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The economics of liquidity lines between central banks*

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December 2021

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Liquidity lines between central banks are a key part of the international financial safety net. In this review article, we lay out some of the economic questions that they pose. For some of them, research has provided some answers. For others, there is still much to discover.

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1 Introduction

In the two decades after the end of the Bretton Woods regime, the liquidity lines through which central banks lent to each other were gradually discontinued. Their previous role of supporting fixed exchange rates became obsolete as countries moved to floating their currencies. This changed with the arrival of a new age of financial crises. The South East Asia crisis of 1997 led to the formation of a network of swap lines between 14 central banks in the region. For a few short weeks in 2001, the disruption to US money markets led to new swap lines between the Federal Reserve, the Bank of Canada, the European Central Bank, and the Bank of England. In 2007-08, these lines were revived and more were added, for a total of 14 bilateral swap lines that had the Federal Reserve at their center. Their repeated use as well as the European sovereign debt crisis led to the creation of a standing network of swap lines among the six major central banks between 2010 and 2013. Finally, with the 2020 pandemic, not only were these liquidity lines extended, but more were created of different types and involving an increasing number of central banks.

A liquidity line between two central banks is an agreement to provide on demand a collateralized loan of the currency issued by the source central bank to the recipient central bank. The loan can be structured as a repurchase agreement, leading to a repo line, or it can be a swap line, in which case the loan is structured as an FX swap where the recipient central bank offers as collateral a deposit of its currency. As of 2021, these lines are one of the pillars of the international financial architecture. They have graduated from crisis-response policies to standing features of the monetary policy toolkit. Across borders, the liquidity lines play a role in capital flows, in the cost of insuring against exchange rate fluctuations, and in the international use of some currencies. This article provides a discussion of the economic trade-offs involved in these roles.

We start with what is reasonably well understood today in section 2.1. This includes defining liquidity lines, so that they are not confused with other central bank tools, or with IMF policies. This is followed by a description of the existing network of liquidity lines in section 2.2.

Next, in section 2.3, we explain their role and usefulness. A few years ago, it was still common to refer to the workings of liquidity lines as "alleviating funding pressures", a description that is as correct as it is vacuous. Today, we have a sharper understanding of how liquidity lines work and which holes they fill in the international financial system. The following section 2.4 discusses alternatives to liquidity lines for recipient central banks or for banks to obtain source currency, and why these are not perfect substitutes

for liquidity lines. Section 2.5 discusses the impact that liquidity lines have on interest rates, with a special emphasis on covered interest parity, while section 2.6 discusses their consequences for bank behavior. Combined, this section provides an overview of what we know about the channels through which liquidity lines have an effect on the economy.

The next section focuses on the open questions that are left for future research. There are many, but we try to group them under three broad headings. The first set of questions focuses on how to write the contract that connects two central banks, as well as the arrangement between financial institutions and their domestic central bank. The second set focuses instead on whether the network should combine different bilateral arrangements, with holes and indirect connections, or instead give way to a multilateral setup with broader coverage. A third broad area of inquiry is the two-way interaction between a central bank providing a liquidity line and its currency being used internationally.

Finally, the conclusion highlights that the implications of liquidity lines for equilibrium asset prices, from the value of exchange rates to interest rates on different loans and returns on investments, are mostly unexplored.

2 What we know

The modern study of central bank liquidity lines started during the global financial crisis, as the Federal Reserve set up its facilities, changed their terms, and expanded them during the pandemic. This section reviews some of the main findings so far.

2.1 What is a central bank liquidity line?

A central bank liquidity line is, in essence, an agreement to provide collateralized loans between two central banks. We refer to the lender as the *source* central bank, which issues source currency, and the borrower as the *recipient* central bank. Most agreements are reciprocal, so either central bank can play either role, even if their setup was often motivated by a demand for loans in only one direction.

In modern usage, the recipient central bank lends the source currency onward to commercial banks in its jurisdiction. To provide a concrete example, since 2010 the European Central Bank (ECB) has carried out regular, scheduled US dollar (USD) repo operations for banks in the Euro area funded by borrowing USD from the Federal Reserve (Fed) through the swap line. The Fed charges an above market interest rate on the borrowing

(which the ECB passes on to banks), and the Fed has to approve every ECB request for using the line. Yet, the ECB has near complete discretion in how to run the repo operations for Euro area banks, including which banks are eligible, against what collateral, and with what haircut. The ECB is also solely responsible for paying the Fed, regardless of whether or not the Euro area banks repay the loans they received.

This combination of risks and responsibilities is typical for a liquidity line. As described in Bahaj and Reis (2022*a*), the net effect of these arrangements is therefore an extension of the source central bank's liquidity umbrella to commercial banks in the recipient's jurisdiction. Because the recipient central bank bears the private credit risk, it is incentivized to monitor the commercial banks and the collateral they post. Arguably, this is a natural distribution of tasks: the recipient is better placed to do the monitoring as it often regulates the banks, while the source central bank is better placed to provide the currency since it can issue it at will. The source central bank is, however, left bearing the sovereign risk from lending to a counterparty central bank. That risk is managed via the choice to enter an agreement and by the choice of what collateral to ask for.

Liquidity lines fall into two categories depending on the collateral that backs the loan between the two central banks. If the recipient central bank provides an equivalent deposit of its own currency, the transaction is superficially structured as a foreign exchange swap. Thus, these are known as swap lines. Unlike a standard swap contract between private parties, however, the recipient currency never enters circulation, as the source central bank has no use for it beyond serving as collateral. If the recipient central bank pledges securities, which are typically source country government debt, the transaction is structured as a repurchase agreement, and the term repo line is used.

Swap lines are more common. They are arguably close to an unsecured loan, as the collateral is just an unsecured deposit (in mismatched currency) at the borrowing institution. This not only exposes the source central bank to the risk that the recipient will default on this deposit, but also, the times when it is triggered are likely times when the recipient currency depreciates, leaving the source central bank with a loss. Therefore, in principle, a repo line exposes the source central bank to less risk (assuming the securities pledged as collateral are of high quality). At the same time, because the recipient cannot just issue the collateral it needs, the repo lines are not as easy to access.

