The Journal of FINANCE
The Journal of THE AMERICAN FINANCE ASSOCIATION

THE JOURNAL OF FINANCE • VOL. LXXV, NO. 6 • DECEMBER 2020

Monetary Policy and Global Banking

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ABSTRACT

When central banks adjust interest rates, the opportunity cost of lending in local currency changes, but—absent frictions—there is no spillover effect to lending in other currencies. However, when equity capital is limited, global banks must benchmark domestic and foreign lending opportunities. We show that, in equilibrium, the marginal return on foreign lending is affected by the interest rate differential, with lower domestic rates leading to an increase in local lending, at the expense of a reduction in foreign lending. We test our prediction in the context of changes in interest rates in six major currency areas.

FOREIGN ("GLOBAL") BANKS PLAY AN important role in many countries. According to the Bank for International Settlements (BIS), as of June 2015, European and Japanese banks' claims on U.S. nonbank firms were USD 1.61 and 0.72 trillion, respectively. DealScan data indicate that foreign banks help originate close to a quarter of all syndicated corporate loans in the United States. Similarly, U.S. banks are important lenders abroad: as of June 2015, U.S. banks held the equivalent of USD 0.74 and 0.11 trillion in claims on European and Japanese nonbank companies, respectively. More generally, it is estimated that

*Bräuning is with the Federal Reserve Bank of Boston and Ivashina is with Harvard Business School, NBER, and CEPR. We thank seminar participants at the AFA 2017, Bank of Canada, Banque de France, Copenhagen Business School, Duke University, European Central Bank, FRIC Annual Conference, Federal Reserve Bank of Boston, Federal Reserve Bank of Chicago, Federal Reserve Bank of Cleveland, Federal Reserve Board, Global Research Forum on International Macroeconomics and Finance 2016, IBEFA Summer Meeting 2016, IMF Spillover Workshop, NBER Summer Institute 2016, Nova School of Business and Economics, UIUC, University of Miami, University of Porto, and WCWIF 2016 for helpful comments. We are particularly grateful to François Gourio; Stefan Nagel (Editor); Ali Ozdagli; Joe Peek; Jeremy Stein; Jenny Tang; Christina Wang; two anonymous referees; and our discussants Morten Bech, Nicola Cetorelli, Stijn Claessens, Ricardo Correa, Linda Goldberg, Michael Hutchison, Jose Lopez, Teodora Paligorova, and Skander Van den Heuvel for detailed feedback. Botao Wu, Kovid Puria, and Sam Tugendhaft provided remarkable research assistance. The views expressed in this paper are those of the authors and do not necessarily represent the views of the Federal Reserve Bank of Boston or the Federal Reserve System. We have read *The Journal of Finance*'s disclosure policy and have no conflict of interest related to this research.

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DOI: 10.1111/jofi.12959

foreign banks account for about 10% of the assets of the French and Italian banking sectors (World Bank (2008)).

Given the economic significance of global banks, questions have been raised about their role in the propagation of economic shocks from one country to another. This is the first paper that provides a framework that shows how monetary policy in one country affects loan supply in different currencies through the balance sheet of global banks. A standard effect of monetary policy is that, by setting the interest rate on reserve assets, it affects the opportunity cost of lending: A higher domestic policy rate increases the required marginal rate of return on domestic lending. We show that if a global bank is capital constrained, that is, if it needs to consider the allocation of a fixed amount of equity to back lending in multiple currencies—monetary policy in one country will affect its loan supply in all currencies. This is because, in equilibrium, marginal returns (expressed in the same currency) on domestic and foreign lending have to be equal. We present a model that formalizes this point and derives testable predictions that guide the empirical analysis. Overall, the central insight of the paper is that global banks' lending decisions in different currencies are interlinked and respond to both foreign and domestic monetary policy shocks.

In addition to lending, banks have a global approach to their liquidity management: They prefer to hold liquidity in countries in which reserve assets, such as central bank reserves or government bonds, carry a higher risk-adjusted yield. Using U.S. Call Report and BIS data, we find a strong positive relationship between foreign reserve holdings and the difference in the interest on excess reserves (IOER) rate between foreign and bank's domestic market. While global liquidity management is not essential to derive cross-currency effects of monetary policy on lending, given that these liquidity flows are sizable and respond to monetary policy, we incorporate global banks' liquidity management in our model.

Our empirical results can be divided into two parts: (i) aggregate macro evidence and (ii) firm- and loan-level micro evidence. In line with the central mechanism of the model, we show that foreign banks in the United States that are headquartered in countries where the interest rate has been lowered decrease their lending to U.S. firms by up to 10% per 25-basis-point increase in the IOER rate differential. The results are robust to using U.S. monetary policy shocks and alternative measures of interest rate differentials. Using BIS data, we show that similar patterns emerge in a cross-country setting: We find a decrease in foreign-currency cross-border claims on foreign firms of 1.2% per 25-basis-point increase in the IOER rate differential between the foreign currency and the currency of a bank's home country. We estimate this effect after controlling for concurrent movements in the spot exchange rate. Consistent with our model predictions and our findings for the United States, the reduction in foreign lending is stronger after we take into account the appreciation of the foreign currency.

Our second set of results is based on loan-level data, which are crucial for a tight empirical identification of the mechanism at work. For this purpose, we employ loan-level data on syndicated loan originations by global banks in six major currencies from 2000 to 2016. At the bank level, we find that, in a given quarter, there is a larger contraction in credit in currencies that carry a higher IOER differential with respect to the bank's home country. With regard to lending volume, a 25-basis-point increase in the IOER rate difference is associated with a roughly 1-percentage-point reduction in the share of foreign currency lending (relative to the bank's lending in both foreign and domestic currencies), which corresponds to a reduction of 2% relative to the mean share of foreign currency lending. The impact on the lending share based on the number of loans is equally sizable. In line with our mechanism, the effect of the IOER rate differential on foreign currency lending is particularly strong for banks with a low equity-to-assets ratio and is not confined to the U.S. dollar but rather holds for all major currencies.

A similar picture arises when we conduct bank-firm-level regressions. Here we find that, among foreign banks, the propensity to lend (extensive margin) and the size of the loan commitment (intensive margin) are negatively related to the difference in interest rates set by the monetary authorities in the host country and a bank's home country. In particular, after controlling for borrower-quarter and lender-quarter fixed effects, we find a decrease of roughly 1.6% in the probability of lending (relative to the mean lending probability) and 3.6% in lending volume for a 25-basis-point differential in IOER. Because the loans in our sample are syndicated, each loan has several banks with large commitments. This setup allows us to include both borrower-quarter and lender-quarter fixed effects, which account for factors related to time-varying loan demand and bank behavior, such as a bank's response to changes in economic conditions in the bank's home country to focus on the differential supply of credit in different currencies. For example, the shock to the Japanese banks analyzed in Peek and Rosengren (1997, 2000) would lead to an overall contraction in credit by Japanese banks, which would be subsumed by the lender-quarter fixed effects.

We also estimate changes in aggregate credit supply at the domestic firm level following foreign monetary policy shocks to provide evidence on whether the reduction in credit is binding for individual firms. We find that firms that, in the past, had a larger share of foreign global banks in the syndicate and that subsequently experienced a monetary easing policy shock in their home country face a stronger contraction in credit than other firms. Economically, we find that a one-standard-deviation increase in the past share of foreign global banks is associated with a 12% lower probability of obtaining a loan and with a 5% reduction in the volume of loans granted after an expansionary monetary policy shock in the foreign bank's home country.

Our paper contributes to several strands of the literature. First, we extend a growing body of research on global banks and the role they play in transmitting shocks across borders. In particular, our work is closely related to empirical work by Cetorelli and Goldberg (2012) and Morais et al. (2019).[1] These

[1] In addition to the seminal contributions of Peek and Rosengren (1997, 2000), other research in this area includes Acharya and Schnabl (2010), Chava and Purnanandam (2011), Schnabl (2012),

papers build on the conceptual framework of Kashyap and Stein (2000) who develop a model that contrasts lending behavior of large versus small banks in a closed economy, to examine the role of global banks' internal capital markets on the international transmission of monetary policy. As in these papers, we rely on the use of the global balance sheet as a central channel for the cross-border spillover of monetary policy. However, our paper is the first to account for the fact that banks' global activity has an intrinsic currency component. Incorporating this insight into a simple model reveals a more complex effect on lending in domestic and foreign markets due to the interaction between global banks' capital constraints and the interest rate differentials between different currencies.

