Does the Dollar Lender of Last Resort Expand Dollar Dominance? Currency Mismatch, Reserves, and Global Liquidity Backstop*

Ding Ding, Karen K. Lewis, Yao Zeng

December 25, 2024
First Draft: May 20, 2024

Click **here** for the latest version

Abstract

We study the feedback loop between dollar dominance, currency mismatch, and the U.S.'s role as a global dollar lender of last resort. Using new administrative data, we find that central bank swap lines act as substitutes for dollar reserves held by foreign central banks in helping fill global banks' dollar funding gaps, particularly when market-based synthetic dollar funding is scarce. U.S. dollar lending of last resort, however, incentivizes global banks to engage in greater currency mismatches while encouraging foreign central banks to hold relatively fewer dollar reserves, exacerbating dollar funding gaps during crises. We develop a model that incorporates swap lines into a framework of global banking and central banking, highlighting the intermediation chain in emergency dollar liquidity provision. Swap lines stabilize dollar funding markets during crises yet lead to ex-ante over-dependence on the dollar due to pecuniary externalities between global banks and foreign central banks. This dependence introduces unintended long-term risks, not only for foreign countries but also, perhaps surprisingly, for the U.S., as it alters Treasury holder composition and the heterogeneous exposure to fire sale risks. Finally, we examine how post-crisis regulations have inadvertently amplified the demand for a global dollar lender of last resort, creating a policy ratchet effect that entrenches systemic reliance on U.S. dollar liquidity backstop.

*Ding, Lewis, and Zeng are all with the Wharton School, University of Pennsylvania. Lewis is also with CEPR and NBER. We thank Luigi Bocola, Antonio Coppola, Chris Clayton, Wenxin Du, Darrell Duffie, Linda Goldberg, Itay Goldstein, Rohan Kekre, Arvind Krishnamurthy, Moritz Lenel, Matteo Maggiori, and seminar participants at Boston University, the Federal Reserve Bank of New York, Korea Advanced Institute of Science and Technology, Korea University, and Seoul National University for helpful comments. We thank various colleagues at the Bank for International Settlements, the European Central Bank, the Federal Reserve Bank of New York, the Bank of Korea, and the Bank of Japan for sharing data as well as many conversations which greatly help us understand the operations of swap lines. We thank Menzie Chinn, Hiro Ito, and Robert McCauley for sharing their updated data on dollar reserves. All errors are ours.

1 Introduction

A few currencies, particularly the U.S. dollar, play critical roles in global trade and finance. Banks and firms engaged in cross-border transactions favor currencies that offer convenience, liquidity, and stability, reinforcing the U.S. dollar's dominance in trade invoicing (e.g., Gopinath, Boz, Casas, Díez, Gourinchas, and Plagborg-Møller 2020, Gopinath and Stein 2021) and the denomination of financial assets (Coppola, Krishnamurthy, and Xu 2024). However, such dependence also introduces systemic vulnerabilities, particularly through currency mismatches in global banking, which expose banks to heightened funding risks during periods of market stress (e.g., Ivashina, Scharfstein, and Stein 2015).[1] Systemic dollar funding risks underscore the need for a global dollar safety net, facilitated by the U.S. Federal Reserve's dollar swap lines with foreign central banks: a form of dollar lending of last resort. The economic magnitude of dollar swap lines is large,[2] and they have proven to stabilize international capital markets by providing essential dollar funding to global banks in times of crisis (Bahaj and Reis 2022a).

Despite the success of dollar swap lines and increasing understanding of their short-term effects, the long-term implications and economics of the global dollar liquidity backstop remain largely unexplored. How do dollar swap lines interact with traditional dollar funding sources, such as private FX swaps and foreign central bank reserves? Are they substitutes or complements? What are the long-term effects of dollar lending of last resort on the capital structure, debt denomination, and risk-taking of non-US global banks? What about the influence on dollar reserve holdings by foreign central banks? Ultimately, does the U.S.'s role as a global dollar lender of last resort expand

[1] Currency mismatches in global banking occur when non-U.S. banks finance long-term, illiquid dollar-denominated assets with short-term dollar liabilities, often relying on wholesale money market instruments such as repos, certificates of deposit (CDs), and commercial papers (CPs). These banks lack sufficient access to retail dollar deposits and depend heavily on wholesale funding, frequently supplied by U.S. money market funds (MMFs). This structural reliance creates an imbalance, leaving banks vulnerable to dollar liquidity stress during market disruptions. Such vulnerabilities were starkly exposed during the 2008 financial crisis and again in early 2020 during the COVID-19 pandemic when severe dollar funding shortages emerged.

[2] For instance, in May 2020, the outstanding amount of U.S. dollar swap lines reached $449 billion, equivalent to 126% of the total Treasury bills held by foreign officials. Data source: FRED, U.S. Department of the Treasury.

dollar dominance and help the global financial system in the long run?

In this paper, we examine the role of the U.S. as a global dollar lender of last resort and its long-term implications. Leveraging new administrative data, we find that central bank swap lines act as substitutes for dollar reserves held by foreign central banks, especially when market-based synthetic dollar funding becomes constrained. In the long run, however, U.S. dollar lending of last resort incentivizes global banks to take on greater currency mismatches while prompting foreign central banks to hold relatively fewer dollar reserves. This dynamic exacerbates dollar funding vulnerabilities during crises. We develop a model that integrates swap lines into a framework of global banking and central banking, emphasizing the intermediation chain in emergency dollar liquidity provision. We show that swap lines lead to ex-ante over-reliance on the dollar, driven by pecuniary externalities between global banks and foreign central banks. These externalities reshape the composition of U.S. Treasury holders and changes their heterogeneous exposure to fire-sale risks, which, surprisingly, could lead to a less stable U.S. Treasury market. Finally, we explore how post-crisis bank regulations, which have led to the retreat of banks in market-making and liquidity provision, have inadvertently amplified the need for a global dollar lender of last resort, creating a policy ratchet effect.

Stylized facts and empirics. We conduct our analysis in several steps. Using new administrative data, we first demonstrate that the Federal Reserve's dollar liquidity swap lines serve as a mechanism for intermediated dollar lending during periods of financial stress, effectively acting as a lender of last resort. Specifically, the Fed commits to providing dollar liquidity to foreign central banks at a predetermined interest rate. These foreign central banks then redistribute the dollars to private financial institutions within their jurisdictions, taking on the credit risk associated with these transactions. This arrangement enables foreign banks to address urgent dollar liquidity shortages, mitigating global dollar funding pressures while shielding the Fed from counterparty risk associated with private banks abroad. Our analysis shows that swap line usage is correlated with the borrowing cost differential between swap lines and the synthetic dollar funding market,

a relationship we directly map to the cross-currency basis as defined by Du, Tepper, and Verdelhan (2018). These findings highlight how global banks trade off public sources of dollar funding against private, market-based ones. During normal times, banks follow a pecking order that prioritizes private market-based funding sources, such as obtaining synthetic dollar funding through FX swaps. However, in periods of financial stress, when private dollar funding markets become prohibitively expensive, banks increasingly rely on the more affordable swap lines to meet their dollar funding needs.[3] This reliance on swap lines helps to stabilize funding markets by preventing further deterioration in private market conditions.

A key novelty of our paper is to study the long-term impacts of dollar swap lines on the behavior of foreign financial institutions, including both foreign banks and central banks. By providing an accessible and affordable dollar backstop as a substitute for synthetic private dollar funding during crises, swap lines incentivize foreign banks to increase dollar-denominated lending and investments, as the availability of swap lines lowers the perceived liquidity risk of holding dollar assets. Simultaneously, foreign central banks, relying on swap lines as the liquidity backstop, reduce their dollar reserves, including U.S. Treasuries, to minimize opportunity and carry costs. This dual response creates a reinforcing cycle: the more dependable the swap lines, the greater the dollar dependence among foreign banks, and the lower the precautionary reserves held by foreign central banks. Over time, this increased dollar exposure raises the vulnerability of foreign financial systems to U.S. monetary policy shocks and dollar liquidity risks, illustrating a trade-off between immediate crisis stability and long-term systemic risk. Moreover, this mechanism not only amplifies currency mismatches in foreign countries but also shifts the holder composition for U.S. Treasuries. As foreign central banks reduce precautionary Treasury holdings, a larger share of Treasuries is held by less insured entities that are more exposed to dollar liquidity and fire-sale risks. This reallocation may have unintended implications for the U.S. financial system, potentially

[3] Although private banks cannot directly access the Federal Reserve's swap lines, they can participate in auctions conducted by their domestic central banks, which allocate dollar liquidity drawn down from the dollar swap lines to local banks.

affecting yield dynamics, market liquidity, and the overall stability of the Treasury market.

Model. To reconcile our empirical findings, we develop a model inspired by Lorenzoni (2008) and Bocola and Lorenzoni (2020), incorporating dollar swap lines within a framework of banking and international risk-sharing. In this framework, swap lines are conceptualized as the U.S.'s commitment to serve as a global intermediated dollar lender of last resort. The key innovation of the model lies in jointly endogenizing private global banks' currency mismatches and foreign central banks' reserve holdings in response to the Fed's optimal design of dollar lending of last resort.

The model reveals a surprising outcome: while dollar swap lines stabilize private dollar funding markets in the short term, they can lead to unintended long-term consequences for both the U.S. and foreign economies. These effects stem from the interplay between two pecuniary externalities—one influencing foreign banks' currency mismatch decisions and the other shaping foreign central banks' reserve holdings—compounded by a time inconsistency problem faced by the Fed. A novel prediction of the model is that U.S. assets, such as Treasuries, may become disproportionately concentrated in the portfolios of foreign private banks, while being under-held by foreign central banks. This shift in holder composition increases the risk of fire sales during crises, introducing vulnerabilities to the global financial system, including the U.S. itself.

Implications. Our study highlights critical implications for U.S. policymakers and global financial regulators. For foreign economies, increased reliance on dollar-denominated debt and dollar liquidity backstops heightens currency mismatch risks, undermining resilience in future crises and amplifying spillover effects from U.S. monetary policy. This dependency reinforces dollar dominance, reducing incentives to diversify reserve assets and limiting monetary autonomy, while also reshaping global demand and supply for dolor-denominated assets. For the U.S., foreign reliance on swap lines could alter the composition of Treasury holders, complicating domestic monetary policy and potentially increasing systemic risks during crises. While swap lines are effective crisis management tools to stabilize dollar funding markets, their design must address these systemic

risks in the long-run, balancing immediate stabilization needs with the broader implications for global financial resilience.

Finally, our analysis of private FX swaps, central bank dollar reserves, and dollar swap lines as substitutes provides fresh insights into the optimal design of government interventions over time. Post-crisis regulations and interventions in the U.S. banking sector have significantly reduced the willingness of U.S. banks to provide liquidity in FX swap markets and key dollar fixed-income markets, such as Treasury and corporate bond markets. This retreat has resulted in a shallower FX swap and U.S. fixed-income markets, diminishing the effectiveness of synthetic dollars and foreign central banks' dollar reserves in addressing global dollar funding shortages. Consequently, the growing reliance on a global dollar lender of last resort illustrates a "policy ratchet effect," where temporary crisis measures evolve into permanent dependencies. This underscores the importance of carefully designing intervention policies to balance immediate crisis needs with their long-term systemic implications.

1.1 Related Literature

This paper contributes to the growing literature on the role of the U.S. dollar as the dominant global currency and its implications (see Gopinath and Itskhoki (2022) for a recent review). In particular, we focus on currency mismatch in global banking driven by dollar dominance (e.g., Correa, Du, and Liao 2020), given the dollar's convenience as a global medium of exchange in trade invoicing and financial transactions (e.g., Gopinath, Boz, Casas, Díez, Gourinchas, and Plagborg-Møller 2020, Gopinath and Stein 2021, Coppola, Krishnamurthy, and Xu 2024), as well as its status as a safe store of value (e.g., Maggiori 2017, He, Krishnamurthy, and Milbradt 2019, Jiang, Krishnamurthy, and Lustig 2021, Brunnermeier, Merkel, and Sannikov 2022, Jiang, Krishnamurthy, and Lustig 2024, Kekre and Lenel 2024). This currency mismatch often manifests as foreign global banks holding U.S. assets, such as Treasuries (Fang, Hardy, and Lewis 2022), without matched dollar retail deposit funding, leading them to rely heavily on U.S. money market funds (MMFs)

for wholesale funding (Ivashina, Scharfstein, and Stein 2015, Aldasoro, Ehlers, McGuire, and von Peter 2020, Anderson, Du, and Schlusche 2021, Aldasoro, Ehlers, and Eren 2022). When funding shocks occur, dollar shortages among these global banks may disrupt key U.S. asset markets, as evidenced by the unprecedented price dislocations in U.S. Treasury markets during March 2020 (e.g., Vissing-Jorgensen 2021, He, Nagel, and Song 2022, Ma, Xiao, and Zeng 2022, Duffie 2023, Duffie, Fleming, Keane, Nelson, Shachar, and Van Tassel 2023) as well as reduced dollar lending and arbitraging activities overall (Ivashina, Scharfstein, and Stein 2015, Anderson, Du, and Schlusche 2021). We contribute to this extensive literature by formalizing this narrative of dollar dominance into a tractable framework that incorporates the roles of foreign dollar reserves and the U.S.'s dollar lending of last resort, which in turn affects the dollar and the U.S. financial system in the long run.[4] To our knowledge, we are the first to treat the stability of U.S. Treasury markets as a significant factor in the design of dollar lending of last resort, a notion supported by the above narrative but largely understudied in the literature.

Focusing on dollar dominance, our paper also contributes to the literature on foreign currency debt by offering a new, complementary explanation for the rise in dollar-denominated debt. In this context, our findings align with Coppola, Krishnamurthy, and Xu (2024), who argue that dollar-denominated debt is increasingly popular due to the liquidity convenience offered by the dollar. We show that the dollar's role as a global liquidity backstop further encourages dollar-denominated debt issuance. While much of the existing literature focuses on "liability dollarization" in emerging economies, where dollar debt is issued to facilitate domestic investment and savings (e.g., Burnside, Eichenbaum, and Rebelo 2001, Ize and Yeyati 2003, Bocola and Lorenzoni 2020), our paper highlights the growing dependence on dollar debt in the banking sectors of relatively developed economies, emphasizing the role of dollar convenience.

[4] A broader literature considers global capital flows and the role of financial intermediation in interest rate and exchange rate determination, which is related yet beyond the scope of this paper. Notable contributions in this literature include Caballero, Farhi, and Gourinchas (2008), Mendoza, Quadrini, and Rios-Rull (2009), Bruno and Shin (2015), Maggiori (2017), Farhi and Maggiori (2018), Itskhoki and Mukhin (2021), and Chernov, Haddad, and Itskhoki (2024).

Our paper also contributes to the understanding of various approaches for addressing financial stability risks arising from currency mismatch in global banking. Since the findings of Du, Tepper, and Verdelhan (2018), it has been well established that post-crisis regulations and monetary conditions have led to large and persistent CIP deviations, indicating that private FX swap markets, traditionally deep and efficient, have struggled to provide adequate synthetic dollar funding, especially during dollar shortages (see also Du and Schreger (2022) for a review). Our framework identifies conditions under which the provision of synthetic dollars is equivalent to CIP deviation arbitrage. In doing so, we provide a unified understanding of the frictions in private dollar funding markets that necessitate government dollar lending of last resort. This finding also sheds new light on Bahaj and Reis (2022a), showing that dollar swap lines effectively function as a cap on CIP deviations.

Our work jointly considers foreign reserve management and the U.S.'s global dollar lending of last resort as two policy arrangements that are typically analyzed separately in the literature, with a particular focus on their long-term impacts on currency mismatch and dollar dominance. In terms of foreign dollar reserve management (see Bianchi and Lorenzoni (2022) for a review), our paper is closely related to Bocola and Lorenzoni (2020), who examine central banks' dollar reserves and their role in dollar lending of last resort, focusing on currency mismatches driven by households' and non-financial firms' precautionary dollar savings in emerging markets.[5] Also closely related is Das, Gopinath, Kim, and Stein (2024) who highlight a notion of foreign central banks being dollar lenders of last resort. They highlight an externality among foreign central banks, where excessive dollar reserve holdings aimed at addressing domestic currency mismatches in turn contribute to the global scarcity of the dollar as a safe asset. In contrast to existing studies in this literature,

[5]See also the related and broader literature on foreign reserve management for precautionary motives, including Obstfeld, Shambaugh, and Taylor (2010), Bianchi, Hatchondo, and Martinez (2018), and Alquist, Kahn, and Stedman (2023), which emphasize the potential for "sudden stops" in emerging markets, that is, rapid reversals of external capital flows, and the role of foreign reserves in mitigating the impact of such episodes, as well as those focus on the role of foreign reserves in stabilizing exchange rate fluctuations, such as Fanelli and Straub (2021).

we focus on currency mismatches in global banking and developed economies stemming from the dollar's convenience as a medium of exchange and a store of value. Our analysis further examines the interaction between dollar reserves and dollar swap lines, exploring the resulting long-term impacts on the dollar's dominance and implications for the U.S. economy.