2.2 How many liquidity lines are there and how did we get here?

There are around 170 bilateral liquidity lines in operation today. There are also two open repo-line facilities in the form of the Fed's *Foreign and International Monetary Authorities* (FIMA) facility and the ECB's *Eurosystem Repo Facility for Central Banks* (EUREP) that allow central banks to borrow USD and euros (EUR), respectively, via an overnight repo transaction without a prior agreement. The modern network of liquidity lines is illustrated in Figure 1.

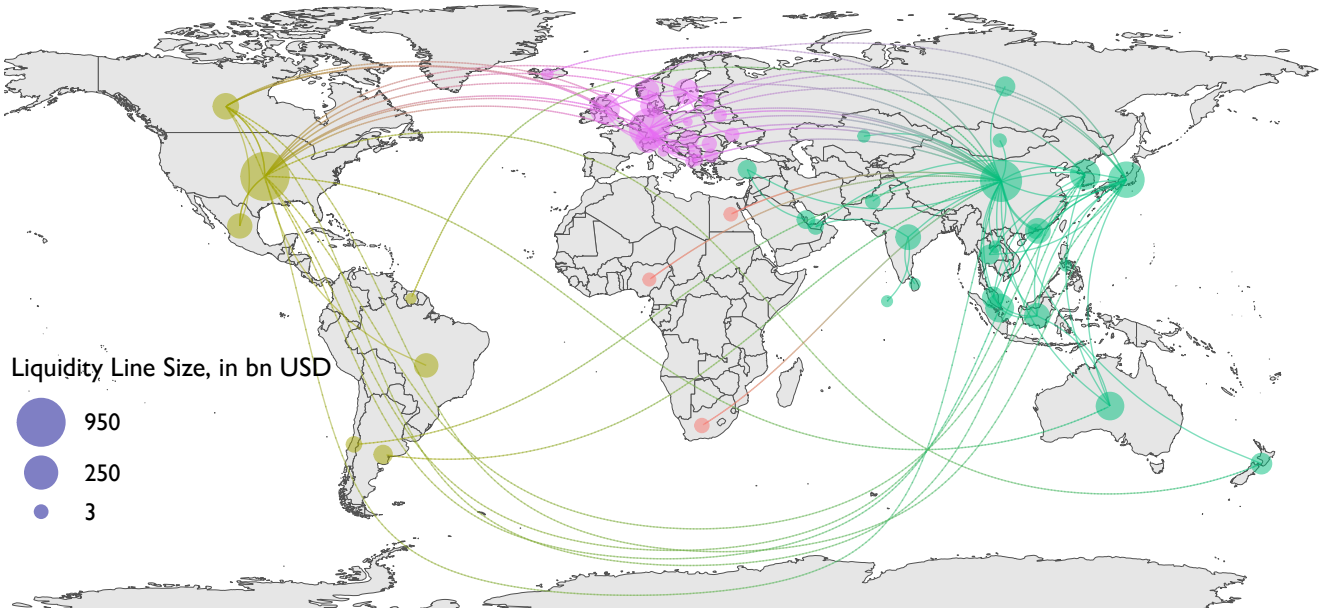
As we will elaborate below, difficulty in accessing funding in USD for banks headquartered outside the US is a source of financial instability given the global importance of the dollar. Hence, the Fed forms a key hub in the network and its liquidity lines have received the most attention in the literature. However, liquidity issues can emerge in other international currencies too. Regional networks have developed in Europe centered around the ECB (Albrizio, Kataryniuk and Molina, 2021), the Swiss National Bank (SNB) (Andries, Fischer and Yesin, 2017), and in Asia centered around the Bank of Japan. The most connected node is China with the People's Bank of China (PBoC) establishing 38 new renminbi (RMB) swap lines in the 2010s. These lines share the same operational features but are motivated by providing funding for trade finance with the goal of internationalizing the RMB.

The numerous arrangements in the figure each have their own idiosyncrasies in terms of how the loan between the source and recipient central bank is structured and, in turn, how the recipient lends the money on to commercial banks. In a companion paper, Bahaj and Reis (2022*b*), we provide an in-depth review of the operational workings of the lines, including some comparisons across institutions.

These modern liquidity lines are quite different from the traditional liquidity lines of the XIXth and XXth century. Historically, the stability of the classical gold standard in the XIXth century was underpinned by loans of specie between different institutions in order to pool resources for foreign exchange (FX) interventions. The failure of central banks to cooperate in this way after WWI contributed to the regime's downfall (Eichengreen, 1996). Most of the modern liquidity lines instead connect countries with floating currencies and the funds are not used to directly intervene in the FX market.

A second stage in the history of liquidity lines emerged in the the 1960s, during the Bretton Woods exchange rate regime (McCauley and Schenk, 2020). They had two complementary goals. First, to stabilize exchange rates through transfers of USD as opposed to transfers of gold. Second, and anticipating their modern usage, to intervene in offshore

Figure 1: The Bilateral Network of Liquidity Lines Between Central Banks – End 2020



Source: Perks et al. 2021 augmented to include ECB's bilateral repo lines sourced from Albrizio, Kataryniuk and Molina 2021. Bubble size reflects the sum of either the notional limit of all liquidity lines available to country or, if the line is unlimited, the historical drawings.

interbank markets, particularly the eurodollar market. Unlike their modern counterparts though, these were genuine FX swaps in the sense that both central banks made use of the currency they received, either for policy purposes or to earn profits. In a modern swap line, the deposit of recipient currency does not enter circulation, and it has limited value as collateral. The structuring of modern liquidity lines as an FX swap is either a vestige of operational practice from the 1960s-70s or, potentially, a fig leaf to not accurately label the lines as an international unsecured loan.

The end of Bretton Woods saw the historical swap lines fall into disuse, with almost all formally discontinued by 1998. The liquidity lines were reestablished in large numbers in the wake of the global financial crisis (Perks et al., 2021). Their stated motivation was financial stability as global banks faced difficulties in funding themselves in foreign currency during the global financial crisis, the euro sovereign debt crisis, and the pandemic. Next, we turn to understanding why this extension of central bank lending facilities across borders was needed.