Second, we contribute to an emerging literature that examines currency effects on loan supply. Ivashina, Scharfstein, and Stein (2015) study how differences in funding in domestic and foreign currencies impact lending. Ongena, Schindele, and Vonnák (2016) analyze the differential impact of domestic and foreign monetary policy on the local supply of bank credit in domestic and foreign currencies using micro data from Hungary. The authors find that domestic monetary policy primarily affects credit supply in the domestic currency. A similar result is obtained in Takats and Temesvary (2016), who examine a cross-country context using aggregate data. The proposed explanation is that the cost of funding in a given currency is influenced by that currency area's monetary authority, while this channel also operates in our model, we show that it interacts with the capital constraint to lead to opposite effects for lending in foreign and domestic currencies.

Third, our paper relates to the large body of work in international finance and macroeconomics that studies the cross-border transmission of monetary policy—specifically, the transmission of U.S. monetary policy—to global financial markets. At the aggregate level, Rey (2018) and Miranda-Agrippino and Rey (2019) highlight the central role of U.S. monetary policy in driving the global financial cycle.[2] Mueller, Tahbaz-Salehi, and Vedolin (2017) and Shah (2018) provide further evidence of the strong impact of U.S. monetary policy on the FX market. Consistent with the important role of U.S. monetary policy, we find stronger effects of banks rebalancing their portfolios in response to interest-rate differential changes for dollar loans, but also show that our results hold more broadly for other major currencies.

Finally, while we do not analyze the effects of capital flows on the exchange rate, our results indicate that—in response to the monetary policy—global

Cetorelli and Goldberg (2011), Acharya, Afonso, and Kovner (2013), Correa, Sapriza, and Zlate (2016), Giannetti and Laeven (2012), and Baskaya, di Giovanni, Kalemi-Ozcan, and Ulu (2017).

[2] Several recent studies link the importance of U.S. monetary policy to the dominant role of the dollar in international trade and finance. For example, McCauley, McGuire, and Sushko (2015) and Bräuning and Ivashina (2020) document a large sensitivity of emerging market debt to U.S. monetary policy. Wiriadinata (2018) show that differences in the dollarization of countries' external debt drives currency risk premium and exchange rate movements in response to U.S. monetary policy shocks. Zhang (2019) argues that heterogeneous U.S. monetary policy spillovers depend on countries' share of dollar-invoiced trade.

banks move significant amount of capital across currencies. This relates to Gabaix and Maggiori (2015) who argue that exchange rates could be influenced by large, international capital flows intermediated by global financial institutions.[3] Similarly, Bruno and Shin (2015, 2017) argue that global banks' risk taking affects monetary policy spillovers to international capital flows and exchange rates

The rest of the paper is organized in four sections. In Section I, we formalize our testable hypotheses. In Section II, we discuss the data. In Section III, we present our core empirical results. In Section IV, we conclude.

I. Theoretical Framework

A. Model

Consider a representative global bank that has investment opportunities in domestic country d and in the foreign country f. All investments are made at time t_0, and returns are realized at time t_1. The bank has lending opportunities in both countries. If the bank lends an amount L^d in the domestic market, it earns a gross amount (principal and interest) of $g(L^d)$. Similarly, if the bank lends an amount L^f in the foreign market, it earns back $h(L^f)$. We assume that both $g(\cdot)$ and $h(\cdot)$ are concave functions, which captures decreasing returns to scale in the loan market. This could be motivated by a price-setting bank facing a downward-sloping demand curve in the loan market. The notion of bank pricing power in lending is rooted in informational frictions, which are a central explanation for the existence of the banking sector (e.g., Diamond (1984, 1991), Rajan (1992), and a large body of empirical work that collaborates these ideas), and direct evidence on market power in lending (e.g., Fama (1985), Cosimano and McDonald (1998)). The basic idea is that banks build a costly expertise in screening and monitoring their borrowers, and thus produce proprietary information that is not easily transferable. This, in turn, leads to switching costs for borrowers.

In addition, the bank can hold reserved R^d at the domestic central bank; these reserves yield a constant return r^d. (While in the model exposition we focus on central bank reserves, our proposed mechanism holds for reserve assets more broadly.) The global bank can also access the deposit facility of the foreign central bank, where it can keep reserves R^f and earn a rate r^f. Similar to Kashyap, Rajan, and Stein (2002), and also motivated by the bank pricing power in the loan market, we assume that the loan return functions do not directly depend on the interest rates on reserve assets. As a result, the pass-through of policy rates to loan markets is a result of

[3] Due to their limited risk-taking capacity, financiers require incentives to absorb the global imbalance in the demand and supply of assets in different currency denominations. In their model, risk-taking is compensated through exchange rate adjustments, which leads to violations of uncovered interest parity (UIP). More broadly, violations of UIP and currency excess returns have been the subject of several studies, including Eichenbaum and Evans (1995), Lustig, Roussanov, and Verdelhan (2011), Colacito et al. (2018), and Hassan and Mano (2019).

credit supply shifts. This assumption can be relaxed, for example, by assuming $g'(L^d) = 1 + \gamma r^d + (1-\gamma)G(L^d)$, with $G > 0,\ G' < 0$, and $\gamma \in (0, 1)$, and a similar function for $h(.)$, that is, assuming direct dependence on policy rates and some direct pass-through—does not alter the mechanism and this leads to the same predictions.

All investments have to be in local currency, that is, investments in the foreign country are in foreign currency, and domestic investments are in domestic currency. Let X_0 be the period 0 spot exchange rate expressed in terms of units of domestic currency per foreign currency. Then, X_0L^f and X_0R^f are the foreign currency loans and reserves, respectively, expressed in bank's domestic currency. (L^d and R^d are already expressed in the bank's domestic currency.)

We assume that the bank's only funding sources for all investments are a fixed amount of capital K and deposits D^d, both denominated in domestic currency. Capital is required to fund a share α of lending—$\alpha\ (L^d + X_0L^f) \leq K$—and we assume that this standard capital constraint is binding in equilibrium.[4] Raising deposits is associated with an increasing cost $d(D^d)$, where $d(\cdot)$ is a convex function. These costs may represent an adjustment cost to the domestic deposit base (Ivashina, Scharfstein, and Stein (2015)), or they may be interpreted as a balance sheet cost (Martin, McAndrews, and Skeie (2013)).

To fund its foreign currency operations, the global bank converts funds raised in domestic currency into foreign currency in the spot market. However, doing so generates a currency mismatch between its assets and liabilities, which banks typically hedge using FX swaps by combining the spot purchase of foreign currency with its forward sale.[5] The bank's FX swap volume is denoted by S (in foreign currency) and the forward exchange rate is X^{Fwd}, again expressed as domestic per foreign currency. While the bank can choose to leave the fraction U of its FX exposure unhedged, regulatory requirements force banks to fund a share α' of such unhedged positions with equity capital. To account for these requirements, we extend the standard capital constraint to $\alpha(L^d + X_0L^f) + \alpha' X_0 U \leq K$. Therefore, in addition to foreign and domestic lending activities, the bank needs to fund any unhedged currency exposure with a share of its capital.

The risk-neutral global bank maximizes expected profits in domestic currency by choosing the amount of deposits, the amount of hedged and unhedged foreign currency exposures, and the portfolio allocation. The bank takes as given the foreign and domestic interest rates, the spot (X_0) and forward (X^{Fwd}) FX rates, and its capital. The formal maximization problem is

$$\max\ (1 + r^d)R^d + g(L^d) + SX^{Fwd} + UE[X_1] - d(D^d),$$

[4] In line with current practices, we assume that assets in foreign currency are converted with the spot exchange rate for accounting and capital requirement purposes, see, for example, https://www.pwc.com/us/en/cfodirect/assets/pdf/accounting-guides/pwc-guide-foreign-currency.pdf, and the Basel capital requirement guidelines, https://www.bis.org/bcbs/publ/d457.pdf.

[5] See Fender and McGuire (2010). Also, BIS data show that FX swaps are the most actively traded foreign exchange derivative, with banks accounting for more than 75% of their turnover.

subject to

$$K - \alpha(L^d - X_0 L^f) - \alpha' X_0 U \geq 0,$$

$$S + U - (1 + r^f)R^f - h(L^f) = 0,$$

$$D^d + K - R^d - L^d - X_0 R^f - X_0 L^f = 0,$$

$$D^d \geq 0, L^d \geq 0, L^f \geq 0, R^d \geq 0, R^f \geq 0,\ S \geq 0, U \geq 0.$$

We focus on an interior solution for the bank's balance sheet positions (deposits, reserves, and lending in both currencies) and swap amount.[6] An interior solution for lending exists if the functions h and g satisfy the Inada conditions. (We will return to the conditions required for the interior solution for reserve holdings.) The exogenous variables in this problem are the spot exchange rate, the foreign and domestic interest rates, which pin down the FX forward premium, and the capital requirements on lending and unhedged exposure. The endogenous variables are the bank's choice variables.

