The Global Network of Liquidity Lines *

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Abstract

At the end of 2024, there were 177 cross-border liquidity lines between central banks connecting countries that account for 80% of world GDP. This paper studies the evolution of these arrangements since 2000. The lines form a network through which banks can indirectly obtain access to the USD even when their central bank has no agreement with the Federal Reserve. The People's Bank of China has a central role in this network, which is fragile to geopolitical tensions. We present cross-country evidence that the indirect connections reduce CIP deviations at the tails, and causal evidence that liquidity lines are substitutes to FX reserves.

JEL codes: E44, F33, G15.
Keywords: swap lines, capital flows, financial crises, IMF, cross-currency basis

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1 Introduction

A central bank cross-border liquidity line is an agreement between two central banks to provide a collateralised loan of currency from one to the other. While they have been around for a long time, the lines rose in prominence following the great financial crisis and the pandemic so that, by 2024, the funds committed to the liquidity lines were well above the lending capacity of the International Monetary Fund (IMF).[1]

These agreements are varied in their signatories and in their characteristics. For instance, while swap lines get most of the attention, there are many repurchase agreements as well. Also, while most lines are bilateral agreements that involve one central bank issuing money, many others are multilateral agreement and/or lend out existing foreign exchange (FX) reserves. Finally, while some lines provide loans to banks in order to preserve financial stability, others have a goal of internationalising the currency, and others are used to intervene in FX markets. The modern literature on liquidity lines has grown quickly using this diversity to shed light on classic questions in international finance.[2]

The first contribution of this paper is to provide in section 2 a comprehensive dataset of central bank cross-border liquidity lines at the agreement level: by date and duration (2000-24), by source currency (USD, EUR, RMB, others), by framework (bilateral or multilateral), by structure (pooled, reciprocal, or unidirectional), by counterparties (central banks), and by some terms (type of collateral, cap on amount, renewal or reactivation). This dataset was collated from public sources, and is freely available for other researchers to use.[3] We map the whole network, while the literature so far has focussed on individual liquidity lines or on subsets of the network.[4]

The second contribution is to use this dataset to provide a new historical account of the evolution of liquidity lines over time and across the world. Section 3 describes how they have spread unevenly in different regions through a decentralised spontaneous process that today sits in parallel to the other centrally negotiated pillars of the international financial system, like the World Bank and the IMF. We show that the lines involving the

[1] For the longer history of the lines and how their recent incarnation compares with previous ones, see Bordo, Humpage and Schwartz (2015), McCauley and Schenk (2020), Bahaj and Reis (2023).

[2] See the survey in Bahaj and Reis (2022*b*) and the recent developments connecting swap lines to the link between funding shocks and bank lending (Cesa-Bianchi, Erugen-Martin and Ferrero, 2022), the terms of sovereign borrowing (Róldan and Sosa-Padilla, 2025), and the existence of long run equilibria involving a global financial crisis (Bohórquez, 2023).

[3] The website https://r2rsquaredlse.github.io/web-lines/ has the data repository.

[4] The closest antecedent with cross-country work are Bahaj and Reis (2023), Perks et al. (2021), which are significantly more limited in their coverage over time, countries, and characteristics.

three major currencies followed different models in their expansion: the People's Bank of China (PBoC) has a large hub-and-spoke network, while the Federal Reserve (Fed)'s lines form a smaller but denser network, and the European Central Bank (ECB)'s network is in between.[5]

The third contribution, in section 4, is to realise that the network provides a bank with indirect access to a loan in a foreign currency even when its own central bank does not have a line that directly involves that currency. As a result, the coverage of the network is broader than is commonly appreciated. In 2024, the three major currencies—the US dollar (USD), the Euro (EUR), and the Renminbi (RMB)—reach countries covering 80% (same as in abstract) of world GDP.[6]

Fourth, we ask how fragile the network is. In section 5, we find that the PBoC has a central role in the network of liquidity lines for both the USD and EUR.[7] If it cancelled its own lines, 9 countries accounting for 20% of global GDP would lose access to the USD network, and the mean path length to access a USD rise from 3.15 to 3.4.[8] [9]

The fifth contribution of the paper is a new result: indirect connections create ceilings on the covered interest parity (CIP) deviations (sometimes also called the cross-currency basis) between two currencies. This extends the well-know result from direct connections, showing that its logic applies to a much wider set of pairs of currencies than previously thought.

Following on this insight, section 6 matches our network dataset with CIP data to form a panel of lines and CIP monthly measures for 42 countries over 16 years.[10] We provide the first cross-country evidence that there is a positive association between the average size of CIP deviations between two currencies and the degree of the connection between the central banks of these currencies. The literature on this connection so far has focussed on time-series analysis of a single or a small set of swap lines, often using high-frequency data.[11] The other side of the coin of showing the relevance of this connection over many

[5]On the evolution over time and motivation behind the PBoC lines, see Bahaj and Reis (2025), Benguria and Novy (2024), on the Fed's see Fleming and Klagge (2010), Kelly (2023), and on the ECB's see Albrizio, Kataryniuk and Molina (2023).

[6]See Coppola et al. (2021) for the network of private capital flows cross currencies.

[7]See also Horn et al. (2023) for the network of lending-of-last resort by the PBoC.

[8]See the survey by Mohr and Trebesch (2025) on how this could be used as a weapon on geopolitical conflict, and the theory by Bacchetta, Davis and van Wincoop (2025) on the importance of the swap line network for the role of the USD as the global safe haven.

[9]as of December 2024

[10]To measure CIP, we build on the work of Du and Schreger (2016), Cerutti and Zhou (2023), Dai and Gourinchas (2025)

[11]See Bahaj and Reis (2022*a*), Ferrara et al. (2022), Albrizio, Kataryniuk and Molina (2023), Goldberg and

countries and years is that we only establish a correlation, while a few of the existing studies find a causal link between the swap lines and CIP deviations.

The fifth and final contribution, laid out in section 7, is a causal connection between then liquidity lines and FX reserves. Insofar as the lines provide some of the same benefits and work through similar channels as FX reserves, studying the two jointly provides a better understanding of their causes for their adoption and their consequences.[12].

To overcome the identification challenge that both creating a line and accumulating reserves are deliberate joint policy choices, we measure what happens to a country's FX reserves around an improvement in the its position in the network line relative to other similar countries whose position did not change. We find that a past drawdown of one of the country's FX reserves predicts it entering a swap agreement. Then, using the unique network structure of our data, we obtain casual estimates of the liquidity lines on FX reserves by zooming in on cases when a country becomes better connected not because it signed an agreement but because one of the counterparties it is connected to improves its position in the network. This improvement in higher-degree connections to tap into the network for foreign currency is not associated with a specific action by the country, so it is plausibly exogenous to other determinants of FX reserves. We find that when a country becomes better connected, this is followed by a fall in FX reserves. We therefore conclude that liquidity lines and FX reserves are substitutes.

Section 8 concludes by collecting all of the results, both theoretical and empirical, in one list of nine lessons.

2 The dataset

The sample covers all active agreements between January 2000 and December 2024, including 73 central banks that had an agreement of some sort at some point during this period.

2.1 The sources of the data

We started by merging the earlier work by Perks et al. (2021), Albrizio, Kataryniuk and Molina (2023), Bahaj and Reis (2023), Horn et al. (2023), Kelly (2023) that had more lim-

Ravazzolo (2022), Kekre and Lenel (2025).

[12]Obstfeld, Shambaugh and Taylor (2009) and Aizenman, Jinjarak and Park (2011) present different arguments for why the two may be complements or substitutes.

ited regional and time coverage. Then, we went through the websites, press releases, publications, and central bank annual reports of each central bank since 2000, looking for announcements of any agreement. Next, we went through websites, press releases, and publications from ministries of finance and embassies. The next step was a general web search, with a focus on the financial and local press. Finally, in several cases, we contacted the central banks.

This provided a first list for which we would find at least one side of a bilateral deal recognising it in some official publication. Often, we were able to cross-check that both sides of the deal reported it, and most of the times they agreed with each other. Just in case, we recorded reciprocal deals as separate line items, so that any discrepancy in the way they are reported is kept for researchers to choose how to deal with those.

2.2 Variables and characteristics

We report the *start date* if this is explicitly mentioned. If not, we took the date of the press release about the line.

Recording a precise *end date* was harder. Almost all liquidity lines are for a fixed term, with standard choices for length of one or three years, but most of them are regularly renewed. One notable exception is the agreement between the PBoC and the Hong Kong Monetary Authority, which has an unlimited length and requires no extension. Sometimes a renewal comes with a new deal, but often it is the result of a mere extension of the end date. Some central banks do not report these renewals. When an end date was missing and no renewal was announced, we recorded it as so. To be consistent, we recorded renewals as separate line items, allowing future researchers to choose how to merge them, and indicated when we make assumption about the end date. As a result, the dataset has 1,589 line items, which corresponds to significantly fewer country-pair arrangements if they were consolidated by arrangement and by pair. The advantage of recording information at the agreement level is that the dataset explicitly tracks whether an agreement renews, supersedes or supplements prior agreements between the two counterparties.

The next characteristic is the *maximum amount* that can be drawn from the lines. When there is a renewal, if no mention is given of this maximum, we assumed it stayed unchanged. Most lines have a cap. An important exception is the sub-network of reciprocal swap lines involving the Fed and five other major central banks (the Bank of Canada, Bank of England, Bank of Japan, Swiss National Bank, and the ECB).

Turning next to *collateral*, for all lines, we were able to ascertain whether they were

swap lines, that exchange one currency for another, or instead repurchase agreements, where one central bank receives currency in exchange for giving a security. In the data, 96% of all agreements are swap lines. Repurchase lines are the exception.

We further recorded if the funding for a line is *pooled*. Most attention has been paid to one-to-one lines, where one central bank is the sole source of the liquidity for another. However, only 52% of the recorded deals are one-to-one. The others share a pooled fund of one currency, most often the USD, across several central banks, that is then exchanged for the borrowing central bank's own currency. The most famous pooled fund is the Chiang Mai Initiative (CMI), which grew from the ASEAN Swap Arrangements, involving Singapore, Malaysia, Philippines, Thailand, Indonesia (all since 1977), Brunei, Cambodia, Laos, Myanmar, Vietnam (joining in 2000) and China, Japan, South Korea (joining in 2009). It is a swap line, in which each local central bank exchanges local currency for USD, or occasionally for other local currencies, like the Japanese yen or the Korean won. Another famous, more recent example is the Contingent Reserve Arrangement (CRA) pooling USD reserves from Brazil, Russia, Mexico, China, and South Africa, signed in 2014 (and no end date).

