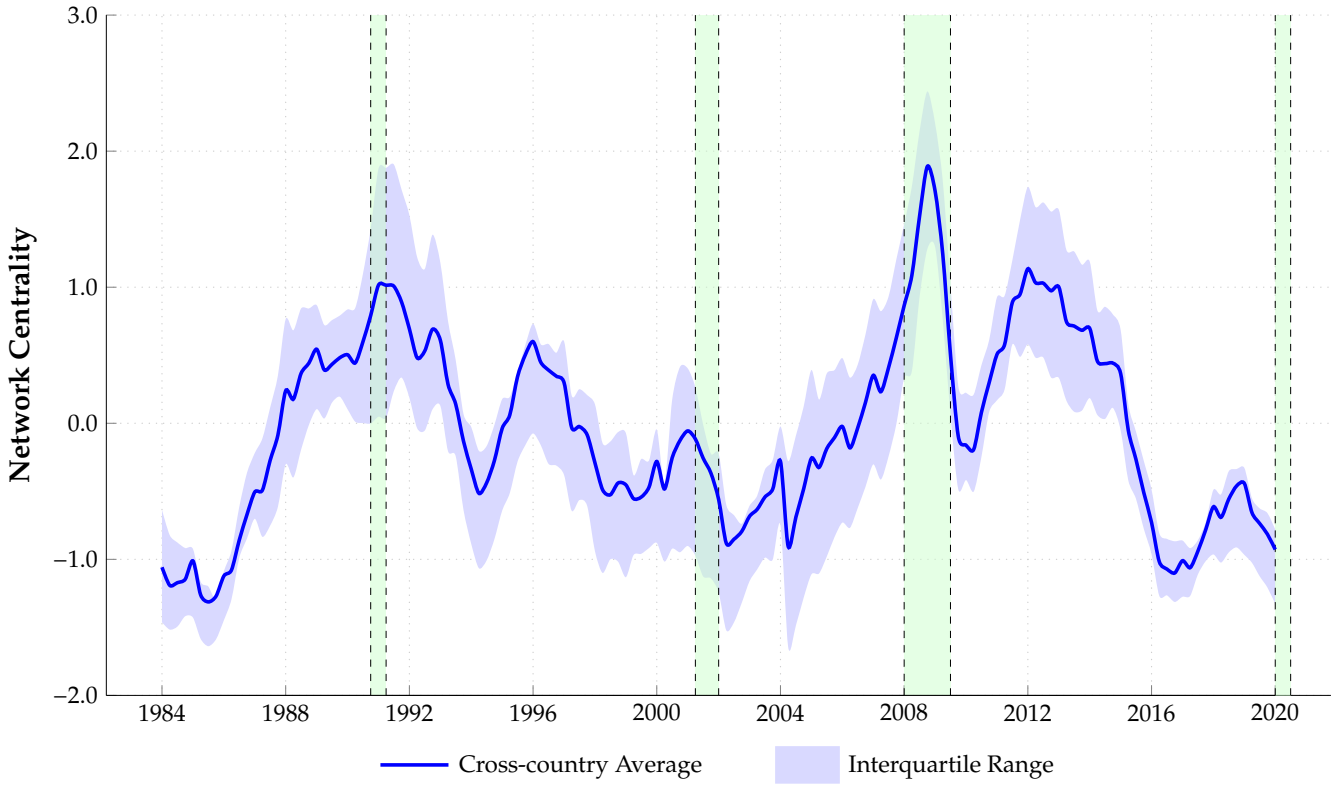


FIGURE A.1. TRADE CENTRALITY

This figure displays the cross-country correlation between two standardized measures of banking centrality, i.e., one based on cross-border claims an liabilities denominated in US dollars and another one based on cross-border claims an liabilities denominated in the local currency of the lender (non-vehicle currencies). Cross-border claims and liabilities are from the Locational Banking Statistics by residence. The vertical shaded areas denote US recessions based on NBER dates. The sample runs at the quarterly frequency between March 1984 and September 2022.