The first-order conditions (FOCs) to the above maximization problem are given by:

$$\partial L/\partial R^d = (1 + r^d) + \lambda = 0, \tag{1}$$

$$\partial L/\partial R^f = \lambda X_0 - \mu(1 + r^f) = 0, \tag{2}$$

$$\partial L/\partial L^d = g'(L^d) - \omega + \lambda = 0, \tag{3}$$

$$\partial L/\partial L^f = -\omega X_0 + \lambda X_0 - \mu h'(L^f) = 0, \tag{4}$$

$$\partial L/\partial D^d = -d'(D^d) - \lambda = 0, \tag{5}$$

$$\partial L/\partial S = X^{Fwd} + \mu = 0, \tag{6}$$

$$\partial L/\partial U = E[X_1] - \omega X_0 + \mu + \gamma = 0, \tag{7}$$

$$\partial L/\partial \omega = K - \alpha(L^d - X_0 L^f) - \alpha' X_0 U = 0, \tag{8}$$

$$\partial L/\partial \mu = S + U - (1 + r^f)R^f - h(L^f) = 0, \tag{9}$$

[6] We only differentiate between a corner solution and an interior solution for unhedged exposure, U.

$$\partial L/\partial\lambda = R^d + L^d + X_0 R^f + X_0 L^f - D^d - K = 0. \tag{10}$$

The Lagrange multipliers on the balance sheet constraint, foreign exchange constraint, and capital constraint are given by λ, μ, and ω, respectively, and γ is the multiplier on the nonnegativity constraint on U.

From FOCs (1) and (5), the total size of the global bank's balance sheet is determined by the interest rate on domestic deposits,

$$d'(D^d) = 1 + r^d, \tag{11}$$

which equates the marginal cost of raising additional deposits to the return on holding domestic excess reserves.

Using (1), the FOC for domestic lending in equation (3) can be rewritten as:

$$g'(L^d) = (1 + r^d) + \omega, \tag{12}$$

where $g'(L^d)$ is the marginal return on domestic lending and ω is the Lagrange multiplier on the bank's capital constraint. This condition highlights that the binding capital constraint restricts domestic lending and imposes an additional (shadow) cost: The bank could increase profits by expanding lending until the marginal return on lending equals the cost of borrowing $(1 + r^d)$, but the lack of additional equity capital restricts its lending.

Using (1) and (6), we can express equation (4), the FOC for foreign lending, as

$$\frac{X^{Fwd}}{X_0} h'(L^f) = (1 + r^d) + \omega, \tag{13}$$

where $h'(L^f)$ is the marginal return on foreign lending and $\frac{X^{Fwd}}{X_0}$ is the forward premium. Equation (13) shows that the marginal return on foreign lending *net* of the forward premium equals the cost of raising domestic deposits plus the shadow cost of capital. From (1), (2), and (6), covered interest parity (CIP) holds: the forward premium equals the interest rate differential, $\frac{X^{Fwd}}{X_0} = \frac{1+r^d}{1+r^f}$.[7] Thus, if the domestic interest rate decreases but the foreign interest rate stays constant (so the forward premium falls), the net marginal return on foreign lending falls. Without the capital constraint, this decline in marginal return does not impact foreign lending because it is offset by the lower cost of domestic funding. However, with a binding capital constraint, the lower net marginal return on foreign lending makes it more attractive to use scarce capital to expand domestic lending. As a result, under the capital constraint, the decrease in the domestic interest rate will trigger an expansion in domestic lending and a contraction in foreign lending until the margin returns net of the forward premium is equal between the two markets.

[7] To simplify notation, we express exchange rates as units of domestic currency per one unit of foreign currency. As a result, the forward premium falls when the interest rate differential between foreign and domestic currencies widens.

Substituting out the forward premium, we can rewrite equation (13) as

$$h'(L^f) = (1 + r^f) + \frac{1 + r^f}{1 + r^d}\omega. \tag{14}$$

Equation (14) further illustrates that, in a world without a binding capital constraint ($\omega = 0$), there would be no spillovers of monetary policy and hence foreign lending would simply be pinned down by the foreign interest rate ($1{+}r^f$). The wedge ($\frac{1+r^f}{1+r^d}\omega$), which reflects cross-currency spillover of monetary policy, arises because the interest rate differential affects the opportunity cost of capital backing foreign lending. As long as foreign and domestic lending requires scarce equity capital, the interest rate differential change affects lending in *both* currencies. (The capital requirement on unhedged currency exposure is not necessary for foreign and domestic lending to become interlinked. We illustrate this point in the Internet Appendix.)[8]

Combining equations (12) and (14), it is easy to see that the bank chooses its lending portfolio in domestic and foreign currencies as a function of the interest rate differential,

$$g'(L^d) = \frac{1 + r^d}{1 + r^f} h'(L^f). \tag{15}$$

This equation highlights the central point of the paper: For a capital-constrained bank, the foreign and domestic lending decisions are connected.

To obtain predictions on banks' holdings of global reserves, we need to derive the equilibrium swap market volumes, which requires introducing a swap counterparty.[9] We assume that the bank's swap counterparty is a representative foreign institution that invests in foreign and domestic markets (e.g., large corporation or a pension fund). We assume that the payoff of a foreign investment is $g_I(.)\big(g_I{}' > 0, g''{}_I < 0\big)$. The investor also has access to domestic projects with payoff of $h_I(.)\big(h'{}_I > 0, h''{}_I < 0\big)$. Concavity of the payoff functions captures decreasing returns to scale.[10] The investor does not hold foreign or domestic reserves; this could be due to different liquidity needs or lack of access to reserve assets.

[8] The Internet Appendix may be found in the online version of this article.

[9] Conditions (1), (2), and (6) indicate that the bank's swap demand is infinitely elastic at the CIP forward premium. Thus, in an interior equilibrium with positive domestic and foreign reserve holdings, the global bank effectively acts as an arbitrageur in the market for reserves and the swap market. This is consistent with anecdotal evidence such as the BNP Paribas 2014 FX/XCCY Swap market overview available through the ECB. https://www.ecb.europa.eu/paym/groups/pdf/mmcg/20140909/item_4.pdf.

[10] This is in line with the assumption in Gabaix and Maggiori (2015) that financiers' cost of intermediation in the FX market is increasing in scale. In our setting, decreasing returns to scale implies a sloped swap supply curve, which ensures that the equilibrium swap volumes are pinned down (recall that the bank's swap demand is infinitely elastic).

The representative bank's counterparty in the FX swap market has a fixed amount of wealth, W.[11] As with the banks, the idea is that the institution's primary funding is denominated in domestic currency, but foreign investments are denominated in foreign currency. The focus of the paper is banks, so in what follows we continue to use the terms "foreign" and "domestic" from the bank's perspective. Thus, W is denominated in foreign currency (i.e., in the currency of the bank's counterparty). Similar to banks (but in the opposite direction), we assume that foreign institutions use the FX swap market to manage the currency mismatch when investing abroad.

The investor chooses swap volume S to maximize expected profits taking FX rates as given,

$$g_I\left(W-S\right)+\frac{h_I\left(SX^0\right)}{X^{Fwd}}.$$

The FOC implicitly defines the supply curve of foreign currency swaps,

$$-g_I{}'\left(W-S\right)+X^0\frac{h_I{}'\left(SX^0\right)}{X^{Fwd}}=0.$$

To obtain analytical solutions for the equilibrium swap quantity, we assume logarithmic return functions, $g_I(.)=\theta\log(.)$ and $h_I(.)=\log(.)$, with scaling factor $\theta>0$.[12] In this case, we can derive the counterparty's (inverse) swap supply function in closed form,

$$X^{Fwd}=\frac{W-S}{\theta S}. \tag{16}$$

To compute the equilibrium quantity in the swap market, for simplicity, we assume that there is a unit mass of N global banks and a unit mass of N foreign investors. Equating aggregate demand and supply gives the aggregate equilibrium swap amount,

$$\hat{S}=\frac{1+r^f}{1+r^f+\left(1+r^d\right)\theta}W, \tag{17}$$

which, assuming an equilibrium in which each bank demands the same swap amount, also equals each individual bank's and counterparty's swap volume, S.

[11] We assumed that the foreign investor is fully equity funded, which is consistent with the counterparty being a pension fund, insurance company, or mutual fund. In the Internet Appendix, we allow leverage and the investor's return function to depend on interest rates directly.