In the aspect of U.S. dollar lending of last resort, our paper contributes to a burgeoning literature that examines the design and implications of dollar swap lines (see Bahaj and Reis (2022b) for a survey). Obstfeld, Shambaugh, and Taylor (2009) provide an early study on how central bank swap lines have substituted reserves in battling the financial stability risks in the 2008 global financial crisis. Bahaj and Reis (2022a) provide the first detailed study on the importance of dollar swap lines, showing that they effectively cap CIP deviations, while Bahaj, Fuchs, and Reis (2024) extend this work to a broader network of currency swap lines involving multiple currencies beyond the dollar and also study the connection between reserves and swap lines. Focusing on the short-term impacts of swap lines, Goldberg and Ravazzolo (2022) find that swap lines reduce strains in global dollar funding markets and US Treasury markets during stress events, Ferrara, Mueller, Viswanath-Natraj, and Wang (2022) demonstrate that recipient banks engage more actively in market making for dollar assets, and Kekre and Lenel (2023) find that news of expanded dollar swap lines reduces liquidity premia, narrows CIP deviations, and leads to dollar depreciation. Theoretically, Bacchetta, Davis, and Van Wincoop (2023) develop a model to reconcile these short-term effects of dollar swap lines. Our contribution to this literature lies in examining the interaction between private FX swaps, foreign reserve holdings, and swap lines and particularly their long-term effects, conceptualizing the latter two as two complementary layers of last-resort lending. This focus also allows us to connect with a new line of research on the coordination of U.S. and non-U.S. monetary policies within the network of global banking and short-term funding markets (e.g., Cetorelli and Goldberg 2012, Clayton and Schaab 2022, Fontanier 2023, Choi, Kirpalani, and Perez 2024) as well as another burgeoning literature focusing on strategic payment and liquidity provision by international "hegemons" such as the U.S. (Clayton, Maggiori, and Schreger 2023,

2024).

Finally, our work extends the literature on central bank commitment to an international context. The modern literature on lending of last resort started from Diamond and Dybvig (1983), and has become extensive (e.g., Acharya, Drechsler, and Schnabl 2014, Drechsler, Drechsel, Marques-Ibanez, and Schnabl 2016, Bocola and Dovis 2019). A growing body of work connects central banks' quantitative easing (QE) policies with the lender of last resort role, examining the roles of a central bank in supporting or targeting conditions in key asset and funding markets (e.g., Haddad, Moreira, and Muir 2023, Caballero, Caravello, and Simsek 2024, Haddad, Moreira, and Muir 2024). These studies focus on single-country settings with a committed domestic central bank. From a theoretical perspective, our work shares the spirit of studies like Farhi and Tirole (2012), Bianchi (2016), Keister (2016), and Jeanne and Korinek (2020), which demonstrate that ex-post central bank bailouts can lead to ex-ante excessive risk-taking and that time inconsistency in central bank policy design exacerbates this issue. In the context of global dollar funding and international finance, our work broadens this message, suggesting that dollar lending of last resort can lead to ex-ante excessive currency mismatches and more interestingly inefficient alternation of Treasury holding composition, potentially generating significant and unintended consequences not only for the rest of the world but also for the U.S. itself.

2 Central Bank Liquidity Backstop: Institution Details and Data

In this section, we describe the institutional arrangements for central bank liquidity backstops and the data used in our analysis, with a focus on the intermediation chain of emergent dollar liquidity provision, which motivates our exploration of the U.S.'s role of dollar lender-of-last-resort role and its long-term implications. For more detailed discussions on institutional arrangements and evidence on the short-term effects of central bank liquidity lines, we refer readers to Bahaj and Reis (2022a), Goldberg and Ravazzolo (2022), and Kekre and Lenel (2023).

2.1 Dollar Swap Lines as Intermediated Dollar Lending of Last Resort

As discussed in Section 1, global financial systems rely heavily on access to foreign currencies, particularly the U.S. dollar, to support international trade, denominate debts in normal times, and stabilize markets during times of crisis. During financial stress, demand for dollar liquidity surges as disruptions in funding and currency markets amplify systemic risks. To address these pressures, central banks deploy liquidity backstops such as the Federal Reserve's Central Bank Swap Lines and the Foreign and International Monetary Authorities (FIMA) repo facility. These mechanisms aim to alleviate dollar funding shortages and maintain financial stability by providing emergency dollar liquidity.

To understand how central bank swap lines, such as the Fed's dollar swap lines, mitigate dollar funding shortages, it is useful to conceptualize these lines as part of an intermediation chain between the Fed, a foreign central bank, and foreign banks. This intermediation operates in two distinct stages, as we describe below.

In the first stage, the swap stage, central bank swap lines are structured as bilateral agreements between major central banks, allowing them to exchange currencies at prearranged terms and exchange rates— resembling some features of a traditional FX swap. The foreign central bank initiates the swap by exchanging a specified amount of its domestic currency for U.S. dollars at the prevailing exchange rate. The dollars are then deposited in the foreign central bank's account at the Fed, while the Fed holds the foreign currency in its account at the foreign central bank. On a predetermined future date, the transaction reverses at the original exchange rate, restoring the currencies to their respective holders. The foreign central bank pays interest on the swapped dollars (which is passed on to private banks in its jurisdiction, as outlined below), with typical swap terms ranging from overnight to three months.

In the second stage, the lending stage, the foreign central bank uses the obtained dollars to provide emergency liquidity to banks and other eligible financial institutions within its jurisdiction,

fulling its role as a lender of last resort. This stage is done by transferring funds from its Federal Reserve account to local banks' clearing accounts. In this process, the foreign central bank assumes full credit risk for the loans it extends and may apply a haircut based on the collateral, typically local-currency-denominated assets, pledged by local banks. While this stage resembles a conventional lender-of-last-resort function, it is different in that the foreign central bank is engaging in dollar-denominated lending made possible by the dollars it secured through the swap line with the Fed.

To illustrate this two-stage intermediated process, consider the benchmark case of domestic banking in the United States and a case of foreign banking relying on dollar funding. A U.S. bank in New York seeking dollar liquidity would directly access the Federal Reserve's discount window, borrowing dollars without intermediaries. However, foreign banks, which lack direct accounts with the Fed, must rely on an intermediated arrangement such as central bank swap lines. Under these arrangements, the Fed swaps U.S. dollars with a foreign central bank, such as the European Central Bank (ECB). The ECB then fulfills its lender-of-last-resort role, extending these dollars to banks operating within its jurisdiction. Importantly, the involvement of the ECB shifts the credit risk from the Fed to the ECB, as the swap contract ensures the Fed remains insulated from direct exposure to loan defaults. If a European bank fails to repay its dollar loan, the ECB—not the Fed—bears the financial loss.

This intermediated structure places the responsibility for monitoring and administering loans entirely on the foreign central bank. For example, in the case of the ECB, it must evaluate which European banks or financial institutions qualify for loans, assess the adequacy of their collateral, and allocate funds accordingly. By tailoring dollar liquidity provision to the specific needs of its banking system, the ECB effectively takes on the operational role of a domestic lender of last resort. Although the arrangement between the Fed and the ECB is legally a currency swap, it functions, in economic terms, as a mechanism for dollar lending and emergency liquidity provision, reinforcing the Fed's role as the global lender of last resort.

This two-staged, intermediated view of dollar swap lines as a mechanism for dollar lending of last resort aligns closely with how economic historians interpret the establishment of swap lines during the global financial crisis of 2008. Notably, Bordo, Humpage, and Schwartz (2012) document that swap lines were introduced in parallel with the Federal Reserve's Term Auction Facility (TAF) program, which was designed to provide short-term loans to domestic U.S. banks during the crisis. However, the Fed quickly observed that the majority of participants in the TAF program were U.S. subsidiaries of foreign banks. The establishment of dollar swap lines, therefore, aimed to extend the reach of the TAF to global banks by leveraging the informational advantage of foreign central banks in distributing and monitoring loans directly to these foreign institutions. At the same time, the arrangement isolated the Federal Reserve from directly assuming credit risk abroad, effectively mitigating its exposure while addressing global dollar funding shortages.

2.2 Data

We combine various sources to provide a comprehensive view of global dollar liquidity provision, the use of swap lines, and their interactions with private and public financial markets.

Swap Line Usage Data: Data on the usage of Federal Reserve dollar swap lines is sourced from multiple sources, including the New York Fed, the Federal Reserve Economic Data (FRED), and detailed records provided by Bahaj, Fuchs, and Reis (2024). This dataset captures the timing, magnitude, and maturity structure of dollar swaps, enabling an analysis of their use under both normal and crisis conditions.

Treasury and FX Swap Markets Data: Information on U.S. Treasury holdings and transactions is obtained from the U.S. Department of the Treasury. This data includes details on aggregate Treasury ownership, allowing us to analyze shifts in holdings by foreign central banks versus private institutions. The volume of FX swap transactions comes from the Commodity Futures Trading Commission (CFTC)'s weekly swaps report, which provides data into the depth and liquidity of private synthetic dollar funding markets. Interest rate data on FX swaps and overnight index swaps

(OIS) is drawn from Bloomberg, which allows for the construction of cross-currency basis deviations and the comparative costs of swap line usage.

Foreign Bank and Central Bank Data: Administrative balance sheet data for Japanese banks is sourced from the Bank of Japan and the Japanese Bankers Association, detailing dollar-denominated liabilities and assets, as well as overall exposure to currency mismatches. Complementing this, swap line auction data on dollar liquidity swap operations is provided by the Bank of Japan (for Japan), the Bank of Korea (for Korea), and the Swiss National Bank (for Switzerland). These records allow us to explore country-specific differences in swap line uptake and allocation among private financial institutions.

Reserve Holdings and Global Macroeconomic Data: Updated data on foreign reserve holdings are kindly shared from Menzie Chinn, Hiro Ito, and Robert McCauley. Their shared dataset extends the foreign reserves data published in Chinn, Ito, and McCauley (2022), providing detailed information on central bank holdings of U.S. dollar-denominated assets. Total reserve levels and macroeconomic indicators such as GDP are drawn from the IMF database, enabling the analysis of reserve adequacy relative to national economic size. Data on foreign currency-denominated liabilities is sourced from the BIS Locational Banking Statistics, which capture global banks' cross-border exposures in different currencies.

3 Stylized Facts and Preliminary Empirics

In this section, we extend the existing literature by presenting new stylized facts and preliminary empirical findings, focusing on the role of dollar swap lines as a mechanism for providing emergency dollar liquidity as a lender of last resort. As outlined in Section 2, we separately examine the two connected yet distinct stages of the intermediated process underlying the entire chain of dollar liquidity backstops. Our analysis highlights how these two stages, when functioning in tandem, jointly enable the Fed to fulfill its role as a global dollar lender of last resort.

Still, several puzzles remain before we can fully explore the long-term implications of these liquidity backstops. In the classic context of a lender of last resort, a domestic liquidity crunch naturally triggers immediate demand for such support. However, in an international context, it is less clear whether a dollar funding shortage in a foreign country would necessarily require U.S. intervention. After all, foreign banks might obtain dollars through private FX swap markets or rely on their own central bank's dollar reserves.

To that end, we also present new empirical results that emphasize how swap lines serve as an appealing alternative when private FX swap markets malfunction or when it is challenging for foreign central banks to liquidate their dollar reserves. Our findings introduce relatively novel insights to the literature and connect to existing studies that detail the fundamentals and implications of swap lines.

Interestingly, we show that the Fed's role in providing emergency dollar liquidity may paradoxically stem from its own post-crisis regulatory changes and interventions on the U.S. banking sector, which prompted U.S. banks to retreat from their roles as liquidity providers in FX swap and Treasury markets. Furthermore, we present evidence suggesting that the establishment of swap lines may have encouraged higher levels of dollar mismatch in foreign banking systems and substituted foreign central banks' dollar reserves. These patterns point to potential unintended consequences of swap line arrangements. Together, these new facts and observations motivate the focus of our model, which we develop and analyze in Section 4.

3.1 Dollar Swap Lines as Commitments between Central Banks

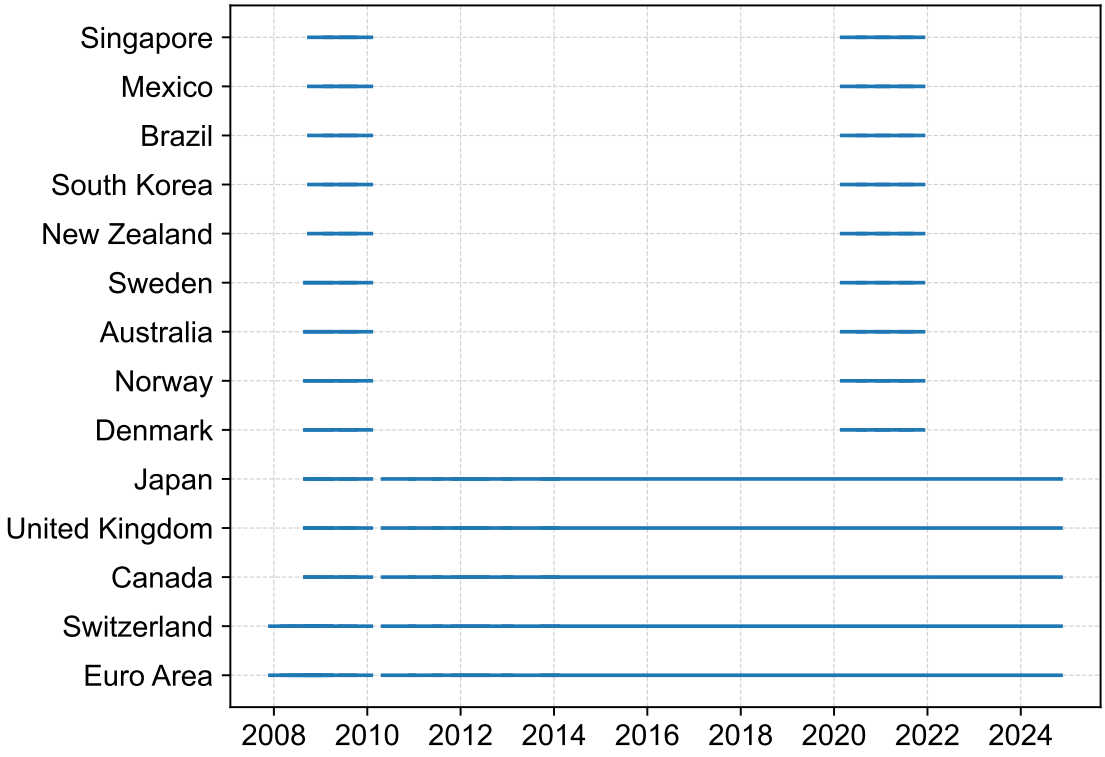
As discussed above, the fulfillment of dollar swap lines as a mechanism for dollar lending of last resort critically depends on the swap stage between the Fed and foreign central banks. It is essential to understand how the Fed establishes and commits to these swaps in the swap stage, given that the demand typically originates from foreign banks seeking dollars rather than U.S. banks requiring foreign currencies.

To this end, the Federal Open Market Committee (FOMC) introduced dollar liquidity swap lines in 2007, initially targeting the European Central Bank (ECB) and the Swiss National Bank (SNB) to alleviate dollar funding pressures. As the financial crisis escalated, the Federal Reserve extended these arrangements to include additional central banks from countries such as Australia, Brazil, Canada, Denmark, the United Kingdom, Japan, South Korea, Mexico, New Zealand, Norway, Singapore, and Sweden in 2008. These temporary lines were phased out in February 2010 but were subsequently reestablished in May 2010 in response to renewed financial stress. By October 2013, the Federal Reserve and its central bank counterparts transitioned the swap lines with the Bank of Canada (BoC), Bank of England (BoE), European Central Bank (ECB), Bank of Japan (BoJ), and Swiss National Bank (SNB) into standing arrangements without predefined limits, underscoring the systemic importance of these facilities. Figure 1 illustrates the timeline of these swap line arrangements.

