BEYOND BILATERAL FLOWS: INDIRECT CONNECTIONS AND EXCHANGE RATES*

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Beyond Bilateral Flows: Indirect Connections and Exchange Rates

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.

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JEL Classification: F21, F30, F31, G12, G15, G21

1 INTRODUCTION

The ability of financial institutions to facilitate the movement of capital between economies is an important determinant of exchange rates (e.g., Bruno and Shin, 2015; Gabaix and Maggiori, 2015; Fang, 2021; Du et al., 2023). 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 connections – i.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 shapes the way capital flows through the financial system. Yet, the role of these indirect financial connections in exchange rate determination remains poorly understood.

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 rates, 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. We also show 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 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]

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 con-

[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.

struct 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).

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. A related literature considers how barriers to the flow of capital between countries affect international portfolio choices and capital allocation in multicountry settings (Minetti, Romanini and Ziv (2024, 2025); Capelle and Pellegrino (2025); Pellegrino, Spolaore and Wacziarg (2025)). The network through which capital can flow is central to this literature. However, unlike our approach, these studies typically model barriers as fixed wedges and exchange rates do not play a central role.

Our work also fits into an extensive literature on understanding the factors behind cross-sectional variation in currency 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 Gabaix and Maggiori (2015)'s model of exchange rate determination with imperfect financial markets of to an arbitrary number of countries. 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 consume a domestic nontradable, a domestic tradable, and imported tradables. The nontradable good is the numéraire, so that exchange rates are the relative price between countries' nontradable goods. Households have endowments of domestic goods, do not discount the future, and there is no uncertainty.

Financial markets are segmented: households trade only local currency risk-free bonds, and our endowment assumptions imply zero net interest rates. Households also have an exogenous (perfectly inelastic) demand for foreign bonds interpreted as noise trading or policy interventions; 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 exchange rate movements. In doing so, financiers intermediate capital flows along a bilateral connection between the corresponding countries. Importantly, a limited commitment problem means financiers' demand for bonds in each currency is downward-sloping. Financier profits are rebated lump-sum so that households are insulated from valuation effects. For brevity, details of households and financiers' problems are in Internet Appendices A.1-A.3 (they are close to Gabaix and Maggiori (2015)); here, we work directly with the resulting balance of payments identities.

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 is country i's size (normalized so $\sum_i h_i = 1$). We assume trade shares equal country sizes, so h_i is also the taste weight on good i. The parameter $\iota_{j,t}$ pins down country j's total 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. An increase is a dollar depreciation. Aggregating across markets, the dollar value of country j's net exports at time t is

$$NX_{j,t} = \underbrace{h_j \textstyle\sum_{i \neq j} (h_i e_{i,t} \iota_{i,t})}_{\text{export revenues}} - \underbrace{h_j (1 - h_j) e_{j,t} \iota_{j,t}}_{\text{import spending}}. \tag{1}$$

Let f_j denote the dollar value of j's inelastic portfolio flow abroad net of foreigners' portfolio flow to j (so that $\sum_j f_j = 0$). Combining this with equation (1) and accounting for financiers' profits, the dollar-denominated balance of payments identities for country j at $t = 0$ and $t = 1$ respectively are

$$NX_{j,0} - \underbrace{f_j}_{\text{net portfolio flows}} + \underbrace{\sum_{i \neq j} \Lambda_{ji} e_{s_{ji},0} \left(\frac{e_{j,1}}{e_{j,0}} - \frac{e_{i,1}}{e_{i,0}} \right)}_{\text{net borrowing from financiers}} = 0, \tag{2}$$

$$NX_{j,1} + \underbrace{f_j}_{\text{net portfolio flows}} - \underbrace{\sum_{i \neq j} \Lambda_{ji} e_{s_{ji},0} \left(\frac{e_{j,1}}{e_{j,0}} - \frac{e_{i,1}}{e_{i,0}} \right)}_{\text{net repayments to financiers}} = 0. \tag{3}$$

The first identity states that the net borrowing from financiers in period 0 must equal the country's trade deficit plus f_j. Financiers lend or borrow with downward-sloping demand curves: the net position intermediated by financiers between countries i and j is $\Lambda_{ji} e_{s_{ji},0} \left(\frac{e_{j,1}}{e_{j,0}} - \frac{e_{i,1}}{e_{i,0}} \right)$. The term $\left(\frac{e_{j,1}}{e_{j,0}} - \frac{e_{i,1}}{e_{i,0}} \right)$ is the dollar return differential from borrowing in currency i and buying bonds in currency j (recall, net interest rates are nil). Financiers value their profits in a currency s_{ji} so their position is scaled by $e_{s_{ji},0}$. The key object is Λ_{ji}: it is symmetric ($\Lambda_{ij} = \Lambda_{ji}$) and governs the slope of the demand curve for country j's bond from the financiers between i and j as a function of the return differential. Hence, the parameter determines how elastically capital can flow between the two countries. A lower Λ_{ji} implies a greater return differential is required to intermediate a given capital flow from i to j.

The $t = 1$ identity states that a country's trade balance plus its net cashflow f_j from its foreign portfolio position is sufficient to repay the financiers the dollar amount the country borrows in period 0. Financiers' profits are rebated lump-sum so that each country's valuation gains/losses vis-à-vis the dollar on foreign-currency positions are exactly offset by the transfer. An equilibrium is a set of exchange rates in both periods that ensure that the balance of payments identities in Equation (2) and Equation (3) are satisfied for all j. In each period, only $N - 1$ balance of payments identities are independent (one is redundant by global aggregation).

Direct and Indirect Connections. Because countries can potentially borrow from $N - 1$ counterparties, how elastically country j can meet its external financing needs depends on the vector $\{\Lambda_{ji}\}_{i \neq j}$. We refer to these as the country's *direct* financial connections. When these connections are stronger (higher Λ_{ji}), financiers intermediate capital flows more elastically, so a given external-balance shock moves $e_{j,0}$ less.

However, capital flows to country j depend not just on the return on its own exchange rate ($e_{j,1}/e_{j,0}$) but also on the return on its counterparties' exchange rates (i.e., the $e_{i,1}/e_{i,0}$ terms in (2) and (3)). Counterparty exchange rates depend not just on the counterparty's connection to j but also on its financial connections to other countries in the global economy. Concretely, imagine a scenario where financiers are borrowing in currency i to lend in currency j. If country i strengthens its direct financial connection with a third country

k, this affects $e_{i,1}/e_{i,0}$, i.e. the dollar value of the borrowing in currency i, and therefore changes the return differential faced by financiers operating between i and j. From country j's perspective, this is a change in its *indirect* financial connection to country k. These indirect connections affect $e_{j,0}$ even holding $\{\Lambda_{ji}\}_{i \neq j}$ fixed.

The role of indirect connections is less intuitive and depends on the source of exchange-rate movements. To build intuition, we first present comparative statics in a three-country case with closed-form solutions. We then briefly discuss the extension to an arbitrary number of financially connected countries, which we solve numerically, before turning to empirical predictions.

2.3 A Three-Country Example

We now consider a simplified example involving three countries. We label country 1 as the US, country 2 as the Eurozone and country 3 as Japan. Their respective sizes satisfy $h_1 < 1/2$ and $h_1 \geq h_2, h_3$. To sharpen our analysis, we 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. We further assume that: (i) financiers operating between the US and Eurozone value profits in euros ($s_{12} = s_{21} = 2$), while those operating between the US and Japan value profits in yen ($s_{13} = s_{31} = 3$); (ii) $f_3 = 0$, so that there are no net portfolio flows from Japan; and (iii) $\iota_{i,1} = 1$ for all i (period-1 shocks are discussed in Appendix B.XXXX).

To explore the role of *direct* and *indirect* connections, we study the response of the euro–dollar exchange rate $e_{2,0}$ to time-0 shocks that generate capital flows. We consider changes in (i) Eurozone import demand, $\iota_{2,0}$; (ii) a portfolio outflow from the Eurozone to the US, f_2; and (iii) US import demand, $\iota_{1,0}$. Our interest is in how these responses vary with the strength of the Eurozone's direct and, more importantly, indirect financial connections. From the perspective of the Eurozone, the direct financial connection is given by Λ_{12}, capturing how elastically capital can flow between the US and the Eurozone, and the indirect financial connection is given by Λ_{13}, capturing how elastically capital can flow between the US and Japan.

Under these assumptions, Internet Appendix B proves the following result:

Lemma 1. *From the perspective of country 2*

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

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

Lemma 1's findings and intuition are identical to the standard two-country model with imperfectly elastic capital flows. Consider 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 fund this deficit by intermediating a capital flow between the Eurozone and the US – borrowing in euros and lending in dollars. For financiers to profit from the flow, the euro appreciates against the dollar in period 0, followed by a depreciation in period 1. The size of the required exchange-rate movement depends on Λ_{12}: the larger Λ_{12}, the more elastic are capital flows between the US and the Eurozone, and the smaller is the required return differential. 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 elasticity of capital flows between the US and Japan alters the response of the euro to changes at home or abroad. How do $de_{2,0}/d\iota_{1,0}$, $de_{2,0}/d\iota_{2,0}$, and $de_{2,0}/df_2$ vary with Λ_{13}? The appendix proves the following result.

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

(i) $de_{2,0}/d\iota_{2,0}$ is decreasing in Λ_{13}: a stronger indirect connection amplifies the current depreciation of country 2's currency in response to an increase in import demand in country 2.

(ii) $de_{2,0}/d\iota_{1,0}$ is decreasing in Λ_{13}: a stronger indirect connection dampens the current appreciation of country 2's currency in response to an increase in import demand in country 1.

(iii) *$de_{2,0}/df_2$ is increasing in Λ_{13}: a stronger indirect connection dampens the current depreciation of country 2's currency in response to a portfolio outflow from country 2.*

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

Proposition 1(i) examines an increase in $\iota_{2,0}$, causing a Eurozone trade deficit, US and Japanese surpluses, and an immediate depreciation of the euro against the dollar. Higher Λ_{13} amplifies this move in $e_{2,0}$. Japan recycles its trade surplus back to Europe via the US. A higher Λ_{13} means that, all else equal, flows of capital from Japan to the US rise.[2] For financiers operating between the Eurozone and the US to absorb this extra Japanese capital, the euro needs to depreciate further against the dollar. Essentially, a higher Λ_{13} acts as a supply shifter that moves the equilibrium along the demand curve of financiers operating between the US and the Eurozone.

Proposition 1(ii) examines an increase in $\iota_{1,0}$, causing a US trade deficit, Japanese and Eurozone surpluses, and an immediate appreciation of the euro against the dollar. A higher Λ_{13} dampens this move in $e_{2,0}$. Intuitively, when Λ_{13} rises, Japan finances a greater share of the US deficit. The Eurozone finances a smaller share. As a result, financiers operating between the US and the Eurozone intermediate a smaller capital flow. This lowers the required return differential, manifesting as a smaller euro appreciation relative to the dollar in period 0 (and a smaller depreciation in period 1).

Proposition 1(iii) examines a portfolio outflow from the Eurozone. The intuition behind this case is very similar to point (ii). An increase in f_2 increases the supply of capital in the US that financiers seek to lend to Japan and the Eurozone. To generate the required

[2] These Japanese outflows generate an immediate yen appreciation against the dollar. A higher Λ_{13} moderates the yen appreciation in line with Lemma 1. 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 is 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 a depreciation in period 1 (see Appendix XXX).

return differentials, there is an immediate euro and yen depreciation. An increase in Λ_{13} means that more of the capital in the US can flow to Japan, easing the pressure on the euro to depreciate and dampening the move in $e_{2,0}$.

Proposition 1(iv), finally, points out that higher Λ_{13} no longer affects the sensitivity of $e_{2,0}$ to domestic shocks when country 2 is small. Intuitively, when country 2 is small, changes in its external balance cannot meaningfully affect the capital flow between countries 1 and 3. Since Λ_{13} is relevant only due to the change in capital flows between the US and Japan, the mechanism vanishes when the induced change in flows is negligible.