[12] Our focus is on situations in which foreign and domestic reserve holdings are nonzero, which is when bank's FX swap demand is perfectly elastic. Using a scale parameter θ ensures that an equilibrium exists in this region.

B. Partial Effects of Changes in Interest Rate Differential

We can obtain several partial derivatives that characterize the effect of a change in the interest rate differential between foreign and domestic markets, Δr, on the bank's portfolio choices. We focus on the case in which the bank is fully hedged, $U = 0$.[13] From equation (15), the capital constraint (8), and the logarithmic approximation $\log((1+r^d)/(1+r^f)) \approx r^d - r^f = -\Delta r$, we obtain $\log(h'(L^f)) = \log(g'(K/\alpha - X_0 L^f)) + \Delta r$. Therefore, foreign lending is an implicit function of the interest rate differential, the spot exchange rate, and capital. Using implicit differentiation, we obtain the partial derivative

$$\frac{\partial L^f}{\partial \Delta r} = \left(\frac{h''}{h'} + \frac{g''}{g'} X_0\right)^{-1} < 0. \tag{18}$$

Equation (18) implies that, the bank's foreign lending (expressed in foreign currency) is a decreasing function of the interest rate differential between foreign and domestic countries. For lending in the domestic currency, we obtain

$$\frac{\partial L^d}{\partial \Delta r} = -X_0 \frac{\partial L^f}{\partial \Delta r} > 0. \tag{19}$$

Equations (18) and (19) together indicate that lending in foreign currency decreases in response to a larger difference between the foreign and domestic interest rates, while lending in domestic currency increases. This means that an increase in the domestic rate—a tightening of domestic monetary policy—leads to an expansion in foreign lending and a contraction in domestic lending.

Using equation (17), it becomes clear that the equilibrium swap volume increases in Δr:

$$\frac{\partial S}{\partial \Delta r} = \frac{e^{\Delta r}\theta W}{(e^{\Delta r} + \theta)^2} > 0. \tag{20}$$

Using equation (9) and the response of the equilibrium swap amount in (20), it follows that foreign reserve holdings increase with the difference between the foreign and domestic interest rates paid on reserves,

$$\frac{\partial R^f}{\partial \Delta r} = \frac{1}{1+r^f}\left[\frac{\partial S}{\partial \Delta r} - h' \frac{\partial L^f}{\partial \Delta r}\right] > 0. \tag{21}$$

This increase in foreign reserve holdings comes from a higher swap amount in equilibrium and the cutback in foreign lending. In contrast, domestic reserve holdings decrease with the difference between the foreign and domestic

[13] The complementary slackness condition requires that $\gamma > 0$ if $U = 0$ and $\gamma = 0$ if $U > 0$. In the Internet Appendix, we discuss the case of unhedged currency exposure.

interest rates paid on reserves,

$$\frac{\partial R^d}{\partial \Delta r} = \frac{\partial D}{\partial \Delta r} - X^0 \frac{\partial L^f}{\partial \Delta r} - \frac{\partial L^d}{\partial \Delta r} - X^0 \frac{\partial R^f}{\partial \Delta r} < 0. \tag{22}$$

To highlight the economics behind these derivatives, consider the case in which domestic interest rates decrease (Δr increases). An increase in the interest rate differential would make lending abroad relatively less attractive. Given the capital constraint, this would lead to a contraction in lending in foreign currency, with the global bank's capital used to expand lending in domestic currency. In addition, for a global bank, a decrease in the domestic interest rate makes foreign reserves more attractive. In equilibrium, FX swap activity increases with an increase in foreign reserve holdings. Both effects—a contraction in lending in foreign currency and a shift into foreign reserve assets—happen absent any policy movement by the foreign central bank.

As discussed above, while an increase in foreign reserve holdings is a direct consequence of the higher interest rate differential, reduced lending in foreign currency results from the binding capital constraint. Absent the binding capital constraint, the bank would simply increase its domestic lending to equate the marginal return on its domestic lending to the lower domestic rate on reserves. However, under a binding capital constraint, the bank responds to a wider interest rate differential by reallocating capital from lending in foreign currency to lending in domestic currency. This rebalancing of the lending portfolio is also reflected in the share of foreign currency lending relative to total lending, which is decreasing in Δr, as $\partial(L^f/((L^f + L^d))/\partial \Delta r < 0$.

C. *Empirical Implications*

To test the theoretical predictions (partial effects), ideally we would measure the effect of changes in the interest rate differential on the global bank's cross-currency flows, net of other confounding effects. However, in the data, to isolate the direct effect of interest rate movements, we need to account for concurrent factors that are correlated with changes in interest rates. To understand the potential indirect effect of concurrent movements in the spot exchange rate (through the exchange rate channel of monetary policy), we use our economic model to derive the *total* effect of a change in the interest rate differential. The total derivative of foreign lending with respect to the interest rate differential is

$$\frac{dL^f}{d\Delta r} = \frac{\partial L^f}{\partial \Delta r} + \frac{\partial L^f}{\partial X_0}\frac{dX_0}{d\Delta r} + \frac{\partial L^f}{\partial K/\alpha}\frac{dK/\alpha}{d\Delta r},$$

which accounts for indirect effects of a change in the interest rate differential through changes in the spot rate ($dX_0/d\Delta r$) and capital ($dK/\alpha/d\Delta r$). Assuming that bank capital is not affected by changes in the interest rate differential—

that is, focusing on the exchange rate channel—we have[14]

$$\frac{dL^f}{d\Delta r} = \left(\frac{h''}{h'} + \frac{g''}{g'}X^0\right)^{-1}\left(1 - \frac{g''}{g'}L^f\frac{dX_0}{d\Delta r}\right) < \frac{\partial L^f}{\partial \Delta r} < 0,$$

under the condition that the spot rate increases (foreign currency appreciates) when the interest rate differential increases, $dX_0/d\Delta r > 0$. A large literature shows that this condition is typically borne out in the data (see Engel (2014) and the references therein). Thus, when we account for the appreciation of foreign currency, the withdrawal of foreign lending in response to an increase in the interest rate differential is accelerated. All else equal, foreign lending decreases when the foreign currency appreciates ($\partial L^f/\partial X_0 < 0$) because the bank's funding is domestic and hence its value in foreign currency shrinks.

Similarly, one can show that the total effects of other variables have the same sign as the partial effects: $dS/d\Delta r > 0,\ dR^f/d\Delta r > 0,\ dR^d/d\Delta r > 0,\ dL^d/d\Delta r > 0$. Moreover, we can derive predictions on the relative size of the total as compared to the partial effects. In particular, we can show that $dS/d\Delta r < \partial S/\partial \Delta r$ and $dR^f/d\Delta r < \partial R^f/\partial \Delta r$; that is, the total effect of a change in interest rate differential on swap activity and foreign reserve assets is smaller compared with the partial effect (because the stronger foreign currency makes foreign reserve holdings less profitable).

In the next sections, we test the model predictions in a linear regression framework. As discussed above, foreign lending—our main variable of interest—is an implicit function of the interest rate differential, the spot exchange rate, and capital. Assuming that the implicit function theorem applies, we can use a Taylor expansion to write L^f as

$$L^f\left(\Delta r, X_0, K/\alpha\right) = \text{constant} + \frac{\partial L^f}{\partial \Delta r}\Delta r + \frac{\partial L^f}{\partial X_0}X_0 + \frac{\partial L^f}{\partial\ K/\alpha}K/\alpha + \text{other terms.}$$

Thus, the economic model suggests that in our empirical tests we should control for the spot exchange rate as well as bank capitalization to recover the partial effects of the interest rate differential. Without controlling for the spot rate, the estimated coefficient on Δr corresponds to the total derivative, which is also economically interesting as it sheds light on the total effect. We therefore also we will report the total derivative throughout.

II. Data

In the empirical analysis, we obtain bank activity data from several sources, which provide information on different aspects of the mechanisms outlined in the previous section. First, to examine the connection between lending and reserve asset holdings, we use Call Reports, which include quarterly balance sheet data on global bank activity in the United States collected as part of bank supervision. The Call Reports also allow us to track the movement of

[14] For simplicity, we assume that FX exposure is fully hedged.

capital between the United States and foreign offices of global banks, which is the key element of their international operations. These data form the core of the analysis in Cetorelli and Goldberg (2012). We consolidate branch and subsidiary-level data at the parent level, so the unit of observation in these data is the bank-quarter.

We complement the aggregate analysis with data on FX swap volumes from the survey conducted by the Federal Reserve Bank of New York. The survey is administered twice a year and collects information on swap volume from individual currencies to U.S. dollars for the months of April and October for dealer banks and the nonfinancial sector. We focus on the former. The data are reported at the level of the currency pair. In addition, for the same sample as the survey data, we use forward premium for a one-year FX swap downloaded from Bloomberg.