We highlight two key insights from Figure 1, which illustrates the Fed's dollar swap lines as a commitment to foreign central banks. First, for the five countries or monetary unions with standing swap line facilities, their central banks benefit from unlimited swap capacity with the Fed. This arrangement enables these central banks to meet any demand for dollars within their banking systems, provided that the Fed assumes no credit risk in swapping U.S. dollars for their local currencies. Since the FOMC's decision to make these arrangements permanent in 2013, the Fed has consistently and successfully upheld these unlimited commitments, effectively empowering these five central banks to function as dollar lenders of last resort within their respective jurisdictions.

Second, for countries or monetary authorities without standing swap line facilities, it is noteworthy that even after the suspension of their temporary arrangements following the global financial crisis, these facilities were swiftly reinstated with no negotiation during the COVID-19 crisis. This rapid reinstallation of swap lines in response to a systemic dollar funding shortage underscores the Fed's broader commitment to maintaining a stable global dollar funding market, especially during periods of heightened financial stress when emergency dollar liquidity is most critical. This ob-

Figure 1: Swap Lines Arrangement Periods by Counterparts Country



Note: This figure illustrates the durations of swap line arrangements between the U.S. Federal Reserve and various counterparty countries, represented by horizontal blue lines for each country. Each line spans the period of an active swap line. The sample period covers Dec 2007 to Oct 2024. Data is sourced from Bahaj, Fuchs, and Reis (2024) and then re-arranged by authors.

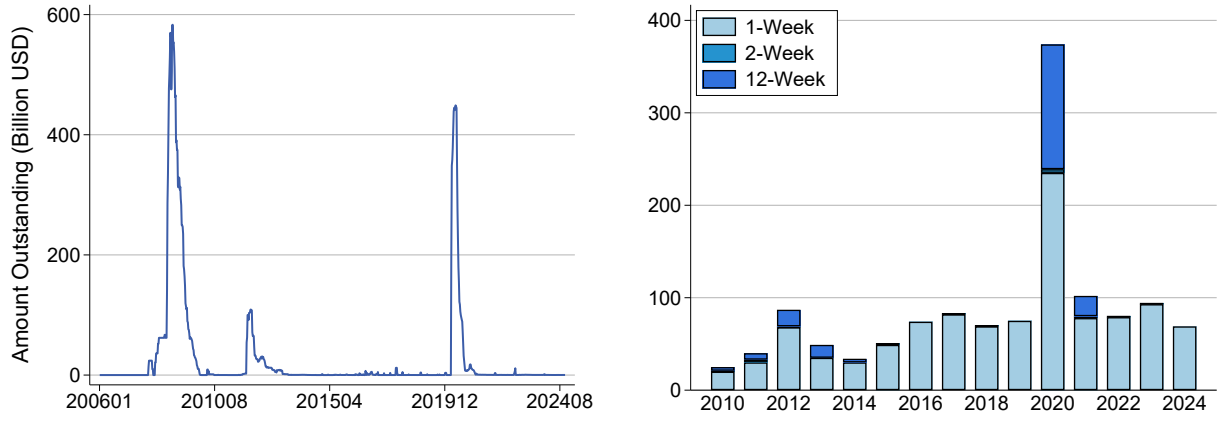
servation blurs the difference between standing and temporary swap lines and highlights the Fed's broad commitment to foreign central banks in arranging dollar swap lines.

3.2 Dollar Swap Lines as Short-Term Dollar Lending of Last Resort

Having understood the Fed's commitments to foreign central banks in the swap stage, we turn to highlight several less-studied aspects of the actual usage of swap lines, with a particular focus on the second stage, that is, the lending stage to foreign banks.

First, Panel (a) of Figure 2 illustrates the usage of USD liquidity swap lines, showing the out-

Figure 2: USD Liquidity Swap Amount and Terms Over Time



(a) USD Liquidity Swap Amount Outstanding

(b) Number of USD Liquidity Swaps by Term

Note: Panel (a) shows weekly Wednesday-level data for Central Bank USD Liquidity Swaps, recorded as assets on the Fed's balance sheet, measured in billions of USD, from Jan 2006 to Oct 2024. Panel (b) illustrates the number of USD liquidity swaps by term, categorized into 1-week, 2-week, and 12-week swaps from May 18, 2010, to Oct 30, 2024. Data of panel (a) is from FRED, Fed of St. Louis; Data of panel (b) is from NY Fed, calculated by authors.

standing amounts from January 2006 to October 2024, with notable peaks during the 2008 Financial Crisis and the 2020 COVID-19 pandemic. The "outstanding" amount represents the total value of USD provided under the swap agreements that have not yet been repaid. We focus on the outstanding amounts of the long leg of dollar swap lines at any given point in time. Economically, this approach treats the dollars swapped out as a dollar-denominated asset on the Fed's balance sheet, which is consistent with how the Fed records swap lines in the H.4 form. This perspective is particularly informative because the outstanding amounts of these swapped dollars effectively correspond to the total amounts of short-term dollar liabilities on foreign banks' balance sheets at the same time, again, provided that the Fed assumes no credit risk in this process.

As shown in the figure, the peak outstanding amount of dollar swaps was $583 billion on December 10, 2008, equivalent to approximately 10% of the notional amount outstanding in the short-term FX swap market.[6] During the COVID-19 pandemic, the outstanding amount of dollar

[6]The notional amount outstanding of 1-30 day term FX swaps and forwards, as reported in the weekly swaps

swaps peaked at $449 billion on May 27, 2020, which again represented around 10% of the total notional outstanding in the short-term FX swap market. These magnitudes, combined with their comparison to private FX swap market benchmarks, demonstrate that the Fed's role as a dollar lender of last resort has been of significant economic importance.

More importantly, Panel (b) of Figure 2 categorizes USD liquidity swaps by term length from May 2010 to October 2024, highlighting the predominance of one-week swaps for addressing immediate dollar liquidity needs from foreign banks.

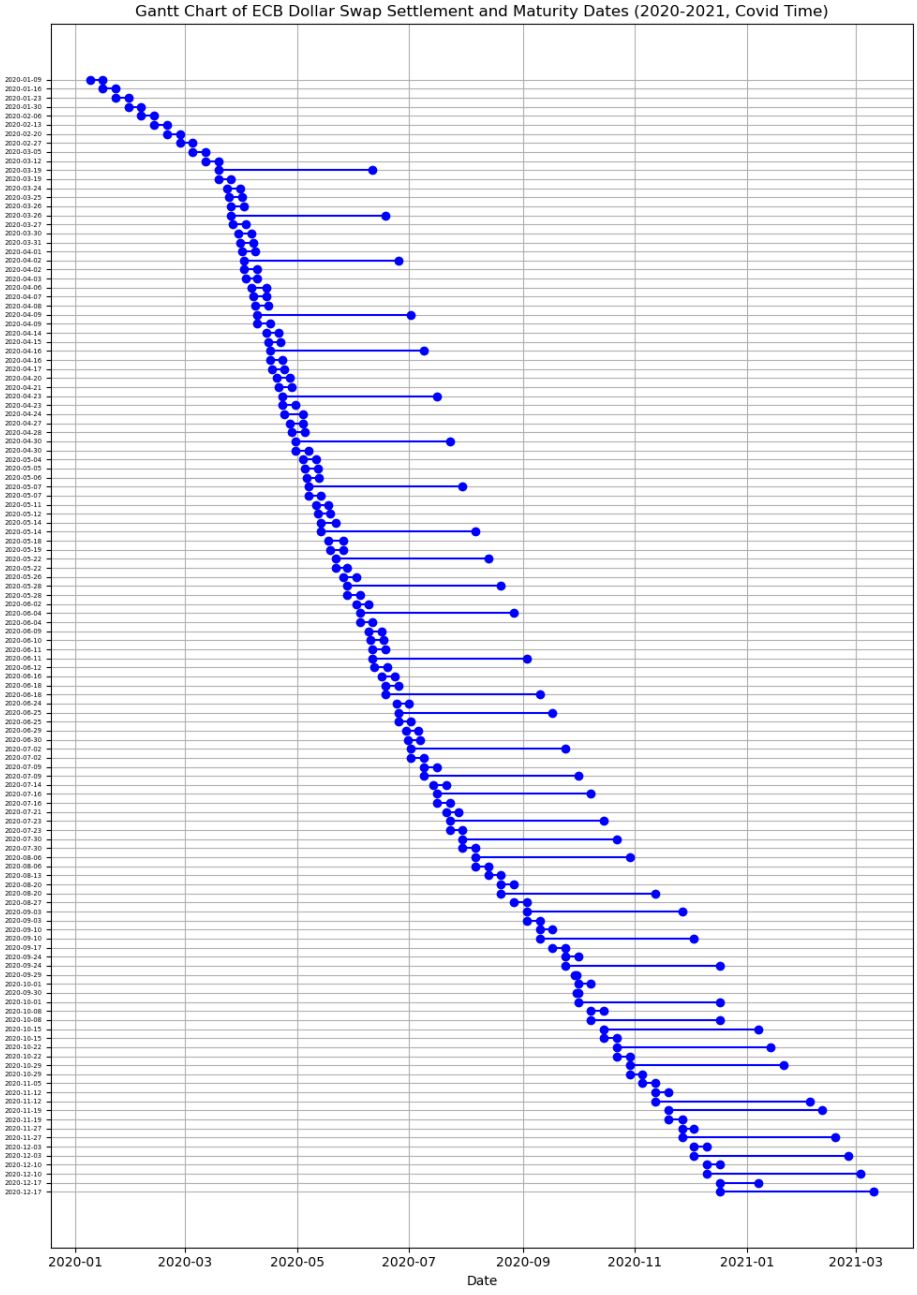
This observed predominance of one-week swaps reflects the prevailing demand for short-term emergency dollar funding, with the Fed accommodating these liquidity needs through committed swap arrangements with foreign central banks. Consistent with this observation, during the COVID-19 crisis, the demand for three-month dollar swaps increased, aligning with heightened and more uncertain dollar funding requirements. However, as global markets stabilized following the peak of the crisis, the demand for three-month dollar lending diminished, and the demand returned predominantly to one-week liquidity provisions. This trend underscores the role of dollar swap lines in addressing the evolving demand from foreign banks for emergency dollar liquidity.

To further support the view of dollar swap lines as effective short-term dollar lending of last resort, we plot a Gantt chart illustrating the settlement and maturity dates of ECB dollar swap transactions during the COVID-19 pandemic period (2020–2021) in Figure 3. There, the vertical axis lists the specific settlement dates of each of the swap contracts between the Fed and the ECB, while the horizontal axis tracks time. Each horizontal blue line represents a single swap transaction, with the starting point indicating the settlement date when dollars were disbursed, and the endpoint marking the maturity date when the swap was unwound.

Three key observations emerge from Figure 3. First, beginning in March 2020, swap line transactions between the Fed and the ECB became highly clustered and overlapping, with multiple lines

report by the CFTC. This 10% estimate is a conservative lower bound because the CFTC data includes all currency pairs in the 1-30 day term reported to its SDRs, while swap lines are USD-specific with mostly 7-day maturities, leading to a potentially overstated denominator.

Figure 3: Gantt Chart: Fed-ECB Dollar Swap Line Usage by Maturity (2020-2021)



Note: The chart displays the temporal distribution of outstanding dollar swap line drawings between the Federal Reserve and European Central Bank during the COVID-19 crisis period (2020-2021).

outstanding at any given point in time. Conversations with both the New York Fed and the ECB confirm that this clustering reflects numerous banks within the Euro area simultaneously approaching the ECB for emergency dollar lending of last resort. The Fed demonstrated its commitment to meeting this demand through swap lines, even as previously established swaps yet to mature, ensuring uninterrupted access to emergency dollar funding.

Second, there was a notable increase in the use of longer-maturity swaps, particularly three-month lines, beginning in March 2020 and continuing throughout the year. These longer-term arrangements were also heavily overlapped and clustered, highlighting the heightened and more uncertain demand for dollar liquidity among Euro area banks during this period of severe funding stress as well as the Fed's commitment in fulfilling them.

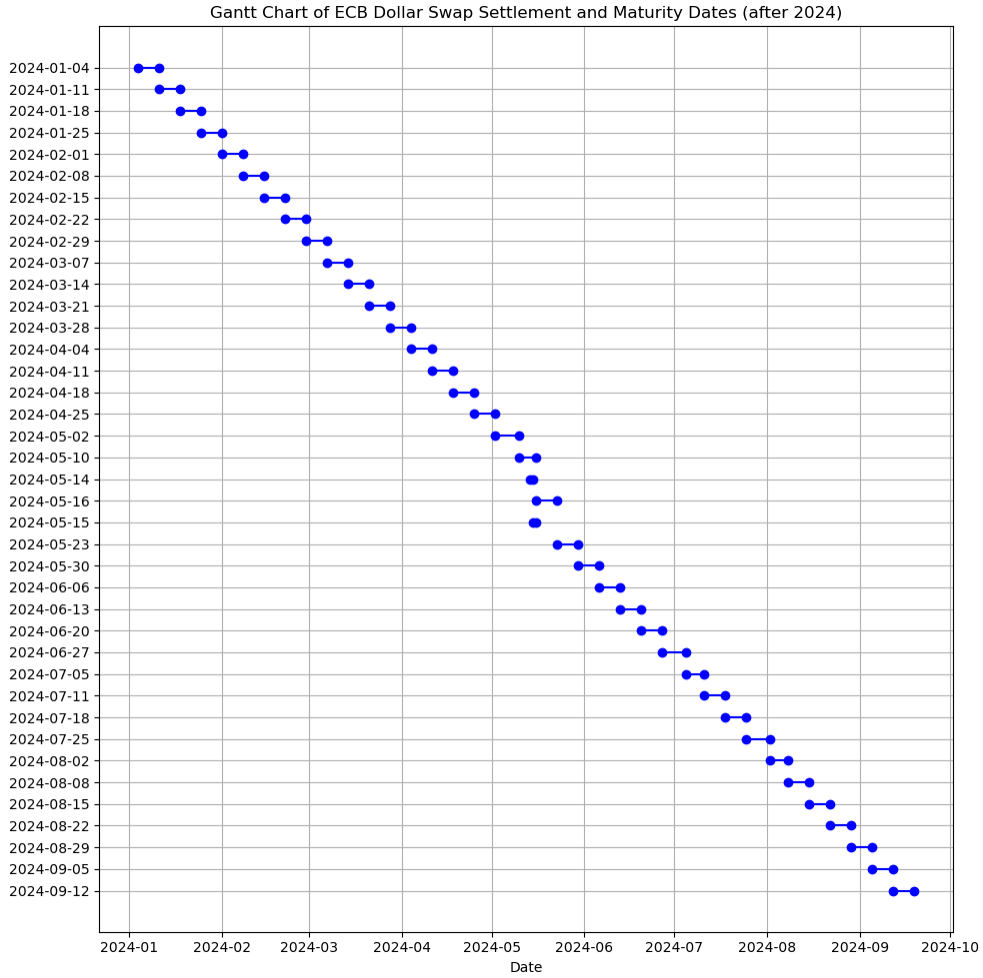
Third, despite the rise in demand for longer-term swaps, one-week swap lines remained the most frequently utilized, underscoring their role as a primary tool for emergency dollar liquidity provision. Much like a domestic discount window, these one-week swap lines were predominantly employed to address short-term liquidity needs, reinforcing the function of swap lines as a last-resort dollar lending backstop during crises.

As a comparison, Figure 4 presents another Gantt chart illustrating the settlement and maturity dates of Fed-ECB dollar swap transactions during a period of normal market conditions in 2024. This figure highlights the use of dollar swap lines by the ECB in the absence of significant financial stress.

Unlike the patterns observed in Figure 3, the transactions depicted in Figure 4 are far less clustered, indicating a more regular and predictable usage of swap lines. This reflects relatively idiosyncratic demand from individual banks rather than widespread systemic stress. The substantially lower volume of transactions suggests that the ECB's reliance on dollar swap lines diminishes significantly during stable market conditions, which ultimately reflects lower demand for emergency dollar funding from European banks.

It is also worth noting that the clustered lines in Figure 3 do not necessarily imply that a single

Figure 4: Gantt Chart: Fed-ECB Dollar Swap Line Usage by Maturity (2024)



Note: The chart displays the temporal distribution of outstanding dollar swap line drawings between the Federal Reserve and European Central Bank during 2024.

Euro area bank was continually renewing short-term dollar loans. Instead, the pattern likely reflects different banks approaching the ECB at various times for dollar liquidity, with the Fed fulfilling these demands as needed.