Another characteristic of line is whether it results from a bilateral agreement (50%) or a *multilateral framework* (50%). Multilateral agreements are made between three or more countries, like the CMI. Countries also sometimes form sub-networks of bilateral lines, like the Fed and the five other major banks. What differentiates a multilateral line is its legal structure: all the counterparties in the initiative sign an overarching umbrella agreement. All pooled funds are multilateral agreements, but there are some multilateral frameworks that do not pool funds. Two important multilateral facilities started in 2020 are the Fed's Foreign and International Monetary Authorities (FIMA) Repo Facility and the ECB's Eurosystem Repo Facility for Central Banks (EUREP) via which foreign central banks can obtain USD and EUR, respectively, in a repurchase agreement against their foreign exchange reserves. Most central banks across the globe can seek approval to access FIMA or EUREP, but we include in our data only the countries that received public approval to join.

The next characteristic is *reciprocity*. The *de jure* norm is that non-pooled lines are reciprocal deals (71%), where each country commits to lend to the other. *De facto*, the Fed has not borrowed currency from any of its counterparties, even as many of them have borrowed USD. In fact, the Fed has not even announced the procedure by which banks in its jurisdiction would at any point receive a foreign currency. The alternative are uni-

directional lines, whereby only one country has agreed to lend. India's swap lines with other countries in South Asia under the SAARC initiative, as well as the ECB's lines with some Eastern European countries fall under this category.

The final important characteristic is the *currency*. Usually, this is the currency of the two central banks signing the agreement, but sometimes it is not, as in the case of the agreements that pool USD. Japan, via the Ministry of Finance and not the Bank of Japan, has several bilateral agreements with other Asian countries that swap USD, rather than JPY, for local currency.

3 The geographical spread of the lines over time

Figure 1 shows the connections between countries with an active line within a given month in our sample. The left-hand panel shows a count of their number, while the right-side panel sums the share of world GDP covered by countries with at least one line.

The figure shows that there were three stages in the expansion of the liquidity lines. The first, between 2008 and 2010, saw a jump associated with the global financial crisis and the Fed has its main driver. The second, comes between 2010 and 2015, when there was a more gradual, but just as large, expansion driven by the ECB and the PBoC. After a period of calm between 2015 and 2020, the pandemic led to a third flurry of expansion. Some of the agreements signed then had expired by 2024, but others remained, so in the end there were 177 active lines connecting countries covering 80% of the world's output.

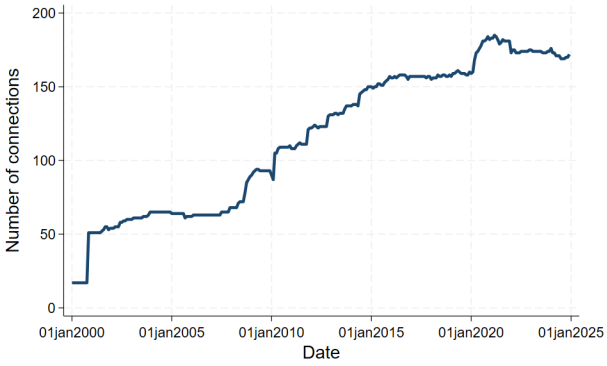
3.1 The move to bilateralism

Figure 2 breaks the connections between those that arise from agreements involving only two central banks (bilateral) and those that involve more than two central banks (multilateral).

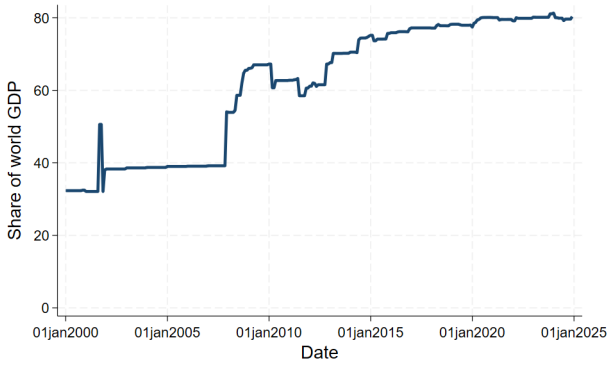
The figure provides a stark illustration of a major change in the international financial system in the XXIst century so far: the rise of bilateralism. In a sense, since all liquidity lines involve individual national central banks, their rise is a retreat from Bretton Woods world based on multilateral international institutions. But even within the lines, two central banks signing a bilateral swap line, potentially as part of a broader political agreement between two nation-states, has been the engine of expansion.

Figure 1: The evolution over time of the liquidity lines

(a) By total number



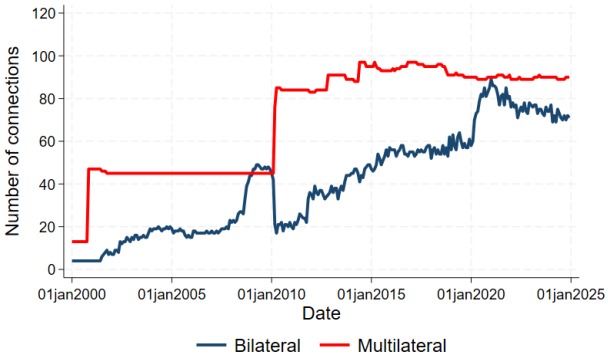
(b) By share of world GDP



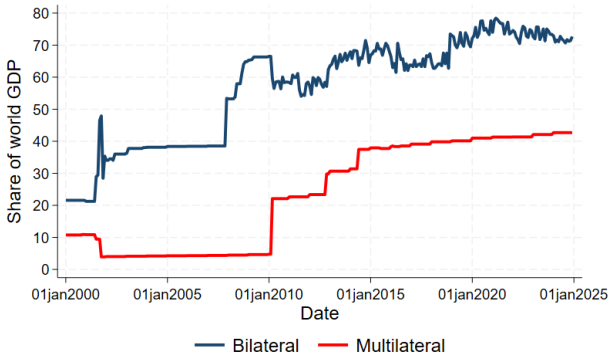
Note: Panel (a) has the total number of direct connections between central banks, including both bilateral and multilateral connections. It counts one for every pair in an agreement, or the number of edges in the network. For example, four countries signing a reciprocal multilateral agreement would generate six connections. Panel (b) has the share of world GDP in PPP units for countries that have at least one line.

Figure 2: Bilateral versus multilateral liquidity lines, by number

(a) By total number



(b) By share of world GDP



Note: Panel (a) splits the connections in figure 1 into those that are strictly bilateral or strictly multilateral. Panel (b) shows the share of GDP in PPP units of countries that have at least one bilateral agreement and no multilateral agreement, at least one multilateral agreements and no bilateral agreements, or at least one of each (dual).

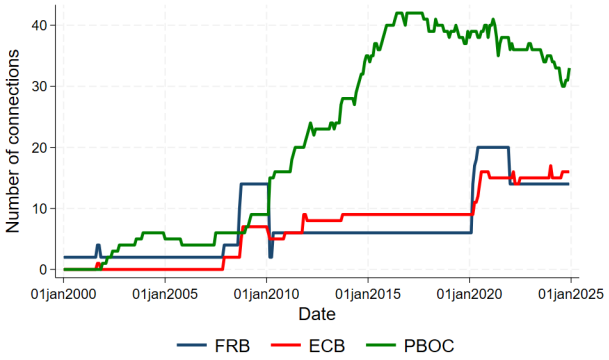
3.2 The three major international currencies

Figure 3 breaks the lines by currency.

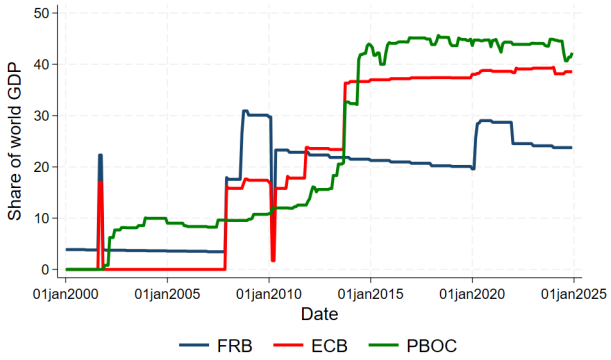
In the 2010–15 period, the ECB and the PBoC were the major players signing bilateral agreements and driving the growth in the network. The actions of the PBoC were part of the internationalisation of RMB, while the ECB was both catching up to the Fed as

Figure 3: The evolution over time of the liquidity lines, by currency

(a) By total number



(b) By share of world GDP



Note: Panel (a) shows the number of direct counterparties (borrowing or lending, via both bilateral and multilateral agreements) of the Fed, the ECB, and the PBoC. Panel (b) shows the share of GDP in PPP units of the direct counterparties of each institution.

well as creating a sub-network in Eastern Europe. Whereas the EUR grew quickly in its network's share of GDP, the RMB grew especially in the number of agreements. While the ECB's lines contain mostly advanced economies, the ones signed by the PBoC have many more, and on average smaller, economies.

3.3 The three main currency networks

Figure 4 shows the coverage of the connections in the world map at three key dates in their evolution.

The network of liquidity lines was regional in 2000. In North America, there was a sub-network of bilateral swap lines connecting the countries in NAFTA. In Asia, the CMI sub-network aimed to prevent a repeat of the late 1990s South East Asia financial crisis.

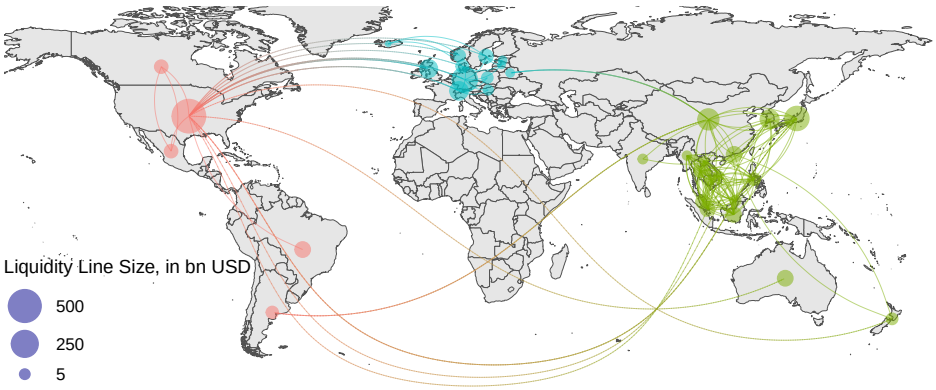
By 2009, the Fed had created a global network of liquidity lines. International banks were unable to renew their funding from US money markets during the global financial crises that they had used to buy USD denominated assets. The Fed's swap lines gave these foreign financial institutions access to a lender of last resort through their national central banks, lowering the demand pressure on US money markets, preventing forced sales of the US assets, and avoiding the failure of foreign banks.