To sum up, Proposition 1 shows that stronger indirect connections can either amplify or dampen the effect of temporary changes to a country's external position, provided the country is sufficiently large. Which case obtains depends on whether the third country's induced capital flow moves in the same or opposite direction as country 2's trade balance. When capital flows from country 1 to both countries 2 and 3 move in the same direction (e.g., when $\iota_{1,0}$ or f_2 increases), a stronger connection to the third country takes pressure off the domestic currency because the third country can finance a larger share of the adjustment. When capital flows move in opposite directions (e.g., when $\iota_{2,0}$ increases), stronger third-country connections imply that more foreign surpluses are recycled back toward country 2 (and foreign deficits draw finance away from it), increasing the flow that financiers on the 1–2 leg must absorb and thus putting additional pressure on the exchange rate.[3]

2.4 A MULTI-COUNTRY MODEL.

We now consider a case with N countries and Λ_{ji} with arbitrary nonnegative values, only imposing that all countries have some path to country 1. We also assume that financiers value their business in dollars so $e_{s_{ji},0} = 1$ for all country pairs. Let $\underline{\iota}_t = (\iota_{2,t}, \ldots, \iota_{N,t})'$, $\underline{f} = (f_2, \ldots, f_N)'$ $\underline{h} = (h_2, \ldots, h_N)'$, $\underline{e}_t = (e_{2,t}, \ldots, e_{N,t})'$. By stacking together the balance-

[3]This logic makes it clear how the results in Proposition 1 extend to shocks to country 3. An increase f_3 and an increase in $i_{3,0}$ both generate financial surpluses in countries 1 and 2 that need to flow back to 3. As a result, capital flows from to 2 and 3 to country 1 are in the opposite direction. Accordingly, increasing Λ_{13}, amplifies the effect of both shocks on $e_{2,0}$, as there is a greater outflow from country 2 to country 1.

of-payments identities for $j = 2, \ldots, N$, we obtain

$$h_1 \iota_{1,0} \underline{h} + \Omega \left(\underline{\iota}_0 \odot \underline{e}_0 \right) - \underline{f} + \mathbf{\Lambda} \left(\underline{e}_1 \oslash \underline{e}_0 \right) - \underline{\lambda} = 0, \tag{4}$$

$$h_1 \iota_{1,1} \underline{h} + \Omega \left(\underline{\iota}_1 \odot \underline{e}_1 \right) + \underline{f} - \mathbf{\Lambda} \left(\underline{e}_1 \oslash \underline{e}_0 \right) + \underline{\lambda} = 0, \tag{5}$$

where $\odot$ and $\oslash$ denote element-wise multiplication and division, $\underline{\lambda} = (\Lambda_{21}, \ldots, \Lambda_{N1})'$ are direct connections to country 1, and $\Omega \equiv \mathrm{diag}(\underline{h})(\mathbf{1}_{N-1}\underline{h}' - I_{N-1})$ and $\mathbf{\Lambda}$ are matrices of trade and financial connections. The latter, defined in full in Internet Appendix B.3, is the grounded Laplacian of the matrix of Λ_{ij}'s. The appendix proves the following

Proposition 2. *Consider a linear approximation of* (4) *and* (5) *around the balanced-trade point* $\underline{\iota}_1 = \underline{\iota}_0 = \mathbf{1}_{N-1}$, $\iota_{1,0} = \iota_{1,1} = 1$, *and* $\underline{f} = 0$, *so that* $\underline{e}_1 = \underline{e}_0 = \mathbf{1}_{N-1}$. *Let variables with a* $\hat{\cdot}$ *denote deviations from balanced trade. Setting* $\hat{\underline{\iota}}_1 = 0$ *and* $\hat{\iota}_{1,1} = 0$, *and assuming the spectral radius of the matrix* $2\Omega^{-1}\mathbf{\Lambda}$ *is less than 1, then the vector of period-0 exchange rates is given by*

$$\hat{\underline{e}}_0 \;=\; -\sum_{m=0}^{\infty} (2\Omega^{-1}\mathbf{\Lambda})^m \, q, \qquad q \;\equiv\; \left(I_{N-1} - \Omega^{-1}\mathbf{\Lambda} \right) \left(\hat{\underline{\iota}}_0 + \Omega^{-1} \underline{h} h_1 \hat{\iota}_{1,0} \right) - \Omega^{-1} \hat{\underline{f}}. \tag{6}$$

At a high level, Proposition 2 confirms that the complete matrix of financial connections, $\mathbf{\Lambda}$, determines the exchange rate. Likewise, the matrix Ω captures network of trade relationships. This links to existing work on trade networks and exchange rate returns (Richmond, 2019). Trade and financial networks are likely correlated, so it is important to control for the former when exploring the role played by the latter.

Beyond this, equation (6) connects to our key notions of *direct* and *indirect* financial connections. One can interpret, q, as aggregating the shocks to period-0 import demand and portfolio flows (period-1 shocks have been set to zero for brevity and are discussed in Appendix B.XXXX). The terms multiplying q capture network propagation through the matrix $2\Omega^{-1}\mathbf{\Lambda}$. The term for $m = 0$ captures the direct effect of the shock, while $m \geq 1$ captures indirect effects operating through chains of counterparties in the financial network (add appropriate references here). The matrix $2\Omega^{-1}\mathbf{\Lambda}$ also has a natural interpretation, it can be decomposed into two terms

$$2\Omega^{-1}\mathbf{\Lambda} \;=\; -2\mathrm{diag}(\underline{h})^{-1}\mathbf{\Lambda} \;-\; \frac{2}{h_1}\mathbf{1}\big(\mathbf{1}'\mathbf{\Lambda}\big).$$

The first term is an inverse-size weighted financial network, where the size weighting essentially just rescales financial connections to per-capita terms. The second term captures average connectivity across the network scaled by the size of the central country. To preview our empirical analysis, our focus will be on variation in country-level connectivity, i.e. the first term, and we will have less to say on the role of average connectivity.

Equation (6) does not specify how direct and indirect connections amplify or dampen specific shocks. And it is not possible to do so without placing structure on the matrices. To ensure that the logic in 1 extends to the multicountry setting we present two additional exercises in the appendix. First in Appendix B.XXXX, we consider a several different multi-country network structures and conduct the same comparative statics as in Proposition XXXX to confirm the findings generalise. Second, in Appendix XXXX, we simulate the multi-country model with an arbitrary N-country networks and confirm using regressions on the simulated data, designed to match our empirical specification, that amplifying and dampening effects are present.

2.5 Summary: Empirical Predictions

Let us summarise the model by providing empirical predictions. These are framed in terms of *direct* and *indirect* connections and how they affect future exchange rate returns. We presented theoretical results on the period-0 value of the exhcnage rate. In the dat but 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 dampens 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. A stronger direct connection to this country should moderate the magnitude of its future exchange rate return.

Prediction 1. *An increase in a country's indirect financial connections dampens 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.

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*.

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 empirical 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 From the Model to the Data: the use of gross flows

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.6. 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 Λ_{ji} using a granular instrumental variables (GIV) approach of Gabaix and Koijen (2024)

3.2 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.[4]

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

[4]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).

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 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 3.3, 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$\times$fund$\times$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.

3.3 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 3.1 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 $\sum_{i \neq j} \Lambda_{ji}$, i.e. for each country it 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:

$$\texttt{Ind}_t = \lambda_t^{-2} A_t^2 1_N + \lambda_t^{-3} A_t^3 1_N + \lambda_t^{-4} A_t^4 1_N + \ldots = \sum_{\ell=2}^{\infty} \lambda_t^{-\ell} A_t^{\ell} 1_N, \tag{7}$$

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. According to our model, the network of financial intermediation that matters for exchange rate determination is the one denominated in the currencies of the countries involved. 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.

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, development, 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.

3.4 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.[5] 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, 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

[5]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.2.

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. Finally, we show the robustness of our results in the last subsection.

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 3.1, we now provide empirical evidence on the relationship between gross banking intermediation and the ability of financiers in absorbing capital flows denominated in local currency.

For reasons that will be become clear momentarily we focus on shocks to portfolio flows. In particular, in Lemma **??** we have shown that an increase in net portfolio outflows is associated with an increase exchange rate returns that is dampened by stronger direct financial connections.

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 response to exogenous portfolio flows declines with higher levels of gross banking intermediation. To test this hypothesis, we run panel regressions subsumed by the following specification

$$y_{j,t} = \alpha \texttt{Dir}_{j,t} + \beta \texttt{Equity}_{j,t} + \delta(\texttt{Equity}_j \times \texttt{Dummy}_{j,\alpha})_t + \texttt{Controls}_{j,t} + fe + \varepsilon_{j,t} \tag{8}$$

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 Granular Instrumental Variables (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 (8), 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

$$z_{j,t} = \mu_{j,t} z^{out}_{j,t} - (1 - \mu_{j,t}) z^{in}_{j,t}, \tag{9}$$

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 (9) 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 (8).[6]

TABLE 4 ABOUT HERE

In Table 4, we report the two-stage least-squares estimates of Equation (8), using $z_{j,t}$ from Equation (9) 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% 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.

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

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 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. Moreover, the magnitude of the estimates is economically significant; for instance, when gross intermediation is above one standard deviation, the exchange rate multiplier to net portfolio equity flows is reduced by about 85%, leading to more elastic exchange rates.

4.2 Indirect Connections and Future Exchange Rate Returns

We now move to testing the theoretical predictions 1 and 2 described in Section 2.5 by running panel regressions based on the following specification

$$\begin{aligned} y_{j,t+1} &= \alpha \texttt{Ind}_{j,t} + \beta(\texttt{Ind}_j \times \texttt{Shock}^{+}_{us})_t + \gamma(\texttt{Ind}_j \times \texttt{Shock}^{-}_{j})_t + \delta(\texttt{Ind}_j \times \texttt{Shock}^{-}_{j} \times \texttt{Large}_j)_t \\ &\quad + \texttt{Controls}_{j,t} + fe + \varepsilon_{j,t+1}, \end{aligned} \tag{10}$$

where $y_{j,t+1}$ is the future exchange rate return of country j expressed in percentage per annum, $\texttt{Ind}_j$ are the *indirect* connections 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 $\texttt{Controls}_j$ includes country-specific variables as the capital account openness of Chinn and Ito (2006), forward premium, the share of world GDP, trade centrality and the trade deficit. 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 a negative import demand shock that originates in 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 a deterioration of its trade balance caused by an idiosyncratic shock originating in the large trading partner. this prediction holds true for either a portfolio or a trade shock. Thus, regardless of the nature of the shock to the external balance, we expect 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 expect a higher future return of currency j in response to a deterioration in its external balance caused by an idiosyncratic shock. As shown in Section 2.3, this prediction holds true for either a portfolio or a trade shock, i.e,. an idiosyncratic portfolio inflow or an 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 zero and a positive estimate of δ.

TABLE 5 ABOUT HERE

Table 5 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 suggest that a domestic deterioration of the external balance associated with a shock that originates abroad (i.e., from a large trading partner like the US) is associated with lower future exchange rate returns for those countries whose counterparties become more central in the global financial network, that is, an improvement in their *indirect* connections. In economic terms, a one standard deviation (negative) shock in the US external balance and a one standard deviation increase in *indirect* connections is associated with an average range of 0.5 to 0.7 percent lower exchange rate returns per annum, depending on the specification.[7].

On the other hand, the positive and statistically significant estimate of δ suggests that a domestic deterioration of the external balance associated with an local idiosyncratic shock (explained either by a portfolio or trade shock) is associated with higher future exchange rate returns for those countries that become more central in the global financial network through stronger indirect connections. Moreover, consistent with our predictions, we cannot reject that γ is statistically different from zero. This would be consistent with the average country in the sample not being large enough to have an impact in global financial markets. In economic terms, when large countries exhibit stronger indirect connections, idiosyncratic shocks to their external balance are associated with an average range of 1.6 to 1.8 percent higher exchange rate returns per annum, depending on the specification.

FIGURE 5 ABOUT HERE

For robustness, Figure 5, reports estimates of the fully saturated regression model described in Equation (10) 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.

[7]This is not a small magnitude considering that the average exchange rate return vis-a-vis the US dollar in our sample is about -0.5 percent per annum.

4.3 Robustness

In this subsection, we assess the robustness of our main empirical findings to alternative specifications and measures. We examine whether our results hold when using different proxies for financial connections, alternative samples, and additional controls.

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 using measures of financial connections based either on cross-border claims or cross-border liabilities.

Table 6 about here

Specifically, in Table 6, we only use cross-border claims to form the adjacency in Equation (7) but find qualitatively similar results, meaning that estimates of β are negative and statistically significant as indicated by Prediction 1, whereas estimates of δ are positive and statistically significant as suggested by Prediction 2.

Table 7 about here

In Table 7, moreover, we only use cross-border liabilities to assemble the adjacency in Equation (7). We confirm our main findings since estimates of β remain negative and statistically significant as suggested Prediction 1, whereas estimates of δ continue to positive and statistically significant as implied from Prediction 2.