Overall, the contrast between Figures 3 and 4 underscores the critical role of swap lines as a lender-of-last-resort tool during systemic dollar funding shortages. In normal times, swap lines appear to function more as a precautionary mechanism for addressing idiosyncratic funding needs

rather than as a response to sector-wide liquidity crises. But in both normal and crisis times, the Fed's commitment in providing dollar swaps to the ECB supports the role of dollar swap lines serving as a form of dollar lending of last resort.

3.3 Dollar Lending of Last Resort and FX Swap Market Conditions

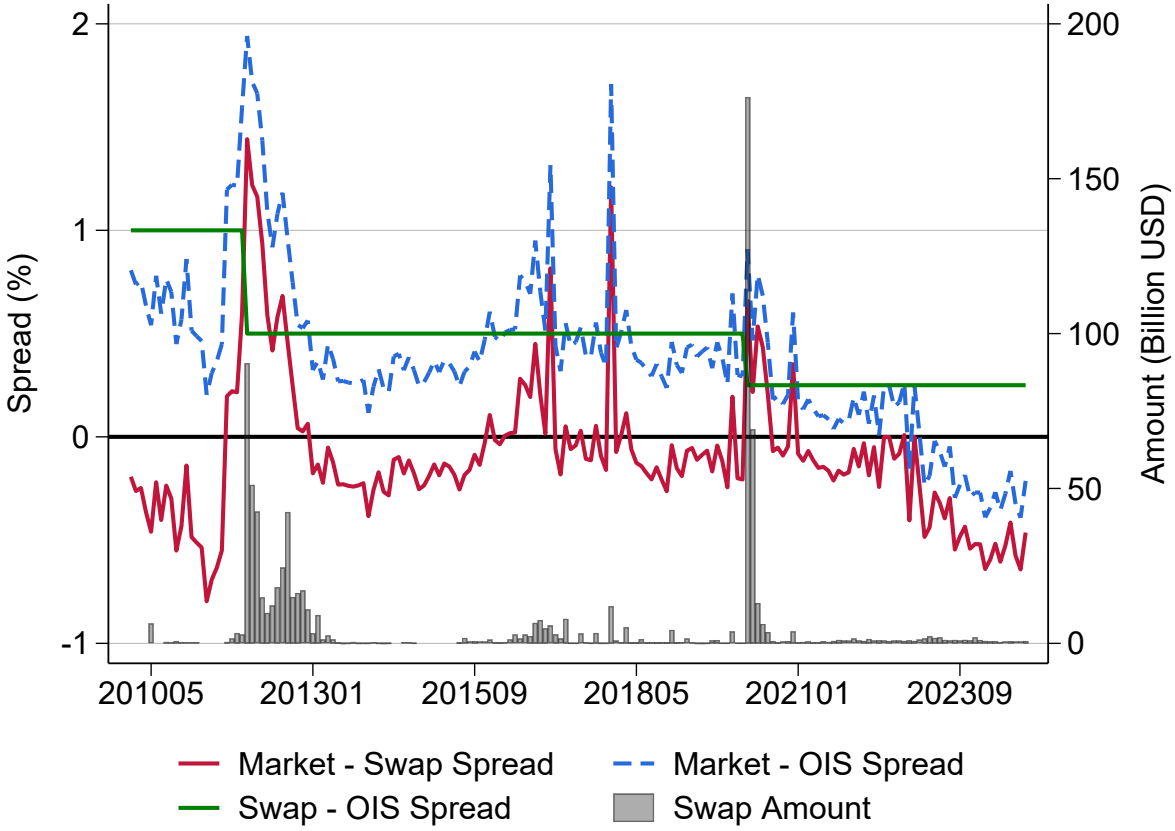
To further examine how the use of dollar swap lines responds to market conditions in FX swap markets and the extent to which dollar swap lines serve as a substitute, we plot the relationship between the spread of market rates, central bank swap line rates, and the overnight index swap (OIS) rate, alongside the volume of central bank USD swap provisions for the Euro Area in Figure 5. Similar plots for the UK, Japan, and Switzerland are provided in Appendix A.

Figure 5 presents several important observations, as we detail below.

Pricing of Swap Lines. We first illustrate how the Fed prices dollar swap lines in terms of the interest rate it charges other central banks using the green solid line, labeled as "Swap - OIS Spread." According to the Federal Reserve Board and Federal Reserve Bank of New York, dollar swap line rates are benchmarked to the market-based dollar OIS rate. Initially set at OIS + 100 basis points, the swap line interest rate was lowered to OIS + 50 basis points on November 30, 2011, during the euro-area crisis, and further reduced to OIS + 25 basis points on March 15, 2020, at the onset of the COVID-19 crisis. The "Swap - OIS Spread" can be understood as a markup over the Fed's marginal cost of providing dollar funding to foreign central banks without incurring interest rate or credit risk, represented by the OIS rate. Notably, the Fed adjusts this markup downward in negotiation with foreign central banks to better address dollar shortages and stabilize funding costs, while also reflecting broader market conditions through the OIS-based benchmark rate. This pattern supports the view of the Fed as a dollar lender of last resort, stepping in when dollar funding shortages are most severe. In that sense, the green line illustrates the Fed's role as a committed dollar lender of last resort for foreign central banks.

Private FX Swap Markets, Cross-Currency Basis, and Swap Lines. To better understand

Figure 5: USD Funding Spreads and Swap line Provision for the Euro Area



Note: This figure illustrates the spreads between market rates, central bank swap line rates, and the OIS rate, along with the amount of central bank USD swap provision. The red solid line, "Market - Swap Spread," represents the difference between the 1-week FX swap-implied USD yield for USD-EUR and the central bank USD swap line interest rate for the ECB. The blue dashed line, "Market - OIS Spread," shows the spread between the market rate and the 1-week Overnight Indexed Swap (OIS) rate. The green solid line, "Swap - OIS Spread," reflects the policy-set differential between the central bank swap line rate and the OIS rate. The gray bars indicate the amount of USD provided through central bank swap lines over time (in billions). The sample period spans May 2010 to Oct 2024. Market rate and OIS data are monthly averages and sourced from Bloomberg, while swap amounts and interest rate data are also monthly averages and sourced from the New York Fed.

how foreign banks and central banks respond to conditions in private synthetic dollar markets and the Fed's role as a lender of last resort, we plot the "Market - Swap Spread," shown as the solid red line. This spread represents the difference between the 1-week FX swap-implied USD yield

for the USD-EUR swap and the interest rate the Fed charges for swap line access.

Economically, the "Market - Swap Spread" in red solid line captures the interest rate differential that a recipient bank in the Euro area would encounter if opting for synthetic dollar funding through the private FX swap market rather than using the Fed's swap lines. During normal times, this spread is often negative, indicating a well-funded synthetic dollar market with lower costs for dollar funding via private market rates. However, the spread turns positive during crises, reflecting a premium on market-based dollar funding and signaling a dollar shortage. In such periods, access to the Fed's dollar lending as a last resort becomes the more affordable option, underscoring the Fed's role in providing a liquidity backstop during heightened demand for dollars.

It is important to note that the private market rate for dollar funding reflects the same economic frictions and limits to arbitrage that have contributed to CIP deviations and the cross-currency basis. Therefore, the red solid line also effectively captures CIP deviations, which, as we demonstrate later, helps us understand how the use of swap lines responds to these deviations.

To that end, we provide a conceptual decomposition of the "Market - Swap Spread" as we depict in red solid line. Recall that the "Market - Swap Spread" is given by

$$\text{Market - Swap Spread} = \underbrace{(1+OIS_{\$})\frac{F_{\$}}{\varepsilon_{\$}} - 1}_{\text{market dollar funding cost}} - \underbrace{(OIS_{\$} + r_{\text{swap}})}_{\text{swap line dollar funding cost}} , \tag{3.1}$$

where $OIS_{\$}$ is the OIS rate for the dollar in the U.S., $F_{\$}$ is the forward rate for EUR, which is the price in euros today for \$1 delivered and paid for in the future, $\varepsilon_{\$}$ is the spot exchange rate, defined as the euro price of \$1, and $r_{\text{swap}} \in \{25, 50, 100\}$ (in bps) represents the swap line markup charged by the Fed, as shown in the green solid line. Note that the "market dollar funding cost" in the Euro area is indeed captured by the FX swap-implied USD yield for EUR we used, reflects the aggregate cost in the private market.

If CIP holds at the aggregate level in the Euro area, then we have

$$(1+OIS_{\$})\frac{F_{\$}}{\varepsilon_{\$}} = 1 + OIS_{€}\,.$$

However, it is well known that CIP does not hold in the post-crisis period (Du, Tepper, and Verdelhan 2018), giving rise to a positive cross-currency basis between the euro and dollar, again, at the aggregate level for the Euro area:[7]

$$r_{\text{basis},€,\$} = (1 + OIS_\$)\frac{F_\$}{\varepsilon_\$} - (1 + OIS_€)\,. \tag{3.2}$$

Plugging (3.2) into (3.1) to replace $F_\$/\varepsilon_\$$ provides an alternative way to interpret the blue solid line:

$$\text{Market - Swap Spread} = \underbrace{(OIS_€ + r_{\text{basis},€,\$})}_{\text{market dollar funding cost}} - \underbrace{(OIS_\$ + r_{\text{swap}})}_{\text{swap line dollar funding cost}}\,. \tag{3.3}$$

In other words, condition (3.3) says that the red solid line also reflects the cost differential that a recipient bank in the Euro area would face if opting for synthetic dollar funding, subject to CIP deviations, instead of using the Fed's swap lines, which effectively bypass any CIP deviations in the private dollar funding markets.

Naturally, we expect a foreign bank to resort to dollar swap lines when the market-based synthetic dollar market is more expensive. That is, for foreign banks that have access to dollar swap lines, the effective "Market - Swap Spread" should always be non-positive. Condition (3.3) thus aligns with the idea put forth by Bahaj and Reis (2022a) that swap line usage effectively places a cap on the cross-currency basis:

$$r_{\text{basis},€,\$} \leq r_{\text{swap}} + OIS_\$ - OIS_€\,.$$

However, we note that this cap may not always hold empirically due to the various constraints on accessing dollar swap lines facing global banks, as we demonstrate below.

To further illustrate the counterfactual cost that a foreign bank would have paid over the private synthetic dollar market, we also plot the "Market - OIS Spread," shown as the blue dashed line in Figure 5, which represents a hypothetical borrowing spread that a foreign bank in the Euro area

[7] Alternatively, one could define internal CIP deviations for an individual bank, capturing the differences between the available forward rate and the implied forward rate from borrowing in one currency, converting at spot, and investing in a deposit in the other currency. Unfortunately, such granular bank-level data on these deviations are generally unavailable.

would pay in the synthetic dollar market relative to a dollar benchmark rate. During periods of stress, both the "Market - OIS Spread" and "Market - Swap Spread" increase sharply, indicating the premium investors are willing to pay for synthetic dollar liquidity in private FX swap markets. Notably, since 2023, the spread has turned negative due to the sharp rise in U.S. policy rates, reflecting a broader increase in short-term funding costs across all money markets during a rate hike cycle. The difference between the red solid and blue dashed lines corresponds to the green line, which illustrates how the Fed sets pricing for dollar swap lines.

Use of Swap Lines and FX Swap Market Conditions. We finally plot the volume of dollars provided through central bank swap lines to the ECB, shown as gray bars in Figure 5, and relate it to the funding spread in the synthetic dollar market, as represented by the blue and red lines. The relationship between the gray bars and the blue line reveals a clear substitution pattern: when the cost of obtaining synthetic dollar funding becomes more expensive than accessing dollar swap lines, the use of dollar swap lines increases. The spikes in the blue and red spreads, particularly during the euro crisis and around 2020 during the COVID-19 market disruptions, correspond with heavy reliance on dollar swap lines, underscoring their role as a lender of last resort for dollar funding.

However, the substitution between synthetic dollar and dollar swap lines is not perfect, as we preview earlier. Swap lines are not always used when the "Market - Swap Spread" is positive, nor is the spread always negative when swap lines are deployed. This suggests other potential benefits and costs of accessing swap lines, such as a possible stigma similar to that associated with traditional discount window access. This is consistent with the discussion above that condition (3.3) may not always hold empirically.

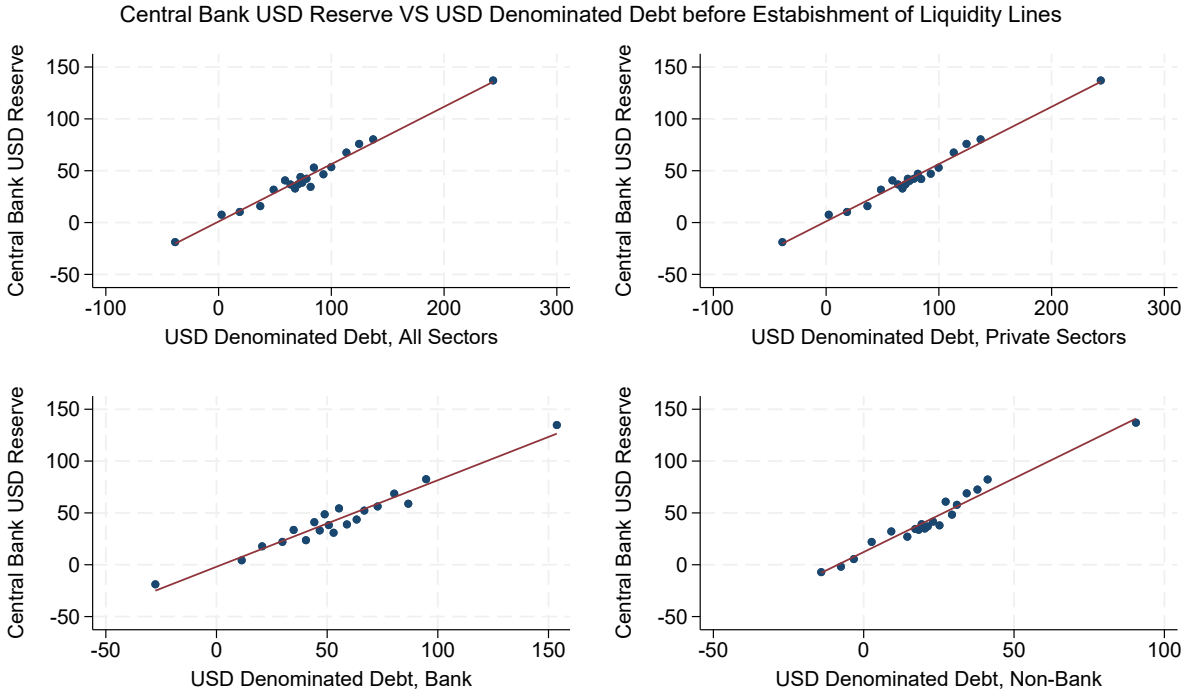
3.4 Long-Term Impacts of Dollar Lending of Last Resort

Finally, we present additional evidence supporting the substitution between dollar swap lines and foreign central banks' dollar reserves. This evidence also provides new insights into the potential

long-term effects of dollar lending of last resort on both the dollar mismatch of foreign banks and, in turn, the dollar asset reserves held by foreign central banks.

To that end, we build on the framework proposed by Das, Gopinath, Kim, and Stein (2024) to investigate how the historically observed positive relationship between central bank dollar reserves and dollar-denominated debt has evolved over time for different countries, particularly before and after the establishment of dollar swap lines.

Figure 6: Dollar Reserves v.s. Dollar Debt before Liquidity Lines



Note: This figure illustrates the relationship between central bank USD reserves and USD-denominated debt before the establishment of central bank liquidity lines. The reserves data is provided by Menzie Chinn, Hiro Ito, and Robert McCauley, extending their prior research in Chinn, Ito, and McCauley (2022). The data on USD-denominated debt is sourced from the BIS International Banking Statistics. The bin scatter plots are categorized by sector—All Sectors, Private Sectors, Banks, and Non-Banks. Each data point represents the average reserves and debt values across bins for each country.

First, the bin scatter plots in Figure 6 and regression results in Table 1 illustrate the relationship

between central bank USD reserves and USD-denominated debt before the establishment of central bank liquidity lines. The scatter plots, divided by sector—All Sectors, Private Sectors, Banks, and Non-Banks—clearly demonstrate a positive correlation across all categories. Specifically, as the level of USD-denominated debt increases, the amount of USD reserves held by central banks also rises, indicating a strong co-movement between these variables. This suggests that central banks preemptively held USD reserves proportional to the USD-denominated liabilities in their economies, highlighting their role in mitigating currency mismatch risks prior to the availability of liquidity backstops like dollar swap lines.

