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The Economics of Liquidity Lines Between Central Banks

Saleem Bahaj[1] and Ricardo Reis[2]

[1]Department of Economics and School of Management, University College London, London, United Kingdom

[2]Department of Economics, London School of Economics and Political Science, London, United Kingdom; email: r.a.reis@lse.ac.uk

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Abstract

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. Research has provided answers to some of these questions, but many more require further research.

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 Southeast 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 (Fed), the Bank of Canada, the European Central Bank (ECB), and the Bank of England. In 2007–2008, 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, during the crisis resulting from coronavirus disease 2019 (COVID-19), 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 (repo), leading to a repo line, or it can be a swap line, in which case the loan is structured as a foreign exchange (FX) swap in which 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. Section 2.2 follows with a description of the existing network of liquidity lines.

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. Section 2.4 presents alternatives to liquidity lines for recipient central banks or for banks to obtain source currency and a discussion of why these are not perfect substitutes for liquidity lines. In Section 2.5, we discuss the impact that liquidity lines have on interest rates, with a special emphasis on covered interest parity, and in Section 2.6 we discuss 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.

In Section 3, we focus on the open questions left for future research. There are many, but we try to group them under three broad headings. The first set of questions, addressed in Section 3.1, 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. Section 3.2 focuses 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 taken up in Section 3.3 on the two-way interaction between a central bank providing a liquidity line and its currency being used internationally.

Finally, the conclusion in Section 3 highlights unexplored implications of liquidity lines, with a focus on equilibrium asset prices. There are many open questions on how they affect the value of exchange rates, interest rates on different loans, and returns on investments, to name a few.

2. WHAT WE KNOW

The modern study of central bank liquidity lines started during the global financial crisis of 2008 (GFC), as the Fed 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 ECB has carried out regular, scheduled US dollar (USD) repo operations for banks in the eurozone area funded by borrowing USD from the 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 nearly complete discretion in how to run the repo operations for eurozone 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 eurozone area banks repay the loans they received.

This combination of risks and responsibilities is typical for a liquidity line. As described in Bahaj & Reis (2022a), 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 FX 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. Not only is the source central bank exposed 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?

Approximately 170 bilateral liquidity lines are in operation today. There are also two open repo line facilities in the form of the Fed's Foreign and International Monetary Authorities (FIMA)

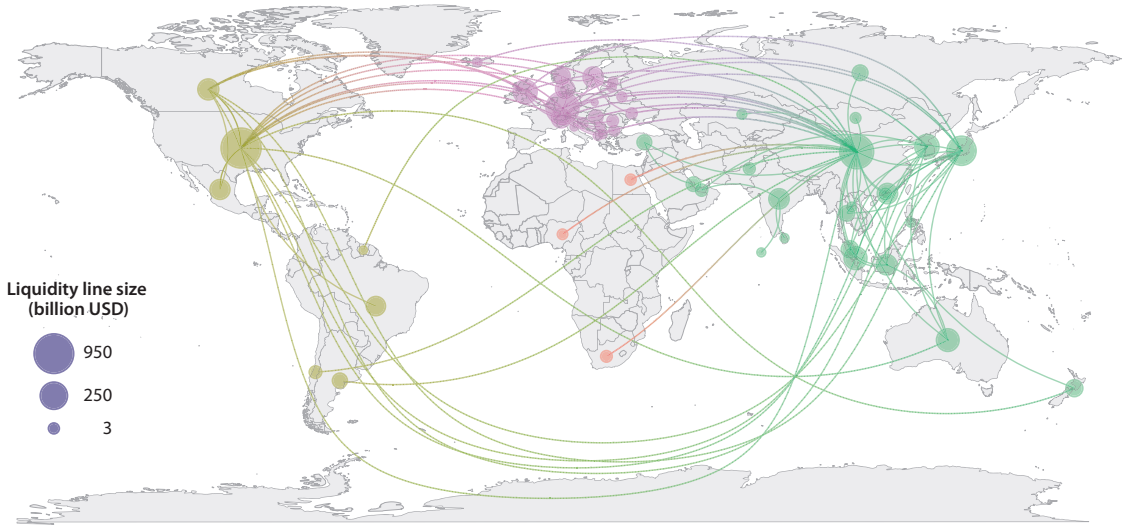

Figure 1

The bilateral network of liquidity lines between central banks at the end of 2020. The bubble size reflects the sum of either the notional limit of all liquidity lines available to a country or, if the line is unlimited, the historical drawings. Bubble color indicates region (continent). **Figure 1** was created with data from Perks et al. (2021) and augmented to include the European Central Bank's bilateral repo lines, which are sourced from Albrizio, Kataryniuk & Molina (2021).