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 8 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 (10) by interacting the key explanatory variables with the dummy variable $\texttt{Peg}_{j,t}$ as

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

We report our estimates in Table 8 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.

PRE AND POST-GFC SAMPLES

In addition, we investigate whether our main results differ between the pre- and post-Global Financial Crisis (GFC) periods. The GFC and subsequent regulatory reforms, such as Basel III, led to a tightening of financial intermediaries' balance sheet capacity and increased the cost of cross-border intermediation. As a result, we expect the relationship between financial connections and exchange rate returns to be stronger in the post-crisis period, when intermediation constraints are more binding.

To test this, we split our sample into pre-crisis (before 2009) and post-crisis (2009 and after) periods and re-estimate our main specification separately for each subsample. The results, reported in the first two columns of Table 9, show that the coefficients of inter-

[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.

est, particularly those capturing the interaction between indirect connections and trade shocks, are mostly significant in the post-crisis period. This finding is consistent with the notion that tighter financial regulation and reduced balance sheet capacity amplify the importance of financial network effects for exchange rate dynamics.

LONG-HORIZON RETURNS

The next three columns in Table 9 present results for long-horizon exchange rate returns. Specifically, the third column reports estimates using rolling 3-month future returns, showing that the effects of indirect connections and trade shocks remain statistically significant and of similar magnitude to the baseline. The fourth and fifth columns display results for 12- and 24-month rolling future returns, respectively. In these longer horizons, the effects, particularly those related to shocks originating in the US, diminish and end up losing statistical significance at the two year horizon. This attenuation suggests that the impact of financial network connections on exchange rate returns is not persistent over the long run, which aligns with the predictions of our theoretical framework. Intuitively, as these idiosyncratic shocks have a relatively high frequency, we would expect their effects to dissipate over longer horizons.

CONNECTION-WEIGHTED EXCHANGE RATE RETURNS

As shown in the Appendix, an alternative way to measure exchange rate returns is to use the average exchange rate return difference between a given country and its counterparties, weighted by the strength of their financial connections. More specifically, for each country j, we compute the connection-weighted exchange rate excess return as

$$y^{w}_{j,t+1} = \sum_{i \neq j} w_{ji}(y_{j,t+1} - y_{i,t+1}) \quad \text{where: } w_{ji} = \frac{A_{ji}}{\sum_{k \neq j} A_{jk}} \tag{11}$$

where A_{ji} is the sum of cross-border claims and liabilities that country j has with reporting banks in country i.

Intuitively, as per our model, a country will be able to absorb a larger amount of capital from abroad if it has a larger financial connection with its counterparties, its UIP deviations vis-a-vis its counterparties are wider, or both. Effectively, this measure of exchange rate returns, compared to raw exchange rate returns vis-a-vis the US dollar, also account for the strength of financial connections with other countries. Our expectation would thus be that our empirical results are robust to this alternative measure of exchange rate returns. Indeed, as per the last column of Table 9, we find that the estimates of β and δ are negative and positive, respectively, and statistically significant. This suggests that our main findings are robust to this alternative measure of exchange rate returns.

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 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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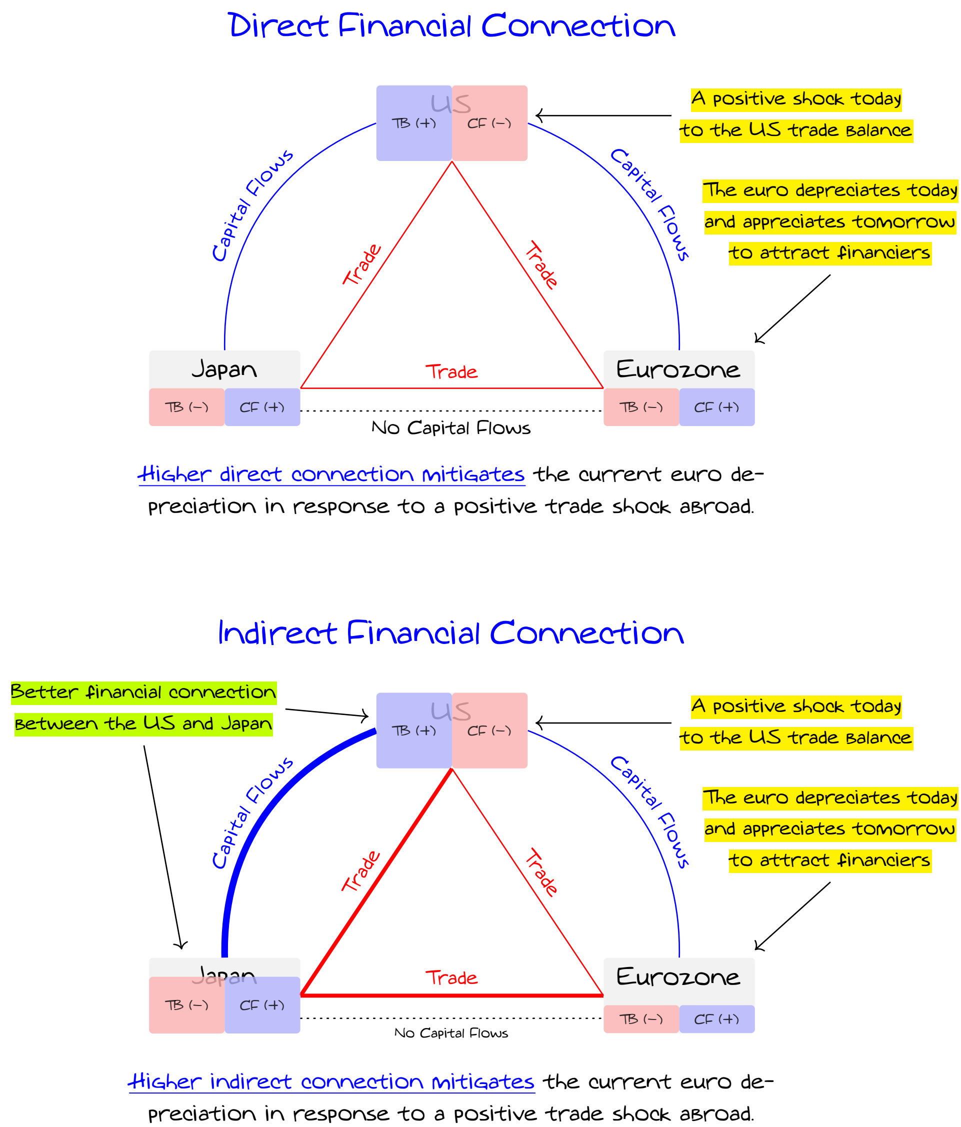


FIGURE 1. FINANCIAL CONNECTIONS: SCENARIO 1

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).

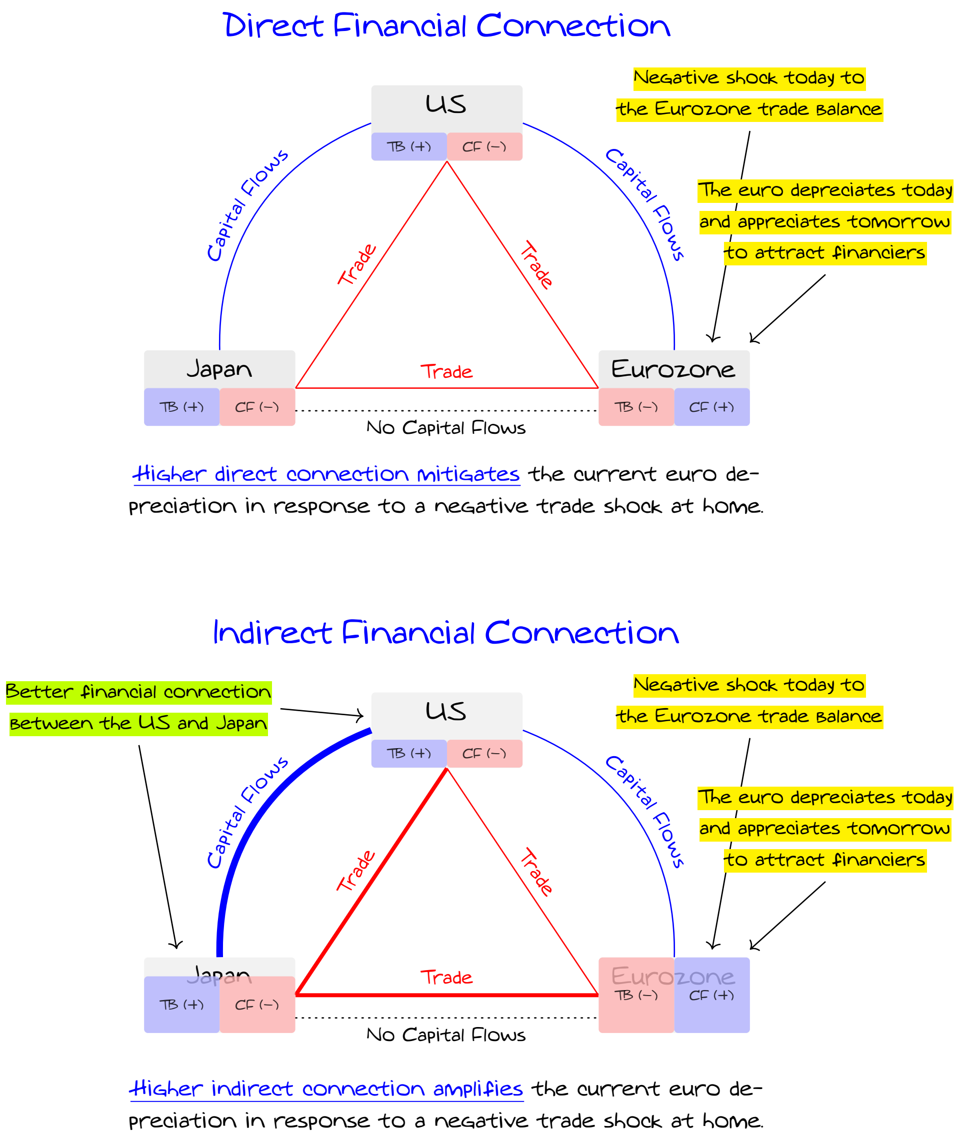


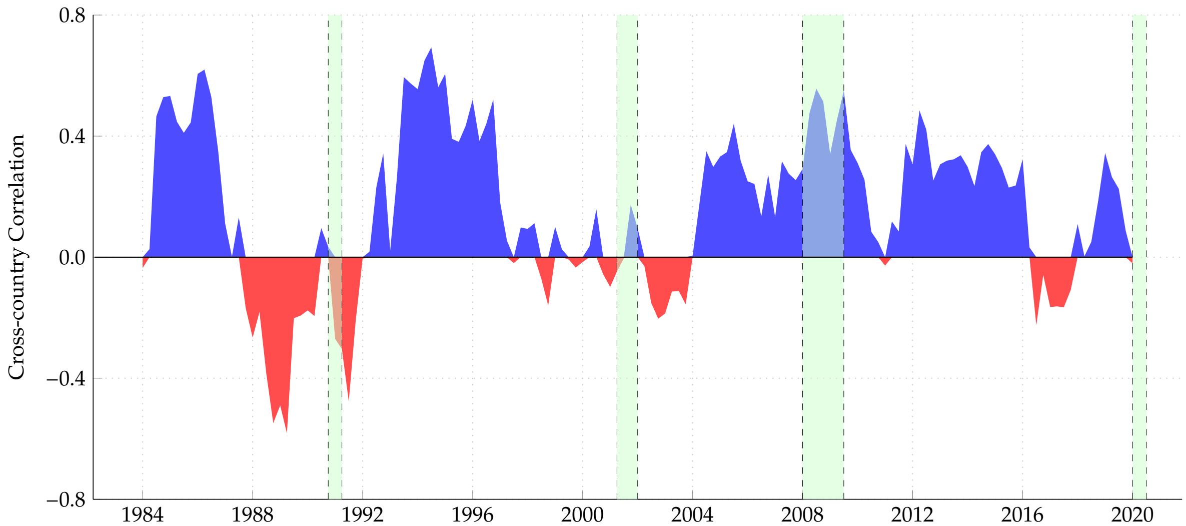
FIGURE 2. FINANCIAL CONNECTIONS: SCENARIO 2

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.