Table 1: USD Reserves v.s. USD Denominated Debt before Liquidity Lines

	(1) All	(2) Private	(3) Banks	(4) Nonbanks
USD-Denominated Debt	0.55^{***}	0.55^{***}	0.83^{***}	1.42^{***}
	(0.02)	(0.02)	(0.03)	(0.05)
Country FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Observations	149	149	149	149
Adjusted R^2	0.952	0.952	0.935	0.952

Note: This table presents the regression results for the relationship between USD reserves held by central banks and USD-denominated debt across different sectors prior to the establishment of liquidity lines. Columns (1) to (4) report results for All Sectors, Private Sector, Banks, and Nonbanks, respectively. The dependent variable is the amount of USD reserves held by central banks, while the key independent variable is the USD-denominated debt for each sector. The regressions include country and year fixed effects to account for unobservable heterogeneity across countries and time periods. Standard errors are clustered at the country level and reported in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

The regression table quantifies this relationship further by estimating the effect of USD-denominated debt on USD reserves using a fixed effects model. Column (1) shows that a 1-unit increase in total USD-denominated debt is associated with a 0.55-unit increase in central bank USD reserves, a result that is highly significant. This finding holds consistently across private sectors (Column 2), while the relationship is even stronger for banks (0.83, Column 3) and non-banks (1.42, Column 4). The adjusted R^2 values, which are consistently above 0.93 across specifications, indicate a high

explanatory power of the models.

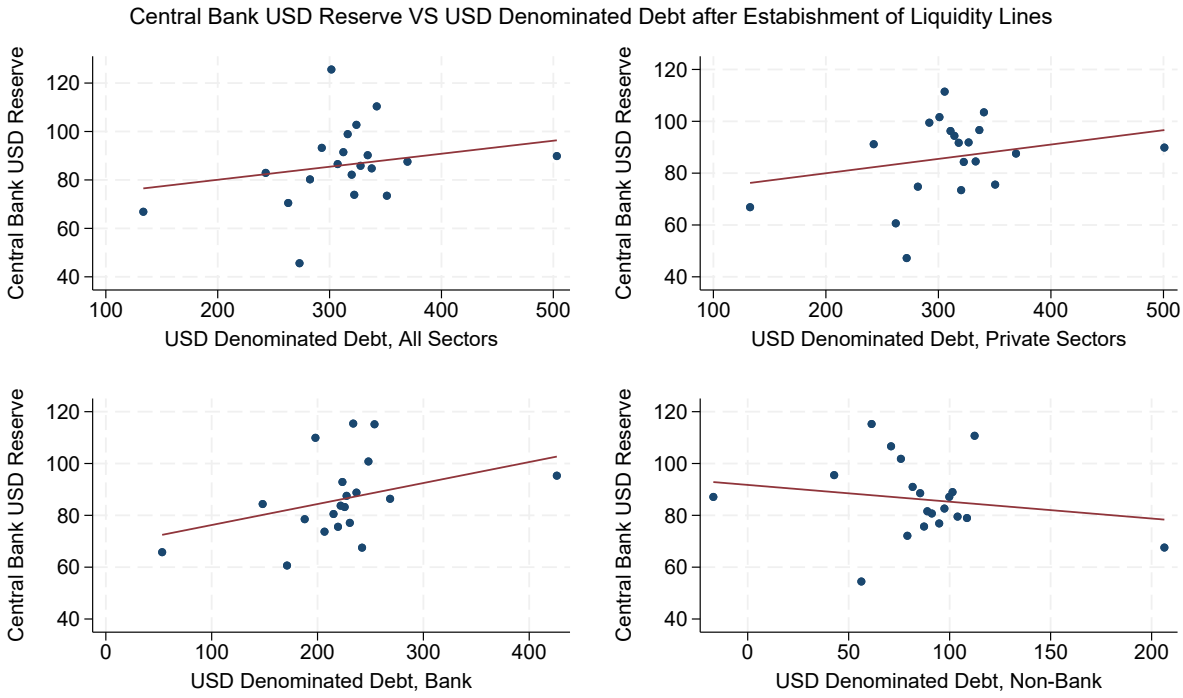
Consistent with the findings in Obstfeld, Shambaugh, and Taylor (2009) and Das, Gopinath, Kim, and Stein (2024), the scatter plots and regressions emphasize that central banks historically relied on dollar reserves to manage private dollar-denominated debt, particularly in banking sectors where currency mismatch risks are more concentrated. Without implying any causal effect for now, this finding underscores the importance of reserves as a buffer against dollar funding pressures before the implementation of liquidity swap lines, providing a baseline against which to evaluate the impact of these facilities in later periods.

We then examine, in Figure 7 and Table 2, the relationship between central bank dollar reserves and private dollar-denominated debt after the establishment of central bank liquidity lines. A notable shift is evident when compared to the pre-liquidity line period, as depicted in the earlier Figure 6 and Table 1.

The scatter plots in Figure 7, segmented by sector—All Sectors, Private Sectors, Banks, and Non-Banks—show a weaker or even negative correlation between central bank dollar reserves and dollar-denominated debt in some cases. For instance, the scatter plot for non-banks reveals a slight negative slope, suggesting that an increase in non-bank USD-denominated debt is not matched by a proportional rise in USD reserves. Across other sectors, while the slopes remain positive, the relationships are far less pronounced compared to the pre-liquidity line period. This reduced correlation reflects a potential shift in central bank reserve management, with less emphasis on holding dollar reserves as a direct response to dollar-denominated debt levels.

The regression table in Table 2 quantifies this change. Column (1) indicates that for all sectors combined, a 1-unit increase in USD-denominated debt corresponds to only a 0.05-unit increase in USD reserves, a stark contrast to the 0.55-unit increase observed before the establishment of liquidity lines. Similarly, Columns (2) and (3) show modest coefficients for private sectors and banks, respectively, while Column (4) for non-banks reports a slightly negative coefficient (-0.06), though it is statistically insignificant. The overall adjusted R^2 values, while still high, have dropped

Figure 7: Dollar Reserves v.s. Dollar Debt after Liquidity Lines



Note: This figure illustrates the relationship between central bank USD reserves and USD-denominated debt after the establishment of central bank liquidity lines. The reserves data is provided by Menzie Chinn, Hiro Ito, and Robert McCauley, extending their prior research in Chinn, Ito, and McCauley (2022). The data on USD-denominated debt is sourced from the BIS International Banking Statistics. The bin scatter plots are categorized by sector—All Sectors, Private Sectors, Banks, and Non-Banks. Each data point represents the average reserves and debt values across bins for each country.

compared to the pre-liquidity line period, suggesting that USD-denominated debt now explains less of the variation in central bank USD reserves.

Again without implying any causal effect for now, these findings jointly highlight the evolving role of dollar reserves post-liquidity line implementation. Central banks appear to rely less on holding reserves as a precaution against dollar funding risks, likely because the dollar swap lines provide an alternative and committed mechanism for accessing emergency dollar liquidity, as we discussed above. This reduced reliance underscores the potential substitution effect between swap

Table 2: USD Reserves v.s. USD Denominated Debt after Liquidity Lines

	(1) All	(2) Private	(3) Banks	(4) Nonbanks
USD-Denominated Debt	0.05	0.06	0.08	-0.06
	(0.04)	(0.04)	(0.06)	(0.10)
Country FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Observations	160	160	160	160
Adjusted R^2	0.866	0.867	0.868	0.866

Note: This table presents the regression results for the relationship between USD reserves held by central banks and USD-denominated debt across different sectors after the establishment of liquidity lines. Columns (1) to (4) report results for All Sectors, Private Sector, Banks, and Nonbanks, respectively. The dependent variable is the amount of USD reserves held by central banks, while the key independent variable is the USD-denominated debt for each sector. The regressions include country and year fixed effects to account for unobservable heterogeneity across countries and time periods. Standard errors are clustered at the country level and reported in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

lines and reserves, which may have long-term implications for central bank reserve management strategies and ultimately the severity of currency mismatches in the global economy.

4 Model

In this section, we develop a model that captures the key aspects of dollar lending as a last resort, as outlined in Section 3. The model is inspired by Lorenzoni (2008) and Bocola and Lorenzoni (2020) yet with significant deviations which highlights currency mismatches driven by dollar dominance and examines how private FX swaps, foreign dollar reserves, and U.S. dollar swap lines help mitigate the resulting financial stability risks. A key innovation of our model is to endogenize foreign banks' decisions regarding dollar debt issuance and foreign central banks' reserve holdings, providing predictions on the long-term implications of the U.S. role as a global dollar lender of last resort. For simplicity, we model a single foreign country, Japan, though the model is applicable to any foreign country or currency union, such as the Euro area as discussed in Section 3.

4.1 Setup

There are three dates, $t = 0, 1, 2$, and two countries, the U.S. and Japan. Each country has its own home-currency-denominated consumption good, which also serves as the numeraire in each respective country. Thus, we refer to the U.S. consumption good as the dollar and the Japanese consumption good as the yen. The spot real exchange rate $\varepsilon_{\$}$ and the real forward rate $f_{\$}$ are expressed in Japanese yen per \$1, so an increase in the exchange rate implies an appreciation of the dollar.

Each country has a continuum of competitive, risk-neutral banks and a central bank. Banks maximize their date-2 profits. The central banks we consider are the Fed and the Bank of Japan (BoJ), with objective functions specified below. To focus on frictions in the private FX swap market, we normalize the net interest rates in both countries to zero.

To emphasize currency mismatch, we assume a single asset class in the world economy: U.S. Treasuries. Following Lorenzoni (2008), we assume that banks invest dollars in Treasuries according to a production function $g(\cdot)$, which is increasing, strictly concave, twice differentiable, and satisfies the Inada conditions. This production function provides a parsimonious way to capture today's dealer-intermediated Treasury markets, which exhibit significant price impacts (e.g., He, Nagel, and Song 2022, Duffie 2023, Duffie, Fleming, Keane, Nelson, Shachar, and Van Tassel 2023). U.S. Treasuries entail no aggregate risks though; they mature at $t = 2$, when the unit value is normalized to one dollar.

4.1.1 U.S. Banks

At $t = 0$, the representative U.S. bank issues dollar deposits d_0, modeled as one-period debt, to U.S. depositors in order to invest in U.S. Treasuries. Thus,

$$q_0 = g(d_0)\,, \tag{4.1}$$

where q_0 represents the bank's position in U.S. Treasuries at the end of date 0.

At $t = 1$, the U.S. bank receives an additional exogenous amount of dollar endowment z_1, which is subject to an aggregate stochastic shock. It repays old deposits d_0, issues new deposits d_1, and potentially purchases $\Delta q = q_1 - q_0$ amount of US Treasuries.

Importantly, the U.S. bank faces a portfolio choice between investing domestically or abroad, which, as discussed in Section 3, closely resembles a CIP arbitrage problem. Specifically, instead of purchasing additional U.S. Treasuries, the U.S. bank can also serve as a dollar provider to the Japanese bank (detailed below) by supplying s_1 dollars in the FX swap market. At $t = 1$, the U.S. bank converts $\$s_1$ to $¥s_1\varepsilon_\$$ at the spot exchange rate $\varepsilon_\$$. Simultaneously, the U.S. bank and the counterparty Japanese bank enter a forward contract at the forward rate $f_\$$. Then, at $t = 2$, the U.S. bank returns $¥s_1\varepsilon_\$$ to the Japanese bank and receives $\$s_1\varepsilon_\$/f_\$$ in return. We denote the net return on this FX swap contract between $t = 1$ and $t = 2$ by μ, which will be endogenously determined in equilibrium and equivalent to the CIP deviation in this stylized economy. This implies, consistent with condition (3.3), that investing in FX swaps and providing dollars is indeed equivalent to arbitraging CIP deviations in our stylized economy.

In funding itself and providing dollar funding at $t = 1$, the U.S. bank faces two financial frictions. First, consistent with Du, Tepper, and Verdelhan (2018), there is a capital cost for the CIP arbitrage, or equivalent, dollar provision, motivated by post-crisis regulations imposed on U.S. global banks. When the U.S. bank provides s_1 and effectively takes the long leg of an arbitrage position on its balance sheet, it must incur an additional fraction ξ of the arbitrage position as capital cost. Second, similar to Lorenzoni (2008), Farhi and Tirole (2012), and Jeanne and Korinek (2020), there is a limited commitment constraint on d_1. Specifically, deposit renegotiation begins immediately after $t = 1$ because deposits are demandable. If the bank fails to repay its deposits, depositors can seize θ units of the U.S. Treasuries held by the bank and sell them at an endogenously determined price p. For simplicity, we assume depositors can seize the full amount of dollars involved in the FX swaps, s_1. Thus, the collateral constraint facing the U.S. bank is

given by

$$d_1 \leq \theta p + s_1 \,, \tag{4.2}$$

and the overall budget constraint of the U.S. bank at $t = 1$ is

$$g^{-1}(\Delta q) + (1 + \xi)s_1 + d_0 \leq z_1 + d_1 \,, \tag{4.3}$$

that is, the U.S. bank receives new dollar endowment, issues new deposits, and uses the funds to repay old deposits before making the portfolio investments between Treasuries and offshore dollar provisions.

At $t = 2$, the U.S. bank's profit is given by

$$\Pi_2 = q_1 + (1 + \mu - \xi)s_1 - d_1 \,, \tag{4.4}$$

where the U.S. bank receives the proceeds from its maturing U.S. Treasury holdings and arbitrage positions, minus capital costs, repays its deposits, and retains the remainder as profit.

4.1.2 Japanese Banks

We now turn to the representative Japanese bank in the economy. Following Ivashina, Scharfstein, and Stein (2015), Gopinath and Stein (2021), and Coppola, Krishnamurthy, and Xu (2024), we assume that the Japanese bank starts by investing in dollar assets and issuing dollar deposits to harvest dollar convenience. Specifically, at $t = 0$, the representative Japanese bank issues dollar deposits d_0^* and invests in U.S. Treasuries:

$$q_0^* = g(d_0^*) \,. \tag{4.5}$$

Our preferred interpretation of condition (4.5) is that, during normal times (represented by $t = 0$ in the model), foreign global banks have access to ample dollar funding from U.S. MMFs (e.g., Ivashina, Scharfstein, and Stein 2015, Aldasoro, Ehlers, McGuire, and von Peter 2020, Anderson, Du, and Schlusche 2021), and they are indeed a major buyer of U.S. Treasuries (Vissing-Jorgensen 2021, Fang, Hardy, and Lewis 2022) during normal times. However, unlike retail deposits which are typically sticky and insured, wholesale deposits from MMFs are flighty during volatile times,

which could potentially give rises to currency mismatch facing the Japanese banks, as we specify below.

At $t = 1$, the Japanese bank also receives an exogenous dollar endowment z_1^*. It repays its old dollar deposits (likely from MMFs) d_0^* and may issue new deposits. However, we assume that the Japanese bank can no longer issue dollar deposits at $t = 1$, potentially due to the retreat of U.S. MMFs as documented in Ivashina, Scharfstein, and Stein (2015), Aldasoro, Ehlers, McGuire, and von Peter (2020), and Anderson, Du, and Schlusche (2021). Instead, it can only issue new deposits d_1^* denominated in Japanese yen and must rely on synthetic dollar funding through the FX swap market to raise dollars from swapping it yen deposits. Additionally, it can liquidate its own Treasury holdings by $\Delta q^* = q_0^* - q_1^*$ to raise dollars. Thus, the budget constraint for the Japanese bank at $t = 1$ is given by:

$$d_0^* \leq z_1^* + \frac{d_1^*}{\varepsilon_\$} + p\Delta q^* \,, \tag{4.6}$$

and the Japanese bank faces a collateral constraint, evaluated in dollars:

$$\frac{d_1^*}{\varepsilon_\$} \leq \theta^* p \,, \tag{4.7}$$

where θ^* represents the amount of U.S. Treasuries that Japanese depositors can seize. The synthetic dollar must be obtained from the FX swap market, so

$$s_1^* = \frac{d_1^*}{\varepsilon_\$} \tag{4.8}$$

At $t = 2$, the Japanese bank's profit, denominated in dollars, is given by

$$\Pi_2^* = q_1^* - \left(\frac{d_1^*}{f_\$} - \frac{d_1^*}{\varepsilon_\$} \right) - \frac{d_1^*}{\varepsilon_\$} \,, \tag{4.9}$$

where, similarly to the U.S. representative bank, the Japanese bank receives the proceeds from its maturing U.S. Treasury holdings, incurs a net cost for accessing synthetic dollar funding between $t = 1$ and $t = 2$, and repays its deposits. Alternatively, this profit can be expressed as:

$$\Pi_2^* = q_1^* - \frac{d_1^*}{f_\$} \,,$$

provided that the spot exchange rate does not change between $t = 1$ and $t = 2$. This indicates

that the Japanese bank receives proceeds from its maturing U.S. Treasury holdings and effectively repays its yen deposits at the forward rate using dollar proceeds.