At the end of 2020, the network reached its peak (so far). Relative to 2009, the network by then included both the 2010-15 catch-up of the ECB and the PBoC relative to the Fed, as well as the large expansion in 2020 led by the Fed and the ECB in response to the

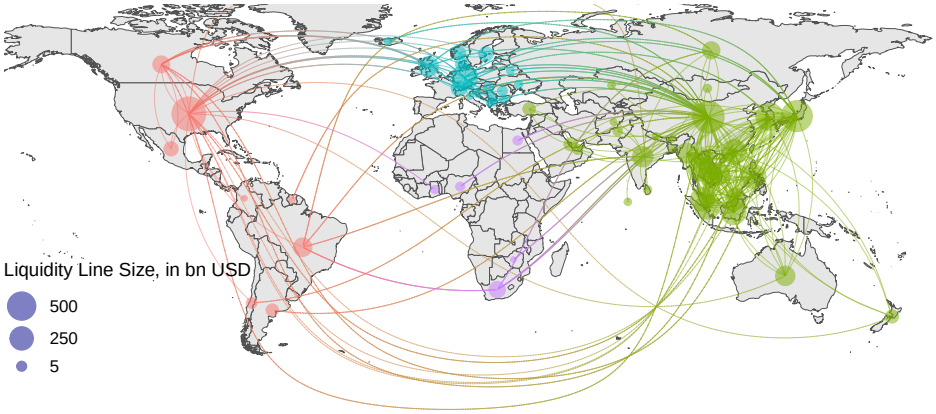
Figure 4: Geographical coverage of the liquidity lines

(a) In 2000

(b) In 2009



(c) In 2020



Note: Each map includes both bilateral and multilateral agreements. The liquidity line size for each country is the total amount that country has committed to liquidity lines across all counterparties, averaged across borrowing and lending, and converted to USD using the contemporary exchange rate. When the line is unlimited we use the maximum of (i) any prior cap on the line and (ii) the maximum reported drawing to date.

pandemic to calm financial markets.

Several of the lines involving the Fed have expired since then. In 2024, the USD network looks like what it as in 2009, consisting primarily of NAFTA and the sub-network with the other five big central banks.

The RMB network instead looks in 2024 similar to what it was in 2020. It is wider, and it is the only one to have counterparties in Africa, the middle East, and South America, as well as the only one to include Russia.

The EUR network lies in between these two, covering most of non-EUR Europe, and with the singularity of including lines between the ECB and both the Fed and the PBoC.

4 Indirect connections and the network by degree

When one country has a line with another, and that one has a line with a third country, then there is an indirect connection between the first and the last of the three countries. This section describes the economics of an indirect connection and looks at the network of liquidity lines by degree of connection.

4.1 Indirect connections

For concreteness, take the example of a hypothetical bank in Korea. Say this bank had USD funding with which it bought illiquid USD assets. Imagine that funding is not rolled over one day, and unable to sell the assets (or unwilling to take the loss in selling them), the bank turns to the Bank of Korea (BoK) for a loan of last resort.

During the pandemic, in 2020-21, the BoK had a swap line with the Fed. Therefore, it would borrow USD from the Fed, giving Korean won (KRW) in return, and lend these USD out to the Korean bank. When the bank repaid the USD, the Bank of Korea would pay them back to the Fed plus interest, receiving its KRW back, which had never entered circulation. This is how most liquidity lines with a direct connection between two countries work.

In 2022, this Fed-BOK liquidity line expired, and was not renewed. Yet, the BoK still had a swap line with the Bank of Japan (BoJ), which in turn had a swap line with the Fed. The BoK could borrow Japanese yen (JPY) from the BoJ and lend them to the Korean bank.[13] This bank could then enter a private forward contract with a private Japanese

[13]This became more direct in 2023, when the BoK signed a swap agreement with the BoJ to borrow USD.

bank to exchange these JPY for USD, with a commitment to exchange them back at a fixed interest rate and exchange rate at the same date that its loan repayment to the BoK was due. In turn, the Japanese private bank could get the USD in the first place by borrowing them from the BoJ, who in turn could get them from the Fed through its swap line in exchange for JPY collateral.

At the end of this chain of transactions, the Korean bank had the USD it wanted and a commitment for a fixed payment at a fixed date to give them back, and the Fed had created and lent out the USD against collateral, just as before when there was a direct line. The two other currencies, the KRW and the JPY, laid inactive as collateral in someone's balance sheet, so the amount of money in circulation changed in the same way as it did with a direct line. The interest rate and exchange rate risk borne by all parties was the same as well.

The only significant difference between the direct and indirect way of accessing foreign currency by the local bank is that the latter involves more counterparties. Making the reasonable assumption that none of the three central banks involved will not honor their commitments, the key new counterparty risk is the private intermediary (the Japanese bank, in our example) not having capacity to provide the funds or defaulting on the contract. Insofar as there is a liquid market with many of these intermediaries, an indirect connection is almost as good as a direct one in providing the desired lender of last resort.

4.2 The network by degree

Replicating this argument, there is indirect access involving not just two, but also three or more intermediary currencies, banks and central banks. From now on, we refer to direct lines as providing access of degree one, while the Korean bank in the example would have access of degree two to the USD, and a hypothetical fourth country with a liquidity line with the Bank of Korea (but not with another central bank of degree one) would have access of degree three. We take the shortest degree when two countries have multiple connections between them. The highest degree of connectivity we observe to the three major central banks is four. Hence, a disconnected country is encoded as having degree five.

Figure 5 adds to figure 3 also the connections of degree higher than one. For each of the three major international currencies, approximately 80% of world GDP is covered under the umbrella of liquidity provided by the network. This is a consequence of the density of the degree of lines between the Fed, ECB, and PBoC, as well as the intermediating role

played by the BoJ and the Bank of Canada.

What differs between them is the degree of each line in that global network, and the weight of each degree in their total connections. For the USD, 20% is the size of the US economy, which has domestic access to USD through the domestic liquidity facilities, another 20% are direct lines, and the indirect connections add another 40% of GDP, roughly doubling the reach of its network. Instead, for either the EUR or the RMB, approximately 60% are covered domestically and directly, with indirect connection adding only 20%.

4.3 The international reach of the three major currencies

Figure 6 shows the geographical dispersion of the networks for each of the three major currencies by degree. The USD's direct network in 2024, measured on the basis of bilateral connections, was geographically narrow. Yet, indirectly via the ECB, it reached Eastern Europe and China. Through China and the PBoC's sub-network, it then reached countries widely spread throughout the world, including even Russia.

4.4 The average degree of each currency network

Figure 7 shows, in panel (a), the mean path length to each of the three major currencies. Confirming the different reliance on indirect connections, the USD has the highest average degree of connection, while the RMB has the lowest.

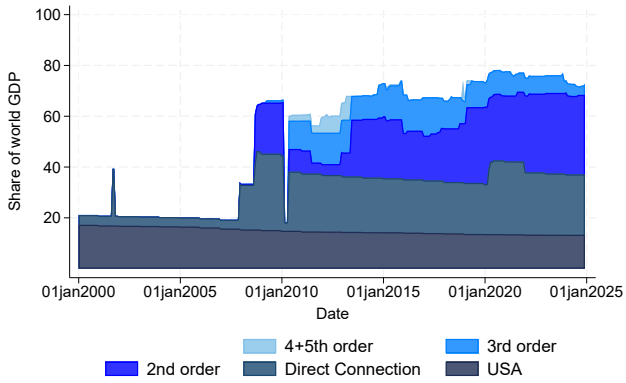
The figure also shows the remarkable progress since the start of the sample. Not only there are more direct lines, as we saw before, but the degree of the connections has steadily fallen.

Panel (b) in figure 7 assesses the importance of each of the three central banks as intermediaries in giving access to the other central banks' currencies through the indirect connections. It shows the impact of dropping each of the three major central banks on the length of the path in the network from each country to one of the three major currencies, averaged across all countries.

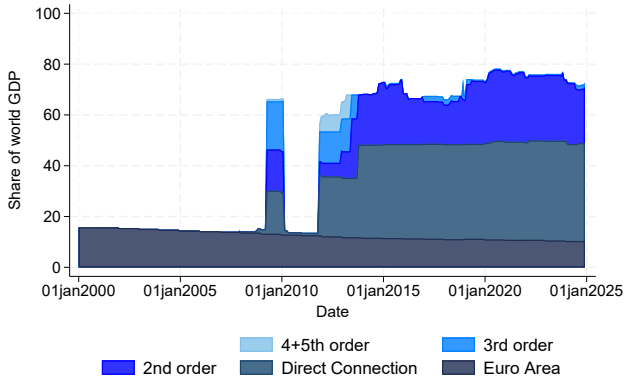
Four results stand out. First, the Fed is not particularly important as an intermediary. If the Fed withdrew from the network, this would have a major impact on access to the USD, of course, but only a negligible impact on the EUR or the RMB. Second, if either the PBoC or the ECB left, the impact would be large on the USD. Third, the PBoC has an even more important role for intermediating access to the EUR than it does for intermediating access to the USD. This reflects the coverage of Asian and Middle Eastern countries that

Figure 5: Countries connected to each currency, as a share of world GDP

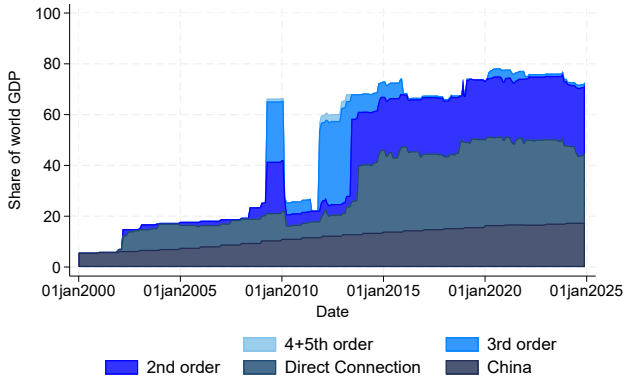
(a) USD (Federal Reserve)



(b) EUR (European Central Bank)



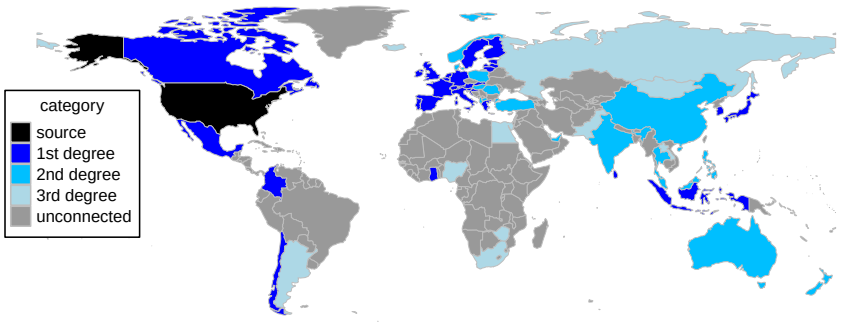
(c) RMB (People's Bank of China)



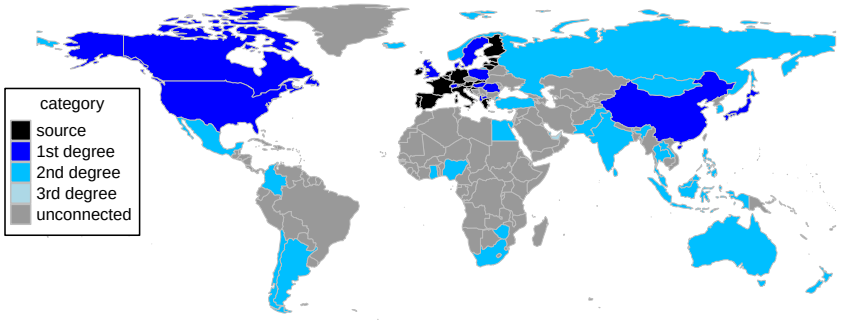
Note: Share of world GDP in PPP covered by the liquidity line network of the Fed in panel (a), the ECB in panel (b), and the PBoC in panel (c), where the coverage is broken down by the degree of connection. Bilateral connections only, excluding multilateral connections.