Panel A: Trade Centrality and Direct Connection



Panel B: Trade Centrality and Indirect Connection

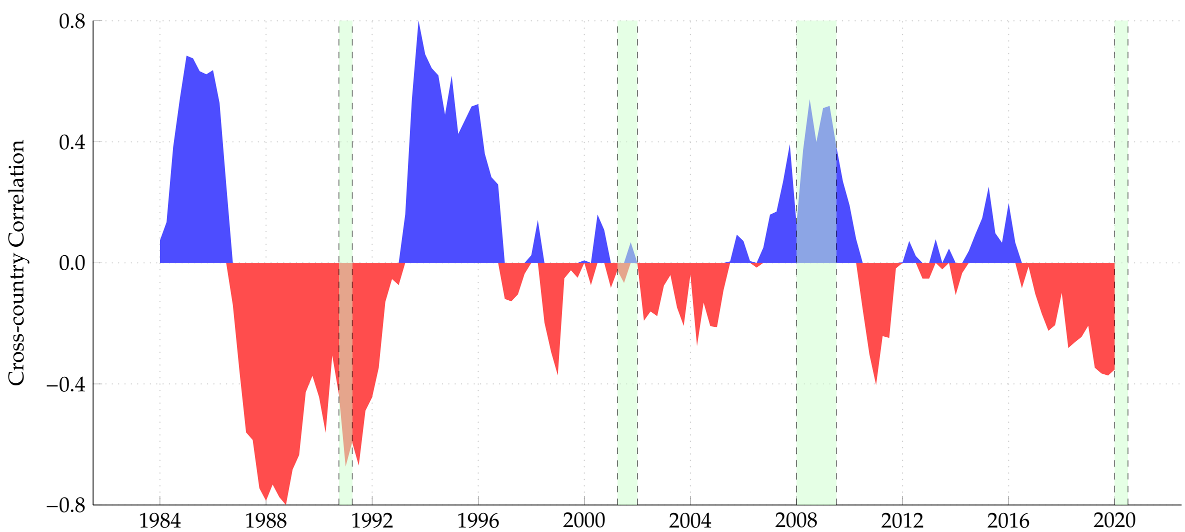


Figure 4. Correlation with Trade Centrality

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.

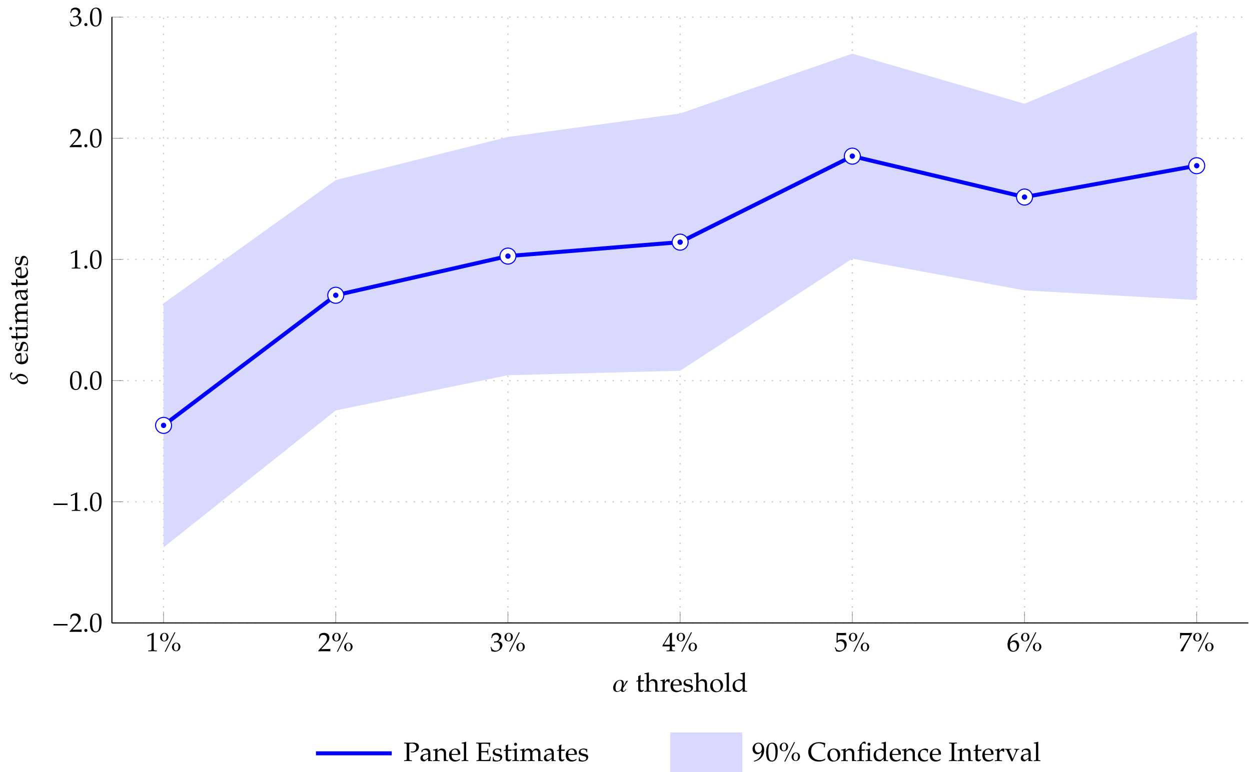


FIGURE 5. COUNTRY SIZE AND CONDITIONAL EXCHANGE RATE RETURNS

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

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

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

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

where e_j is the exchange rate of country j, $\mathtt{Dir}_j$ and $\mathtt{Ind}_j$ are *direct* and *indirect* connections of country j, respectively, $\mathtt{Shock}^+_1$ is a positive shock to country 1 net exports, $\mathtt{Shock}^-_j$ is a negative shock to country j net exports, $\mathtt{Deficit}_j$ is the trade deficit (net exports multiplied by minus one) of country j, $\mathtt{Large}_j$ is a binary variable that selects a large country and $\mathtt{Controls}_j$ includes additional regressors (e.g., $\mathtt{Large}_j$, $\mathtt{Deficit}_j$) and other interactions (e.g., $\mathtt{Dir}_j \times \mathtt{Large}_j$ and $\mathtt{Shock}^-_{j,0} \times \mathtt{Large}_j$). 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.5.

	(1)	(2)	(3)
$\mathtt{Ind}_j$	0.005	0.000	−0.005
$\mathtt{Ind}_j \times \mathtt{Shock}^+_{1,0}$	−0.007	−0.005	−0.003
$\mathtt{Ind}_j \times \mathtt{Shock}^-_{j,0}$	−0.012	−0.006	0.002
$\mathtt{Ind}_j \times \mathtt{Shock}^-_{j,0} \times \mathtt{Large}_j$	−0.088	−0.028	0.036
$\mathtt{Dir}_j$		−0.001	0.005
$\mathtt{Dir}_j \times \mathtt{Shock}^+_{1,0}$		0.006	0.004
$\mathtt{Dir}_j \times \mathtt{Shock}^-_{j,0}$		0.007	−0.001
$\mathtt{Dir}_j \times \mathtt{Deficit}_{j,0}$		−1.149	−0.545
$\mathtt{Ind}_j \times \mathtt{Deficit}_{j,0}$			−0.554
$\mathtt{Dir}_j \times \mathtt{Shock}^-_{j,0} \times \mathtt{Large}_j$			−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 (9), $\texttt{Dummy}_{j,\alpha}$ 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.

Dep. Variable:	(1) $y_{i,t}$	(2) $y_{i,t}$	(3) $y_{i,t}$	(4) $y_{i,t}$	(5) $y_{i,t}$	(6) $y_{i,t}$
$\texttt{Equity}_j$	1.473**	1.486***	1.989**	2.032***	1.671***	1.653***
	(0.578)	(0.506)	(0.780)	(0.710)	(0.622)	(0.525)
$\texttt{Dir} \times \texttt{Equity}_j$	−0.551	−0.545				
	(0.539)	(0.422)				
$\texttt{Dummy}_{\{\texttt{Dir}_j > 0.5\sigma\}} \times \texttt{Equity}_j$			−1.697*	−1.777**		
			(0.870)	(0.768)		
$\texttt{Dummy}_{\{\texttt{Dir}_j > 1\sigma\}} \times \texttt{Equity}_j$					−1.505*	−1.343**
					(0.806)	(0.587)
R^2	0.56	0.57	0.56	0.57	0.56	0.57
Num. Obs	890	890	890	890	890	890
Num. Countries	17	17	17	17	17	17
(FE) Time	✓	✓	✓	✓	✓	✓
(FE) Country	✓	✓	✓	✓	✓	✓
Controls		✓		✓		✓
F-statistic (First Stage)	4892.17	1216.71	4914.65	1223.08	4867.1	1209.46

TABLE 5. INDIRECT FINANCIAL CONNECTIONS, TRADE BALANCE SHOCKS, AND EXCHANGE RATES

This table presents panel regression estimates based on the following specification

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

where $y_{j,t+1}$ is the future exchange rate return of country j in percentage per annum, $\texttt{Ind}_j$ are *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, and $\texttt{Large}_j$ is a binary variable that selects the top 5% economies in terms of share of global trade (amounting to the largest 8 economies). $\texttt{Controls}_j$ includes country-specific variables as the capital account openness of Chinn and Ito (2006), forward premium, share of world GDP trade deficit, and the trade network centrality of Richmond (2019). We also include other regressors (e.g., $\texttt{Shock}^{+}_{us}$, $\texttt{Shock}^{-}_j$, and $\texttt{Large}_j$) 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. In addition, the vector of controls also include the interactions: $\texttt{Dir}_j \times \texttt{Shock}^{+}_{us}$, $\texttt{Dir}_j \times \texttt{Shock}^{-}_j \times \texttt{Large}_j$, and $\texttt{Dir}_j \times \texttt{Deficit}_j$, as well as any other relevant combinations of these interactions that require to be controlled for. 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)	(6)
Dep. Variable:	y_{t+1}	y_{t+1}	y_{t+1}	y_{t+1}	y_{t+1}	y_{t+1}
$\texttt{Ind}_j$	−0.813***	−0.880***	−0.815***	−0.871***	−0.754**	−0.932**
	(0.272)	(0.310)	(0.274)	(0.313)	(0.350)	(0.382)
$\texttt{Ind}_j \times \texttt{Large}_j$		0.733		0.686	0.962	1.392
		(0.783)		(0.802)	(1.121)	(1.131)
$\texttt{Shock}_j$	−0.610**	−0.889***		−0.864***	−0.728***	−0.805***
	(0.264)	(0.253)		(0.255)	(0.261)	(0.264)
$\texttt{Shock}_j \times \texttt{Large}_j$		3.083***		3.137***	2.663***	2.877***
		(0.560)		(0.552)	(0.462)	(0.468)
$\texttt{Ind}_j \times \texttt{Shock}_j$	−0.167	−0.320		−0.276	−0.259	−0.286
	(0.277)	(0.281)		(0.285)	(0.305)	(0.307)
$\texttt{Ind}_j \times \texttt{Shock}_j \times \texttt{Large}_j$		1.823***		1.896***	1.603***	1.833***
		(0.576)		(0.627)	(0.544)	(0.519)
$\texttt{Ind}_j \times \texttt{Shock}^{+}_{us}$			−0.672***	−0.677***	−0.566***	−0.552**
			(0.214)	(0.220)	(0.213)	(0.217)
R^2	0.40	0.40	0.40	0.40	0.40	0.39
Num. Obs	14902	14902	14902	14902	14902	14902
Num. Countries	70	70	70	70	70	70
(FE) Time	✓	✓	✓	✓	✓	✓
(FE) Country	✓	✓	✓	✓	✓	
Controls					✓	✓

TABLE 6. CROSS-BORDER CLAIMS AND FINANCIAL CONNECTIONS

This table presents panel regression estimates based on the following specification