4.1.3 Market Clearing

To clear the markets, we impose the following two market-clearing conditions. First, the Treasury market clears at $t = 1$ such that the positions liquidated by Japanese banks must be absorbed by U.S. banks:

$$\Delta q^* = \Delta q \,, \tag{4.10}$$

which is consistent with empirical findings in, for example, Vissing-Jorgensen (2021), He, Nagel, and Song (2022), and Duffie, Fleming, Keane, Nelson, Shachar, and Van Tassel (2023) that U.S. financial institutions assorted Treasury selling pressures from foreigners during the Covid crisis.

Second, the synthetic dollar market clears at $t = 1$, meaning the synthetic dollars demanded by Japanese banks must be matched by those supplied by U.S. banks:

$$s_1^* = s_1 \,, \tag{4.11}$$

which is consistent with the idea that it is the U.S. banks, particularly the largest ones, who serve as dealers in the global synthetic dollar markets providing dollar liquidity (e.g., Du, Tepper, and Verdelhan 2018, Correa, Du, and Liao 2020).

Intuitively, these two market-clearing conditions will help determine the two endogenous prices at $t = 1$, p for Treasuries and μ for FX swaps, the latter of which also effectively captures the magnitude of CIP deviation and the economic cost of market-based dollar funding.

4.2 Central Banks and Policy Tools

Beyond the private FX swap market (i.e., synthetic dollar market), we now introduce and compare two alternative, government-supported approaches for the Japanese bank to address its currency mismatch dollar funding shortage at $t = 1$. First, the Bank of Japan, acting as a lender of last resort

for Japanese banks, can accumulate U.S. Treasuries to help its banks manage currency mismatches that arise from dollar funding shortages at $t = 1$. Alternatively, Japanese banks can obtain a dollar liquidity backstop directly from the Fed through dollar swap lines, which effectively serve as a global dollar lending facility of last resort.

4.2.1 Dollar Reserves

First, we build upon Farhi and Tirole (2012), Bocola and Lorenzoni (2020), and Das, Gopinath, Kim, and Stein (2024) to model the Bank of Japan's (BoJ's) role as a domestic lender of last resort. Specifically, the BoJ borrows d^R from Japanese depositors to invest in q^R U.S. Treasuries at $t = 0$ using the same investment technology $g(\cdot)$. It accumulates these Treasury investments and lends them to Japanese banks at $t = 1$ if needed, rebating any remaining proceeds from maturing Treasury holdings to Japanese banks at $t = 2$. The BoJ also repays its deposits at $t = 2$. Unlike private banks, the BoJ is not subject to any collateral constraint in raising funds.

With the BoJ's reserve holdings q^R, the date-1 budget constraint of the representative Japanese bank becomes:

$$d_0^* \leq z_1^* + \frac{d_1^*}{\varepsilon_\$} + p\Delta(q^* + q^R)\,. \tag{4.12}$$

To finance d^R, Japan must tax Japanese banks at $t = 0$, which are effectively owned by Japanese depositors, and then rebate these taxes at $t = 2$. This process incurs a deadweight cost $\tau(\cdot)$, which is increasing and strictly convex. Thus, the BoJ chooses d^R to maximize the date-2 profit of the representative bank minus the deadweight cost of taxation.

4.2.2 Dollar Swap Lines

Inspired by Bahaj and Reis (2022a) and Bahaj, Fuchs, and Reis (2024), we model the Fed's dollar swap lines, emphasizing its role as a global dollar lender of last resort. Specifically, at $t = 1$, the Fed borrows s^L from U.S. depositors and extends the same amount to the Japanese bank via the Bank of Japan through a dollar swap line, consistent with the two-staged intermediated lending

process as described in Section 2. Notably, the Fed does not incur the capital costs that the representative U.S. bank faces in providing dollar swap lines. At $t = 2$, the Fed receives repayment of $(1+\mu)s^L$, where μ is determined in equilibrium, and repays s^L to U.S. depositors, who effectively own U.S. banks. Any remaining net return from operating the swap lines, μs^L, is also rebated to U.S. banks at $t = 2$.

With the BoJ's reserve holdings q^R and the Fed's swap lines, the date-1 budget constraint of the representative Japanese bank becomes:

$$d_0^* \leq z_1^* + s^L + \frac{d_1^*}{\varepsilon_{\$}} + p\Delta(q^* + q^R)\,. \tag{4.13}$$

In operating the swap lines, the Fed aims to maximize U.S. banks' expected date-2 after-rebate profits, which effectively represents the welfare of U.S. depositors. This aligns with the Federal Reserve Act, which requires the Fed to return its profits to the U.S. Treasury after covering operational expenses.

We consider two designs for the Fed's dollar swap lines to capture different levels of commitment in its role as a global lender of last resort. First, as outlined in Section 3, the Fed commits to meeting the emergency dollar demand of foreign central banks arising from realized dollar funding gaps facing global banks in the respective foreign jurisdictions. This approach can be understood as the Fed determining the optimal amount of dollar provision, s^L, at $t = 1$ in a discretionary manner after all shocks are realized. This is consistent with what the literature refers to as "ex-post intervention" (e.g., Farhi and Tirole 2012, Bocola and Lorenzoni 2020).

Second, we examine an optimal design problem where the Fed commits at $t = 0$ to a predetermined rule for emergency dollar provision, $s^L(z_1, z_1^*)$, which aligns with the notion of "ex-ante intervention" in the literature. It is important to distinguish this type of commitment from the notion of committed swaps discussed in Sections 2 and 3, where the focus is on the Fed's commitment to swap dollars with a foreign central bank. Here, the commitment involves the Fed adhering to a pre-specified policy rule, consistent with the framework of commited rules-based

policymaking proposed by Kydland and Prescott (1977) and Barro and Gordon (1983).

4.3 Equilibrium Analysis

We solve the model using backward induction. First, we analyze the equilibrium at $t = 1$, taking as given the assets and liabilities determined at $t = 0$. Specifically, we take the level of dollar dominance and the resulting currency mismatch in the Japanese banking sector as given and study the consequences of a dollar funding shortage. We consider both a "laissez-faire" equilibrium—where neither the BoJ acts as a domestic lender of last resort through dollar reserve holdings nor the Fed intervenes as a global dollar lender of last resort via dollar swap lines.

In this setting, we show that a "dash-for-dollar" equilibrium emerges, where Japanese banks liquidate Treasuries to raise dollars. This behavior leads to Treasury fire sales and elevated CIP deviations, effectively signaling a scarcity of dollar funding. We then examine how the Fed's dollar swap lines mitigate these fragilities by boosting Treasury prices and reducing dollar funding costs.

Next, we analyze the long-term equilibrium outcomes under different designs of dollar lending of last resort, which is the key innovation of the model. Particularly, we examine how the BoJ's optimal dollar reserve holdings respond to the Fed's global dollar liquidity backstops. We emphasize two pecuniary externalities: one between Japanese banks and another between Japanese banks and the BoJ. The focus on foreign central banks' optimal responses and the interdependence between the two externalities are novel and have not been previously explored in the literature.

4.3.1 Dollar Dominance and Dash for Dollar

To begin, we analyze the equilibrium at $t = 1$, taking as given the assets and liabilities determined at $t = 0$. In particular, we assume the level of dollar dominance and the resulting currency mismatch in the Japanese banking sector, that is, d_0 and d_0^* are exogenously given. This setup allows us to focus on the immediate consequences of a dollar funding shortage, focusing on the dis-allocation of both the global asset and funding markets.

To this end, we consider a "laissez-faire" equilibrium as a baseline scenario, in which neither the Bank of Japan (BoJ) acts as a domestic lender of last resort by utilizing its dollar reserve holdings, nor the Fed intervenes as a global dollar lender of last resort through the provision of dollar swap lines. We have the following result:

Proposition 1. *For any given d_0, there exists a "dash-for-dollar" equilibrium at $t = 1$ in which $p < 1$ and $\mu > 0$ without foreign dollar reserves or dollar swap lines, if and only if the following holds:*

$$-\frac{g''(d_0)}{g'(d_0)^2}(\theta + \xi\theta^*) > 1\,. \tag{4.14}$$

Proposition 1 highlights that fire sales of U.S. Treasuries and widening CIP deviations arise jointly under the "laissez-faire" equilibrium. These effects are particularly pronounced when the U.S. Treasury market is shallower, the collateral constraints faced by Japanese banks are tighter, or the capital costs for U.S. banks to arbitrage CIP deviations are higher. Intuitively, under the "laissez-faire" equilibrium, Japanese banks must rely solely on private funding mechanisms—such as FX swaps or the liquidation of assets like U.S. Treasuries—to meet their dollar funding needs. In the presence of heightened market frictions, this reliance triggers fire sales of U.S. Treasuries by Japanese banks, leading to downward pressure on Treasury prices. Simultaneously, the inability of U.S. banks to effectively arbitrage CIP deviations due to high capital costs further exacerbates the divergence between synthetic and direct dollar funding costs, amplifying CIP deviations. These outcomes underscore the scarcity of dollar liquidity in the absence of central bank interventions and illustrate the fragility of the global financial system under such conditions. They provide a benchmark for analyzing the stabilizing role of central bank interventions, such as dollar reserve holdings by the BoJ or the Fed's dollar swap lines, which we explore below.

4.3.2 Dollar Lending of Last Resort: Short-Term Effects

Having analyzed the "laissez-faire" equilibrium at $t = 1$ and the associated dash-for-dollar episode, we assume that condition (4.14) underlying Proposition 1 holds and examine how a given amount of dollar swap line provision can alleviate the dollar funding shortage. We present the following result:

Proposition 2. *When condition* (4.14) *holds, a higher provision of dollar swap lines leads to a higher U.S. Treasury price* p *and a lower CIP deviation captured by* μ*:*

$$\frac{\partial p}{\partial s^L} > 0\,, \text{ and } \frac{\partial \mu}{\partial s^L} < 0\,. \tag{4.15}$$

Proposition 2 suggests that the larger the swap line provision by the Fed, the higher the price of U.S. Treasuries (p) and the lower the CIP deviation (μ) during a dash-for-dollar episode. In this way, the dollar funding shortage is alleviated, and financial market stability is enhanced. This finding echoes the insight in Bahaj and Reis (2022a) that central bank swap lines impose a cap on CIP deviations. Our contribution extends this insight by showing that the Fed's dollar lending of last resort simultaneously caps both the fire sale discount of U.S. Treasuries and the CIP deviations in a dash-for-dollar episode.

At the heart of Proposition 2 is the mechanism by which the Fed's dollar lending of last resort at $t = 1$ increases the pool of available dollars, effectively relaxing the collateral constraint faced by Japanese banks in financing their dollar funding gaps. This shows how swap line interventions can serve as a stabilizing force in the short-term, particularly during periods of systemic dollar funding shortages, mitigating financial market disruptions.

4.3.3 Dollar Lending of Last Resort: Long-Term Effects

We now consider the long-term equilibrium effects of U.S. dollar lending of last resort, a key innovation of our model. Following the literature (e.g., Lorenzoni 2008, Farhi and Tirole 2012,

Jeanne and Korinek 2020), we jointly examine Japanese banks' and the BoJ's optimal choices regarding dollar deposit-taking and dollar reserve holdings at $t = 0$. Importantly, these choices determine the composition of U.S. Treasury holders at $t = 0$, leading to novel predictions relative to the existing literature. In this analysis, we assume that Japanese banks and the BoJ correctly anticipate the Fed's provision of dollar swap lines at $t = 1$, corresponding to the "anticipated interventions" case in Bocola and Lorenzoni (2020).

Crucially, the long-term outcomes depend on whether the Fed designs swap lines in a discretionary or committed manner—that is, whether it optimizes s^L at $t = 1$ ex-post or commits to a rule $s^L(d_0, d_0^*)$ at $t = 0$. We analyze these two design problems separately.

Under a discretionary design, where the Fed optimizes s^L ex-post at $t = 1$, we have the following result:

Proposition 3. *When the Fed designs swap lines in a discretionary manner at $t = 1$, Japanese banks borrow more d_0^*, and the BoJ accumulates lower q^R at $t = 0$ compared to both the case without swap lines and the first-best. Consequently, q_0^* is higher compared to both the case without swap lines and the first-best.*

Proposition 3 reconciles the empirical findings in Section 3 and generates novel predictions about the long-term impacts of dollar lending of last resort.

First, the Fed's dollar swap lines incentivize excessive and inefficient dollar deposit-taking by Japanese banks ex-ante. This result aligns with the literature on the ex-ante risk-taking effects of ex-post intervention policies but highlights a specific context where the risk arises from currency mismatch and resulting dollar funding shortages. At the core of this inefficiency is a pecuniary externality: when an individual bank decides its level of dollar deposit-taking, it fails to internalize the negative externality imposed on other banks during a "dash-for-dollar" episode. These episodes depress U.S. Treasury prices and tighten collateral constraints, amplifying systemic risks. Even when optimally designed at $t = 1$, ex-post dollar lending exacerbates this externality, increasing

currency mismatches ex-ante.

Second, dollar lending of last resort leads to insufficient and inefficient dollar reserve holdings by the BoJ. This result introduces a novel notion of pecuniary externality in central banking, arising from a single, globally dominant market for U.S. Treasuries.[8] To see this, notice that The BoJ, in deciding its dollar reserve holdings, fails to account for the positive externality it provides to other countries' private banks during a dash-for-dollar episode by supporting U.S. Treasury prices. Despite occurring at the central banking level whether the collateral constraint is not present, this externality still violates the First Welfare Theorem when dollar funding gaps at $t = 1$ are sufficiently large, as private banks face binding collateral constraints during central bank reserve liquidations in the integrated market for U.S. Treasuries. These dynamics are unique to an economy where one currency dominates, as is the case with the U.S. dollar and U.S. Treasuries. The above results imply that U.S. Treasury holdings are inefficiently concentrated in the portfolios of foreign private banks, with foreign central banks holding an insufficient share. This misallocation increases systemic risks during crises, particularly through fire-sale dynamics.

To explore these frictions further, we analyze a committed swap line provision rule $s^L(d_0, d_0^*)$ at $t = 1$. We establish the following result:

Proposition 4. *When the Fed designs swap lines under a committed rule at $t = 0$, Japanese banks borrow more (less) d_0^*, and the BoJ accumulates lower (higher) q^R compared to the case without swap lines (with discretionary swap lines). Consequently, q_0^* is higher (lower) compared to the case without swap lines (with discretionary swap lines). However, the allocation does not implement the first-best.*

Proposition 4 reflects the classic time-inconsistency problem identified by Kydland and Prescott (1977) and Barro and Gordon (1983). The inefficiencies in Proposition 3 arise because the Fed

[8] We emphasize that our notion of pecuniary externality differs from those in Lorenzoni (2008), Bocola and Lorenzoni (2020), and Schmitt-Grohé and Uribe (2021), which focus on private agents' inefficient over- or under-borrowing, as well as that in Das, Gopinath, Kim, and Stein (2024), which highlights central banks' inefficient over-accumulation of dollar reserves, thereby exacerbating dollar scarcity.

faces a time-inconsistency problem: at $t = 0$, it would prefer to commit to not deploying swap lines to mitigate the two externalities but finds it optimal to intervene ex-post at $t = 1$ when a dollar funding gap materializes. By committing to a state-contingent rule, the Fed can achieve better outcomes ex-ante, aligning more closely with its objective of maximizing U.S. welfare.

However, even an optimal state-contingent design cannot fully eliminate inefficiencies. When dollar funding gaps at $t = 1$ are sufficiently large, collateral constraints remain binding for global banks, perpetuating the dash-for-dollar equilibrium. This reflects the challenges posed by post-crisis regulations and interventions in the U.S. banking sector, which have significantly reduced U.S. banks' willingness to provide liquidity in FX swap markets and key dollar fixed-income markets. This retreat has resulted in shallower FX swap and Treasury markets, diminishing the effectiveness of synthetic dollars and foreign central banks' dollar reserves in addressing global dollar funding shortages. Consequently, the growing reliance on a global dollar lender of last resort illustrates a "policy ratchet effect," where temporary crisis measures evolve into permanent dependencies. This underscores the importance of carefully designing intervention policies to balance immediate crisis needs with their long-term systemic implications.