Figure 6: The world network in 2024 by line degree for the three major currencies

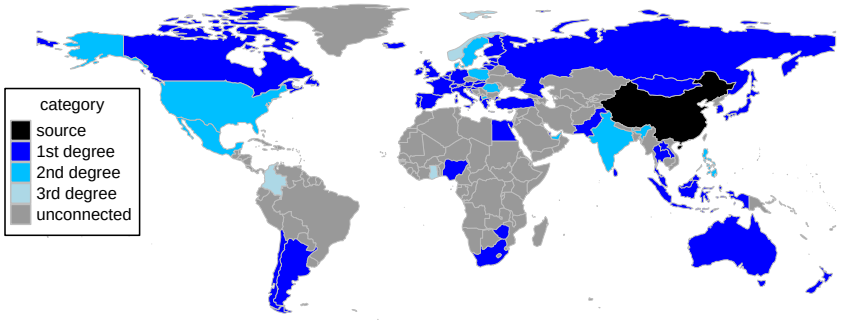
(a) USD (Federal Reserve)



(b) EUR (European Central Bank)



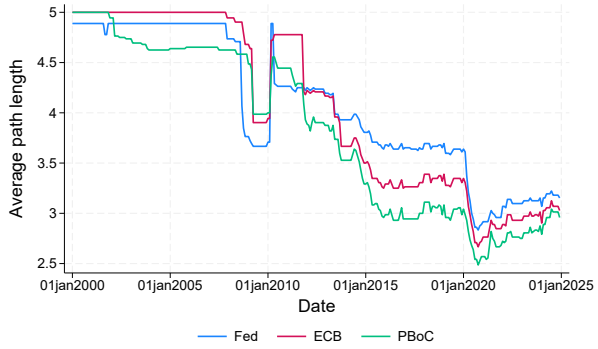
(c) RMB (People's Bank of China)



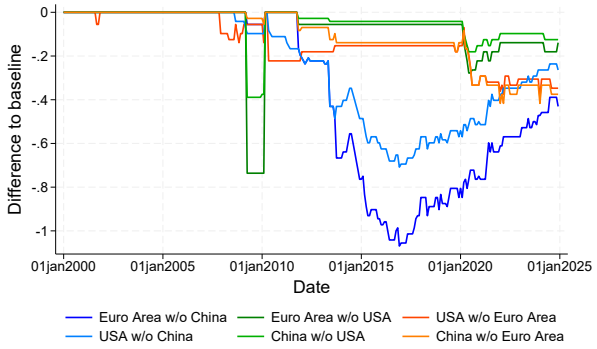
Note: Bilateral connections with the Fed in panel (a), the ECB in panel (b), or PBoC in panel (c) at any point in 2024.

Figure 7: Average path lengths and the intermediary role of the major central banks

(a) Average path length



(b) Change from dropping major central banks



Note: Panel (b) shows the difference in average path length from baseline bilateral network when eliminating selected country from network. A difference of -1 indicates the length of the average path to the source is one unit longer upon elimination of the specified node.

is unique to the PBoC sub-network. Fourth, and finally, the numbers are large. The mean path length in the network for the USD in 2023 was 3.3, which without either the ECB or the PBoC would jump to 3.8. This leads us in the next section to investigate the fragility of the network to these central nodes.

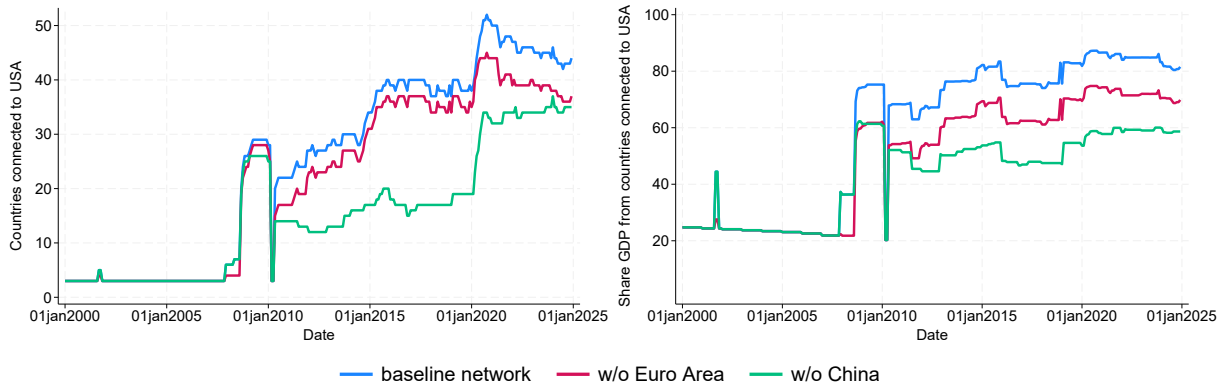
5 The fragility of the USD network

Indirect connections may substitute for direct ones, but they are arguably more fragile since they rely on more central banks to keep on renewing past agreement, and on banks and arbitrageurs doing some of the intermediation. While the Fed's role is central to world liquidity, since the USD is the overwhelming dominant currency in international transactions, the previous section found that the USD network relies more on indirect connections. This section investigates the fragility of the USD network, with an emphasis on geopolitical tensions potentially leading the ECB and the PBoC to no longer intermediate these indirect connections.

5.1 The relevance of the PBoC and the ECB

Figure 8 revisits the importance of the other central banks on the USD network. It counts the number of countries with direct or indirect access to the Fed through the network in two counterfactuals, where we removed the ECB or the PBoC, with all of their respective

Figure 8: The ECB and PBoC's role in access to the USD



Note: Countries with direct or indirect connections to the Fed to access the USD in baseline bilateral network and in the bilateral network when eliminating selected counterparties. GDP weighted measures use countries' share of PPP annual world GDP.

lines. When a central bank drops from the network, the effect is as much the loss of official access to funding, as it is the higher cost for private funding through elevated CIP deviations.[14]

The PBoC's relevance is clear: without it, 9 countries accounting for 20% of global output would lose access to the USD network. By comparison, the presence of the ECB is essential for countries that produce 11% of global GDP. If, hypothetically one of these major central banks were excluded from USD transactions, this would have a major impact on the coverage of USD backstop liquidity.

5.2 Centrality of other central banks

The network has some redundancy in it. Banks in a country have several routes through which they can access foreign currency. A central bank that is particularly preponderant in shorter connections would appear as having a front role in the previous figures, but perhaps other central banks in back roles could keep the network going.

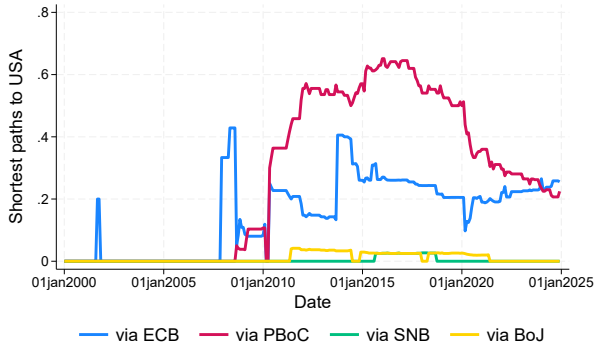
To investigate this, panel (a) in figure 9 calculates what share of indirect connections go through the ECB, PBoC, the BoJ or the Swiss National Bank in providing access to the USD. It turns out that these last two central banks are close to irrelevant. This shows the extent of intermediation being done by the ECB and the PBoC. The importance of the ECB has risen since the pandemic (already visible in figure 7) as it expanded its network

[14]The next section shows the direct link between indirect connections and CIP deviations.

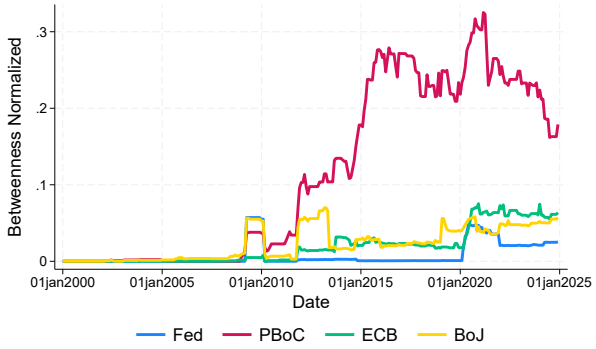
(while the Fed let some of its lines expire).

Figure 9: Shortest paths via selected nodes

(a) Shortest path to access USD



(b) Betweenness centrality of central banks



Note: Panel (a) shows the share of shortest paths to the USD running through each counterparty central bank as a percentage of all paths. Panel (b) shows betweenness centrality $b(c)$ of node c. Letting $k_{s,t}$ be the shortest paths between nodes s and t containing c, and $K_{s,t}$ be the total number of shortest paths from s to t, then betweenness centrality is $b(c) = \sum_{s,t \neq c} k_{s,t}(c)/K_{s,t}$. We normalize it by dividing by 69*68, which is the total number of potential shortest paths among the 72 countries in our network. The measure is calculated for the bilateral connections only.

A final measure of the importance of a node is whether, for any two nodes in the network, most of the shortest paths go through this particular node. Panel (b) in figure 9 calculates network centrality for the three major central banks and the BoJ. This is a relative measure of the shortest paths between any two countries in the network that is intermediated by one central bank. Across currencies, the PBoC is in the centre of the vast majority of connections, so it is especially powerful in affecting access to USD liquidity. While the ECB and the Bank of Japan are also relevant, both have less power in this sense.