The second source of aggregate data is BIS Locational Banking Statistics, which provides quarterly data on cross-border bank claims on private non-bank counterparties (firms), claims on the official sector (including the government and the central bank), and intragroup claims on related bank offices. One shortcoming of these data is that claims on firms include corporate bonds and other claims held by banks, and not just loans. The BIS data aggregate banks at the country level. However, unlike Call Reports, they provide information for a range of countries and they disaggregate holdings by currency denomination. Thus, the unit of observation for this data set is the country-currency-quarter.

Our third and most granular source of information on bank activity is Thompson Reuters DealScan database of global corporate loan issuance. This data set contains information on individual loan issuance and allows us to identify borrowers, borrowers' home country, lenders in the syndicate, and contractual details such as loan amount and currency denomination. The difference between DealScan coverage as compared to Call Reports or BIS data is that it primarily covers syndicated loans, that is loans funded by a group of lenders (under the same credit agreement). Thus, the loans covered in DealScan represent a subset of the activity captured in our aggregate data sources, in particular, they correspond to the largest loans. Based on the sample covered by the Shared National Credits (SNC) Program, in 2006, syndicated loan issues and syndicated loans in the United States amount to \$4.1 trillion and \$2.0 trillion, respectively, outstanding (i.e., drawn). This is comparable to the stock of commercial and industrial (C&I) loans held by the entire commercial banking sector. SNC estimates that about 45% of syndicated loan commitments were held by U.S. banks, and 34% by foreign banking institutions. Revolving lines tend to be funded primarily by banks. Thus, in 2016, as a lower bound, syndicated loans represented about 45% of all U.S. C&I lending activity. Overall, syndicated lending activity captures a substantial fraction of commercial credit.

Syndicated loans often have multiple facilities within the same loan. In our analysis, we look at total loan volume without distinguishing between the individual parts of a loan. In addition, we focus on top-tier lenders within a syndicate by excluding lenders marked as a "Participant," which typically comprise lenders with small financial commitments. Information on the share held by banks is scarce in the international sample, so when looking at individual bank lending volume, we prorate the loan amount among lenders in our sample.[15] As with the Call Report data, loans are aggregated at the lender-parent level. Our sample contains 166 global banks with foreign offices in at least one of the six currency areas. A complete list of the global banks included in the sample, as well as a list of the currency areas in which they have access to the monetary authority, is reported in the Internet Appendix.

Although BIS and DealScan data allow us to see the underlying currency of the transaction, all activity is reported in U.S. dollars. Therefore, movements in the dollar exchange rate (relative to the currency of the loan) could mechanically introduce variation in loan volumes. To ensure that we pick up variation in actual loan volumes and not just variation in dollar exchange rates, all specifications based on loan volume include controls for the exchange rate between the U.S. dollar and the currency of the loan. (The coefficient estimates are not reported in the tables.)

Throughout our analysis, the central explanatory variable is the difference in interest rates on reserve assets between two currency areas. As a benchmark, we look at the *IOER difference* ($\Delta r = r^f - r^d$), the difference between the interest rate paid on excess reserves in a given foreign currency and the interest rate paid on excess reserves in the domestic currency of the bank.[16] As in the model, "foreign currency" (investment currency) is defined relative to the bank's domestic currency (funding currency), which is the currency of the country in which the bank is headquartered. Unless stated otherwise, we focus on interest rates paid on excess reserves by central banks in six major currency areas—the United States, the Eurozone, the United Kingdom, Japan, Switzerland, and Canada—and global banks and borrowers headquartered in these markets. Table I presents changes in the IOER rates for the six major currencies from 2000 to 2016. For robustness, we report results based on the overnight interbank lending rate. All interest rate data come from Haver Analytics and are collected at a daily frequency (in the regressions, we take the quarterly average of the daily variables).

[15] All of the loans in our sample are syndicated. The exact share of the loan kept by the originating lenders is rarely reported, especially in the international sample. However, we know that there are three tiers of lenders in a syndicate, and we can detect the corresponding tier based on the title of the role receive in the syndicate: (i) originators/arrangers (tier 1), (ii) other anchor investors (e.g., "co-arrangers") (tier 2), and (iii) small investors (tier 3) that receive an undistinguished title "participant." (The titles are important, and thus reasonably accurate, because they are used to compute league tables.) We compute loan share by dividing the loan amount by the number of anchor lenders. Excluding tier 3 lenders from the sample helps reduce measurement bias.

[16] With large amounts of excess reserves, central banks operate under an effective floor system, where the interest rate paid on excess reserves is the main tool for controlling short-term interest rates in the market. We therefore use the IOER rate as our main policy variable, but we also show that our results are robust to using alternative monetary policy measures such as the overnight interbank rate.

Table I
Changes in Interest Rate Paid on Excess Reserves, 2000–2016

Date	US	EA	CA	GB	CH	JP	Date	US	EA	CA	GB	CH	JP	Date	US	EA	CA	GB	CH	JP
01/03/00	0.00	2.00	4.50	0.00	0.00	0.00	06/10/04	0.00	1.00	1.75	3.50	0.00	0.00	04/10/08	0.00	3.00	3.25	4.00	0.00	0.00
02/03/00	0.00	2.00	4.75	0.00	0.00	0.00	08/05/04	0.00	1.00	1.75	3.75	0.00	0.00	04/22/08	0.00	3.00	2.75	4.00	0.00	0.00
02/04/00	0.00	2.25	4.75	0.00	0.00	0.00	09/08/04	0.00	1.00	2.00	3.75	0.00	0.00	05/07/08	0.00	3.00	2.75	4.75	0.00	0.00
03/17/00	0.00	2.50	4.75	0.00	0.00	0.00	10/19/04	0.00	1.00	2.25	3.75	0.00	0.00	07/09/08	0.00	3.25	2.75	4.75	0.00	0.00
03/22/00	0.00	2.50	5.00	0.00	0.00	0.00	03/14/05	0.00	1.00	2.25	4.50	0.00	0.00	07/10/08	0.00	3.25	2.75	4.00	0.00	0.00
04/28/00	0.00	2.75	5.00	0.00	0.00	0.00	08/04/05	0.00	1.00	2.25	4.25	0.00	0.00	10/08/08	0.00	3.25	2.25	4.75	0.00	0.00
05/17/00	0.00	2.75	5.50	0.00	0.00	0.00	09/07/05	0.00	1.00	2.50	4.25	0.00	0.00	10/09/08	0.75	3.25	2.25	3.50	0.00	0.00
06/09/00	0.00	3.25	5.50	0.00	0.00	0.00	10/18/05	0.00	1.00	2.75	4.25	0.00	0.00	10/20/08	0.75	3.25	2.25	4.25	0.00	0.00
09/01/00	0.00	3.50	5.50	0.00	0.00	0.00	12/06/05	0.00	1.25	3.00	4.25	0.00	0.00	10/21/08	0.75	3.25	2.00	4.25	0.00	0.00
10/06/00	0.00	3.75	5.50	0.00	0.00	0.00	01/24/06	0.00	1.25	3.25	4.25	0.00	0.00	10/23/08	1.15	3.25	2.00	4.25	0.00	0.00
01/23/01	0.00	3.75	5.25	0.00	0.00	0.00	03/07/06	0.00	1.25	3.50	4.25	0.00	0.00	10/29/08	0.65	3.25	2.00	4.25	0.00	0.00
03/06/01	0.00	3.75	4.75	0.00	0.00	0.00	03/08/06	0.00	1.50	3.50	4.25	0.00	0.00	11/06/08	1.00	3.25	2.00	2.75	0.00	0.00
04/17/01	0.00	3.75	4.50	0.00	0.00	0.00	04/25/06	0.00	1.50	3.75	4.25	0.00	0.00	11/12/08	1.00	2.75	2.00	2.75	0.00	0.00
05/11/01	0.00	3.50	4.50	0.00	0.00	0.00	05/18/06	0.00	1.50	3.75	3.50	0.00	0.00	11/17/08	1.00	2.75	2.00	2.75	0.00	0.10
05/29/01	0.00	3.50	4.25	0.00	0.00	0.00	05/24/06	0.00	1.50	4.00	3.50	0.00	0.00	12/04/08	1.00	2.75	2.00	1.75	0.00	0.10
06/27/01	0.00	3.50	4.25	4.25	0.00	0.00	06/07/06	0.00	1.50	4.00	4.25	0.00	0.00	12/09/08	1.00	2.75	1.25	1.75	0.00	0.10
07/17/01	0.00	3.50	4.00	4.25	0.00	0.00	06/15/06	0.00	1.75	4.00	3.50	0.00	0.00	12/10/08	1.00	2.00	1.25	1.75	0.00	0.10
08/02/01	0.00	3.50	4.00	4.00	0.00	0.00	07/05/06	0.00	1.75	4.00	4.25	0.00	0.00	12/16/08	0.25	2.00	1.25	1.75	0.00	0.10
08/28/01	0.00	3.50	3.75	4.00	0.00	0.00	08/03/06	0.00	1.75	4.00	3.75	0.00	0.00	01/08/09	0.25	2.00	1.25	1.25	0.00	0.10
08/31/01	0.00	3.25	3.75	4.00	0.00	0.00	08/09/06	0.00	2.00	4.00	3.75	0.00	0.00	01/20/09	0.25	2.00	0.75	1.25	0.00	0.10
09/17/01	0.00	3.25	3.25	4.00	0.00	0.00	09/06/06	0.00	2.00	4.00	4.50	0.00	0.00	01/21/09	0.25	1.00	0.75	1.25	0.00	0.10