2.3 Why are liquidity lines needed?

In the three roles that money plays—store of value, unit of account and medium of exchange—there are strong complementarities. This creates a strong force for one currency to become internationally dominant (Krugman, 1984). In the international monetary system a few currencies disproportionately dominate international trade, cross border capital flows, financial assets, and official FX reserves (Gourinchas, Rey and Sauzet, 2019). Firms that engage in international trade have an incentive to choose the same unit of account as the one used by both their suppliers and competitors (Mukhin, 2022, Gopinath et al., 2020), and to use the same liquid currencies as a medium of exchange for payments (Rey, 2001). Large economies also issue currencies that are more correlated with aggregate consumption risk (Hassan, 2013) and are better able to supply safe assets (Caballero, Farhi and Gourinchas, 2008), making their currencies more suitable as a store of value.

Currently, the USD is dominant in trade invoicing (Gopinath, 2015), denomination of international bonds (Coppola et al., 2021), and exchange rate pegs (Ilzetzki, Reinhart and Rogoff, 2019). The other currencies that are used internationally, like the EUR, the Japanese yen (JPY) and the RMB are issued by central banks that form key hubs in the global liquidity line network. This is surely not a coincidence. As private agents use these international currencies for their cross-border activities and portfolio holdings, global banks end up having assets and liabilities denominated in those currencies. In the event of a shock to their funding, these financial intermediaries require foreign currency that their local central bank will not have in abundance. A liquidity line with the issuing central bank as the source is a means to get these resources.

In the case of the USD, the literature has carefully documented the plumbing of the financial system and the resulting vulnerabilities that arise from the nature of dollar funding markets. As described in Aldasoro, Ehlers and Eren (2019), non-US banks had $12.7 trillion in USD denominated assets by the end of 2017, which is almost the same amount as the assets of US banks. Non-US global banks raise dollars onshore in US credit markets, via their US branches, subsidiaries, or correspondents. These banks then channel the dollars around the rest of the global financial system either through their own internal capital markets (Cetorelli and Goldberg, 2012) or through credit lent to regional banks in the offshore market for dollars (the eurodollar market). These flows then provide the credit to fund offshore USD lending to corporate and retail customers. The eurodollar market, offshore USD credit flows, and USD denominated bank leverage today are all

very large, so that the USD exchange rate has become an asset pricing factor (Bruno and Shin, 2015).

The key vulnerability within this setup is that non-US banks lack a stable USD denominated retail deposit base. Their important sources of funding are, instead, commercial paper and certificates of deposits issued to US prime money market funds (MMFs). These funds are prone to runs. Their liabilities are highly liquid in the sense that they offer redemption on demand to their shareholders. However, prime MMFs invest in short-term securities that are designed to be held to maturity and can become difficult to liquidate in the event of a common shock. Economic stress events tend to lead to outflows from prime funds due to: (i) increased demands for cash, (ii) a flight to quality from investors towards government bonds (or the funds that hold them), and (iii) the first mover advantage from withdrawing before liquidation costs are born. Schmidt, Timmermann and Wermers (2016) provide a detailed analysis of runs experienced by MMFs in the global financial crisis. In spite of the regulatory reforms of 2016, during the 2020 pandemic, the same large outflows from MMFs took place. Again, this caused a loss of dollar funding for non-US banks (Eren, Schrimpf and Sushko, 2020). In response, these banks turned to their own central banks USD for lending facilities funded through liquidity lines with the Federal Reserve (Bahaj and Reis, 2020*a*).

More recently, there are signs of substitution away from MMFs as a way to fund global credit in USD. They have been replaced by foreign banks issuing debt denominated in USD, occasionally at longer maturities, as well as by an increase in USD deposits by other non-banks. Aldasoro, Eren and Huang (2021) show that there was a reduction in MMF funding to non-US banks by $300bn between end-2019 and end-2020 (or about 25% of pre-pandemic levels). One cause for the decline in MMF funding may be reforms to liquidity regulation, as wholesale funding (such as that from MMFs) with a term of less than 30 day has a 100% run rate in the calculation of the denominator in the liquidity coverage ratio (LCR). Hence, this funding can only be used to invest in very liquid securities or to fund short-maturity arbitrage positions, because these activities either count towards the numerator in the LCR calculation, or generate cashflows that can be netted off the denominator (Anderson, Du and Schlusche, 2021). A detailed anatomy on who exactly is funding non-US banks' dollar denominated lending in the post-pandemic world, and whether it is more prone to needing lending of last resort via the liquidity lines, are open questions.

Cross-border funding for banks in currencies other than the USD has not received as

much attention in the literature. When it has, the same fundamental appears to underpin any demand for a liquidity line: banks in the recipient country facing a supply shock to non-deposit funding denominated in source currency. For example, the SNB network of swap lines in the 2008-2010 period arose from the prevalence of CHF denominated mortgages in central and eastern Europe (in particular, Hungary and Poland). Banks in these countries borrowed CHF in the Swiss interbank market in order to fund these loans. As the availability of funding from that market declined during the crisis, the SNB coordinated with the Hungarian and Polish central banks to provide an alternative funding source via a liquidity line (Andries, Fischer and Yesin, 2017).

In short, the need for the liquidity lines is, at its heart, the same as the need for any central bank lending of last resort: financial institutions making long term investments using short term funding that sometimes goes missing. In a world with international capital markets and a few international currencies, many banks will make investments and loans in foreign currencies sustained by borrowing in money markets, which are prone to runs. The liquidity lines are a way to create access to the central banks of the major international currencies for banks all over the world that need them as lenders of last resort.

2.4 Why don't private alternatives make the liquidity lines redundant?

Before a bank turns to the central bank, and pays its penalty rates, it could potentially turn to private markets to obtain the funding it needs. Most of the time, this is possible. During a financial crisis, however, there is a well-known flight to safety across borders. Investors become reluctant to lend to banks outside the major financial markets. Moreover, in crisis times, regulators often tighten constraints over foreign investments, which are treated as being riskier on account of the inferior information that the regulator has on counterparties outside its jurisdiction. Therefore, when the MMFs withdraw, often other investors withdraw as well. Perhaps at a high enough interest rate, foreign banks could still replace the MMF funding. But, as in the traditional analysis of lending of last resort, the central bank puts a ceiling on how high these interest rates can rise through its lending programme.