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 elaborate below, difficulty in accessing funding in USD for banks headquartered outside the United States 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 & Molina 2021) and the Swiss National Bank (SNB) (Andries, Fischer & 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 **Figure 1** 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 & Reis (2022b), 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 19th and 20th centuries. Historically, the stability of the classical gold standard in the 19th century was underpinned by loans of specie between different institutions to pool resources for FX interventions. The failure of central banks to cooperate in this way after World War I 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 1960s, during the Bretton Woods exchange rate regime (McCauley & Schenk 2020). The lines had two complementary goals: first, to stabilize exchange rates through transfers of USD as opposed to transfers of gold; and second, anticipating their modern usage, to intervene in offshore 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–1970s 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 GFC (Perks et al. 2021). Their stated motivation was financial stability, as global banks faced difficulties in funding themselves in foreign currency during the GFC, the European sovereign debt crisis, and the COVID-19 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 & 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 (Gopinath et al. 2020, Mukhin 2022) 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 & 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 & 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 USD funding markets. As described by Aldasoro, Ehlers & 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 & 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 & 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 the following: (*a*) increased demands for cash, (*b*) a flight to quality from investors toward government bonds (or the funds that hold them), and (*c*) the first-mover advantage from withdrawing before liquidation costs are born. Schmidt, Timmermann & Wermers (2016) provide a detailed analysis of runs experienced by MMFs in the GFC. 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 & Sushko 2020). In response, these banks turned to their own central banks' USD for lending facilities funded through liquidity lines with the Fed (Bahaj & Reis 2020a).

More recently, there have been 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 nonbanks. Aldasoro, Eren & Huang (2021) show that there was a reduction in MMF funding to non-US banks by $300 billion between the end of 2019 and the end of 2020 (or approximately 25% of prepandemic 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 fewer than 30 days has a 100% run rate in the calculation of the denominator in the liquidity coverage ratio (LCR). Hence, this funding can be used to invest only in very liquid securities or to fund short-maturity arbitrage positions, because these activities either count toward the numerator in the LCR calculation or generate cash flows that can be netted off the denominator (Anderson, Du & Schlusche 2021). Who exactly is funding non-US banks' dollar-denominated lending in the postpandemic 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 face a supply shock to nondeposit funding denominated in the source currency. For example, the SNB network of swap lines in the 2008–2010 period arose from the prevalence of Swiss franc (CHF)–denominated mortgages in central and eastern Europe (in particular, Hungary and Poland). Banks in these countries borrowed CHF in the Swiss interbank market 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 & 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 option is possible. During a financial crisis, however, a well-known flight to safety across borders occurs. 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, other investors often 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 program.

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 3 months and then swapping that EUR for USD via a 3-month FX swap is equivalent to borrowing a USD for 3 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 & Sarno 2008). However, since the GFC, CIP has broken down, with large deviations visible even in times of market calm (Du, Tepper & Verdelhan 2018). Moreover, the data suggest 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 to explain 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 & Verdelhan 2018). Second, the postcrisis 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 & Song 2019). Third, in crisis times a counterparty with spare source currency is needed 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 & 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 Fed's liquidity lines over the past decade and a half. The major of drawings align with periods of market turmoil: the GFC in 2007–2009, the European 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 needed from their recipient central 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