(*Continued*)

Table I—*Continued*

Date	US	EA	CA	GB	CH	JP	Date	US	EA	CA	GB	CH	JP	Date	US	EA	CA	GB	CH	JP
09/18/01	0.00	2.75	3.25	3.75	0.00	0.00	10/11/06	0.00	2.25	4.00	3.75	0.00	0.00	02/05/09	0.25	1.00	0.75	0.75	0.00	0.10
10/04/01	0.00	2.75	3.25	3.50	0.00	0.00	11/08/06	0.00	2.25	4.00	4.50	0.00	0.00	03/03/09	0.25	1.00	0.25	0.75	0.00	0.10
10/23/01	0.00	2.75	2.50	3.50	0.00	0.00	11/09/06	0.00	2.25	4.00	4.00	0.00	0.00	03/05/09	0.25	1.00	0.25	0.50	0.00	0.10
11/08/01	0.00	2.75	2.50	3.00	0.00	0.00	12/06/06	0.00	2.25	4.00	4.75	0.00	0.00	03/11/09	0.25	0.50	0.25	0.50	0.00	0.10
11/09/01	0.00	2.25	2.50	3.00	0.00	0.00	12/13/06	0.00	2.50	4.00	4.00	0.00	0.00	04/08/09	0.25	0.25	0.25	0.50	0.00	0.10
11/27/01	0.00	2.25	2.00	3.00	0.00	0.00	01/10/07	0.00	2.50	4.00	4.75	0.00	0.00	07/20/10	0.25	0.25	0.50	0.50	0.00	0.10
01/15/02	0.00	2.25	1.75	3.00	0.00	0.00	01/11/07	0.00	2.50	4.00	4.25	0.00	0.00	09/08/10	0.25	0.25	0.75	0.50	0.00	0.10
06/04/02	0.00	2.25	2.25	3.00	0.00	0.00	02/07/07	0.00	2.50	4.00	5.00	0.00	0.00	04/13/11	0.25	0.50	0.75	0.50	0.00	0.10
12/06/02	0.00	1.75	2.50	3.00	0.00	0.00	03/14/07	0.00	2.75	4.00	4.25	0.00	0.00	07/13/11	0.25	0.75	0.75	0.50	0.00	0.10
02/06/03	0.00	1.75	2.50	2.75	0.00	0.00	04/04/07	0.00	2.75	4.00	5.00	0.00	0.00	07/11/12	0.25	0.00	0.75	0.50	0.00	0.10
03/04/03	0.00	1.75	2.75	2.75	0.00	0.00	05/10/07	0.00	2.75	4.00	4.50	0.00	0.00	06/11/14	0.25	−0.10	0.75	0.50	0.00	0.10
03/07/03	0.00	1.50	2.75	2.75	0.00	0.00	06/06/07	0.00	2.75	4.00	5.25	0.00	0.00	09/10/14	0.25	−0.20	0.75	0.50	0.00	0.10
04/15/03	0.00	1.50	3.00	2.75	0.00	0.00	06/13/07	0.00	3.00	4.00	4.50	0.00	0.00	01/21/15	0.25	−0.20	0.50	0.50	0.00	0.10
06/06/03	0.00	1.00	3.00	2.75	0.00	0.00	07/04/07	0.00	3.00	4.00	5.25	0.00	0.00	01/22/15	0.25	−0.20	0.50	0.50	−0.75	0.10
07/10/03	0.00	1.00	3.00	2.50	0.00	0.00	07/05/07	0.00	3.00	4.00	4.75	0.00	0.00	07/15/15	0.25	−0.20	0.25	0.50	−0.75	0.10
07/15/03	0.00	1.00	2.75	2.50	0.00	0.00	07/10/07	0.00	3.00	4.25	4.75	0.00	0.00	12/09/15	0.25	−0.30	0.25	0.50	−0.75	0.10
09/03/03	0.00	1.00	2.50	2.50	0.00	0.00	08/01/07	0.00	3.00	4.25	5.50	0.00	0.00	12/17/15	0.50	−0.30	0.25	0.50	−0.75	0.10
11/06/03	0.00	1.00	2.50	2.75	0.00	0.00	12/05/07	0.00	3.00	4.00	5.50	0.00	0.00	02/16/16	0.50	−0.30	0.25	0.50	−0.75	−0.10
01/20/04	0.00	1.00	2.25	2.75	0.00	0.00	01/22/08	0.00	3.00	3.75	4.50	0.00	0.00	03/16/16	0.50	−0.40	0.25	0.50	−0.75	−0.10
02/05/04	0.00	1.00	2.25	3.00	0.00	0.00	02/06/08	0.00	3.00	3.75	5.25	0.00	0.00	08/04/16	0.50	−0.40	0.25	0.25	−0.75	−0.10
03/02/04	0.00	1.00	2.00	3.00	0.00	0.00	02/07/08	0.00	3.00	3.75	4.25	0.00	0.00	12/15/16	0.75	−0.40	0.25	0.25	−0.75	−0.10
04/13/04	0.00	1.00	1.75	3.00	0.00	0.00	03/04/08	0.00	3.00	3.25	4.25	0.00	0.00							
05/06/04	0.00	1.00	1.75	3.25	0.00	0.00	03/05/08	0.00	3.00	3.25	5.00	0.00	0.00							

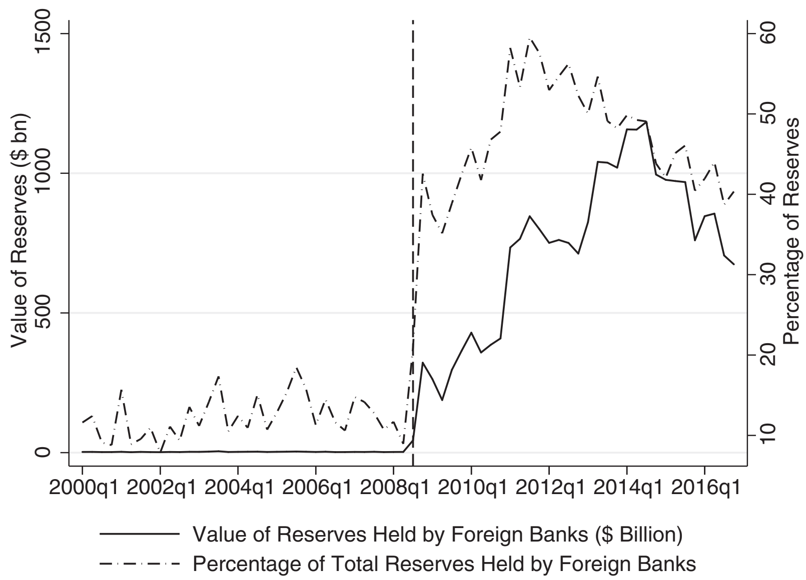

Figure 1. Foreign banks' reserve holdings at the Federal Reserve. The solid line shows the deposits (in billions of USD) held by foreign banks at U.S. Federal Reserve banks for the period from 2000:Q1 to 2016:Q4. The dashed line (secondary axis) shows foreign holdings as a percentage of total reserves. The vertical dashed line indicates 2008:Q4, when the Federal Reserve started paying interest on reserves held against deposits.

Finally, when using Call Reports (U.S. only), we focus on the period 2008:Q3 through 2016:Q4, a period during which excess reserves in the system were abundant.[17] For the rest of our analysis, we use data for the period 2000:Q1 through 2016:Q4.