Alternatively, when the supply of funding denominated in source currency is constrained, commercial banks could borrow in recipient currency instead. A currency mismatch is risky because exchange rates are volatile, and banks are obliged to report significant mismatches to supervisors. Hence, banks turn to the FX swap market to hedge

out the exchange rate risk. In cash flow terms, borrowing a EUR wholesale for three months and then swapping that EUR for USD via a three-month FX swap is equivalent to borrowing a USD for three months. This form of transaction is known as synthetic USD borrowing. Covered interest parity (CIP) simply states that the effective interest rate on these two forms of borrowing should be the same.

CIP held well prior to 2007, with genuine arbitrage opportunities typically lasting just a few seconds (Akram, Rime and Sarno, 2008). However, since the global financial crisis, CIP has broken down with large deviations visible even in times of market calm (Du, Tepper and Verdelhan, 2018). Moreover, the data suggests that the supply curve of FX swaps is upward sloping: in times of market turmoil, high demand for FX hedging drives up its cost and, therefore, the cost of synthetic borrowing and CIP deviations.

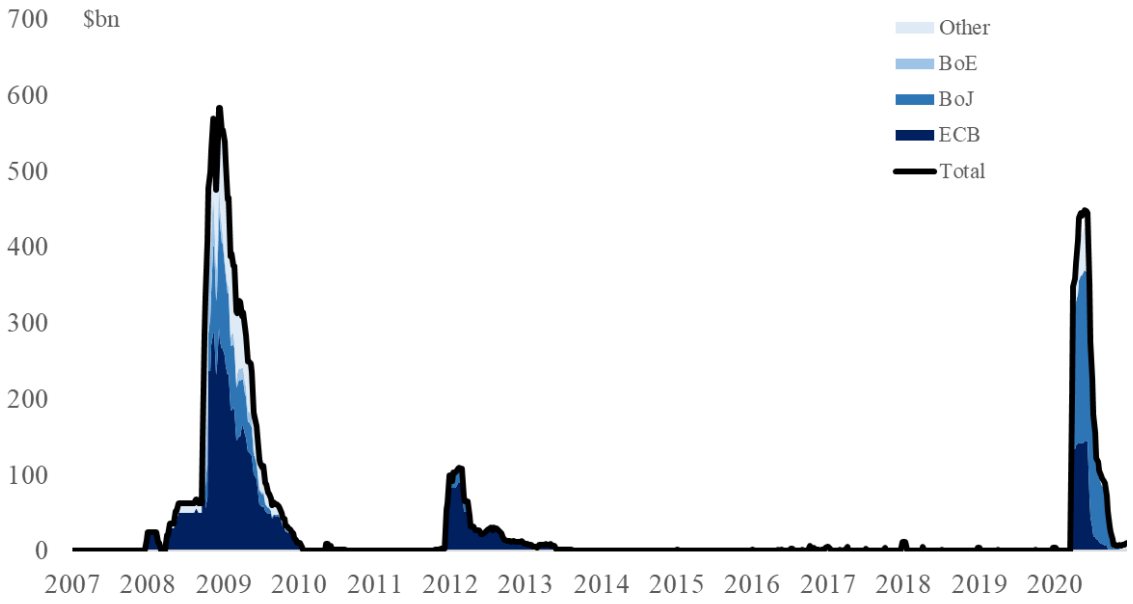
The literature has presented a few arguments for why CIP has failed to hold in the post-2007 world. First, the Basel III leverage ratio implies that trades to arbitrage away a CIP deviation must be partially funded through equity capital which is viewed as a more expensive form of financing (Du, Tepper and Verdelhan, 2018). Second, the post-crisis world has led to a reevaluation of bank credit worthiness, raising the cost of unsecured finance and generating something akin to a debt overhang problem that prevents risk-free arbitrage opportunities being fully exploited (Andersen, Duffie and Song, 2019). A third explanation is that in crisis times there needs to be a counterparty with spare source-currency to take the other side of the FX swap transaction, and if obtaining source-currency is difficult, such a counterparty may be hard to find (Goldberg, Kennedy and Miu, 2011).

This overview of different funding alternatives makes clear that liquidity lines between central banks become relevant when lenders in private funding markets are unable or unwilling to provide source currency credit to recipient country banks. In other words, the liquidity lines are facilities of last resort that become active during crises. They are a backstop rather than a tool for banks to manage their liquidity positions on a day-to-day basis.

To illustrate this, Figure 2 plots the time series of drawings from the Federal Reserve's liquidity lines over the past decade and a half. The major of drawings align with periods of market turmoil: the global financial crisis in 2007-2009, the Euro area sovereign debt crisis in 2012 and the pandemic in 2020.

A different set of alternatives comes in the relation between the two central banks. Commercial banks could get the source currency they need from their recipient central

Figure 2: Drawings from the Federal Reserve's liquidity lines



Source: Bahaj and Reis (2022*a*).

bank if it had accumulated a large stock of it before a crisis.

For example, the Central Bank of Russia, which does not have an agreement with the Fed, has a standing facility to provide USD to Russian banks backed by its reserves. Swap lines and FX reserves are essentially substitutes. Rather than borrow from the source central bank via a swap line, the recipient central bank could liquidate its reserves to obtain the source currency it needs to provide funding to its banks. Obstfeld, Shambaugh and Taylor (2009) make this point and show that for countries without access to a swap line, FX reserve holdings relative to bank financing needs were a key predictor of exchange rate movements in 2008. Yet, as Figure 2 shows, the drawings can be large in short periods of time. The cost of keeping a large stock of reserves that are rarely used can be substantial. A liquidity line may be an attractive alternative that saves on these costs.

The recent repo lines blur this distinction. In order to access currency from the source central bank, the recipient can now pledge as collateral some liquid securities that it holds. As these are almost always liquid government bonds in the jurisdiction of the source central bank, now the recipient central bank no longer needs to sell its reserves of these securities. Insofar as the securities may be hard to sell in time of crisis, this is attractive to the recipient central bank. In contrast with the swap lines, repo lines are complementary

with reserves as the latter are needed to access the facility. Yet, the repo line is only really useful if liquidating reserves becomes costly. This was possibly the case during the Covid pandemic when the FIMA facility was introduced (Duffie, 2020).