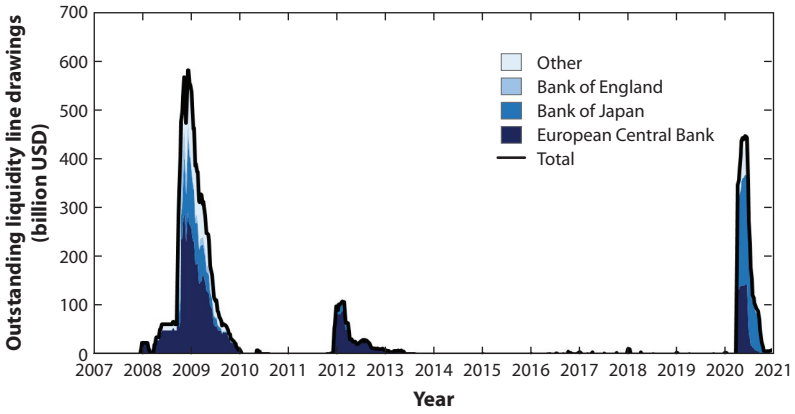

Figure 2

Outstanding drawings from the Federal Reserve's liquidity lines. Figure adapted with permission from Bahaj & Reis (2022a).

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 & 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 within 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. 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 times 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-19 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 used only 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, 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 another ceiling that is at least as tight exists.

However, another ceiling is 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 not only to borrow the source currency from but also to deposit recipient currency at that central bank. Consider the arbitrage trade described by Bahaj & Reis (2022a). 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 is 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

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

Let i and i^* denote the equivalent net market interest rates for borrowing in source and recipient currency, respectively. The deviation from CIP 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:

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

Equation 2 shows that the liquidity line places a ceiling on deviations from CIP. 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 GFC and an E-GARCH model of CIP deviations, Baba & Packer (2009) document a decline in EUR/USD CIP deviations around scheduled USD operations by the ECB. Using the same framework, Baba & Shim (2010) document the same effect on South Korean won/USD CIP deviations using the Bank of Korea's USD operations during 2007–2009. Likewise, Moessner & Allen (2013) show that the ECB's USD operations caused a fall in CIP deviations during the European sovereign debt crisis. A problematic feature of these early papers is that they include 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 & Reis (2022a) provide the first credible causal estimates of the effect of liquidity lines on CIP deviations. They use two complementary strategies with consistent results. First, a difference-in-differences setup that compares CIP deviations with the USD for currencies whose central banks did or did not have a liquidity line with the Fed following an unexpected 50 basis points (bp) cut in the rate i^l in November 2011. They find strong empirical 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 fall but the effect is particularly noticeable on the right tail of the CIP distributions. Second, they exploit 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 that 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 no operations in source currency occur. 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 & Pasricha 2021). Albrizio, Kataryniuk & 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. In turn, the associated increase in X causes the ceiling to bind and commercial banks to start demanding source-currency liquidity from their central bank. As the penalty rate $i^{\$} - i$ becomes lower, the probability of hitting the ceiling rises. For the Fed's swap line, this penalty rate has been cut from 100 bp in 2007 to 25 bp in 2020; in the future, it may take smaller shocks to drive commercial banks to the liquidity lines.

2.6. What Are the Consequences for Banks' and Central Banks' Behavior?

Banks seem to adjust their credit supply in response to changes in synthetic borrowing costs. Ivashina, Scharfstein & Stein (2015) argue that high USD/EUR CIP deviations during the European sovereign debt crisis caused eurozone 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 & Reinhardt (2019) corroborate this effect using supervisory data in the foreign currency positions of banks operating in the United Kingdom over a longer sample period.

Bahaj & Reis (2022a) directly test the impact of a change in $i^{\$}$, for USD-denominated liquidity lines, on commercial banks' portfolio decisions by analyzing 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 approximately 13 bp.

Another effect of the liquidity lines is the increase in value of the banks that benefit from it. Andries, Fischer & Yesin (2017) find that Polish and Hungarian banks' equity returns rose by 25 bp 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 & Reis (2022a) 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 & Molina (2021) find an effect on the other side of the swap line as well: The equity valuations of eurozone 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 (*a*) improving the prospects of banks in its jurisdiction that may be exposed to the recipient country; (*b*) ensuring that recipient

banks can continue to lend and purchase securities in source currency, potentially averting costly fire sales or a credit crunch; and (*c*) increasing 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: (*a*) How should the policies be structured and coordinated? (*b*) Where should the perimeter of the liquidity line network lie and who should determine it? (*c*) 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 that we now discuss 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 these questions around a few common themes.