III. Empirical Results

A. Aggregate Evidence: United States

Due to data availability, the analysis of foreign banks' reserve holdings is constrained to deposits at the Federal Reserve as reported in the quarterly Call Reports. Using these data, we find that the introduction of the interest rate paid on excess reserves in the United States led to a large increase in foreign banks' deposits at the U.S. central banking system. As Figure 1 shows, at its highest point, foreign banks' reserve holdings were USD 1.2 trillion. While the large increase in the value of reserve holdings is also related to the increase in reserve supply through the Fed's unconventional monetary policy, we also find

[17] The Fed started paying interest on reserves in October 2008 to have an additional policy tool to stabilize short-term interest rates given the large supply of reserves. See https://www.federalreserve.gov/monetarypolicy/20081006a.htm.

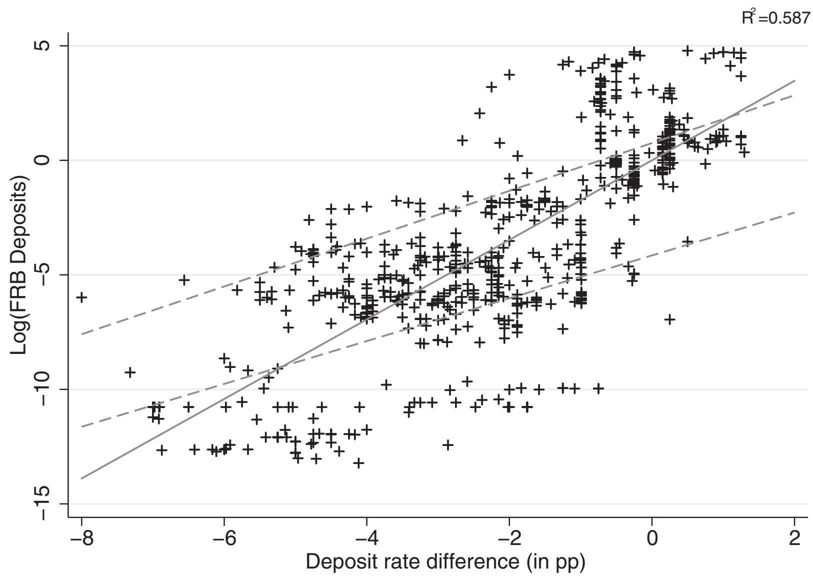

Figure 2. IOER differential and foreign banks' reserve holdings at the Federal Reserve. Log(*FRB Deposits*) is the (logarithm of) a foreign bank's deposits held at the Federal Reserve. *Deposit Rate Difference* is the difference in the interest paid on reserves in the United States and the foreign bank's home country. Log(*FRB Deposits*) is adjusted for currency area fixed effects. That is, we first estimate the regression Log(*FRB Deposits*) $= \alpha + \beta$ *Deposit Rate Difference* + *Currency Area FE* + *residual*; we then plot (Log(*FRB Deposits*) − *Estimated Currency Area FE*) against the deposit rate difference. The sample covers reserve holdings by foreign banks from 16 currency areas from 2000:Q1 to 2016:Q4.

that the relative share of foreign banks' holdings increased to more than 50% of all reserves.[18]

However, an important cross-sectional heterogeneity in reserve holdings stands out: As Figure 2 illustrates, there is a strong positive correlation between the reserves held with the U.S. Federal Reserve Banks and the difference between the rates on reserves paid by the U.S. central bank and the foreign banks' domestic monetary authorities.

The vertical axis in Figure 2 is (the logarithm of) the deposits net of currency-area fixed effects held by foreign banking sectors at U.S. Federal Reserve Banks. The horizontal axis is Δr, the difference between the U.S. deposit rate and the deposit rate of the foreign-currency area. Each observation in Figure 2 corresponds to a foreign banking sector-quarter (e.g., the sum of Japanese

[18] As explained in McCauley and McGuire (2014), this specific episode was driven by changes in the assessment base of the Federal Deposit Insurance Corporation (FDIC) in 2011 that did not apply to a large set of foreign banks in the United States. Our focus is on the variation *within* foreign banks at a given point in time, and thus our results are not driven by this anomaly, as they hold (i) for different subperiods, (ii) in the cross-section, and (iii) for currencies other than U.S. dollars.

banks' deposits at the Federal Reserve Banks in a given quarter). For the analysis of the reserves, we were able to collect data for foreign banks from 16 currency areas for the period 2000:Q1 through 2016:Q4. To highlight the role of differences in the IOER rates of the U.S. and the foreign-currency area, we look at quarters with $\Delta r \neq 0$. The positive relation between the IOER rate difference and (the logarithm of) reserve holdings is remarkably strong, with a correlation of 0.80, highlighting that foreign banks that face a higher interest rate differential hold more dollar reserves at the Fed.

Column (1) of Table II, Panel A, relates to the point illustrated in Figure 2, but instead focuses on individual banks from the major currency areas.[19] The positive coefficient estimate on the IOER differential confirms that the positive relation between a bank's reserve holdings and the IOER rate differential continues to hold for this sample, and is robust to the inclusion of bank fixed effects and hence cannot be driven by compositional shifts in the bank sample. For example, bank fixed effects control for differences among foreign banks operating in the United States primarily through subsidiaries versus branches. Specification (2) includes quarter fixed effects and indicates that, for a cross-section of banks, a higher IOER rate difference between a foreign and a domestic country is associated with higher reserves in the foreign country. Quarter fixed effects net out common time-varying factors such as an increase in the total supply of reserves through the Fed's large-scale asset purchases or changes in the 2011 FDIC assessment base, which led to a surge in foreign banks' reserves held at the Federal Reserve. Based on our estimates, an increase in the IOER rate differential of 25 basis points increases the dollar deposits at the Federal Reserve by 15% (the coefficient estimate is marginally significant with a t-statistic of 1.68).

The estimated effects in column (2) correspond to a total effect that includes indirect effects on reserve holdings through concurrent movements in the spot exchange rate (see our theoretical discussion in Section II). To isolate the direct (partial) effect of a change in the IOER differential, in column (3) we include the spot exchange rate between the United States and the foreign country. Consistent with our theoretical prediction, the coefficient estimate increases and is significant at the 5% level, suggesting a 19% increase in reserve deposits per 25-basis-point increase in the IOER rate differential. Panel A shows similar results when using the overnight interest rate differential. (Unreported results based on the three-month interest rate differential confirm this finding.)

Policy rates could be endogenous to economic conditions, potentially raising concerns about a causal interpretation of the estimated effects. Therefore, in columns (4) and (5), we instrument the interest rate differentials with two different monetary policy shocks identified from high-frequency financial market

[19] In Table II, standard errors are clustered at the bank and quarter levels. When using multicurrency micro data, we cluster standard errors at the bank and currency*quarter levels. In the borrower-level analysis, we cluster at the bank*borrower and currency*quarter levels. This design choice reflects our view that investments are likely to be correlated both within bank-borrower and across banks for investments made in the same currency and quarter.

Table II

Reserve Assets and Bank Lending by Foreign Banks in the United States

The dependent variables are selected balance sheet positions of foreign branches and subsidiaries in the United States, consolidated at the bank-parent level. *Reserves* is the amount of reserves held at the Federal Reserve banks. *Treasuries* is the amount of U.S. Treasury debt securities. *C&I Loans* are commercial and industrial loans. *Loans and Leases* refers to total loans and leases. The independent variables of interest are difference (in percentage points) between the rate in the United States (r^{US}) and the equivalent rate of the country in which the bank is headquartered (r^d). *IOER* is the interest on excess reserves. *ON Rate* is the overnight interbank lending rate. As an example, specification (3) in Panel A corresponds to:

$$Log(Reserves)_{it} = D_i + D_t + \beta(r_t^{US} - r_t^d) + \delta FX\ Spot\ Rate_t^{d/US} + \epsilon_{it},$$

where D_i are bank fixed effects and D_t are quarter fixed effects. *FX Spot Rate* is the spot exchange rate between the United States and the country in which the bank is headquartered. Columns (4) and (5) show the results when the federal funds rate is instrumented with different monetary policy shocks; see the text for details. Robust t-statistics are in parentheses. Standard errors are two-way clustered at the bank and quarter level. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% level, respectively.