Finally, the recipient central bank could simply offer a pure swap contract to the banks in its jurisdiction for them to hedge their source-currency exposure (with the foreign reserves ultimately only used as backup in these contracts). The Central Bank of Russia, which does not have a liquidity line with the Fed, does so. By transferring the exchange rate risk from the banks to the taxpayers, this arrangement make clear that these operations are risky. Perhaps this is why they are so rarely done this way.

2.5 What is their effect on interest rates?

Because the liquidity line generates loans of source currency of possibly unlimited size at a fixed interest rate, then this interest rate puts a ceiling on any comparable interest rates on short-term safe source-currency borrowing. This is the standard effect of a lender of last resort. Because the source central banks also have domestic liquidity facilities, and they would not like to privilege the international liquidity lines over them, typically the lending rate in the liquidity lines is at least as high as the rate for the domestic liquidity facility. Therefore, the effect on source currency interest rates is typically not noticeable since there is another ceiling that is at least as tight.

However, there is another ceiling imposed by the liquidity lines that is more subtle but just as direct. It arises because of the involvement of the recipient central bank, and the ability that banks have to not just borrow the source currency from, but also to deposit recipient currency at that central bank. Consider the arbitrage trade described in Bahaj and Reis (2022*a*). A commercial bank under the jurisdiction of the recipient central bank borrows in source currency from a lending facility operated by the recipient central bank, and funded through a liquidity line with the source central bank. Assume the gross interest rate on this borrowing is $(1 + i^l)$. The commercial bank then buys recipient currency with the borrowed source currency at the current spot exchange rate S and deposits the currency at the recipient central bank's deposit facility earning $(1 + i^{*,v})$. Last, the commercial bank sells the recipient currency forward for source currency at forward price F to hedge out the exchange rate risk from the mismatched positions. This trade involves borrowing and lending from the same central bank and, abstracting from any demands for collateral and the counterparty risk from the forward, such a trade should

not be profitable. Hence, we must have:

$$(1 + i^l) \geq \frac{S}{F}(1 + i^{*,v}). \tag{1}$$

Let i and i^* denote the equivalent net market interest rates for borrowing in source and recipient currency. The deviation from covered interest parity is given by $X = \frac{S}{F}(1 + i^*) - (1 + i)$: this corresponds to the interest rate from borrowing source currency synthetically through the FX swap market less the interest rate on borrowing source currency directly. Substituting the definition of X into equation (1) yields the following result:

$$(i^l - i) + \frac{S}{F}(i^* - i^{*,v}) \geq X. \tag{2}$$

Equation (2) shows that the liquidity line places a ceiling on deviations from covered interest parity. This ceiling is equivalent to the penalty rate on borrowing from the facility $(i^l - i)$ plus the spread on the deposit money at the recipient central bank (adjusted by the forward premium to reflect that this spread is denominated in recipient currency).

The empirical literature has focused on CIP deviations as a proxy for the effectiveness of liquidity lines. Using data from the early phase of the global financial crisis and an E-GARCH model of CIP deviations, Baba and Packer (2009) document a decline in EUR/USD CIP deviations around scheduled USD operations by the ECB. Using the same framework, Baba and Shim (2010) document the same effect on KRW/USD CIP deviations using the Bank of Korea's USD operations during 2007 to 2009. Likewise, Moessner and Allen (2013) show that the ECB's USD operations caused a fall in CIP deviations during the Euro area sovereign debt crisis. A problematic feature of these early papers is that they included the size of the commercial bank drawings from the USD lending facilities as explanatory variables. Since the demand for USD denominated loans from the local central banks is endogenous to the cost of raising funds via the FX swap market, this creates a bias in the estimates. Moreover, during the global financial crisis, the USD operations were conducted on an ad-hoc schedule, creating a selection problem since the timing of the policy interventions were not random.

Bahaj and Reis (2022*a*) provided the first credible causal estimates of the effect of liquidity lines on CIP deviations. They used two complementary strategies with consistent results. First, a difference-in-differences setup that compares CIP deviations versus the USD for currencies whose central banks did or did not have a liquidity line with the Fed following an unexpected 50bp cut in the rate i^l in November 2011. They find strong em-

pirical support for the ceiling hypothesis in Equation (2) once the new operations at the lower rate take place. Not only did the average CIP deviation fell, but the effect is particularly noticeable on the right tail of the CIP distributions. Second, they exploited the fact that CIP deviations spiked at the end of quarters between 2016 and 2019 and yet the USD liquidity lines were only open once a week. Using the variation in whether the day of the week that the swap line is open is closer or farther from the end of the quarter, they find that the ceiling is broken at the quarter end but CIP deviations immediately fall below it as soon as the liquidity line opens a few days later.

Another recent set of papers has found an effect of the liquidity lines on CIP deviations even when there are no operations in source currency. The mere announcement of a new liquidity line with the Fed had an impact on USD CIP deviations during the March 2020 financial stress (Aizenman, Ito and Pasricha, 2021). Albrizio, Kataryniuk and Molina (2021) document a similar effect on EUR CIP deviations from the announcement of the ECB's liquidity lines.

The ceiling result in Equation (2) also explains the observation in Figure 2 that the liquidity lines are primarily used in periods of crises. Periods of turmoil in source-currency credit markets cause banks to turn to the FX swap market for their funding. The associated increase in X in turn causes the ceiling to bind and commercial banks to start demanding source currency liquidity from their central bank. As the penalty rate $i^l - i$ becomes lower, the probability of hitting the ceiling rises. For the Fed's swap line this penalty rate has been cut from 100bp in 2007 to 25bp in 2020; in the future, it may take smaller shocks to drive commercial banks to the liquidity lines.

2.6 What are the consequences on banks' and central banks' behavior?

Banks seem to adjust their credit supply in response to changes in synthetic borrowing costs. Ivashina, Scharfstein and Stein (2015) argue that high USD/EUR CIP deviations during the Euro crisis caused Euro area banks to cut back on their dollar denominated lending. In particular, they show that eurozone banks cut back their participation in dollar denominated syndicated loans versus loans in other currencies. Eguren-Martin, Busch and Reinhardt (2019) corroborate this effect using supervisory data in the foreign currency positions of banks operating in the UK over a longer sample period.