5.3 The role of private banks and arbitrageurs

Go back to our discussion of a Korean bank seeking USD and finding it by borrowing JPY from the BOK through its line with the BoJ to then swap them for USD using a private bank in Japan. This dependence on the swap market and on a private bank suggests another potential point of fragility in the network.

We suggested that this private bank obtained the USD by borrowing from the BoJ who would get them from its line with the Fed. There is strong evidence that banks use the liquidity lines to offset pressure on forward markets. But, that use is, strictly speaking, not even required for the argument. The Japanese bank might have had the USD to start

with or be able to borrow them in the open market. The original problem facing the Korean bank in a crisis—it could not get private USD funding—need not extend to the Japanese or other banks. Outside of a global meltdown in USD financial markets, it is in fact unlikely that it does.

Continuing with the previous argument, the Japanese bank may even be dispensed with entirely. As long as there is an arbitrageur taking advantage of deviations between the KRW-JYP and the JPY-USD CIP deviations, relative to the KRW-USD CIP deviation, and moving to take advantage of it, this arbitrageur would provide the USD to the Korean bank.

This is relevant in light of geopolitical tensions. Imagine that Chinese banks need USD. Perhaps the Fed would be averse to lending them to the ECB, knowing they are making their way to China. Yet, the logic behind indirect connections does not require it. Chinese banks can borrow EUR from the ECB swap line with the PBoC and swap those into USD in the private market. Since this puts pressure on the price of a USD-EUR forward or swap contracts, European banks will be motivated by the market prices to trade in the opposite direction, potentially (but not necessarily) using the USD swap lines between the ECB and the Fed. There will be no direct association between the actions of Chinese banks and the credit given by the Fed, and yet the indirect connection in the network of liquidity lines was the force behind it all.

6 CIP deviations with indirect connections

The network of lines affects credit and prices beyond the actual use of the lines, through their backstop role as lenders of last resort. It is known that, with a direct connection, the swap line puts a ceiling on the CIP deviation through an arbitrage trade in the absence of direct credit by the central banks. This section shows the same is true with indirect connections.

6.1 Indirect ceilings on CIP deviations

Bahaj and Reis (2022*a*) first derived the following result: imagine a Japanese bank borrowing USD from the BoJ via the swap line with the Fed. The borrowing rate at the line is $i^{\$,l}$, and the USD converts to JPY at the spot exchange rate $S^{¥,\$}$. The bank can convert the USD for JPY, deposit the yen at the BoJ earning the deposit rate $i^{¥,v}$, and sell forward

the future JPY return to exchange them back into USD at the forward rate $F^{¥,\$}$. At the end of this operation, the Japanese bank will receive $(S^{¥,\$}/F^{¥,\$})(1+i^{¥,v})$ in USD for sure (neglecting counterparty risk in the forward contract, which should be negligible). The cost in USD of getting the funds for this operation is $(1+i^{\$,l})$. For there to not be an arbitrage opportunity, the cost must be as large as the gain.

Then, let $X^{¥,\$}$ be the deviation from covered interest parity (CIP) between the two currencies, also known as the cross currency basis. By definition: $X^{¥,\$} = (1+i^{\$}) - (S^{¥,\$}/F^{¥,\$})(1+i^{¥})$, where these are interbank rates. Since in our sample, the interbank rate was close to the deposit rate at the central bank, $i^{¥} \approx i^{¥,v}$, it then follows that, by no arbitrage, there is a *direct connection ceiling* put by the swap line rate minus the interbank rate on the JPY-USD CIP deviations:

$$-X^{¥,\$} \leq i^{\$,l} - i^{\$}. \tag{1}$$

Consider now an indirect connection, and take again the arbitrary example of a Korean bank accessing USD via the network. The private bank can do the same trade involving the KRW and the JPY, from which follows the corresponding ceiling:

$$-X^{₩,¥} \leq i^{¥,l} - i^{¥}. \tag{2}$$

In turn, a standard triangular arbitrage argument involving three currencies states that the sum of the CIP deviation between any two pairs should be the same as the CIP deviation between any two of them:[15]

$$X^{₩,¥} + X^{¥,\$} \approx X^{₩,\$}. \tag{3}$$

Adding up the two equations, one derives an *indirect connection ceiling*, in this case between the KRW and the USD:

$$-X^{₩,\$} \leq (i^{\$,l} - i^{\$}) + (i^{¥,l} - i^{¥}). \tag{4}$$

In short, for an indirect connection, the sum of the ceilings of the direct connections that constitute it provides itself a ceiling. This argument extends to connections of a higher degree.

[15]While there are many deviations from arbitrage in swap markets, triangular arbitrage holds very well empirically, with deviations from it rarely exceeding more than a few basis points.

6.2 A proposed test of the prediction on ceilings over CIP deviations

Measuring CIP deviations of advanced economies with respect to the USD is relatively straightforward. There are markets for forward contracts with prices that are routinely and consistently quoted, as well as liquid interbank markets with reliable interest rates. The direct ceiling result has been tested and confirmed in the data.[16]

Extending this work beyond a handful of major economies is difficult. Du and Schreger (2016) calculate CIP deviations for 10 developed countries and 18 emerging markets for 10-year government bonds, while Cerutti and Zhou (2023) complement this work with CIP deviations at 1-month and 3-month tenors using money market rates for the same G-10 countries, as well as 20 emerging markets. Starting from their work, we extend it to have a sample of 42 countries among the 72 that have signed a liquidity line at some point during the sample in a monthly unbalanced panel running from January 2007 (when CIP deviations started to appear as the global financial crisis started) to August 2023. Many liquidity line loans are for a one-week maturity, suggesting a one-week tenor would be appropriate to measure CIP, but one-week interest rates are not widely available. We use 3-month and 1-month tenors, as they are available for each country.

The noise in the data makes it hard to trust the precise measures of CIP deviations. This precludes a test that relies on within-month changes in CIP, or on the exact numerical value for the ceilings, as done before in the literature. Instead, we take a different approach. First, we calculate the average CIP deviations within our network by averaging across all existing observations within one month for a particular currency across the available tenors. Second, we proxy for the value of the ceiling for a currency with the degree of its connection with the network of that currency, since the theory predicts these should be strongly positively related.

With these two measures we test whether, all else equal, connections of higher degree should be associated with higher average CIP deviations. This is not a causal statement, since the country can change its degree of connection in response to the CIP deviations of its currency. It is a prediction derived from the theory of arbitrage that we can test in the data.

[16] For the USD see Bahaj and Reis (2022*a*), Kekre and Lenel (2025), for the EUR see Albrizio, Kataryniuk and Molina (2023), and for the RMB see Bahaj and Reis (2025).

6.3 Results using the distribution of CIP deviations

Figure 10 plots, in panel (a), our estimate of the implicit ceilings based on the limited information we have on liquidity line borrowing rates (see Appendix B for more details). We average them over all years and over all pairs of currencies of the same degree of connection with either the USD, the EUR, or the RMB. As predicted, the ceiling rises, approximately doubling, with each degree increase in the connection.

Turning to CIP deviations, panel (b) takes individual observations per currency-month relative to the USD and pools them in an empirical cumulative density function by degree of connection. Reflecting our interest in ceilings, the figure zooms in on the left tail.

A ceiling would, strictly speaking, cut these distributions, with zero mass to the left of the ceiling. However, for at least three reasons, we cannot test this sharp prediction in the data. First, for the whole network there is counterparty risk for some currencies that should be included in the ceiling, but we do not have a way to measure it accurately over time, country, and currency. Second, the ceiling will be different for different currencies and different years as the contract changes, so our estimates of its location are noisy. Third, and perhaps most importantly, the significant noise in measuring CIP could easily lead to false rejections of the null hypothesis.

Instead, we ask: is the distribution further to the left when the degree of connection is higher? The evidence in panel (b) supports this prediction.

Panel (c) repeats the exercise but after regressing the CIP deviations on year and country fixed effects, to help address the first two of the three problems that affected panel (b), namely country-specific or time-specific variation in CIP deviations driven by counterparty risk and global financial conditions. The result is still there.

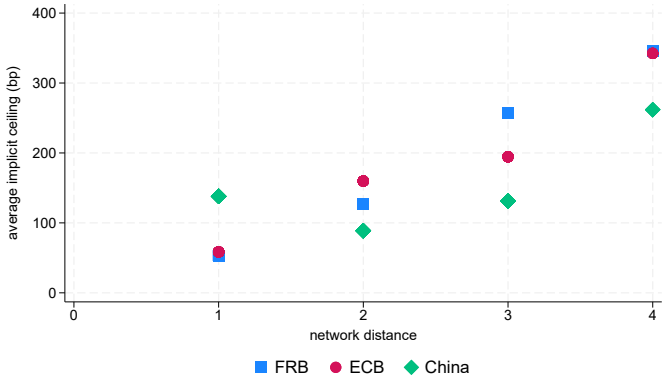
6.4 Statistical estimates using regressions

Table 1 uses regression models to test more formally the relationship between CIP deviations, as the dependent variable, and the degree of connections, as the independent variable. This lets us judge statistical significance and control for common factors that affect both variables, without taking a stand or drawing conclusions on the causal link between the two.

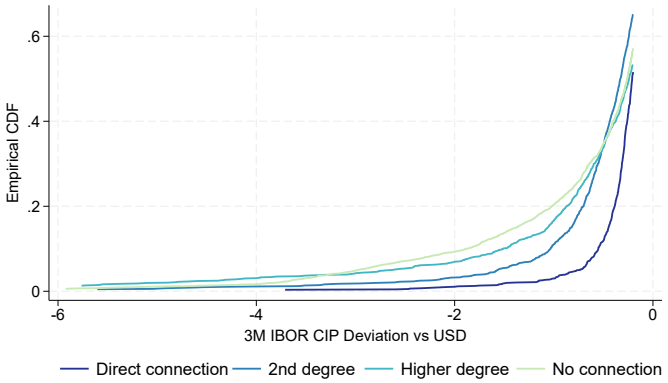
The independent variables are three dummies that take a value of one if the observation for line i in month t has a second-degree, higher-degree, or no connection with the Fed. The baseline is where there is a direct connection (the omitted dummy variable). The

Figure 10: CIP ceilings and connection degree in the world network of liquidity lines

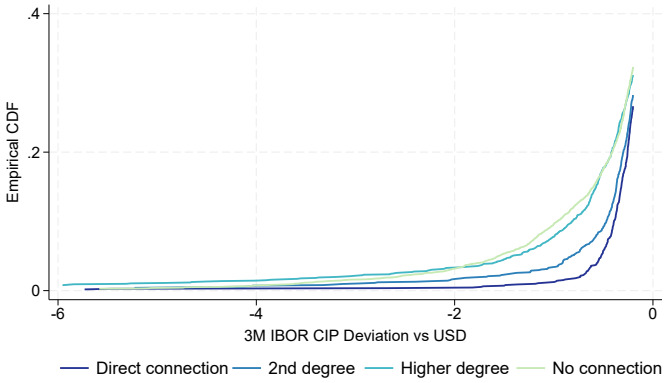
(a) Average ceiling versus connection degree



(b) Tail of empirical cumulative density function for USD CIP deviations



(c) Tail of empirical CDF residualised by time and country fixed effects



Note: Panel (a) shows the average implicit ceiling by degree of connection to the Fed, ECB, and PBoC. We measure the degree by the shortest path from the network of bilateral lines, and ceilings by using the minimum cost shortest path. Panel (b) shows the left tail of the empirical cumulative density function of monthly USD CIP deviations pooled across currencies by degree of connection to the Fed. We winsorize the left hand tail of the distribution at the 0.1% level to aid with visualisation. Panel (c) repeats the exercise in panel (b) after residualising the CIP deviations with respect to time and country fixed effects.