3.1. The Liquidity Lines as a Contracting Problem

Ever since Henry Thornton and Walter Bagehot's writings, 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 three agents are 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 problems. 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 scenario 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 & Reis 2022b).

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 occurring.

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 the different ex ante inefficiencies in the source and recipient countries created by the liquidity line. Any lending facility implicitly subsidizes 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 how moral hazard affects 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 & Werning 2016, Korinek & 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 & Smets 2016).

Empirical evidence on the moral hazard created by liquidity lines is mixed. 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 in both recipient-country markets and the United States—and especially in long-dated options. The authors suggest that a liquidity line providing credit for 3 months will have an effect on tail risk 10 years from now, because it reveals a commitment to a Fed backstop in the future causing moral hazard.

The general contracting problem is related to the one in models with multiple layers of lenders with differing incentives (Holmstrom & Tirole 1997, Diamond & 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 confirm this, as recipient central banks often impose additional haircuts on collateral compared with a standard lending facility, reflecting 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 0% for the SNB (Bahaj & Reis 2022b). 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. Some evidence suggests 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 & Schwartz (1971) discuss how coordination failures across districts prevented the Fed from acting as an effective lender of last resort during the Great Depression, and Richardson & 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 lead to broader questions regarding the perimeter of the liquidity line network. We turn to this topic 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 International Monetary Fund (IMF) or the Bank for International Settlements (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 & Schenk 2020). In the modern standard network around the Fed, coordination does occur 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 internalize 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 consideration is counterparty risk, broadly defined. If the recipient central bank fails to repay the loan from a swap line, the source central bank 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 purpose than was intended. 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 of 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 Federal Open Market Committee (FOMC) 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 policy making. 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 United States, for example, the Dodd-Frank Wall Street Reform and Consumer Protection Act modified Section 13(3) of the Federal Reserve Act, which permits lending to financial institutions in crises, to legislate that all programs established under the Section must be broad-based (not in support of a specific failing institution) and must receive prior approval from the US Treasury. There is some debate about the legal underpinnings in the United States 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 & 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 & 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-19 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 on March 19, 2020, of these new lines had a substantial impact on market prices (Aizenman, Ito & 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 toward an exorbitant privilege. This brings us to our discussion of 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 toward 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 & Reis (2020b) 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.

Relatedly, 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, however, this effectiveness and the mechanisms through which it works are less clear. A rich literature demonstrates why some currencies are used internationally. One mechanism is 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 & Rigobon 2010). Therefore, firms want to use a currency that is also used by suppliers and competitors. Since many suppliers and competitors are located 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 & Reis (2020b) add a further complementarity: If imported inputs are purchased using trade credit in some currency subject to funding risk, 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,

thus raising 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 & 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 boosts 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 & 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, this provides an incentive to price exports in it as well. Chahrour & 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 & 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 & Malamud (2022) note that firms differ in the maturity of their debt and they will want to borrow in a currency that depreciates during a global downturn over the horizon of this maturity. Salomao & 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 or less use of the currency abroad, 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 borrowers in foreign currency. Much research is required to clarify when each of these mechanisms will be stronger, to suggest other mechanisms, and to provide 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 evidence shows that investment choices are affected. It is not clear yet how wide and thick the network of liquidity lines will grow to be, especially once the incentives of the different central banks involved are considered. This uncertainty 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 & 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 & Engel 2021). Much work needs to be done to clarify these connections both in theory and empirically.

DISCLOSURE STATEMENT

R.R. is an academic consultant at the Bank of England, the Bundesbank, the Federal Reserve Bank of Richmond, and the Riksbank, and he frequently gives lectures at the ECB and the IMF. None of these affected the research presented in this review. S.B. has a part-time research advisor position at the Bank of England; this position did not alter the content of this review.

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