Bahaj and Reis (2022*a*) directly test the impact of a change in i^l, for USD denominated liquidity lines, on commercial banks' portfolio decisions by analysing fine-grained corporate bond trading behavior around the Fed's November 2011 rate cut. They find that

commercial banks headquartered in a country with a liquidity line with the Fed brought additional USD denominated bonds worth 5% of the bank's typical trading volume relative to non-USD bonds and commercial banks headquartered in jurisdictions without access to the liquidity line. At the same time, the yield on those bonds fell by around 13bp.

Another effect of the liquidity lines is the raise in the value of the banks that benefit from it. Andries, Fischer and Yesin (2017) find that Polish and Hungarian banks' equity returns rose by 25bp following the announcements of swap lines with the SNB and their home central banks. This effect was concentrated in banks with large quantities of CHF denominated loans and a reliance on short term funding. Similarly, Bahaj and Reis (2022*a*) show that equity returns for non-US headquartered banks that have a US presence rise when the Fed cuts the interest rate on its liquidity lines. Albrizio, Kataryniuk and Molina (2021) find an effect on the other side of the swap line as well: the equity valuations of Euro area banks with exposures in a particular recipient country rise when the ECB signs a swap line agreement with that country.

These economic effects of liquidity lines underpin why central banks are so willing to set them up in the first place. The lines appear to be win-win arrangements. The recipient central bank benefits from averting a liquidity crisis among commercial banks in its jurisdiction. The increase in equity values also signals confidence in the banking system and, potentially, an increase in its capacity to supply credit. The source central bank benefits through (i) improving the prospects of banks in its jurisdiction that may be exposed to the recipient country; (ii) ensuring that recipient banks can continue to lend and purchase securities in source-currency, potentially averting costly fire sales or a credit crunch and (iii) an increase in asset prices in its jurisdiction.

Despite these benefits, the costs of liquidity lines remain understudied. A liquidity facility has the potential to generate moral hazard that needs to be managed. This gives rise to fundamental questions: (i) How should the policies be structured and coordinated? (ii) Where should the perimeter of the liquidity line network lie and who should determine it? (iii) Do the liquidity lines cement the dominance of particular currencies? These questions have received less direct attention, but there are clues from elsewhere in the literature and so this is where we turn to in the second half of this article.

3 What we need to know

With barely a decade of published work on liquidity lines, it is no surprise that many questions remain unanswered. To guide researchers into this area, this section groups some of them around a few common themes.

3.1 The liquidity lines as a contracting problem

Ever since Thornton and Bagehot, central banks have discussed how central banks should design the lending facilities in domestic currency to banks in their jurisdiction. What makes the new liquidity lines different is that there are three agents involved: the two central banks and the borrowing commercial bank. The incentives of all three agents are likely to be different and involve some thorny incentive problem. The contracting problem between them has not been explicitly studied in the academic literature and, in practice, the current rules were put together at short notice under crisis conditions

A first pass at the problem notes that since the recipient central bank bears the private credit risk, the moral hazard problem manifests as a cost for taxpayers in the recipient country. As an agent for these taxpayers, the recipient central bank bears the cost and so has sole responsibility for designing the lending facility for the commercial banks and monitoring them. The source central bank needs to only concern itself with the sovereign risk from lending to another central bank, which is likely to be negligible. This is close to what happens in reality. As described, the recipient determines which banks are able to borrow from it, the collateral requirements on the loans, when the operations take place, and their tenor. The source central bank determines which recipient central banks it deems sufficiently safe to lend to, places constraints on quantities (if not allowing for unlimited borrowing) and approves requests for drawings from the liquidity line upon demand from the recipient central bank (Bahaj and Reis, 2022*b*).

Even from the perspective of this first pass, however, the current arrangements exhibit a major anomaly. Effectively, it is the source central bank that sets the interest rate on the loans, as in practice the recipient central bank passes on the same rate to banks in its jurisdiction. This seems inconsistent with the recipient central bank monitoring the commercial banks that borrow from it and designing a lending facility to mitigate moral hazard. In principle, nothing stops the recipient central bank from charging a higher rate than the source central bank charges, and yet we do not observe this.

This first pass is also incomplete. The two central banks do not benefit equally from

preventing inefficient liquidations during a crisis. Take the example of the ECB borrowing from the Fed. If the ECB sees a narrower benefit than the Fed then, *ceteris paribus*, it will set overly tight terms on borrowing from the lending facility. Perhaps more relevant, the ECB will, through the setting of terms in its lending facilities, target the funds to the parts of its financial system that are more relevant for its goals. For instance, in a crisis, the ECB may prefer to lend the USD to banks that need the funding to finance domestic activity. The Fed instead may wish that the USD are used to prevent the liquidation of assets in the United States and to prevent an increase in the wholesale cost of dollars in US money markets.

A further problem is that there are different ex-ante inefficiencies in the source and recipient countries created by the liquidity line. Any lending facility implicitly subsidises bank activity and creates ex-ante costs in the form of moral hazard. It is well understood that the liquidity lines will encourage too much lending in source currency by recipient-country banks and potentially expose the financial system to currency mismatches. This is the classic case of the recipient-country banks taking on too much risk once the liquidity lines remove some of the tail risk in its activities. Less appreciated is that there is moral hazard affecting the source central bank as well. The liquidity lines may lead to excessive credit provision by recipient banks that are active in the source country. This may come with externalities from fire sales (Lorenzoni, 2008) or from the effect of recipient lending on aggregate demand in the source country (Farhi and Werning, 2016, Korinek and Simsek, 2016). Finally, the liquidity lines encourage recipient banks to finance their source currency activity in wholesale markets in the source country, knowing that they can be replaced in case of a market freeze (Boissay, Collard and Smets, 2016).

There is some mixed empirical evidence on the moral hazard created by liquidity lines. Bevilacqua et al. (2021) use the prices of equity options to evaluate how market-based measures of tail risks at different horizons reacted to Fed interventions during the Covid-19 pandemic. They find that the liquidity line announcements had the greatest impact, both in recipient-country markets and in the US, and especially in long-dated options.