Table 1: The degree of the liquidity line connection and CIP deviations

	Pooled Quantile Regression	Time Fixed Effects	15th Quantile	5th Quantile	For Euro (ECB)	For Renminbi (PBoC)	Country Fixed Effects	Linear Probability Models	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
2nd degree	-0.450**	-0.235	-0.170	0.048	-0.380	0.364	0.605**	0.083**	0.022*
vs direct	(0.203)	(0.387)	(0.240)	(0.778)	(0.451)	(0.467)	(0.374)	(0.039)	(0.016)
Higher degree	-1.261***	-0.870	-0.561	-1.350	-0.600**	-0.036	-0.637	0.179***	0.089***
vs direct	(0.724)	(0.776)	(0.547)	(1.376)	(0.457)	(0.493)	(0.606)	(0.072)	(0.046)
No connection	-1.234***	-0.891**	-0.549**	-1.002	-1.228***	-0.731 *	0.130	0.173***	0.079***
vs direct	(0.454)	(0.535)	(0.382)	(0.856)	(0.461)	(0.470)	(0.574)	(0.053)	(0.036)
Higher degree	-.810*	-.635	-.391	-1.397	-.22	-.4	-1.243**	.097*	.068**
vs 2nd degree	(0.69)	(0 .681)	(0.504)	(1.207)	(0 .594)	(0.537)	(0.64)	(0.073)	(0.045)
no connection	-.783***	-.657*	-.38*	-1.05+	-.848*	-1.095**	-.475	.09*	.058**
vs 2nd degree	(0.436)	(0 .451)	(0.342)	(0.686)	(0.568)	(0.526)	(0.449)	(0.06)	(0.038)
N	7786	7786	7786	7786	7786	7786	7786	7786	7786
Time F.E.	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country F.E.	No	No	No	No	No	No	Yes	No	No
Counterparty	Fed	Fed	Fed	Fed	ECB	PBoC	Fed	Fed	Fed
Quantile	0.10	0.10	0.15	0.05	0.10	0.10	0.10		
Ceiling								-100	-200

Note: Estimates of the impact of the degree of liquidity line connectivity between a country and a source central bank (the counterparty) on the average CIP deviation between their respective currencies for the month. The explanatory variables are three dummy variables that take a value of one if the country has respectively a second degree connection, higher degree connection, or no connection with the source central bank (all relative to no connection). Sample period is an unbalanced monthly panel covering 42 countries from January 2007 and August 2023. Standard errors and p-values (one-sided test) were calculated using 1000 replications of a blocked bootstrap, where the sample size is kept constant by resampling an equal number of blocks as in the original data from each group of blocks with the same size. + $p < 0.15$, * $p < 0.1$ * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Column (1) has a pooled quantile regression at the 10th percentile using the US as a counterparty. Column (2) adds a time fixed effect using the Canay (2011) quantile fixed effects estimator. Columns (3)-(4) are as column (2) but considering the 5th and 15th percentiles. Columns (5)-(6) are as column (2) but use the ECB and PBoC as counterparties. Column (7) is as column (2) but includes a country fixed effect. Columns (8) and (9) use a linear probability model with the explanatory variable taking a value of one if the negative of the average CIP deviation exceeds a value of a ceiling: column (8) uses a ceiling of 100bp, (9) a ceiling of 200bp.

prediction is that the higher is the degree of the connection, the more likely are we to find larger negative CIP deviations.

Column (1) has the estimates of a pooled quantile (10th percentile) regression of $X^{\$}_{i,t}$ on the three dummy variables. The prediction is that the coefficients would be negative, and increasingly so as the degree of the connection increases. This holds in the estimates.

The primary identification concern is that the agreements are entered into at times of crises, when CIP deviations are volatile. Perhaps the expansion in the network is simply calming overall market conditions, which reflects itself in CIP deviations not through the

ceiling channel. Or, perhaps the expansion in the liquidity lines is a lagged response to the crisis, which then coincides with financial conditions easing (including CIP deviations) as shocks revert to the mean. To deal with this problem, we introduce time fixed effects using the fixed location shift panel quantile model of Canay (2011). Column (2) shows this has little impact on the estimates.

The next four columns show robustness to other choices. Columns (3) and (4) show that the coefficients continue to be negative, and more so as the degree rises, at other quantiles. Columns (5) and (6) show that the result is not USD specific, as it applies to the EUR and RMB as well. Connections with the ECB or the PBoC also lower CIP deviations, although the effects are not as precisely estimates.

Column (7) controls for country fixed effects. The results are now weaker, although the effect of a higher connection degree relative to a direct or 2nd order connection are still negative and statistically significant. Weaker results are to be expected given the limited time-series variation in the lines in our sample. The effects found in other columns are mostly estimated using cross-sectional variability, particularly in stress episodes when CIP deviations are in the tail of the distribution.

Columns (8) and (9) consider an alternative specification to the quantile regression. They show the estimates of a linear probability model, that regresses $Pr(X_{i,t} < c)$ on time fixed effects and the degree of the connection. The prediction of the theory is that the coefficients should be positive: the higher is the degree of the connection, the more likely there would be violations of the soft ceiling. We choose the ceiling in the regression c motivated by the numbers in panel (a) of figure 10. Throughout, the coefficients are always positive, statistically significant, and increasing in the degree of connection.

7 Are the liquidity lines complements or substitutes for FX reserves?

Many central banks hold large reserves of foreign currency and assets. One of their uses is to lend to domestic banks in a financial crisis. Another is to buy the domestic currency and prop up its exchange rates to other currencies, either to pursue a peg, or to slow down a balance of payment crisis. A third use for FX reserves is as a precaution against capital outflows. In all of these uses, liquidity lines provide a substitute to FX reserves in accessing foreign currency.

At the same time, FX reserves and liquidity lines can also be complements for several

reasons. First, as a country and its currency become more financially integrated with the world, both FX reserves and liquidity lines can work together to support a financial centre and reduce counterparty risk for their financial institutions. Second, an improvement in a country's position in the liquidity line network can attract flows of international capital that enable the country to bolster its reserves. Third, repurchase lines like the Fed's FIMA or the ECB's repo lines explicitly embed a complementarity. These lines allow investors to quickly convert foreign bond holdings into foreign currency at a guaranteed price that is elastic to stress in bond markets. By averting the risk of having illiquid reserves, a repo line raises their marginal value leading to having higher FX reserves.

As a final hypothesis, if accumulating reserves is a response to trade surpluses to prevent an appreciation of the exchange rate, then the lines may be independent of reserves altogether.

In this section, we investigate the interplay between reserves and liquidity lines in our rich panel dataset.

7.1 An empirical strategy using event studies

Our dataset has several events when a country becomes better integrated in the liquidity line network. These include not just it signing a first swap line that gives it access to the network of a currency, but also signing further agreements that lower its degree of access to the network, or having this degree change because of paths breaking or being formed in other nodes of the network. We index each of these events by e for country i and measure the evolution of log reserves, denoted by V, in the months s before and after the date of the event: $\{V_{e,i,s}\} = \{V_{i,t_e-12}, V_{i,t_e-11}, \ldots, V_{i,t_e+18}\}$. We use a window of 12 months before and 18 months after the event, but the results are not sensitive to these choices (and our estimates suggest that the effects are largely complete after 18 months).

However, because liquidity lines and FX reserves are both policy choices, they depend on the same macro-financial variables. This could easily lead to a spurious correlation between the two. To assess the treatment effect of each event e in country i at time t_e, we need a control group that has the same macro-financial evolution as the countries improving their position in the network at the time. We select three control countries from our sample that: (i) do not change their position in the network during the event window $[t_e - 12, t_e + 18]$; (ii) are not initially directly connected to the issuer of the currency, that country i's position is changing relative to, (iii) are the closest to country i according to a Mahalanobis distance measure that considers the reserves to import ratio, GDP per capita

in PPP units, population, and geographical distance, all at time $t_e - 12$.

With these stacked events, we estimate the regression over the j countries (both treated and control):

$$V_{e,j,s} = \alpha_{j,e} + \delta_{s,e} + \beta_s \times \mathbf{1}\left[j = \text{event country}\right] + \text{controls}_{e,j,s} + \text{error}_{e,j,s}. \tag{5}$$

Normalising $\beta_{-1} = 0$ as the base effect, then the estimates of β_s give the average evolution of FX reserves before and after an improvement in a country's position in the liquidity line network.

If liquidity lines substitute for reserves, we would expect to see a pattern of declining estimates of β_s over s. In advance of the agreement ($s < 0$) the country's liquidity position would be deteriorating, prompting it to enter an agreement. Afterwards ($s > 0$), the stronger positions of the country in the network would allow it to substitute away from holding so many FX reserves.