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

where $y_{j,t+1}$ is the future exchange rate return of country j in percentage per annum, $\texttt{Ind}_j$ are *indirect* connections of country j relative to banks located in the reporting countries (using only claims, excluding liabilities), respectively, $\texttt{Shock}^+_{us}$ is a positive shock to US net exports, $\texttt{Shock}^-_j$ is a negative shock to country j net exports, and $\texttt{Large}_j$ is a binary variable that selects the top 5% economies in terms of share of global trade (amounting to the largest 8 economies). $\texttt{Controls}_j$ includes country-specific variables as the capital account openness of Chinn and Ito (2006), forward premium, share of world GDP trade deficit, and the trade network centrality of Richmond (2019). We also include other regressors (e.g., $\texttt{Shock}^+_{us}$, $\texttt{Shock}^-_j$, and $\texttt{Large}_j$) 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. In addition, the vector of controls also include the interactions: $\texttt{Dir}_j \times \texttt{Shock}^+_{us}$, $\texttt{Dir}_j \times \texttt{Shock}^-_j \times \texttt{Large}_j$, and $\texttt{Dir}_j \times \texttt{Deficit}_j$, as well as any other relevant combinations of these interactions that require to be controlled for. 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)	(6)
Dep. Variable:	y_{t+1}	y_{t+1}	y_{t+1}	y_{t+1}	y_{t+1}	y_{t+1}
$\texttt{Ind}_j$	−0.748***	−0.728***	−0.763***	−0.729***	−0.898***	−1.099***
	(0.209)	(0.224)	(0.211)	(0.224)	(0.339)	(0.349)
$\texttt{Ind}_j \times \texttt{Large}_j$		−0.057		−0.195	0.217	0.707
		(0.506)		(0.520)	(0.675)	(0.651)
$\texttt{Shock}_j$	−0.616**	−0.821***		−0.786***	−0.642**	−0.701***
	(0.264)	(0.253)		(0.255)	(0.262)	(0.265)
$\texttt{Shock}_j \times \texttt{Large}_j$		3.286***		3.318***	2.626***	2.629***
		(0.601)		(0.604)	(0.456)	(0.469)
$\texttt{Ind}_j \times \texttt{Shock}_j$	−0.113	−0.211		−0.177	−0.134	−0.150
	(0.279)	(0.279)		(0.283)	(0.275)	(0.279)
$\texttt{Ind}_j \times \texttt{Shock}_j \times \texttt{Large}_j$		1.717**		1.882**	1.660**	1.989**
		(0.823)		(0.851)	(0.842)	(0.910)
$\texttt{Ind}_j \times \texttt{Shock}^+_{us}$			−0.746***	−0.746***	−0.617***	−0.632***
			(0.228)	(0.233)	(0.223)	(0.233)
R^2	0.40	0.40	0.40	0.40	0.40	0.39
Num. Obs	14902	14902	14902	14902	14902	14902
Num. Countries	70	70	70	70	70	70
(FE) Time	✓	✓	✓	✓	✓	✓
(FE) Country	✓	✓	✓	✓	✓	
Controls					✓	✓

TABLE 7. CROSS-BORDER LIABILITIES AND FINANCIAL CONNECTIONS

This table presents panel regression estimates based on the following specification

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

where $y_{j,t+1}$ is the future exchange rate return of country j in percentage per annum, $\texttt{Ind}_j$ are *indirect* connections of country j relative to banks located in the reporting countries (using only liabilities, excluding claims), respectively, $\texttt{Shock}^+_{us}$ is a positive shock to US net exports, $\texttt{Shock}^-_j$ is a negative shock to country j net exports, and $\texttt{Large}_j$ is a binary variable that selects the top 5% economies in terms of share of global trade (amounting to the largest 8 economies). $\texttt{Controls}_j$ includes country-specific variables as the capital account openness of Chinn and Ito (2006), forward premium, share of world GDP trade deficit, and the trade network centrality of Richmond (2019). We also include other regressors (e.g., $\texttt{Shock}^+_{us}$, $\texttt{Shock}^-_j$, and $\texttt{Large}_j$) 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. In addition, the vector of controls also include the interactions: $\texttt{Dir}_j \times \texttt{Shock}^+_{us}$, $\texttt{Dir}_j \times \texttt{Shock}^-_j \times \texttt{Large}_j$, and $\texttt{Dir}_j \times \texttt{Deficit}_j$, as well as any other relevant combinations of these interactions that require to be controlled for. 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)	(6)
Dep. Variable:	y_{t+1}	y_{t+1}	y_{t+1}	y_{t+1}	y_{t+1}	y_{t+1}
$\texttt{Ind}_j$	−0.532*	−0.560*	−0.536*	−0.559*	−0.505	−0.641
	(0.280)	(0.301)	(0.284)	(0.304)	(0.367)	(0.424)
$\texttt{Ind}_j \times \texttt{Large}_j$		0.790*		0.765*	0.855	0.916
		(0.451)		(0.439)	(1.157)	(1.105)
$\texttt{Shock}_j$	−0.613**	−0.811***		−0.802***	−0.661**	−0.722***
	(0.264)	(0.257)		(0.260)	(0.271)	(0.273)
$\texttt{Shock}_j \times \texttt{Large}_j$		3.280***		3.313***	3.038***	2.952***
		(0.694)		(0.748)	(0.694)	(0.751)
$\texttt{Ind}_j \times \texttt{Shock}_j$	−0.109	−0.174		−0.169	−0.210	−0.255
	(0.250)	(0.244)		(0.249)	(0.336)	(0.335)
$\texttt{Ind}_j \times \texttt{Shock}_j \times \texttt{Large}_j$		1.351**		1.464**	1.631***	2.089***
		(0.677)		(0.686)	(0.567)	(0.738)
$\texttt{Ind}_j \times \texttt{Shock}^+_{us}$			−0.569***	−0.578***	−0.466**	−0.480**
			(0.216)	(0.218)	(0.215)	(0.223)
R^2	0.39	0.40	0.39	0.40	0.40	0.39
Num. Obs	14902	14902	14902	14902	14902	14902
Num. Countries	70	70	70	70	70	70
(FE) Time	✓	✓	✓	✓	✓	✓
(FE) Country	✓	✓	✓	✓	✓	
Controls					✓	✓

TABLE 8. FINANCIAL CONNECTIONS AND PEGGED CURRENCIES

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

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., $\texttt{Ind}_j$, $\texttt{Dir}_j$, $\texttt{Ind}^{\$}_j$, $\texttt{Dir}^{\$}_j$, $\texttt{Shock}^{-}_j$, $\texttt{Shock}^{+}_{us}$, $\texttt{Large}_j$, 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.

Dep. Variable:	(1) y_{t+1}	(2) y_{t+1}	(3) y_{t+1}	(4) y_{t+1}	(5) y_{t+1}	(6) y_{t+1}
$\texttt{Ind}_j$	−0.813***	−0.880***	−0.815***	−0.871***	−2.106***	−2.249***
	(0.272)	(0.310)	(0.274)	(0.313)	(0.632)	(0.663)
$\texttt{Ind}_j \times \texttt{Large}_j$		0.733		0.686	4.010***	4.345***
		(0.783)		(0.802)	(1.091)	(0.928)
$\texttt{Shock}_j$	−0.610**	−0.889***		−0.864***	−1.447***	−1.538***
	(0.264)	(0.253)		(0.255)	(0.465)	(0.462)
$\texttt{Shock}_j \times \texttt{Large}_j$		3.083***		3.137***	3.708***	3.991***
		(0.560)		(0.552)	(0.593)	(0.584)
$\texttt{Ind}_j \times \texttt{Shock}_j$	−0.167	−0.320		−0.276	−0.291	−0.387
	(0.277)	(0.281)		(0.285)	(0.514)	(0.522)
$\texttt{Ind}_j \times \texttt{Shock}_j \times \texttt{Large}_j$		1.823***		1.896***	2.026**	2.216**
		(0.576)		(0.627)	(0.935)	(0.902)
$\texttt{Ind}_j \times \texttt{Shock}^{+}_{us}$			−0.672***	−0.677***	−1.146***	−1.128**
			(0.214)	(0.220)	(0.438)	(0.439)
R^2	0.40	0.40	0.40	0.40	0.40	0.40
Num. Obs	14902	14902	14902	14902	14902	14902
Num. Countries	70	70	70	70	70	70
(FE) Time	✓	✓	✓	✓	✓	✓
(FE) Country	✓	✓	✓	✓	✓	
Controls					✓	✓

Table 9. Several Robustness

This table presents panel regression estimates based on the following specification

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

where $y_{j,t+1}$ is the future exchange rate return of country j in percentage per annum, $\texttt{Ind}_j$ are *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, and $\texttt{Large}_j$ is a binary variable that selects the top 5% economies in terms of share of global trade (amounting to the largest 8 economies). $\texttt{Controls}_j$ includes country-specific variables as the capital account openness of Chinn and Ito (2006), forward premium, share of world GDP trade deficit, and the trade network centrality of Richmond (2019). We also include other regressors (e.g., $\texttt{Shock}^+_{us}$, $\texttt{Shock}^-_j$, and $\texttt{Large}_j$) 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. In addition, the vector of controls also include the interactions: $\texttt{Dir}_j \times \texttt{Shock}^+_{us}$, $\texttt{Dir}_j \times \texttt{Shock}^-_j \times \texttt{Large}_j$, and $\texttt{Dir}_j \times \texttt{Deficit}_j$, as well as any other relevant combinations of these interactions that require to be controlled for. 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.

	Pre-2009	Post-2009	Long H3	Long H12	Long H24	Adj. Ret
Dep. Variable:	y_{t+1}	y_{t+1}	$\sum_h^3 y_{t+h}$	$\sum_h^{12} y_{t+h}$	$\sum_h^{24} y_{t+h}$	y^w_{t+1}
$\texttt{Ind}_j$	0.076	−1.060*	−0.739**	−0.877***	−0.617**	−0.561
	(0.508)	(0.616)	(0.328)	(0.274)	(0.279)	(0.354)
$\texttt{Ind}_j \times \texttt{Large}_j$	0.769	−0.395	1.055	1.065	1.033	1.299
	(1.340)	(0.778)	(1.086)	(0.825)	(0.670)	(1.102)
$\texttt{Shock}_j$	−1.074**	−0.469*	−0.687***	−0.311	−0.121	−0.358
	(0.446)	(0.267)	(0.256)	(0.259)	(0.167)	(0.246)
$\texttt{Shock}_j \times \texttt{Large}_j$	3.230***	2.022***	2.595***	1.953***	1.957***	1.809***
	(0.722)	(0.631)	(0.529)	(0.564)	(0.629)	(0.516)
$\texttt{Ind}_j \times \texttt{Shock}_j$	−0.517	−0.008	−0.054	0.323*	0.288**	−0.058
	(0.542)	(0.403)	(0.273)	(0.182)	(0.125)	(0.323)
$\texttt{Ind}_j \times \texttt{Shock}_j \times \texttt{Large}_j$	1.435*	1.752***	1.371**	0.954**	0.811	1.752***
	(0.870)	(0.544)	(0.535)	(0.454)	(0.510)	(0.500)
$\texttt{Ind}_j \times \texttt{Shock}^+_{us}$	−0.146	−1.182***	−0.605***	−0.115	−0.027	−0.457**
	(0.314)	(0.335)	(0.224)	(0.162)	(0.137)	(0.215)
R^2	0.43	0.36	0.42	0.51	0.58	0.13
Num. Obs	7863	7039	14766	14154	13349	14902
Num. Countries	64	56	70	70	69	70
(FE) Time	✓	✓	✓	✓	✓	✓
(FE) Country	✓	✓	✓	✓	✓	✓
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

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

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 $\{\chi_{j,t}, l_{j,t}, \iota_{j,t}, \theta_{j,t}\}$ satisfy $\chi_{j,t} + l_{j,t} + \sum_{i \neq j} h_i \iota_{j,t} = \theta_{j,t}$.

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. So $e_{j,t} p_{ji,t}^T = p_{1i,t}^T$, where $p_{ji,t}^T$ is the price of the imported tradeable good from country i in currency j and $p^T_{1i,t}$ is the price of the same currency 1.