The general contracting problem is related to the one in models with multiple layers of lenders with differing incentives (Holmstrom and Tirole, 1997, Diamond and Rajan, 2012). This work suggests that the optimal contract likely involves a combination of borrowing limits, collateral requirements, and variation in the interest rate it charges, and that it varies across different recipient central banks. The data confirms this as recipient central banks often impose additional haircuts on collateral compared to a standard lend-

ing facility to reflect the fact that they are lending a foreign currency and therefore face some extra risk. These extra haircuts are heterogeneous across lending institutions, varying between 13% for the ECB to zero for the SNB (Bahaj and Reis, 2022*b*). Borrowing USD from the SNB is therefore cheaper than borrowing USD from the ECB.

However, this diversity also implies that, because commercial banks operate across multiple jurisdictions, they can choose which central bank they go to and arbitrage differences in the terms of loans. There is some suggestive evidence that this has happened in the SNB's case, with foreign banks borrowing from its USD operations (Pozsar, 2020). Looking further back in history, Friedman and Schwartz (1963) discuss how coordination failures across districts prevented the Fed from acting as an effective lender of last resort during the Great Depression, and Richardson and Troost (2009) find empirical support for this by comparing bank failure rates and economic activity in the 1930s in the Atlanta district (which had a generous discount window) relative to the St. Louis District (with a tight discount window.)

More generally, the opportunities for banks to choose between different liquidity lines leads to broader questions regarding the perimeter of the liquidity line network, which is the topic we turn to next.

3.2 The perimeter of the liquidity line network

From the perspective of global welfare, the source country will ignore the external benefits that the liquidity lines bring to other countries that we discussed in the previous section. Perhaps an international institution like the IMF or the BIS could play a role in determining which central banks obtain liquidity lines and how those lines are structured. The BIS played an informal coordinating role for the network of liquidity lines in the 1960s (McCauley and Schenk, 2020). In the modern standard network around the Fed, there is coordination among the five central banks on the timing of their operations. Nonetheless, the liquidity lines are still primarily operated on a bilateral basis, with the multilateral Chiang-Mai initiative in Asia being a notable exception. Reis (2019) argues that the IMF could play a more formal role in managing liquidity line arrangements, as it is well placed to judge the counterparty risk associated with the liquidity lines and to internalise risks to the stability of the global financial system as a whole. The IMF has experience lending to developing economies and could underwrite the loans, removing political concerns for the source central banks.

Under the current system of bilateral agreements, a source central bank has two broad

considerations when determining the perimeter of its liquidity line network. The first is counterparty risk broadly defined. If the recipient central bank fails to repay the loan from a swap line it would incur a loss, since there is no haircut in the collateral of recipient currency that is held by the source central bank. The source central bank could recover this through legal action, but this would undermine domestic political support for the liquidity lines and would fall under the purview of foreign diplomatic relations, outside of the central bank's control. A separate risk from default is that the recipient central bank uses the currency from the liquidity lines for a different purposes than their intention. For example, the recipient could use the source currency to inflate its exchange rate reserves or to prop up its currency. The PBoC, which has established a large number bilateral swap lines, has seen them used in this unintended manner (McDowell, 2019). Managing counterparty risk seems to have been the main factor in the FOMCs deliberations on who should get liquidity lines during the global financial crisis (FOMC, 2008)

This discussion of counterparty risks also makes clear that the liquidity lines cross over into other realms of policymaking. Even though central banks acted independently when establishing and operating the lines, bilateral loans are part of foreign policy, and any losses that are ultimately borne by taxpayers come with fiscal implications. How central banks coordinated with their foreign and finance ministries is unclear, and the appropriate delegation of tasks or the legal framework have not been extensively studied. For the liquidity lines to be a solid pillar of the global financial architecture, they require political support. In the US, for example, the Dodd-Frank Act modified Section 13(3) of the Federal Reserve act, which permits lending to financial institutions in crises, to legislate that all programmes established under the Section must be broad-based (not in support of a specific failing institution) and require prior approval from the Treasury. There is some debate about the legal underpinnings in the US of the Fed providing liquidity lines to foreign institutions (Menand, 2021), and a loan to a foreigner is perhaps more vulnerable to changes in political views than a domestically focused policy.

The second consideration for the source central bank pushes in the other direction: the liquidity lines provide a positive signal to market participants. The literature on self-fulfilling currency crises has emphasized that the influence of an international lender of last resort in preventing costly runs depends on the size of its interventions (Corsetti, Guimaraes and Roubini, 2006). A broad liquidity line network is a signal that a large intervention is possible. A separate signal arises if the source central bank pays a cost in setting up a new liquidity line in a recipient country that does not need it now, but in

which a future liquidation crisis would have a large impact on the source economy. The central bank is signaling that it is willing to subsidize unconstrained banks today and to create moral hazard for the future because of its fear of a future crisis (Farhi and Tirole, 2012). These two signaling effects may explain why the Fed established swap lines with the central banks of Australia and New Zealand during the Covid pandemic, together with seven other new countries. Banks in both countries displayed no clear need for USD, and the recipient central banks never drew on the lines. Yet, the announcement in March 19 of 2020 of these new lines had a substantial impact on market prices (Aizenman, Ito and Pasricha, 2021).

The introduction of the FIMA and EUREP repo facilities in 2020 has changed these considerations to an extent. These facilities are nearly universally available to any recipient central bank that wishes to borrow USD and EUR, from the Fed and ECB respectively. They require, however, that the recipient central banks have sufficiently large FX reserves in the form of the securities needed to pledge against this funding, which makes counterparty risk significantly lower for these standing repo facilities. They might also bring about a potential increase in the demand for FX reserves denominated in the source currency to ensure recipients have adequate collateral. This may be to the source country's advantage if that increase in demand for reserves contributes towards an exorbitant privilege. This brings us onto how the liquidity lines interact with the source currency's role in the international financial system.

3.3 Dominant and international currencies

Section 2.3 noted that the need for liquidity lines arose from the dominance of certain currencies, particularly the USD, in the international monetary system. In the other direction, establishing a broad network of liquidity lines will contribute towards a currency being used internationally and becoming dominant.