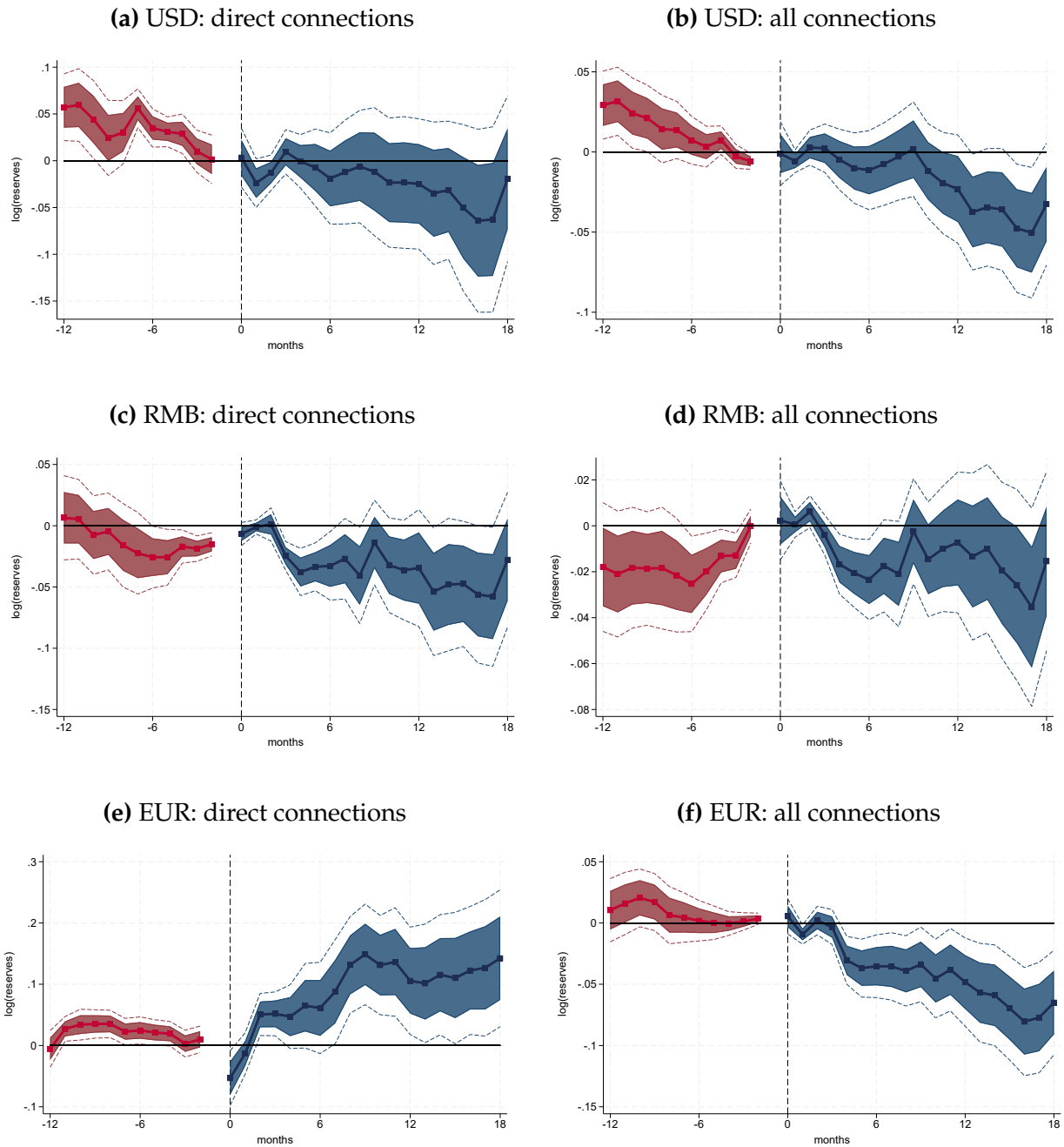
7.2 FX reserves after a fall in the degree of connection to the network

Figure 11 shows the estimates of $\{\beta_s\}$ across events that bring the country closer to the source of each of the three major currencies in each of the three rows. The right column includes all events, while the left panel considers only the subset of events that created a direct connection between the country and the currency. Considering indirect connections and with them the whole network structure leads to sharper results with tighter confidence intervals.

Looking at the first row of the figure, before the event, the country was bleeding foreign exchange reserves. The fall in USD reserves is especially pronounced when the country chose to sign a direct line with the Fed (panel a). A likely explanation is that sharp falls in FX reserves often come in the midst of financial crises. Countries face stigma and political backlash if they ask for IMF support. If liquidity lines are effective substitutes, an alternative is to improve the position in the network of liquidity lines to access foreign funds through bilateral routes. The evidence is consistent with this substitution pattern, since a fall in USD is predictive of the central bank signing a liquidity line with the Fed, or with other central banks that lowers its degree of connection in the USD's network.

The second and third row shows a similar, but weaker pattern, for the RMB and EUR FX reserves before the events. This is consistent with the dominant role of the USD in FX reserves.

Figure 11: Foreign reserves around improvements in the connection to the network



Note: Estimates of $\{\beta_s\}$ in equation (5) measuring the impact on FX reserves of signing a bilateral liquidity line that moves the signing country to a lower degree in the network that gives access to USD, EUR, RMB respectively at date zero. Confidence intervals are constructed from standard errors clustered by event-country and by observation time. Left panel: improving to direct connection (moving to degree 1 from any higher degree); Right panel: improving to any lower level. Number of events unique considered per panel: (a) 26, (b) 116, (c) 16, (d) 111, (e) 59, (f) 98.

After the event, the estimates in five out of the six panels in figure 11 show a further decline in FX reserves after the improvement in access through the network of liquidity lines. The substitution between the liquidity lines and the FX reserves continues for approximately 12-18 months.

An exception to this pattern is the response of FX reserves after the country signs a direct agreement with the ECB in panel (e). One explanation for this difference is that many more of the ECB's direct connections are in the form of repo lines. These have an additional complementary effect. When we include the indirect connections to the EUR (panel (f)), this extra effect is not present, and the evidence shows the substitution effect dominating again.

7.3 Assessing the causal effects of liquidity lines on FX reserves

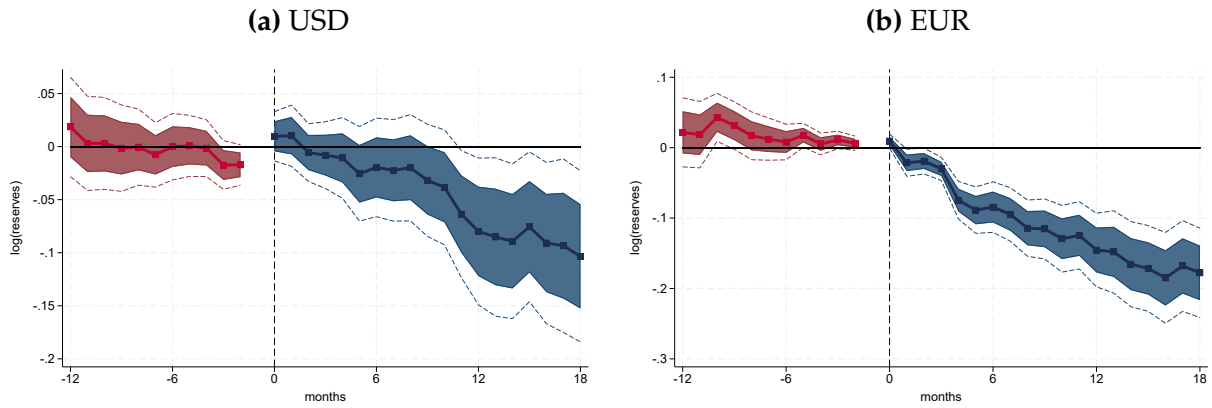
The estimates of figure 11 do not reflect a causal effect of the liquidity lines on FX reserves. After all, entering into a liquidity agreement is an endogenous decision. In fact, our interpretation of the estimates was that a drawdown of the FX reserves is what causes the country to agree to a liquidity line.

Ideally, one would want a country to suddenly sign a swap line for reasons beyond its control, and measure what it then chooses to do to its FX reserves (or alternatively, to have it suddenly lose some of its FX reserves and observe whether it runs to sign a swap lines). Such experiments do not exist. But, having understood the power of indirect connections, there is a substitute for them.

In our data, a country can improve its position without taking any action itself but because one its counterparties (or one of the counterparties' counterparties) did so. If country A improves its access to the network of the currency of country B because country C signed a liquidity line, this event was plausibly outside of country A's control. The estimates would not be confounded by other shocks that may be hitting country A at the same time, including the evolution of FX reserves, and that may have prompted signing an agreement. The identifying assumption is simply that the reserves of the event country would have followed a similar path to its control countries if not for this third country liquidity line agreement.

Figure 12 repeats the regression in equation (5) including only the events where there is an improvement in higher-degree access to the network of a country that happens as a result of an action taken by other countries. Panel (a) presents results from 23 events when a country gets closer to USD without an action of its own. Panel (b) shows the

Figure 12: Foreign reserves after network access improves due to another country's action



Note: Estimates of $\{\beta_s\}$ in equation (5) with the impact on FX reserves of a country signing a liquidity line that leads to a country lowering its degree of connection in the network at date 0, for access to the USD in panel (a), EUR in panel (b), and RMB in panel (c). Note there is an overlap in the events across these specifications.

similar figure for the EUR. Unfortunately, there are too few such events to produce an equivalent estimate for the RMB.

The estimates shows that now there is no initial bleeding of reserves before the event. This absence of any pre-trend in reserves of the treated countries relative to the control countries is consistent with the identifying assumption for causality. It is also consistent with our interpretation of the previous results: when there is no bleeding of reserves, the country does not try to improve its position in the network through its own actions.

Stronger than in the previous estimates, there is clear evidence for a sustained decline in reserves after the exogenous improvement in the position in the network. This is compelling evidence for swap lines being substitutes for FX reserves.

8 Conclusion: nine lessons

Empirical studies of the international financial system face many challenges. A major one is that some of its main institutions, like the IMF, some of its main discretionary policies, like official loans within regions, and some of its main tools, like official FX reserves, change only infrequently and almost always in response to the variables that they want to affect. With little variation, and much of it endogenous, it is hard to assess their effects.

The liquidity lines signed between central banks offer a new path for progress. They are large, work through important economic channels, and have evolved quickly in the XXIst century so far, with plenty of differences across time and countries. This variability gives the hope for identification.

This paper provided one step towards realising this hope by bringing to the table a comprehensive dataset of cross-border central bank liquidity lines between 2000 and 2024. Studying the full cross-country network of swap lines illuminated some historical patterns, some theoretical predictions, and some empirical facts collected as nine lessons:

1. There was as much growth in the network in 2010–15 as there was during the great financial crisis. Bilateral lines signed during this period mostly by the ECB and the PBoC overtook the big-5 multilateral network set up by the Fed during the crisis.

2. The network globalised during the 2007–09 great financial crisis and reached a peak during the 2020 pandemic. The Fed and PBoC sub-networks are partly segmented from each other, with the ECB (and the BoJ to a smaller extent) providing a bridge in between them.

3. Because the liquidity lines form a network, it is possible for banks to indirectly have access to a currency that its central bank does not have direct access to.

4. Using the indirect connections, banks in countries accounting for approximately 80% of the world GDP have access to USD, in spite of the small number of liquidity lines involving the Fed. The coverage of the USD is similar to that of the EUR and the RMB, but they differ in the degree of their connections, with the USD having more indirect connections.

5. With indirect connections, other central banks intermediate the access to a currency that is not their own. The PBoC plays a relevant and powerful role in the USD network. If geopolitical tensions or other events were to exclude the PBoC from the network, the reach of the USD network would fall by 25% of world GDP, and the average degree of its connections would rise by 0.5.

6. Indirect connections create (soft) ceilings on the size of CIP deviations. As the degree of a connection increases, the ceiling tends to rise with it.