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

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

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

$$\sum_{t=0}^{1} R_j^{-t} \left(Y^{NT}_{j,t} + p^T_{j,t} Y^T_{j,t} \right) + (h_j R_j e_{j,1})^{-1} \left[\Pi_j + \sum_{i \neq j} \left(R_i \frac{e_{i,1}}{e_{i,0}} - R_j \frac{e_{j,1}}{e_{j,0}} \right) f_{ji} \right] = \sum_{t=0}^{1} R_j^{-t} \left(C^{NT}_{j,t} + p^T_{j,t} C^T_{j,t} + \sum_{i \neq j}^{N} p^T_{ji,t} C^T_{ji,t} \right). \tag{A.4}$$

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

$$\max_{\{C^T_{j,t}, C^{NT}_{j,t}, C^T_{ji,t}\}} \quad \chi_{j,t} \ln C^{NT}_{j,t} + l_{j,t} \ln C^T_{j,t} + \iota_{j,t} \sum_{i \neq j}^{N} h_i \ln C^T_{ji,t} + \lambda_{j,t} \left(CE_{j,t} - C^{NT}_{j,t} - p^T_{j,t} C^T_{j,t} - \sum_{i \neq j}^{N} p^T_{ji,t} C^T_{ji,t} \right) \tag{A.5}$$

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

$$\frac{\chi_{j,t}}{C^{NT}_{j,t}} = \lambda_{j,t}$$
$$\frac{\iota_{j,t}}{C^{T}_{j,t}} = \lambda_{j,t} p^{T}_{j,t}$$
$$\frac{h_i \iota_{j,t}}{C^{T}_{ji,t}} = \lambda_{j,t} p^{T}_{ji,t} \quad \forall i \neq j$$

Imposing that nontradable goods are produced by an endowment process $Y^{NT}_{j,t} = \chi_{j,t}$, we obtain $\lambda_{j,t} = 1$. Therefore, per capita spending on imports from country i by households in country j is

$$p^{T}_{ji,t} C^{T}_{ji,t} = h_i \iota_{j,t}. \tag{A.6}$$

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

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

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 $C^{NT}_{j,t} = \chi_{j,t}$. 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 imposed 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

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

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

$$NX_{j,1} + \sum_{i \neq j} \frac{e_{i,1}}{e_{i,0}} f_{ji} - \frac{e_{j,1}}{e_{j,0}} NB_j + \Pi_j = 0, \tag{A.8}$$

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 currencies 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

$$\sum_{i \neq j} Q_{ji} = NB_j - \sum_{i \neq j} f_{ij}. \tag{A.9}$$

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

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

Using the household import demand condition, Equation (A.6), we have that

$$NX_{j,t} = h_j \sum_{i \neq j} h_i e_{i,t} \iota_{i,t} - h_j (1 - h_j) e_{j,t} \iota_{j,t}. \tag{A.11}$$

Defining $f_j = \sum_{i \neq j} (f_{ji} - f_{ij})$ and using Equation (A.11) , we recover equation Equation (2) 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, $\sum_j f_j = 0$.

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

$$\Pi_j = \left(\frac{e_{j,1}}{e_{j,0}} - 1 \right) \left(\sum_{i \neq j} (Q_{ji} + f_{ij}) \right) - \sum_{i \neq j} \left(\frac{e_{i,1}}{e_{i,0}} - 1 \right) f_{ji}. \tag{A.12}$$

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.9) and Equation (A.12) with the period 1 balance of payment condition we obtain

$$NX_{j,1} + f_j - \sum_{i \neq j} e_{s_{ji},0} \Lambda_{ji} \left(\frac{e_{j,1}}{e_{j,0}} - \frac{e_{i,1}}{e_{i,0}} \right) = 0. \tag{A.13}$$

where f_j is the net portfolio flow defined above. Solving for net-exports recovers Equation (3).

A.4 INDIRECT CONNECTIONS IN RICHER NETWORK STRUCTURES

The comparative statics presented in the main text of the paper rely on a specific, stylized network structure with three countries. This allows us to develop intuition in closed form but raises the question how far the results extend to other networks. To explore this, in Figure A.1 considers whether the comparative statics discussed in proposition 1 are robust to alternative network. Since a richer network comes at the cost of tractability we present numerical solutions.

We focus on the less intuitive result that an improvement in an indirect connections amplifies the effect of a domestic trade shock. We consider the weighted differential exchange rate return in country 2, $r_{1,2}$, defined as

$$r_{1,2} = \left(\sum_{i \neq 2} \Lambda_{i2} \right)^{-1} \sum_{i \neq 2} \Lambda_{i2} \left(e_{1,2}/e_{0,2} - e_{1,i}/e_{0,i} \right).$$

The use of this weighted differential return is what is relevant in the theory ( )allows for a general network structure where country 1 may not be

defined on a weighted basis reflecting the reasoning in section XXXX, reacts to an increase in import demand in country 2 in the first period $\iota_{0,2}$. Naturally the derivative, $\frac{dr_{1,2}}{d\iota_{0,2}}$, is positive as an increase in $\iota_{0,2}$ raises country 2's trade deficit and so the exchange rate return rises in order to attract capital from abroad. Of interest, is whether an increase in the connectivity of different edges in the network that are not directly connected to country 2 increase this derivative and therefore amplify the shock.

The left hand column in figure presents the different network's under consideration. The nodes indicated with a grey diamond are financial centres with strong connections to country 2, with edges marked in black. Peripheral countries are nodes indicated with green squares and they have either weak or no financial connection to country 2. Weak connections are shown with thin grey lines and unless, otherwise stated, are calibrated to a quarter of the size of a strong connection. The edge in red, never directly connected to country 2, is the financial connection over which we conduct our comparative static on $\frac{dr_{1,2}}{d\iota_{0,2}}$ as presented in the right column of the figure.

The figure lays out three different networks,[9] we now discuss each in turn.

I) THREE COUNTRY NETWORK WITH NO MISSING CONNECTIONS. The first alternative network, at the top left of Figure A.1, is similar to the main text except now we allow for some financial connection between countries 2 and 3, Λ_{23}. This connection is still set to be weaker than the connection of both countries with country 1. Initially focus on the case where $\Lambda_{23} = 0.25\Lambda_{13}$: as the red line on the right panel shows increasing country 2's indirect connect, i.e. Λ_{13}, amplifies the effect of the import demand shock on its exchange rate return. The intuition is the same as the main text. Some of trade surplus in country 3, flows back to country 2 via country 1 since Λ_{23} is a relatively weak connection. The stronger indirect connection, the more capital is able to flow to country 2 and the higher the return needs to be to absorb it.

What happens if the direct connection between country 2 and 3 is strengthened? The dashed blue line in the right hand panel shows the case where $\Lambda_{23} = 0.4\Lambda_{13}$. There is still an increasing relationship between the return and the indirect connection but it is flatter than in the prior case. An increase in Λ_{23} means more of country 3's trade surplus flows back to country 2 directly rather than going via country 1, this mutes the amplifying effect on an increase in indirect connections.

Increasing Λ_{23} further further mutes the effect of an indirect connection. The indirect connection becomes irrelevant at the knife edge case when $\Lambda_{23} = \Lambda_{12}$: in this case, a trade shock in country 2 generates no capital flow between countries 1 and 3 and so Λ_{13} is not relevant for determining the exchange rate response to $\iota_{0,2}$. However, going further still so that $\Lambda_{23} > \Lambda_{12}$, reverses the capital flow between 1 and 3. Now some of country 1's surplus is intermediated via country 3 and it is again the case that improving the connection between 1 and 3 will amplify the effect of a change in $\iota_{0,2}$ on the return in Country 2's exchange rate.

[9] The size of the countries in each of these three networks are as follows. Network 1: $h_1 = h_2 = h_3 = 1/3$. Network 2: $h_1 = h_2 = 1/3; h_3 = h_4 = 1/6$. Network 3: $h_1 = h_2 = h_3 = 1/4; h_4 = h_5 = h_6 = h_7 = 1/16$.

ii) Adding an extra peripheral country to the network. The middle panel in Figure A.1, considers an additional peripheral country, 4, that is weakly connected to the rest of the network. The country 4's connection to country 3 allows it better access the financial centre. So when country 2 has a trade deficit some of the corresponding surplus in country 4 is intermediated through country 3 (and then through country 1). Strengthening the connection between 3 and 4 allows a greater capital flow back to country 2 and therefore country 2's currency needs to offer a higher return to absorb that flow. This can be seen by the right middle panel in Figure A.1; $\frac{dr_{1,2}}{d\iota_{0,2}}$ is increasing in Λ_{34}.

This finding does not require that capital flows from country 4 to 3 in response to an increase in $\iota_{0,2}$. The flow could be in the other direction, for instance if Λ_{24} was large. The same intuition would hold, improving the indirect connection, Λ_{34}, would require country 2 to absorb a greater capital flow and therefore offer higher FX returns.

iii) Two financial centres. The lower panel in Figure A.1, considers a case where there are two financial centres both connected to country 2 and their own peripheral countries. The comparative static is over the connection between the second financial centre, now country 3, and its two peripheral countries (6 and 7). Increasing Λ_{36} and Λ_{37} again amplifies the effect of an increase in $\iota_{0,2}$ on country 2's exchange rate return as can be seen from the lower right panel. And the intuition is the same: the improved indirect connection allows more of country 6 and 7's surpluses to flow back to country 2, and therefore country 2's currency needs to offer a higher return to absorb that flow.

It is also interesting to ask whether a stronger connection between the two financial centres, Λ_{13}, also increases $\frac{dr_{1,2}}{d\iota_{0,2}}$. In the knife edge case where countries 1 and 3 and their associated peripheral countries are perfectly symmetric both in terms of connections and size, the answer is no. The logic is similar to that of network i); if the two centres are symmetric no capital will flow between them when there is a change in $\iota_{0,2}$ and so Λ_{13} plays no role in determining country 2's exchange rate return. However, as soon as there is any asymmetry, an improved connection between the two centres allows for capital to flow more efficiently to country 2 and so its exchange rate return must rise to absorb it.

A.5 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 $\Lambda_{ji} \sim$ 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 simulated 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.6 From the Model to the Data

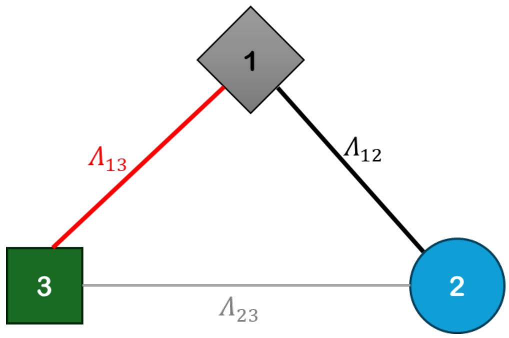
In this appendix we present a a straightforward extension of our model, where we introduce heterogeneous intermediaries with different demand curves for the long-short currency trade. This heterogeneity generates a theoretical link between gross financial claims that we use as an proxy for financial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

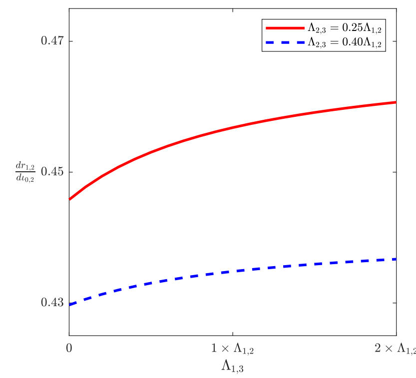
Following Bacchetta and Wincoop (2006) and Bippus et al. (2023), we assume that each cross is occupied by a mass of intermediaries indexed by a and period 1 outcomes are now uncertain. Each intermediary has a stochastic heterogeneous valuation of the forward position in peripheral currency given by b^a_{ji},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

Figure A.1. Exchange Returns and Indirect Connections in Alternative Network Structures

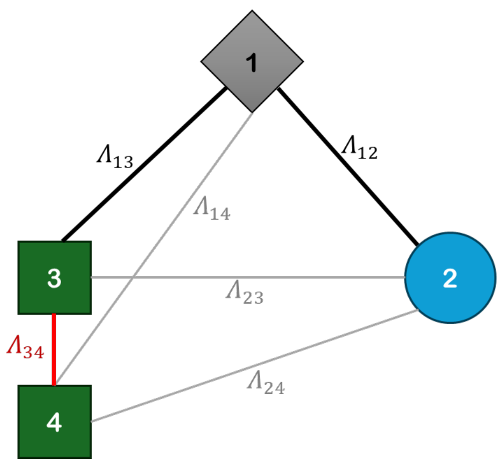
Network Structure | Comparative Static on $\frac{dr_{1,2}}{d\iota_{0,2}}$