In principle, the liquidity lines allow a currency to gain an international status. By putting a ceiling on the interest rate paid to synthetically borrow in that currency, the source central bank is removing tail risk in rolling over loans in its currency. This makes it more attractive to borrow in this currency across borders. Bahaj and Reis (2020*b*) find support for this mechanism using data on RMB usage combined with the introduction of the PBoC's liquidity line network. Exploiting variation on when the PBoC signed liquidity lines with different central banks, and different identification strategies, they find that these liquidity lines allowed the RMB to jumpstart as an international currency after

2010.

Related, repo lines also prevent the sale of government bonds of the source country during times of crisis. During the March of 2020 pandemic turmoil, the market for US Treasuries had trouble dealing with the pressure from the large volume of sales. The Fed's FIMA facility enabled foreign central banks to borrow dollars from the Fed against their reserves rather than increase the pressure in already stressed bond markets. In this way, the liquidity line contributes to financial stability in the source country and helps to reinforce any safe haven status.

Looking deeper at the literature though, this effectiveness and the mechanisms through which it works are less clear. There is a rich literature on why some currencies are used internationally. One mechanism notes that, with sticky prices, exporters want to price their goods in a currency that minimizes the risk that their markup fluctuates with exchange rates (Gopinath, Itskhoki and Rigobon, 2010). Therefore, firms want to use a currency that is also used by suppliers and competitors. Since many of these are abroad, this creates a strategic complementarity in currency choice among firms engaged in international trade. Mukhin (2022) shows that when the exports of some countries are used as inputs by others, the international monetary system can coordinate on a dominant currency. Bahaj and Reis (2020*b*) add a further complementarity. If imported inputs are purchased using trade credit in some currency subject to funding risk, then firms will also want this currency choice to match the currency of pricing. Because a liquidity line curtails the funding risk for source-currency borrowing, it makes it more attractive for firms to borrow in that currency, which makes costs now depend more on that currency, and thus raises the incentive to price in that currency as well. Central bank liquidity lines can spur a currency becoming used for trade purposes.

An alternative role for liquidity lines is suggested by Bocola and Lorenzoni (2020). In emerging economies, savers want to hold assets in foreign currency because the local currency depreciates during a financial crisis. Therefore, foreign-denominated assets provide a hedge against these crises. With more foreign-denominated assets, foreign-denominated debt will rise, which makes a financial crisis more likely due to the "original sin". This further boosting the demand for foreign assets. The liquidity line, by insuring the borrowers against tail risk in borrowing costs in the international currency, protects the income of savers during the financial crisis and reduces their demand for the insurance that the foreign-currency asset provides. This may reverse the adverse feedback loop, and reduce the incentive to borrow in the foreign currency, lowering the probability

of a crisis. In this case, the liquidity lines reduce the usage of the currency internationally.

A different literature has focused on the role of the financial system in currency dominance in trade. Gopinath and Stein (2020) note that if imports of consumption goods are in an international currency, then households will want to keep local deposits in that currency to pay for their purchases. Local banks, wanting to match the currency of their assets with that of their liabilities, will charge less to local exporting firms that borrow in this international currency. Once firms borrow in that currency, again this provides an incentive to price exports in it as well. Chahrour and Valchev (2022) instead note that firms trading across borders need to choose a matching currency to denominate the assets that are pledged as collateral in cross-border loans. Once a currency is heavily used, its value as collateral rises, households want to use it to save, and this currency is easier to find when collateral is needed. While their models do not study liquidity lines, in both of them the offshore supply of assets denominated in a particular currency is central to the mechanism (although a large increase in the asset supply has an effect of opposite sign between the two models). Since the liquidity lines provide loans in source currency, they act on the liability side of the balance sheet of the recipient country, so they would be neutral in their frameworks. In Gopinath and Stein (2020) instead, banks already have an excess supply of dominant-currency liquidity through household deposits, so providing more does not change the equilibrium.

Finally, a different branch of the literature has noted that firm characteristics will affect their desired capital structure and especially how much they want to borrow in foreign currency. Eren and Malamud (2021) note that firms differ in the maturity of their debt, and that they will want to borrow in a currency that depreciates during a global downturn over the horizon of this maturity. Salomao and Varela (2022) show that the more productive firms want to borrow more in foreign currency to take advantage of their lower cost while being able to tolerate the exchange rate risk that comes with it. Depending on how the recipient central bank targets the lending of source currency in this economy through financial intermediaries, the liquidity lines can change the composition of firms that borrow in source currency.

Therefore, whether the liquidity lines promote more use of the currency abroad, less use, or have no effect, depends on the economic forces at play. Moreover, how the liquidity line is designed, for instance to be focused on bank's financial investments (as the USD and EUR lines are) versus the supply of trade credit (as the RMB lines are), may enhance one of the mechanisms relative to others and affect the composition of borrow-

ers in foreign currency. There is much research to be done on clarifying when each of these mechanisms will be stronger, suggesting other mechanisms, as well as providing empirical validation and quantification.

4 Conclusion

An active literature has clarified how liquidity lines provide lending of last resort in source currency, which is needed in a world where banks are involved in large capital flows across borders. Their direct effect can be measured by their impact on CIP deviations, and there is evidence that this then affects investment choices. It is not clear yet how wide and thick will the network of liquidity lines grow to be, especially once the incentives of the different central banks involved are considered. This may well cause a lack of resilience against some large international shocks. Also uncertain is whether any type of liquidity line will promote the dominance of a currency in international transactions, as the literature on international currencies has highlighted mechanisms that work in different directions. Finally, while at first pass the existing contracts connecting the two central banks as well as the recipient financial institution that borrows source currency seem sensible, some further thought shows that they are likely inefficient, creating different forms of coordination problems and moral hazard.

Even less clear are the asset pricing implications of the liquidity lines. By affecting CIP and the costs of borrowing in source currency, the liquidity lines surely affect the exchange rate of the currency involved (Avdjiev et al., 2019, Jiang, Krishnamurthy and Lustig, 2020). By affecting the funding risk in source currency, the liquidity lines also surely change the desired precautionary holdings of foreign reserves, and the extent to which the source currency is a safe haven that appreciates during crises (Bianchi, Bigio and Engel, 2021). Much work needs to be done to clarify these connections both in theory and empirically.

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