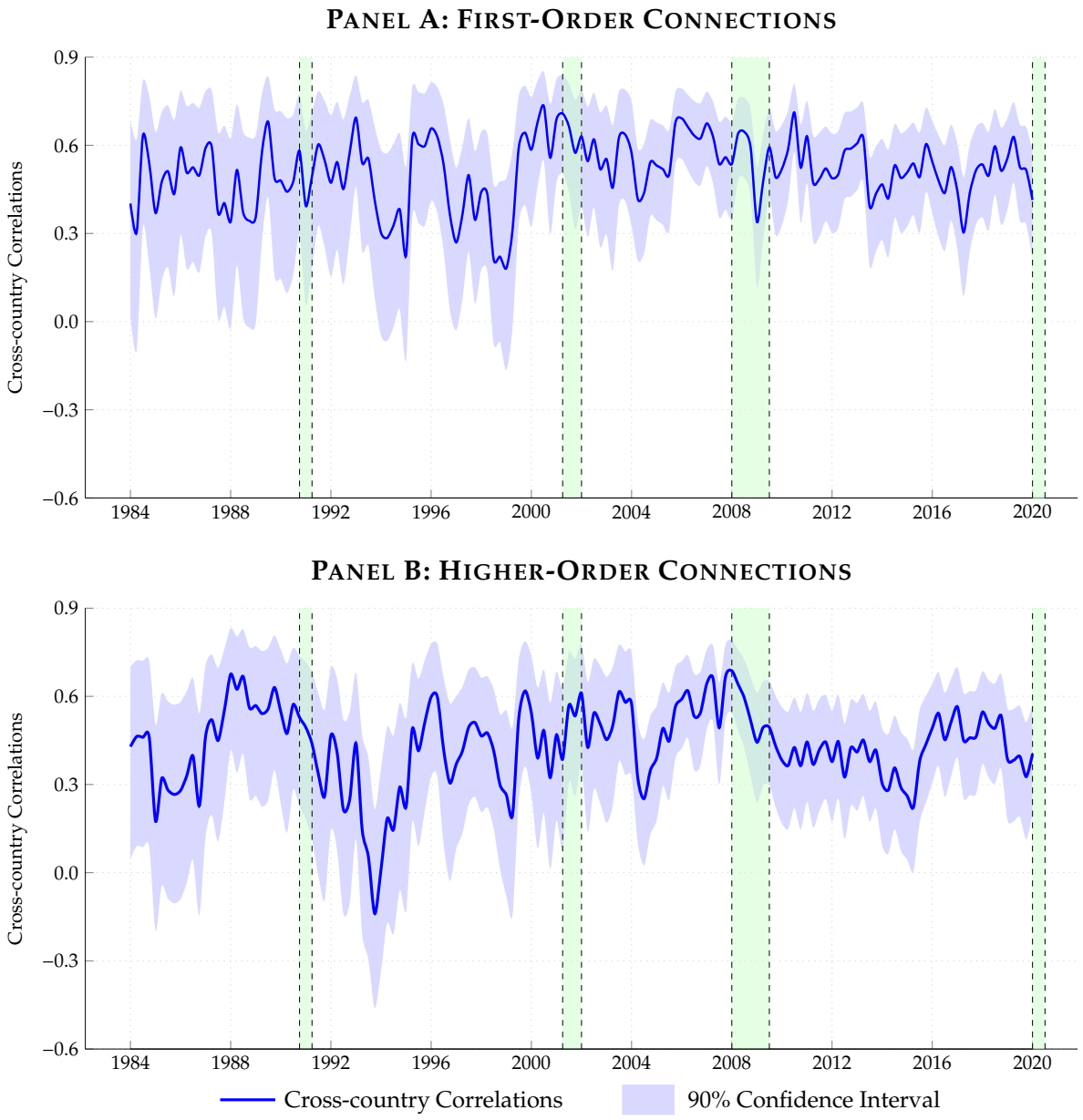


FIGURE A.2. BANKING CENTRALITY: US DOLLARS VS LOCAL CURRENCIES

This figure displays the cross-country correlation between two standardized measures of banking centrality, i.e., one based on cross-border claims an liabilities denominated in US dollars and another one based on cross-border claims an liabilities denominated in the local currency of the lender (non-vehicle currencies). Cross-border claims and liabilities are from the Locational Banking Statistics by residence. The vertical shaded areas denote US recessions based on NBER dates. The sample runs at the quarterly frequency between March 1984 and September 2022.