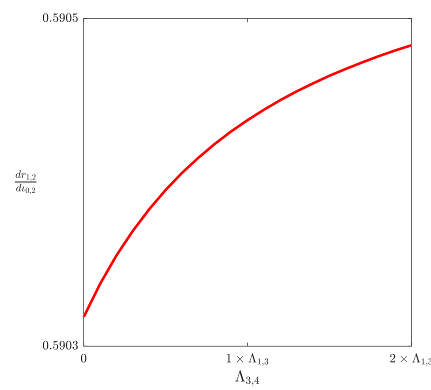
i) Three 3 Countries With Full Network



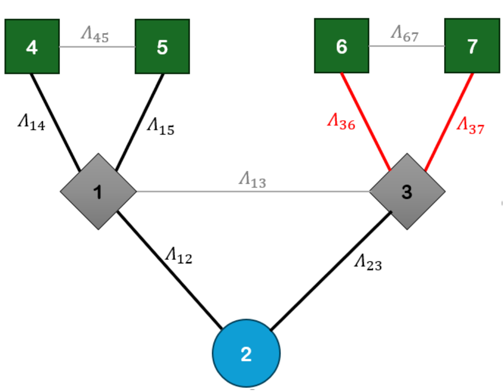


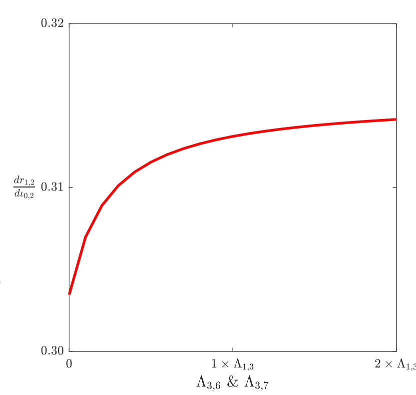
ii) Adding Fourth Peripheral Country





iii) Two Financial Centres





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

$$V_{12}^a = \left(b_{ji}^a \frac{e_{2,1}}{e_{2,0}} - 1 \right) Q_{12}^a,$$

and assuming that V_{12}^a enters the financial constraint and that profits are valued in dollars, we obtain a demand curve at the intermediary level as

$$Q_{12}^a = \Lambda_{12} \left(b_{21}^a \frac{e_{2,1}}{e_{2,0}} - 1 \right).$$

However, we also have that

$$Q_{12} = \int Q_{12}^a da = \Lambda_{12} \left(\frac{e_{2,1}}{e_{2,0}} - 1 \right),$$

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, they are right on average and so when summing across intermediaries the exchange rate that clears the market is the same. 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

$$\int \left| Q_{21}^a \right| da \approx \Lambda_{12} \left(\int_1^\infty \left(b_{21}^a - 1 \right) dF(b_{12}^a) + \int_{-\infty}^1 \left(1 - b_{21}^a \right) dF(b_{21}^a) \right).$$

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_{21}.

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 $Q_{21} = \Lambda_{21}\left(e_{2,1} - e_{2,0}\right)$, whereas the net bond position between country 1 and country 3 corresponds to $Q_{31} = \Lambda_{31}\left(e_{3,1} - e_{3,0}\right)$.

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, using definition of net exports in Equation (A.11):

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

so that

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

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

$$\begin{pmatrix} h_1 h_2 \iota_{1,0} - f_2 \\ h_1 h_3 \iota_{1,0} \end{pmatrix} + \begin{pmatrix} -h_2(1-h_2)\iota_{2,0} & h_2 h_3 \iota_{3,0} \\ h_2 h_3 \iota_{2,0} & -h_3(1-h_3)\iota_{3,0} \end{pmatrix} \begin{pmatrix} e_{2,0} \\ e_{3,0} \end{pmatrix} = \\ - \begin{pmatrix} \Lambda_{21}\left[(1+\iota_{1,0}) - (1+\iota_{2,0})\, e_{2,0}\right] \\ \Lambda_{31}\left[(1+\iota_{1,0}) - (1+\iota_{3,0})\, e_{3,0}\right] \end{pmatrix}.$$

Rearrange as

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

$$\times \begin{pmatrix} \Lambda_{31}(\iota_{3,0}+1) + h_3(1-h_3)\iota_{3,0} & h_2 h_3 \iota_{3,0} \\ h_2 h_3 \iota_{2,0} & \Lambda_{21}(\iota_{2,0}+1) + h_2(1-h_2)\iota_{2,0} \end{pmatrix} \begin{pmatrix} \Lambda_{21}(1+\iota_{1,0}) + h_1 h_2 \iota_{1,0} - f_2 \\ \Lambda_{31}(1+\iota_{1,0}) + h_1 h_3 \iota_{1,0} \end{pmatrix},$$

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

$$e_{2,0} = \frac{\left(\Lambda_{21}(1+\iota_{1,0}) + h_1 h_2 \iota_{1,0} - f_2\right)\left(\Lambda_{31}(\iota_{3,0}+1) + h_3(1-h_3)\iota_{3,0}\right) + h_2 h_3 \iota_{3,0}\left(\Lambda_{31}(1+\iota_{1,0}) + h_1 h_3 \iota_{1,0}\right)}{\left(\Lambda_{31}(\iota_{3,0}+1) + h_3(1-h_3)\iota_{3,0}\right)\left(\Lambda_{21}(\iota_{2,0}+1) + h_2(1-h_2)\iota_{2,0}\right) - (h_2 h_3)^2\, \iota_{2,0}\iota_{3,0}}.$$

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

$$\frac{de_{2,0}}{d\iota_{1,0}} = \frac{\left(\Lambda_{21} + h_1 h_2\right)\left(\Lambda_{31}(\iota_{3,0}+1) + h_3(1-h_3)\iota_{3,0}\right) + h_2 h_3 \iota_{3,0}\left(\Lambda_{31} + h_1 h_3\right)}{\left(\Lambda_{31}(\iota_{3,0}+1) + h_3(1-h_3)\iota_{3,0}\right)\left(\Lambda_{21}(\iota_{2,0}+1) + h_2(1-h_2)\iota_{2,0}\right) - (h_2 h_3)^2\, \iota_{2,0}\iota_{3,0}}, \tag{B.14}$$

which is positive as $h_3(1-h_3)h_2(1-h_2)\iota_{2,0}\iota_{3,0} > (h_2 h_3)^2\, \iota_{2,0}\iota_{3,0}$ (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

$$\frac{de_{2,0}}{d\iota_{2,0}} = -\frac{\left(\Lambda_{31}(\iota_{3,0}+1) + h_3(1-h_3)\iota_{3,0}\right)\left(\Lambda_{21} + h_2(1-h_2)\right) - (h_2 h_3)^2\,\iota_{3,0}}{\left(\Lambda_{31}(\iota_{3,0}+1) + h_3(1-h_3)\iota_{3,0}\right)\left(\Lambda_{21}(\iota_{2,0}+1) + h_2(1-h_2)\iota_{2,0}\right) - (h_2 h_3)^2\,\iota_{2,0}\iota_{3,0}} e_{2,0}, \tag{B.15}$$

which is negative as $h_3(1-h_3)h_2(1-h_2)\iota_{2,0}\iota_{3,0} > (h_2h_3)^2\,\iota_{2,0}\iota_{3,0}$ 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

$$\frac{de_{2,0}}{df_2} = \frac{-\left(\Lambda_{31}(\iota_{3,0}+1) + h_3(1-h_3)\iota_{3,0}\right)}{\left(\Lambda_{31}(\iota_{3,0}+1) + h_3(1-h_3)\iota_{3,0}\right)\left(\Lambda_{21}(\iota_{2,0}+1) + h_2(1-h_2)\iota_{2,0}\right) - (h_2 h_3)^2\,\iota_{2,0}\iota_{3,0}}. \tag{B.16}$$

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. These results are derived at the point where $\iota_{i,0} = 1$ for any country i and $f_2 = 0$, so that all exchange rates initially equally one and there is balanced trade. We show that a stronger financial connection between countries 1 and 2 moderates the impact of an increase in import demand in country 1 by proving that

$$\frac{d^2 e_{2,0}}{d\iota_{1,0} d\Lambda_{21}} < 0 \tag{B.17}$$

In particular, by setting $\iota_{i,0} = 1$ for any country i and $f_2 = 0$, Equation (B.14) simplifies to

$$\frac{de_{2,0}}{d\iota_{1,0}} = \frac{(\Lambda_{21} + h_1 h_2)(2\Lambda_{31} + h_3(1-h_3)) + h_2 h_3 (\Lambda_{31} + h_1 h_3)}{(2\Lambda_{31} + h_3(1-h_3))(2\Lambda_{21} + h_2(1-h_2)) - (h_2 h_3)^2}. \tag{B.18}$$

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

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

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

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

$$(2\Lambda_{31} + h_3(1-h_3))\left[(2\Lambda_{31} + h_3(1-h_3))(2\Lambda_{21} + h_2(1-h_2)) - (h_2 h_3)^2\right] <$$
$$2(2\Lambda_{31} + h_3(1-h_3))\left[(\Lambda_{21} + h_1 h_2)(2\Lambda_{31} + h_3(1-h_3)) + h_2 h_3 (\Lambda_{31} + h_1 h_3)\right],$$

which simplifies to

$$0 < 2h_2\Lambda_{31} + h_2 h_3.$$

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

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

Imposing $\iota_{i,0} = 1$ for any country i and $f_2 = 0$ in, and noting $e_{2,0} = 1$ at this point, we obtain a modified version of Equation (B.15)

$$\frac{de_{2,0}}{d\iota_{2,0}} = -\frac{\left(2\Lambda_{31} + h_3(1-h_3)\right)\left(\Lambda_{21} + h_2(1-h_2)\right) - \left(h_2h_3\right)^2}{\left(2\Lambda_{31} + h_3(1-h_3)\right)\left(2\Lambda_{21} + h_2(1-h_2)\right) - \left(h_2h_3\right)^2}. \tag{B.20}$$

The necessary condition to satisfy Equation (B.19) is that

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

which reduces to

$$0 < \left[\left(2\Lambda_{31} + h_3(1-h_3)\right)h_2(1-h_2) - \left(h_2h_3\right)^2\right].$$

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

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

This follows directly from inspection of Equation (B.15) 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.18) 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

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

is obtained by showing that

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

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

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

which reduces to

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

or equivalently to

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

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.20) 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

$$\begin{aligned}
2\left(2\Lambda_{21}+h_2(1-h_2)\right)\left(\left(2\Lambda_{31}+h_3(1-h_3)\right)\left(\Lambda_{21}+h_2(1-h_2)\right)-(h_2h_3)^2\right)< \\
2\left(\Lambda_{21}+h_2(1-h_2)\right)\left(\left(2\Lambda_{31}+h_3(1-h_3)\right)\left(2\Lambda_{21}+h_2(1-h_2)\right)-(h_2h_3)^2\right),
\end{aligned} \tag{B.22}$$

which reduces to an always true condition

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

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

To prove point (iii) of Proposition 1 recall Equation (B.16) and evaluate it at the point where $\iota_{i,0}=1$ for any country i to obtain:

$$\frac{de_{2,0}}{df_2}=\frac{-\left(2\Lambda_{31}+h_3(1-h_3)\right)}{\left(2\Lambda_{31}+h_3(1-h_3)\right)\left(2\Lambda_{21}+h_2(1-h_2)\right)-(h_2h_3)^2}. \tag{B.23}$$

The derivative of the numerator in Equation (B.23) 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

$$2\left(2\Lambda_{13}+h_3(1-h_3)\right)\left(2\Lambda_{13}+h_2(1-h_2)\right)>2\left(\left(2\Lambda_{13}+h_3(1-h_3)\right)\left(2\Lambda_{12}+h_2(1-h_2)\right)-(h_2h_3)^2\right), \tag{B.24}$$

which reduces to the always true condition

$$2\left(h_2 h_3\right)^2 > 0.$$

To prove point (iv) of Proposition 1, it is sufficient to show that Equation (B.22) and Equation (B.24) hold with equality as $h_2 \to 0$. This is obvious from inspection. This completes the proof of Proposition 1.

B.3 Proof of Proposition 2

Start with the stacked expressions for the balance of payments conditions across countries $j = 1, \ldots, 2$ given by equations (4) and (5)

$$\underline{h} h_1 \iota_{1,0} + \Omega\left(\underline{\iota}_0 \odot \underline{e}_0\right) - \underline{f} + \Lambda\left(\underline{e}_1 \oslash \underline{e}_0\right) - \underline{\lambda} = 0,$$

$$h_1 \underline{h} \iota_{1,1} + \Omega\left(\underline{\iota}_1 \odot \underline{e}_1\right) + \underline{f} - \Lambda\left(\underline{e}_1 \oslash \underline{e}_0\right) + \underline{\lambda} = 0.$$

where Λ is an $(N-1) \times (N-1)$ matrix with $\sum_{i \neq j} \Lambda_{ji}$ on its $(j-1)$th diagonal with the $(i-1)$ and $(j-1)$ off diagonals equal to $-\Lambda_{ji}$.