7. Across 42 countries and over many years, there is a strong correlation between the degree of the connection between two currencies in the network and the size of the CIP deviations in these currencies.

8. Signing a liquidity line is typically preceded by a strong decline in USD reserves. In this sense, countries try to substitute for declining reserves by improving their position in the network of liquidity lines. The ECB is an exception, because its lines take a repo form, which promotes complementarity.

9. The indirect connections in the network create variation in the access to foreign currency that is plausibly exogenous with respect to what was happening to a country's FX reserves. Using this variation, we find that an exogenous increase in the degree of integration in the network of liquidity lines is followed by a decrease in the FX reserves. Also in this sense, lines and reserves are substitutes.

Many questions are left unanswered. Who chooses to join the network, and what country features or global variables drive the choice? How has the global network affected and been affected by the networks of international tarde, capital flows, and cross-border bank loans? Would indirect connections resist a large global shock? When a country has multiple connections to a currency in the network, is one route systematically used? What games of tit-for-tat could play out in the network in case of geopolitical tension if there is a further move from multilateral to bilateral relations? The nine findings above, and the dataset made available by this paper provides a starting point for future research to explore some of these.

References

Aizenman, Joshua, Yothin Jinjarak, and Donghyun Park. 2011. "International Reserves and Swap Lines: Substitutes or Complements?" *International Review of Economics and Finance*, 20(1): 5–18.

Albrizio, Silvia, Iván Kataryniuk, and Luis Molina. 2023. "ECB Euro Liquidity Lines." *IMF Working Paper 2023/96*.

Bacchetta, Philippe, J. Scott Davis, and Eric van Wincoop. 2025. "Offshore Dollar Funding Shocks and the Dollar Exchange Rate." University of Lausanne mannuscript.

Bahaj, Saleem, and Ricardo Reis. 2022*a*. "Central Bank Swap Lines: Evidence on the Lender of Last Resort." *Review of Economic Studies*, 89(4): 1654–1693.

Bahaj, Saleem, and Ricardo Reis. 2022*b*. "The Economics of Liquidity Lines Between Central Banks." *Annual Review of Financial Economics*, 14(1): 57–74.

Bahaj, Saleem, and Ricardo Reis. 2023. "The Workings of Liquidity Lines Between Central Banks." In *The Research Handbook of Financial Markets*. , ed. Refet Gurkaynak and Jonathan Wright. Edward-Elgar.

Bahaj, Saleem, and Ricardo Reis. 2025. "Jumpstarting an International Currency." *Review of Economic Studies*, forthcoming.

Benguria, Felipe, and Dennis Novy. 2024. "How to Grow an Invoicing Currency: Micro Evidence from Argentina." Warwick University manuscript.

Bohórquez, Diego. 2023. "The United States as the International Lender of Last Resort." Universitat Pompeu Fabra manuscript.

Bordo, Michael D, Owen F Humpage, and Anna J Schwartz. 2015. "The Evolution of the Federal Reserve Swap Lines since 1962." *IMF Economic Review*, 63(2): 353–372.

Canay, Ivan A. 2011. "A Simple Approach to Quantile Regression for Panel Data." *The Econometrics Journal*, 14(3): 368–386.

Cerutti, Eugenio M, and Haonan Zhou. 2023. "Uncovering CIP Deviations in Emerging Markets: Distinctions, Determinants and Disconnect." *IMF Economic Review*, 72: 196–252.

Cesa-Bianchi, Ambrogio, Fernando Erugen-Martin, and Andrea Ferrero. 2022. "Dollar Shortages and Central Bank Swap Lines." Oxford University manuscript.

Coppola, Antonio, Matteo Maggiori, Brent Neiman, and Jesse Schreger. 2021. "Redrawing the Map of Global Capital Flows: The Role of Cross-Border Financing and Tax Havens." *Quarterly Journal of Economics*, 136(3): 1499–1556.

Dai, Mao, and Pierre-Olivier Gourinchas. 2025. "Covered Interest Parity in Emerging Markets: Measurement and Drivers." *IMF Working Paper 2025/57*.

Du, Wenxin, and Jesse Schreger. 2016. "Local Currency Sovereign Risk." *The Journal of Finance*, 71(3): 1027–1070.

Ferrara, Gerardo, Philippe Mueller, Ganesh Viswanath-Natraj, and Junxuan Wang. 2022. "Central Bank Swap Lines: Micro-level Evidence." *Bank of England Working Paper 977*.

Fleming, Michael J., and Nicholas Klagge. 2010. "The Federal Reserve's Foreign Exchange Swap Lines." *Current Issues in Economics and Finance*, 16(4): 1–7.

Goldberg, Linda S., and Fabiola Ravazzolo. 2022. "The Fed's International Dollar Liquidity Faciltiies: New Evidence on Effects." *NBER Working Paper 29982*.

Horn, Sebastian, Brad Parks, Carmen M. Reinhart, and Christoph Trebesch. 2023. "China as an International Lender of Last Resort." *NBER Working Paper 31105*.

Kekre, Rohan, and Moritz Lenel. 2025. "The High Frequency Effects of Dollar Swap Lines." *American Economic Review: Insights*, 7(1): 107–123.

Kelly, Steven. 2023. "United States: FIMA Repo Facility, 2020." *Journal of Financial Crises*, 5: 1558–1579.

McCauley, Robert N., and Catherine R. Schenk. 2020. "Central Bank Swaps Then and Now: Swaps and Dollar Liquidity in the 1960s." *BIS Working Paper 851*.

Mohr, Cathrin, and Christoph Trebesch. 2025. "Geoeconomics." *CEPR Discussion Paper 19856*.

Obstfeld, Maurice, Jay C. Shambaugh, and Alan M. Taylor. 2009. "Financial Instability, Reserves, and Central Bank Swap Lines in the Panic of 2008." *American Economic Review Papers and Proceedings*, 99(2): 480–86.

Perks, Michael, Yudong Rao, Jongsoon Shin, and Kiichi Tokuoka. 2021. "Evolution of Bilateral Swap Lines." *IMF Working Paper 2021/210*.

Róldan, Francisco, and César Sosa-Padilla. 2025. "The Pirals of Bilateral Sovereign Debt." University of Notre Dame manuscript.

Data Appendix

A More details on the data

Liquidity lines. We used the January 2024 vintage of the data available from https://r2rsquaredlse.github.io/web-lines/. The data is at the agreement level, and has the day when the agreement went into effect and the day when it expired. We convert it into a monthly panel by looking at whether there is an active agreement between any given country pair at the start of the month. The network is directed: unidirectional liquidity lines are recorded as a one way connection and reciprocal lines are recorded as a two way connections. When we focus on bilateral connections only, we exclude connections that are formed via multilateral agreements like the Chiang-Mai initiative.

FX reserves, Macroeconomic and distance data. Data on FX reserves comes from the IMF International Financial Statistics database (last accessed on November 29th of 2023). We use data item "Official Reserve Assets and Other Foreign Currency Assets in US Dollars" (RAF_USD) at a monthly frequency from January 2000. GDP data is also from the IMF International Financial Statistics database.

CIP deviations. We use daily financial market data from Datastream and Bloomberg, with a preference for the former when both sources are available. The exact tickers we use are available in the supplementary materials. The CIP deviation for currency g vis-a-vis the USD is:

$$X^{g,\$} = (1 + i^{\$}) - (S^{g,\$}/F^{g,\$})(1 + i^{g})$$

We measure i^{g} as currency g's interbank offered rate (IBOR) at a 3-month tenor. $(S^{g,\$}/F^{g,\$})$ is the 3-month forward premium on currency g vis-a-vis the USD computed using mid prices. We use outright forward rates when available, if not, we calculate the implicit forward rate from the swap rate as an alternative. We always take forward (or swap) and spot rates from the same source (Datastream or Bloomberg). If 3-month tenors are not available, we switch to a 1-month tenor. If neither are available, we code the observation as missing. The USD interest rate at 3 and 1 month tenors is, of course, always available.

When computing CIP deviations vis-a-vis the RMB or Euro we impose that triangular

arbitrage holds in FX markets. So for RMB deviations for example, we have:

$$X^{g,€} \approx X^{g,\$} + X^{€,\$}$$

This approximation relieves us from having to find FX derivatives for multiple different crosses.

Our raw sample covers all available trading days from January 2007 to August 2023 for 42 countries. The daily data is exposed to occasional outliers which cause CIP deviations to spike for one trading day. This could be due to a stale price or a data entry mistake, so we impose a filter that trims such values.

B Constructing CIP Ceilings

To construct the CIP ceilings used in figure 10a, we make the following assumptions:

1. The Fed priced its swap lines at 100bp over OIS from their start until 1st December 2011, after which it switched to 50bp. This was further cut to 25bp on 15 March 2020. The Fed does not appear to distinguish by counterparty. This gives a time series of $i^{l,\$} - i^{\$}$ for all central banks with a direct connection to the Fed.

2. We assume the remaining five central banks in the swap line network with the Fed (that is the ECB, Bank of Japan, Bank of England, Bank of Canada and Swiss National Bank), follow the same pricing strategy on their swap lines with each other and with the Fed. These central banks reciprocate and coordinate on terms amongst themselves. Since most of the lines are inactive most of the time this assumption cannot be verified. However, consistent with the assumption, the BoE and ECB have activated their reciprocal liquidity line using the same spread as the Fed's lines with the ECB and BoE and also implemented the same rate cut on 15 March 2020.

3. We assume that the ECB prices its swap lines with other EU countries in line with its line with the Bank of England. This does not extend to its repo lines.

4. The PBoC's swap lines with developed economies (Singapore, Korea, Japan, UK, Australia, New Zealand and the Euroarea) are priced according to prevailing interbank rates and do not have a spread attached to them. The spread on the PBoC's lines with the HKMA and Macau was 50bp until 22nd July 2022 when it was cut

to 25bp, reflecting the spread charged on the HKMA's RMB liquidity facility. For the remaining PBoC lines to developing economies, without any information, we impose a 250bp spread consistent with the work of Horn et al. (2023).

5. The above covers 66% of liquidity lines in existence. For the remainder it is hard to get precise figures. We assume a 100bp spread reflecting anecdotal information.

The implicit ceiling behaves slightly differently for CIP deviations vis-a-vis the RMB, as the PBoC appears to operate a two-tiered pricing strategy: for lines with developed economies is charges prevailing market rates to access the liquidity line. For developing economies it charges approximately a 250bp spread (Horn et al. (2023)). This spread is higher than that typically charged by the Fed or the ECB. Countries that have a second degree connection with the PBoC are typically going via the ECB and paying the lower spread, and in turn, the ECB would pay the market rate to access the PBoC. As a result, and counterintuitively, the ceiling for the second degree connections with the PBoC ends up being lower than for the typical direct connection.