5 Conclusion

This paper examines the feedback loop between currency mismatch driven by dollar dominance and the U.S.'s role as a global dollar lender of last resort, providing both theoretical and empirical contributions. Using new administrative data, we demonstrate that dollar swap lines serve as a critical mechanism for providing emergency liquidity during crises, acting as substitutes for private FX swaps and foreign central bank reserves. However, these swap lines also generate long-term externalities, incentivizing global banks to take on greater currency mismatches while reducing foreign central banks' incentives to hold precautionary dollar reserves. These dynamics exacerbate dollar funding vulnerabilities during crises, reinforcing global reliance on U.S. dollar liquidity

backstops.

Our findings have several key implications. First, while dollar swap lines stabilize markets during periods of stress, they also create trade-offs between short-term financial stability and long-term systemic risks. By altering the composition of U.S. Treasury holders—shifting holdings from foreign central banks to foreign private banks—swap lines may inadvertently increase the fragility of the U.S. Treasury market, exposing it to higher fire-sale risks during crises. Second, the increasing reliance on swap lines amplifies the structural dependence of foreign banking systems on dollar liquidity, deepening their exposure to U.S. monetary policy shocks. Third, post-crisis regulations, which have led to a retreat of U.S. banks from market-making and liquidity provision, appear to have amplified the global reliance on dollar lending of last resort, highlighting a "policy ratchet effect" that entrenches systemic dependence on the Fed's liquidity backstop.

Our theoretical framework integrates swap lines into a broader model of global banking and central banking, highlighting the intermediation chain in emergency dollar liquidity provision. We emphasize the role of pecuniary externalities between global banks and foreign central banks in shaping currency mismatch and reserve allocation decisions. This approach not only provides a unified explanation for the short-term and long-term impacts of swap lines but also underscores the challenges of designing optimal intervention policies in a globalized financial system.

Looking forward, several avenues for future research remain. First, further empirical work could investigate the heterogeneous responses of global banks and central banks across different countries to dollar swap lines, providing deeper insights into the global spillovers of U.S. monetary policy. Second, an extension of our framework could explore the role of other international liquidity arrangements, such as FIMA repo facilities, in mitigating global dollar funding risks. Finally, studying the interaction between dollar swap lines and the evolving structure of private FX and Treasury markets could provide valuable guidance for policymakers seeking to balance the trade-offs between financial stability and long-term market efficiency.

References

Acharya, Viral, Itamar Drechsler, and Philipp Schnabl. 2014. "A pyrrhic victory? Bank bailouts and sovereign credit risk." *The Journal of Finance* 69 (6): 2689–2739. 9

Aldasoro, Iñaki, Torsten Ehlers, and Egemen Eren. 2022. "Global banks, dollar funding, and regulation." *Journal of International Economics* 137 103609. 6

Aldasoro, Iñaki, Torsten Ehlers, Patrick McGuire, and Goetz von Peter. 2020. "Global banks' dollar funding needs and central bank swap lines." *BIS Bulletin* (27): . 6, 34, 35

Alquist, Ron, R Jay Kahn, and Karlye Dilts Stedman. 2023. "Central Banker to the World: Foreign Reserve Management and US Money Market Liquidity." 7

Anderson, Alyssa G, Wenxin Du, and Bernd Schlusche. 2021. "Arbitrage capital of global banks." *Journal of Finance* (forthcoming): . 6, 34, 35

Bacchetta, Philippe, J Scott Davis, and Eric Van Wincoop. 2023. "Dollar Shortages, CIP Deviations, and the Safe Haven Role of the Dollar." 8

Bahaj, Saleem, Marie Fuchs, and Ricardo Reis. 2024. "The Global Network of Liquidity Lines." 8, 12, 16, 37

Bahaj, Saleem, and Ricardo Reis. 2022a. "Central bank swap lines: Evidence on the effects of the lender of last resort." *The Review of Economic Studies* 89 (4): 1654–1693. 1, 7, 8, 9, 25, 37, 41

Bahaj, Saleem, and Ricardo Reis. 2022b. "The economics of liquidity lines between central banks." *Annual Review of Financial Economics* 14 (1): 57–74. 8

Barro, Robert J, and David B Gordon. 1983. "Rules, discretion and reputation in a model of monetary policy." *Journal of monetary economics* 12 (1): 101–121. 39, 43

Bianchi, Javier. 2016. "Efficient bailouts?" *American Economic Review* 106 (12): 3607–3659. 9

Bianchi, Javier, Juan Carlos Hatchondo, and Leonardo Martinez. 2018. "International reserves and rollover risk." *American Economic Review* 108 (9): 2629–2670. 7

Bianchi, Javier, and Guido Lorenzoni. 2022. "The prudential use of capital controls and foreign currency reserves." In *Handbook of International Economics*, Volume 6. 237–289, Elsevier. 7

Bocola, Luigi, and Alessandro Dovis. 2019. "Self-fulfilling debt crises: A quantitative analysis." *American Economic Review* 109 (12): 4343–4377. 9

Bocola, Luigi, and Guido Lorenzoni. 2020. "Financial crises, dollarization, and lending of last resort in open economies." *American Economic Review* 110 (8): 2524–2557. 4, 6, 7, 31, 37, 38, 42, 43

Bordo, Michael D, Owen Humpage, and Anna J Schwartz. 2012. "Epilogue: foreign-exchange-market operations in the twenty-first century."Technical report, National Bureau of Economic Research. 12

Brunnermeier, Markus K, Sebastian Merkel, and Yuliy Sannikov. 2022. "Safe assets: A dynamic retrading perspective." *Journal of Political Economy, forthcoming*. 5

Bruno, Valentina, and Hyun Song Shin. 2015. "Cross-border banking and global liquidity." *The Review of Economic Studies* 82 (2): 535–564. 6

Burnside, Craig, Martin Eichenbaum, and Sergio Rebelo. 2001. "Prospective deficits and the Asian currency crisis." *Journal of political Economy* 109 (6): 1155–1197. 6

Caballero, Ricardo J, Tomás E Caravello, and Alp Simsek. 2024. "Financial Conditions Targeting." 9

Caballero, Ricardo J, Emmanuel Farhi, and Pierre-Olivier Gourinchas. 2008. "An equilibrium model of "global imbalances" and low interest rates." *American economic review* 98 (1): 358–393. 6

Cetorelli, Nicola, and Linda S Goldberg. 2012. "Banking globalization and monetary transmission." *The Journal of Finance* 67 (5): 1811–1843. 8

Chernov, Mikhail, Valentin Haddad, and Oleg Itskhoki. 2024. "What do financial markets say about the exchange rate?". 6

Chinn, Menzie D, Hiro Ito, and Robert N McCauley. 2022. "Do central banks rebalance their currency shares?" *Journal of International Money and Finance* 122 102557. 13, 27, 30

Choi, Jason, Rishabh Kirpalani, and Diego Perez. 2024. "Us public debt and safe asset market power." *Journal of Political Economy* (forthcoming): . 8

Clayton, Christopher, Matteo Maggiori, and Jesse Schreger. 2023. "A framework for geoeconomics." 8

Clayton, Christopher, Matteo Maggiori, and Jesse Schreger. 2024. "A Theory of Economic Coercion and Fragmentation." 9

Clayton, Christopher, and Andreas Schaab. 2022. "Multinational banks and financial stability." *The Quarterly Journal of Economics* 137 (3): 1681–1736. 8

Coppola, Antonio, Arvind Krishnamurthy, and Chenzi Xu. 2024. "Liquidity, debt denomination, and currency dominance." 1, 5, 6, 34

Correa, Ricardo, Wenxin Du, and Gordon Y Liao. 2020. "US banks and global liquidity." 5, 36

Das, Mitali, Gita Gopinath, Taehoon Kim, and Jeremy C Stein. 2024. "Central Banks as Dollar Lenders of Last Resort: Implications for Regulation and Reserve Holdings." 7, 27, 29, 37, 43

Diamond, Douglas W, and Philip H Dybvig. 1983. "Bank runs, deposit insurance, and liquidity." *Journal of political economy* 91 (3): 401–419. 9

Drechsler, Itamar, Thomas Drechsel, David Marques-Ibanez, and Philipp Schnabl. 2016. "Who borrows from the lender of last resort?" *The Journal of Finance* 71 (5): 1933–1974. 9

Du, Wenxin, and Jesse Schreger. 2022. "CIP deviations, the dollar, and frictions in international capital markets." In *Handbook of International Economics*, Volume 6. 147–197, Elsevier. 7

Du, Wenxin, Alexander Tepper, and Adrien Verdelhan. 2018. "Deviations from covered interest rate parity." *The Journal of Finance* 73 (3): 915–957. 3, 7, 25, 33, 36

Duffie, Darrell. 2023. "Resilience redux in the US Treasury market." In *Jackson Hole Symposium, Federal Reserve Bank of Kansas City*. 6, 32

Duffie, Darrell, Michael J Fleming, Frank M Keane, Claire Nelson, Or Shachar, and Peter Van Tassel. 2023. "Dealer capacity and US Treasury market functionality." *FRB of New York Staff Report* (1070): . 6, 32, 36

Fanelli, Sebastián, and Ludwig Straub. 2021. "A theory of foreign exchange interventions." *The Review of Economic Studies* 88 (6): 2857–2885. 7

Fang, Xiang, Bryan Hardy, and Karen K Lewis. 2022. "Who holds sovereign debt and why it matters." *Review of Financial Studies* forthcoming. 5, 34

Farhi, Emmanuel, and Matteo Maggiori. 2018. "A model of the international monetary system." *The Quarterly Journal of Economics* 133 (1): 295–355. 6

Farhi, Emmanuel, and Jean Tirole. 2012. "Collective moral hazard, maturity mismatch, and systemic bailouts." *American Economic Review* 102 (1): 60–93. 9, 33, 37, 38, 41

Ferrara, Gerardo, Philippe Mueller, Ganesh Viswanath-Natraj, and Junxuan Wang. 2022. "Central bank swap lines: micro-level evidence." 8

Fontanier, Paul. 2023. "Sovereign Bond Purchases and Rollover Crises." 8

Goldberg, Linda S, and Fabiola Ravazzolo. 2022. "The Fed's International Dollar Liquidity Facilities: New Evidence on Effects." 8, 9

Gopinath, Gita, Emine Boz, Camila Casas, Federico J Díez, Pierre-Olivier Gourinchas, and Mikkel Plagborg-Møller. 2020. "Dominant currency paradigm." *American Economic Review* 110 (3): 677–719. 1, 5

Gopinath, Gita, and Oleg Itskhoki. 2022. "Dominant currency paradigm: A review." *Handbook of international economics* 6 45–90. 5

Gopinath, Gita, and Jeremy C Stein. 2021. "Banking, trade, and the making of a dominant currency." *The Quarterly Journal of Economics* 136 (2): 783–830. 1, 5, 34

Haddad, Valentin, Alan Moreira, and Tyler Muir. 2023. "Whatever it takes? The impact of conditional policy promises." *American Economic Review* forthcoming. 9

Haddad, Valentin, Alan Moreira, and Tyler Muir. 2024. "Asset purchase rules: How QE transformed the bond market." 9

He, Zhiguo, Arvind Krishnamurthy, and Konstantin Milbradt. 2019. "A model of safe asset determination." 5

He, Zhiguo, Stefan Nagel, and Zhaogang Song. 2022. "Treasury inconvenience yields during the COVID-19 crisis." *Journal of Financial Economics* 143 (1): 57–79. 6, 32, 36

Itskhoki, Oleg, and Dmitry Mukhin. 2021. "Exchange rate disconnect in general equilibrium." *Journal of Political Economy* 129 (8): 2183–2232. 6

Ivashina, Victoria, David S Scharfstein, and Jeremy C Stein. 2015. "Dollar funding and the lending behavior of global banks." *The Quarterly Journal of Economics* 130 (3): 1241–1281. 1, 6, 34, 35

Ize, Alain, and Eduardo Levy Yeyati. 2003. "Financial dollarization." *Journal of International Economics* 59 (2): 323–347. 6

Jeanne, Olivier, and Anton Korinek. 2020. "Macroprudential regulation versus mopping up after the crash." *The Review of Economic Studies* 87 (3): 1470–1497. 9, 33, 42

Jiang, Zhengyang, Arvind Krishnamurthy, and Hanno Lustig. 2021. "Foreign safe asset demand and the dollar exchange rate." *The Journal of Finance* 76 (3): 1049–1089. 5

Jiang, Zhengyang, Arvind Krishnamurthy, and Hanno Lustig. 2024. "Dollar safety and the global financial cycle." *Review of Economic Studies* 91 (5): 2878–2915. 5

Keister, Todd. 2016. "Bailouts and financial fragility." *The Review of Economic Studies* 83 (2): 704–736. 9

Kekre, Rohan, and Moritz Lenel. 2023. "The high frequency effects of dollar swap lines." *American Economic Review: Insights* forthcoming. 8, 9

Kekre, Rohan, and Moritz Lenel. 2024. "The flight to safety and international risk sharing." *American Economic Review* 114 (6): 1650–1691. 5

Kydland, Finn E, and Edward C Prescott. 1977. "Rules rather than discretion: The inconsistency of optimal plans." *Journal of political economy* 85 (3): 473–491. 39, 43

Lorenzoni, Guido. 2008. "Inefficient credit booms." *The Review of Economic Studies* 75 (3): 809–833. 4, 31, 32, 33, 41, 43

Ma, Yiming, Kairong Xiao, and Yao Zeng. 2022. "Mutual fund liquidity transformation and reverse flight to liquidity." *The Review of Financial Studies* 35 (10): 4674–4711. 6

Maggiori, Matteo. 2017. "Financial intermediation, international risk sharing, and reserve currencies." *American Economic Review* 107 (10): 3038–3071. 5, 6

Mendoza, Enrique G, Vincenzo Quadrini, and Jose-Victor Rios-Rull. 2009. "Financial integration, financial development, and global imbalances." *Journal of Political economy* 117 (3): 371–416. 6

Obstfeld, Maurice, Jay C Shambaugh, and Alan M Taylor. 2009. "Financial instability, reserves, and central bank swap lines in the panic of 2008." *American economic review* 99 (2): 480–486. 8, 29

Obstfeld, Maurice, Jay C Shambaugh, and Alan M Taylor. 2010. "Financial stability, the trilemma, and international reserves." *American Economic Journal: Macroeconomics* 2 (2): 57–94. 7

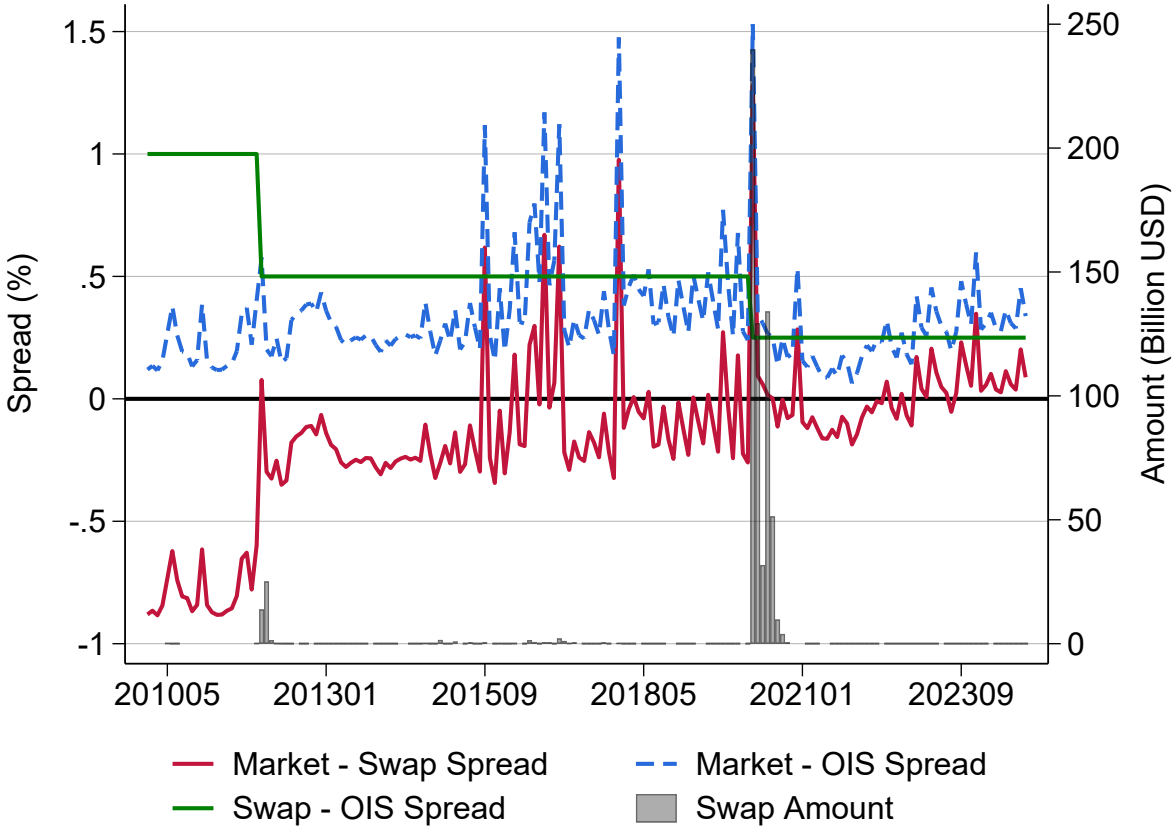
Schmitt-Grohé, Stephanie, and Martín Uribe. 2021. "Multiple equilibria in open economies with collateral constraints." *The Review of Economic Studies* 88 (2): 969–1001. 43