Now consider a first order approximation about the balanced trade point $\underline{\iota}_1 = \underline{\iota}_0 = \mathbf{1}_N$ and $\underline{f} = 0$, so $\underline{e}_1 = \underline{e}_0 = \mathbf{1}_N$. Let variables with $\hat{}$ denote deviations from balanced trade. As described, we set $\hat{\underline{\iota}}_1 = 0$ and $\hat{\iota}_{1,1} = 0$. With this approximation, the two stacked conditions become

$$\underline{h} h_1 \hat{\iota}_{1,0} - \hat{\underline{f}} + \Omega\left(\hat{\underline{\iota}}_0 + \hat{\underline{e}}_0\right) + \Lambda\left(\hat{\underline{e}}_1 - \hat{\underline{e}}_0\right) = 0, \tag{B.25}$$

$$\Omega \hat{\underline{e}}_1 + \hat{\underline{f}} - \Lambda\left(\hat{\underline{e}}_1 - \hat{\underline{e}}_0\right) = 0.$$

Summing across the two conditions we obtain

$$\underline{h} h_1 \hat{\iota}_{1,0} + \Omega\left(\hat{\underline{\iota}}_0 + \hat{\underline{e}}_0\right) + \Omega \hat{\underline{e}}_1 = 0,$$

so that $\underline{\hat{e}}_1 = -\underline{\hat{e}}_0 - \underline{\hat{\imath}}_0 - \Omega^{-1}\underline{h}h_1\hat{\imath}_{1,0}$. Replacing out $\underline{\hat{e}}_1$ in equation (B.25), we obtain

$$\underline{\hat{e}}_0 = -\left(I - 2\Omega^{-1}\Lambda\right)^{-1}\left[\left(I - \Omega^{-1}\Lambda\right)\left(\underline{\hat{\imath}}_0 + \Omega^{-1}\underline{h}h_1\hat{\imath}_{1,0}\right) - \Omega^{-1}\underline{\hat{f}}\right]. \tag{B.26}$$

Note that the matrix Ω is invertible using the Sherman-Morrison formula and is given by $\Omega^{-1} = -\text{diag}(\underline{h})^{-1} - \frac{1}{h_1}\mathbf{1}\mathbf{1}'$.

If the spectral radius of $2\Omega^{-1}\Lambda$ is less than 1 then we can use the Neumann series identity to write

$$\left(I - 2\Omega^{-1}\Lambda\right)^{-1} = \sum_{m=0}^{\infty}(2\Omega^{-1}\Lambda)^m.$$

Rearranging, substituting this series into equation (B.26) yields equation (6)

Even if the spectral radius is greater than 1 the matrix inverse of $\left(I - 2\Omega^{-1}\Lambda\right)$ exists, as $\left(I - 2\Omega^{-1}\Lambda\right) = -\Omega^{-1}(2\Lambda - \Omega)$ and it is straightforward to verify $(2\Lambda - \Omega)$ is a strictly diagonally dominant matrix. Hence, a unique $\underline{\hat{e}}_0$ exists.

Turning to comparative statics, first define auxiliary matrices

$$M = (I - 2\Omega^{-1}\Lambda)^{-1},\ B = M(1 - \Omega^{-1}\Lambda);$$

so we write

$$\underline{\hat{e}}_0 = -B\left(\underline{\hat{\imath}}_0 + \Omega^{-1}\underline{h}h_1\hat{\imath}_{1,0}\right) - M\Omega^{-1}\underline{\hat{f}}.$$

Hence, we know that the response to a period-0 trade shock outside of country-1 is given by

$$\frac{d\underline{\hat{e}}_0}{d\underline{\hat{\imath}}_0} = -B$$

Now consider an infinitesimal change in an arbitrary financial connection ab. From the structure of Λ we have that

$$d\Lambda = (E_{aa} + E_{bb} - E_{ab} - E_{ba})d\Lambda_{ab},$$

where E_{ab} is an $(N-1)\times(N-1)$ matrix with a 1 in element $(a-1, b-1)$ and zeros elsewhere. Now, from matrix differentiation we have the following expressions

$$dM = M(2\Omega^{-1}(E_{aa} + E_{bb} - E_{ab} - E_{ba}))Md\Lambda_{ab},$$

and so

$$dB = M(\Omega^{-1}(E_{aa} + E_{bb} - E_{ab} - E_{ba}))(2B - I)d\Lambda_{ab}.$$

Now consider the response of currency k to a change in local import demand, it is given by

$$\frac{d\hat{e}_{0,k}}{d\hat{\iota}_{0,k}} = -B_{(k-1,k-1)},$$

the $k-1$th diagonal of B. Defining z_k as a $N-1$ column vector a one in its $k-1$th element and zeros elsewhere, we obtain

$$\frac{d\hat{e}_{0,k}^2}{d\hat{\iota}_{0,k}d\Lambda_{ab}} = -z_k' M\Omega^{-1}(E_{aa} + E_{bb} - E_{ab} - E_{ba})(2B - I)z_k,$$

Let r' be the $k-1$th row of $M\Omega^{-}1$ so that $r' = z_k' M\Omega^{-1}$ and let the column vector $c = (2B - I)z_k$ be the $k-1$th column of $2B - I$. Since

$$r'(E_{aa} + E_{bb} - E_{ab} - E_{ba}) = r_a e_a' + r_b e_b' - r_a e_b' - r_b e_a'.$$

C Empirics

C.1 Eigenvector Centrality

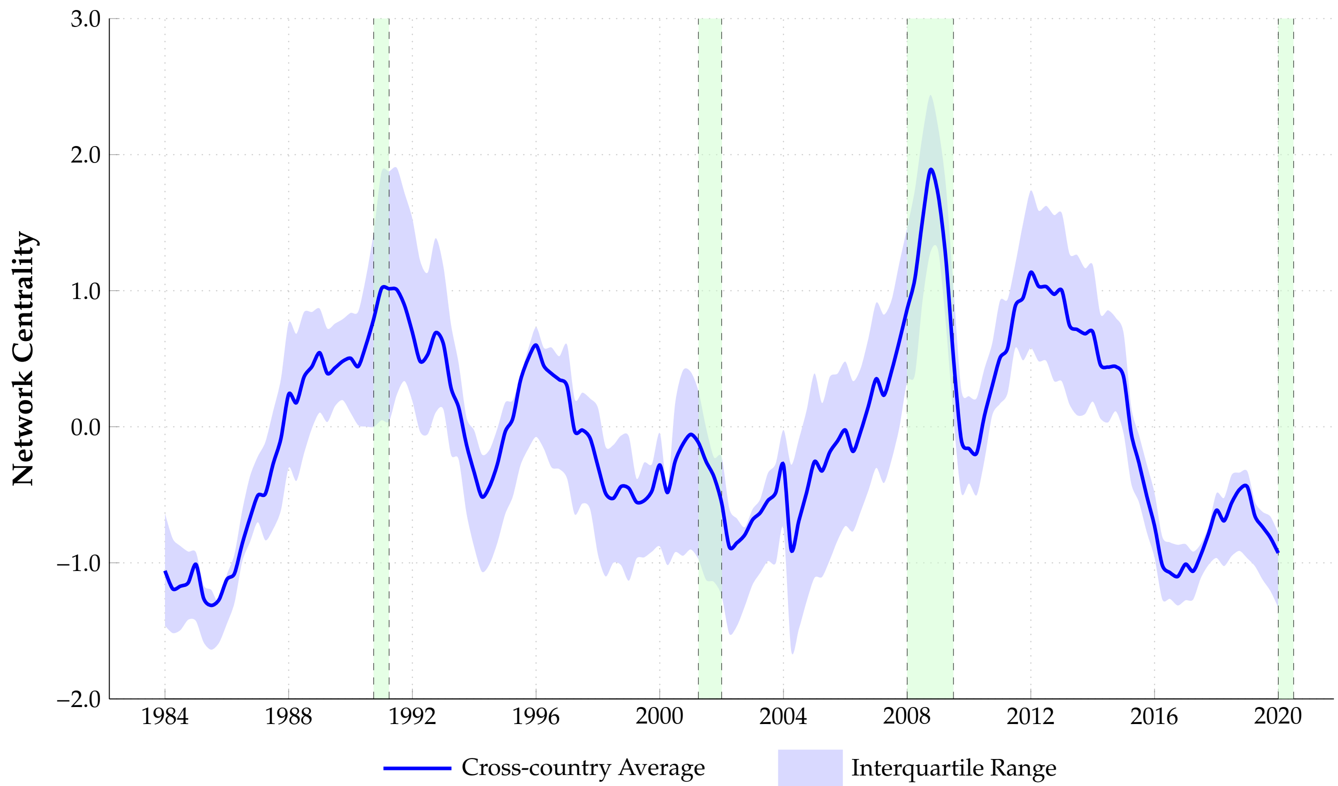


FIGURE A.2. TRADE CENTRALITY

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.

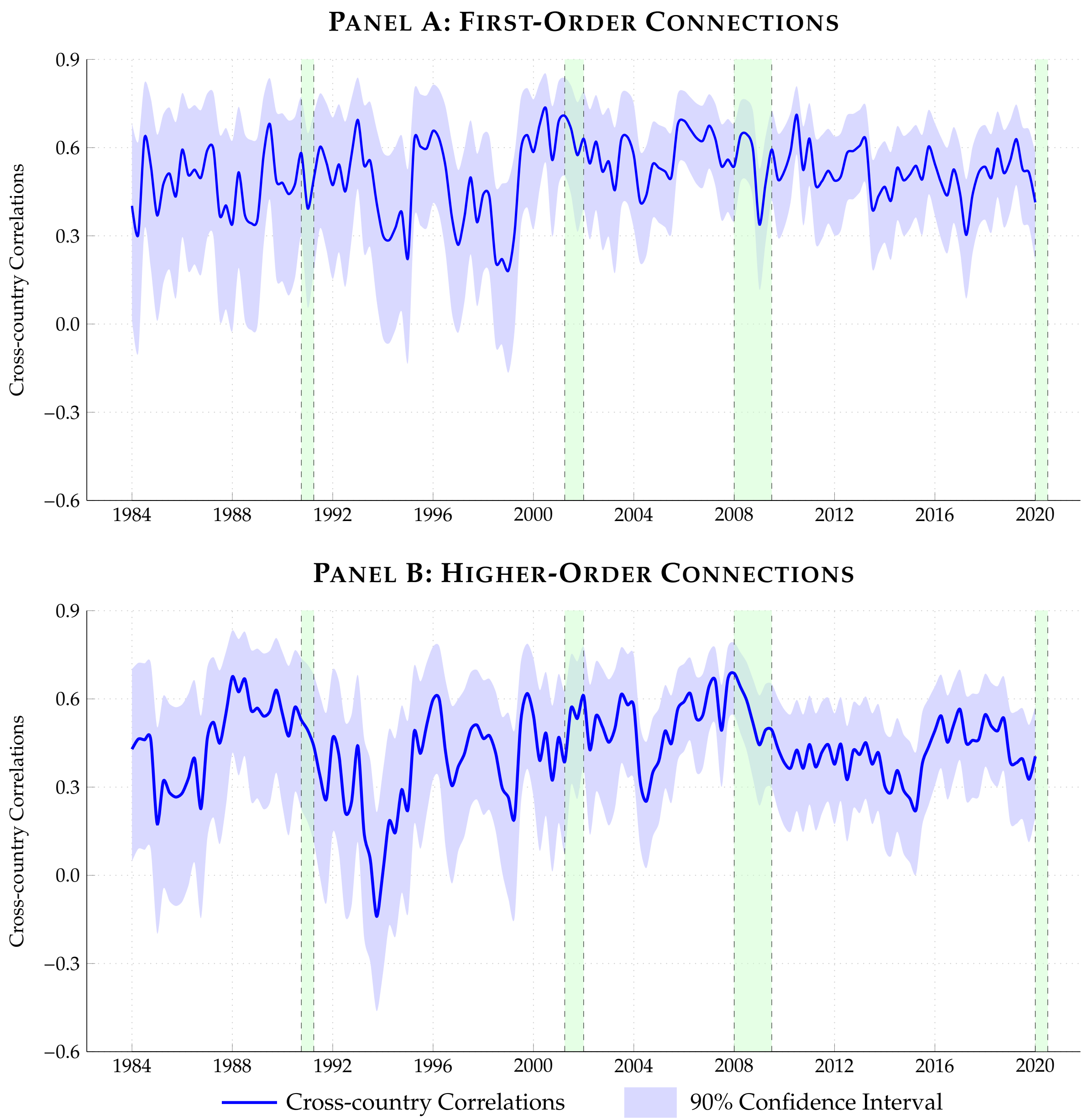


FIGURE A.3. BANKING CENTRALITY: US DOLLARS VS LOCAL CURRENCIES

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.