Vissing-Jorgensen, Annette. 2021. "The Treasury market in spring 2020 and the response of the Federal Reserve." *Journal of Monetary Economics* 124 19–47. 6, 34, 36

Appendix

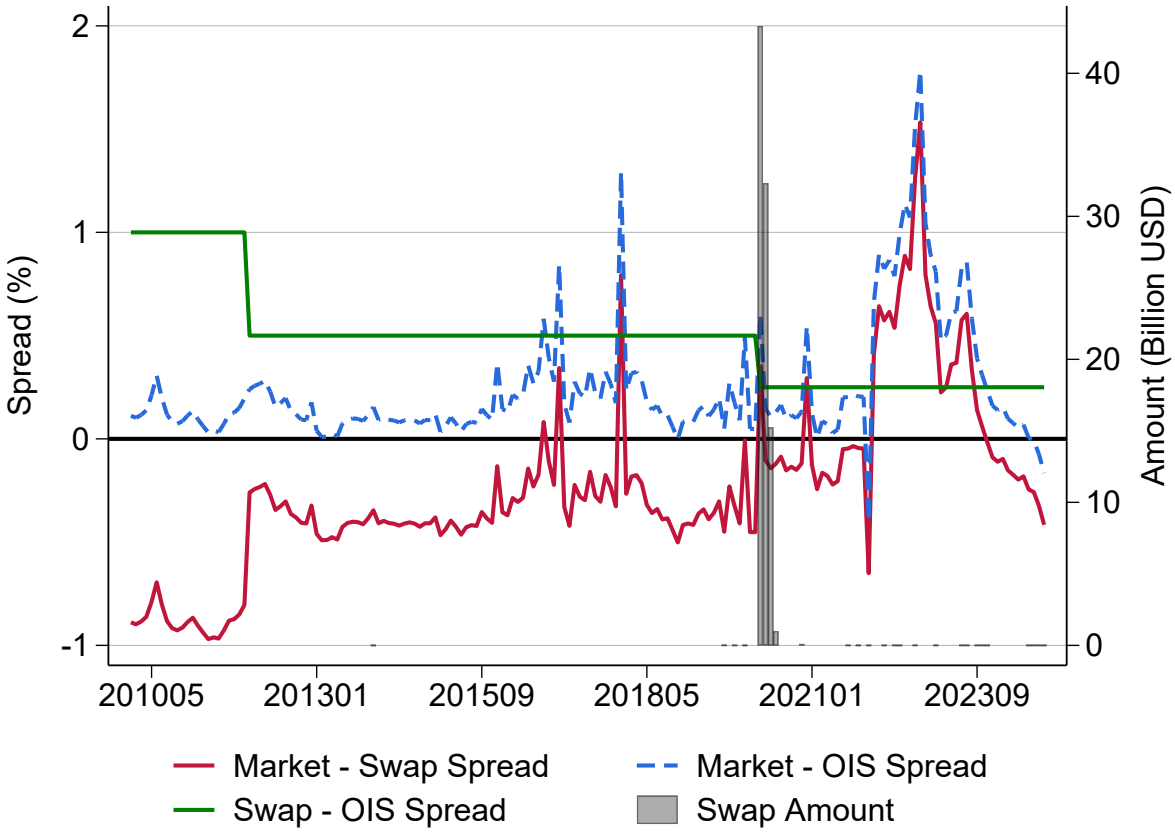
A Dollar Funding Spreads and Swap Lines: Other Countries

Figure A-1: USD Funding Spreads and Swap line Provision for Japan



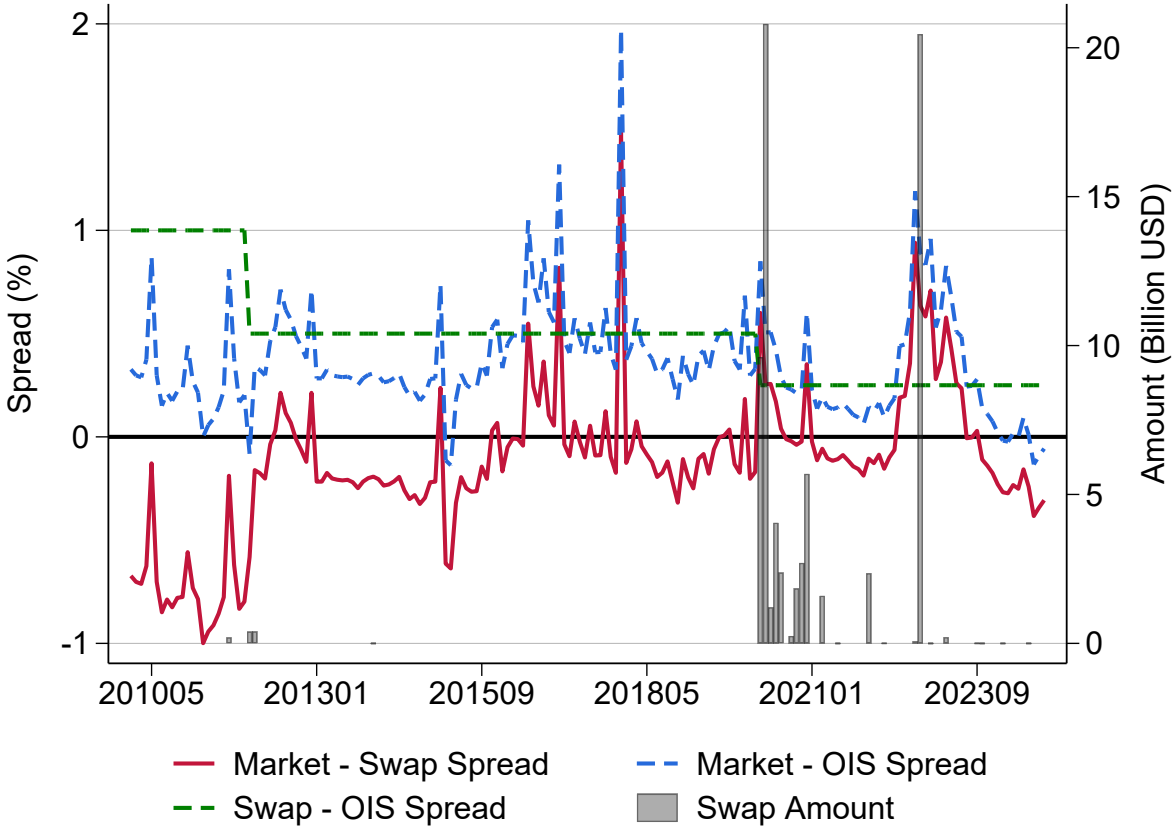
Note: This figure illustrates the spreads between market rates, central bank swap line rates, and the OIS rate, along with the amount of central bank USD swap provision. The blue line, "Market - Swap Spread," represents the difference between the 1-week FX swap-implied USD yield for USD-JPY and the central bank USD swap line interest rate for the BOJ. The red line, "Market - OIS Spread," shows the spread between the market rate and the 1-week Overnight Indexed Swap (OIS) rate. The green line, "Swap - OIS Spread," reflects the policy-set differential between the central bank swap line rate and the OIS rate. The gray bars indicate the amount of USD provided through central bank swap lines over time (in billions). The sample period spans May 2010 to Oct 2024. Market rate and OIS data are sourced from Bloomberg, while swap amounts and interest rate data are from the New York Fed.

Figure A-2: USD Funding Spreads and Swap line Provision for the United Kingdom



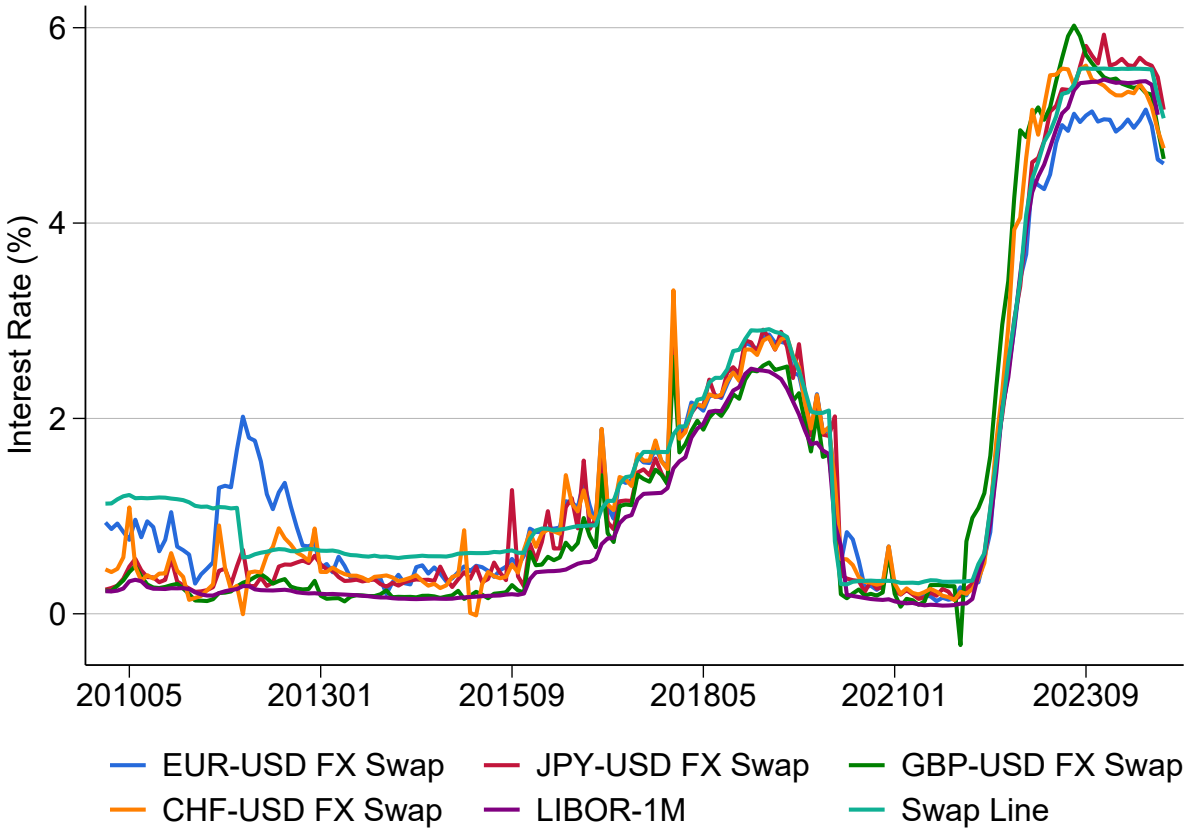
Note: This figure illustrates the spreads between market rates, central bank swap line rates, and the OIS rate, along with the amount of central bank USD swap provision. The blue line, "Market - Swap Spread," represents the difference between the 1-week FX swap-implied USD yield for USD-GBP and the central bank USD swap line interest rate for the BOE. The red line, "Market - OIS Spread," shows the spread between the market rate and the 1-week Overnight Indexed Swap (OIS) rate. The green line, "Swap - OIS Spread," reflects the policy-set differential between the central bank swap line rate and the OIS rate. The gray bars indicate the amount of USD provided through central bank swap lines over time (in billions). The sample period spans May 2010 to Oct 2024. Market rate and OIS data are sourced from Bloomberg, while swap amounts and interest rate data are from the New York Fed.

Figure A-3: USD Funding Spreads and Swap line Provision for Switzerland



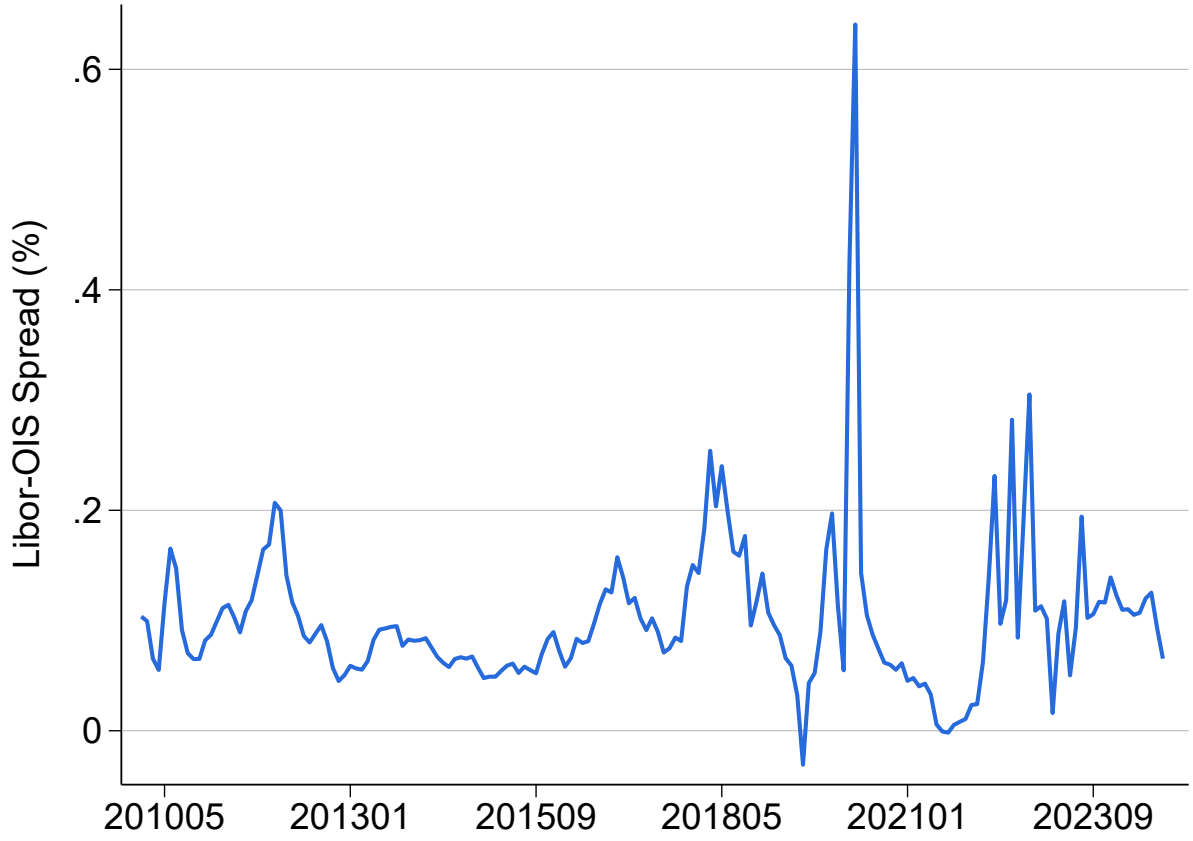
Note: This figure illustrates the spreads between market rates, central bank swap line rates, and the OIS rate, along with the amount of central bank USD swap provision. The blue line, "Market - Swap Spread," represents the difference between the 1-week FX swap-implied USD yield for USD-CHF and the central bank USD swap line interest rate for the SNB. The red line, "Market - OIS Spread," shows the spread between the market rate and the 1-week Overnight Indexed Swap (OIS) rate. The green line, "Swap - OIS Spread," reflects the policy-set differential between the central bank swap line rate and the OIS rate. The gray bars indicate the amount of USD provided through central bank swap lines over time (in billions). The sample period spans May 2010 to Oct 2024. Market rate and OIS data are sourced from Bloomberg, while swap amounts and interest rate data are from the New York Fed.

Figure A-4: Interest Rates



Note: The figure shows the implied USD yield (%) for various FX swaps, including EUR-USD, JPY-USD, CHF-USD, and GBP-USD, as well as the 1-month LIBOR rate and the swap line interst rate, from Jan 2010 to Oct 2024. The data is from bloomberg.

Figure A-5: Libor-OIS Spread



Note: The figure shows the Libor-OIS spread (%) from Jan 2010 to Oct 2024. The data is from Bloomberg. Note that the Libor was discounted as a benchmark rate in June 2023 but it was still provided and available until October 2024.