	(1)	(2)	(3)	(4) IV: Fed Funds	(5) IV: Policy News	(1)	(2)	(3)	(4) IV: Fed Funds	(5) IV: Policy News
	Panel A. Dependent Variable: Log(Reserves)					Panel B. Dependent Variable: Log(Treasuries)				
IOER Difference (pp)	1.230***	0.584	0.757**	1.909***	2.083***	1.029**	0.382	0.187	1.001***	0.698***
	(5.02)	(1.68)	(2.46)	(4.85)	(3.12)	(2.58)	(0.88)	(0.50)	(3.77)	(2.84)
R^2	0.753	0.787	0.789	0.751	0.766	0.796	0.814	0.818	0.796	0.854
ON Rate Difference (pp)	0.976***	0.425	0.597*	1.574***	1.758***	0.812**	0.281	0.091	0.805***	0.584***
	(4.10)	(1.11)	(1.72)	(4.67)	(2.85)	(2.49)	(0.63)	(0.23)	(3.93)	(2.86)
R^2	0.750	0.787	0.789	0.748	0.761	0.793	0.813	0.817	0.793	0.853
Observations	1,923	1,923	1,923	1,923	1,318	847	847	847	847	561
	Panel C. Dependent Variable: Log(C&I Loans)					Panel D. Dependent Variable: Log(Total Loans)				
IOER Difference (pp)	−0.065	−0.418**	−0.392**	−0.152*	−0.169*	−0.124	−0.462**	−0.411**	−0.165*	−0.207
	(−0.51)	(−2.26)	(−2.15)	(−1.80)	(−1.79)	(−1.20)	(−2.66)	(−2.65)	(−1.88)	(−1.70)
R^2	0.905	0.909	0.910	0.906	0.942	0.927	0.931	0.932	0.929	0.937
ON Rate Difference (pp)	−0.066	−0.435**	−0.415**	−0.124*	−0.142*	−0.108	−0.454***	−0.408***	−0.134*	−0.174
	(−0.63)	(−2.42)	(−2.24)	(−1.81)	(−1.77)	(−1.29)	(−3.04)	(−2.91)	(−1.89)	(−1.65)
R^2	0.905	0.910	0.910	0.906	0.942	0.927	0.932	0.932	0.929	0.937
Observations	1,836	1,836	1,836	1,836	1,270	1,892	1,892	1,892	1,892	1,309
Fixed Effects:										
Bank (D_i)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Quarter (D_t)	–	Yes	Yes	N/A	N/A	–	Yes	Yes	N/A	N/A
FX Spot Rate	–	–	Yes	Yes	Yes	–	–	Yes	Yes	Yes

data. First, we use surprise changes in the federal funds rate identified from fed funds future movements on Federal Open Market Committee (FOMC) announcement days (e.g., Bernanke and Kuttner (2005), Gürkaynak, Sack, and Swanson (2007)). Second, we use the monetary policy shock measure of Nakamura and Steinsson (2017), which incorporates other high-frequency asset price changes in a narrow 30-minute window around FOMC announcement.[20] Because movements in a tight time window around FOMC announcements are likely to be unrelated to changes in both U.S. and foreign economic conditions, these shocks qualify as exogenous instruments. In line with the rest of our data, we aggregate the monetary policy shocks to a quarterly frequency and use current and lagged values of these aggregated monetary policy shocks as instruments for the interest rate differential. (The Kleinbergen-Paap statistic suggests that these instruments are relevant with an LM statistic of 15.77 and p-value $< 1\%$ for the fed funds shocks, and an LM statistic of 14.83 and p-value $< 1\%$ for the Nakamura-Steinsson shocks.)

Results based on monetary policy shocks confirm that an increase in the IOER differential between the United States and abroad leads to a surge in foreign banks' reserve holdings. For example, the estimate in column (4) suggests that reserve holdings rise by about 48% in response to a 25-basis-point surprise increase in the interest rate differential (the standard deviation of the fed funds surprise is 9 basis points during our sample period). Similarly, in Panel B we find that foreign banks operating in the United States increase their holdings of U.S. Treasuries—another important class of reserve assets—if the interest rate differential between the Fed and the central bank in the foreign banks' home country increases. For example, in column (4), we estimate an increase in Treasury holdings of 25% per 25-basis-point surprise increase in the IOER rate differential. Results are quantitatively similar using the Nakamura-Steinsson shocks. Note that due to a lack of homogeneous monetary policy shock measures in a cross-country setting, in columns (4) and (5), we only identify movements in the interest rate differentials from surprise changes in U.S. monetary policy. This is different from our cross-sectional analysis in columns (2) and (3), where variation comes from differences in foreign interest rates within a given quarter, while U.S. conditions are absorbed in the time fixed effects.

In Panels C and D, we examine the extent to which foreign banks adjust their U.S. lending in response to changes in the IOER rate differential. In line with our predictions, we find that an increase in the difference in the interest rate on reserves is associated with a strong reduction in both C&I loans (to U.S. addressees) and total loans and leases. Consistent with our model prediction, we also find that partial effects (columns 3) are larger than total effects (columns 2), that is, when we do not control for simulations movement in the spot rate, the reduction in foreign lending in response to an increased interest rate differential is stronger. In column (3), we estimate that a 25-basis-points-higher

[20] Nakamura and Steinsson (2017) shocks come from Emi Nakamura's website and are available only until 2014:Q4.

interest rate differential is associated with a decrease in the dollar amount of C&I loans of about 10%, while the dollar amount of total loans and leases decreases by about 12%.[21] Results based on monetary policy shocks are qualitatively similar, albeit smaller (in absolute values) in magnitude. For example, in column (4), we find that C&I loans and total loans decrease by 3.75% and 4.13%, respectively. Recall again that monetary policy shocks are only available for the United States and do not take into account foreign monetary policy shocks. We should also point out that—while signs of the estimated coefficients are consistent across different specifications—the statistical significance is not stable in all cases.

In Table III, Panel A, we look at the funding side of the balance sheet. We use the Call Reports data to analyze internal capital flows between U.S. branches and the foreign offices of foreign global banks ("net due to" and "net due from"). To this end, for each bank-parent, we compute the net intragroup borrowing (from foreign offices outside of the United States) by adding up the "net due to" positions (borrowing) and subtracting the "net due from" positions (lending). Consistent with the theory of internal capital markets, we find that banks actively reallocate funds to smooth out local shocks, such as a monetary tightening in the United States. The coefficient estimate in column (3), which includes bank and quarter fixed effects as well as a control for the spot rate, indicates that U.S. branches of global banks that face a 25-basis-points-higher IOER rate differential increase their net borrowing from offices outside of the United States by about USD 2.1 billion. The result in column (4), the specification that instruments the interest rate differential with the surprise change in the federal funds rate target, shows a qualitatively similar estimate. Taken together, the results suggest a strong internal capital reallocation toward the U.S. offices of global banks in response to an increase in the interest rate differential between the United States and the country in which the bank is headquartered.[22]

In Table III, we also look at the volume and cost of FX swaps. The results in column (3) indicate that in response to a 25-basis-point increase in the IOER difference between the U.S. dollar and the foreign currency, the swap volume into U.S. dollars increases by about USD 5.5 billion. The results using federal funds rate surprises support this finding (column (4)). Results based on the policy news shock are smaller in value and not statistically significant (note the smaller sample). Along with the increase in the swap volume, we document in Panel C, column (3), an increase in the cost of swapping by 15.8 basis points,

[21] While we use the interest rate differential based on the IOER rate—the main monetary policy tool since 2008—as the benchmark case, Table II shows that the main results are robust to interest rate differentials based on the overnight interbank rate, which is closely linked to the IOER rate set by the central bank. Results on other short-term rates, such as three-month rates, are similar, but not shown to avoid cluttering.

[22] The estimated effects for reserve assets, lending, and internal capital reallocation of foreign banks in the United States are qualitatively similar, but significantly smaller, in the period before the United States introduced the interest on reserves policy in 2008:Q4 and abundant reserves were available in the system.

Table III

Internal Capital Reallocation by Foreign Banks in the U.S. and the Dollar FX Swap Market

The dependent variables in columns (1) to (4) are selected balance sheet positions of foreign branches and subsidiaries in the United States, consolidated at the bank-parent level. *Net Internal Borrowing* (in USD billion) is defined as internal borrowing ("net due to") minus internal lending ("net due from"). *USD FX Swaps* (in USD billion) refers to the amount of FX swaps from each foreign currency into USD. *USD Forward Premium* (in percentage points) is the forward premium for a one-year swap, that is, the total "cost" of an FX swap. The independent variables of interest are the difference (in percentage points) between the rate in the United States (r^{US}) and the equivalent rate of the country where the bank is headquartered (r^d). *IOER* is the interest on excess reserves. *ON Rate* is the overnight interbank lending rate. *FX Spot Rate* is the spot exchange rate between the U.S. and the foreign country/currency. The empirical specifications in Panel A are similar to those presented in Table II. In Panel B and C, due to the nature of the data, D_i refers to currency fixed effects and D_t to month fixed effects. Robust t-statistics are in parentheses. Standard errors are two-way clustered at the bank and quarter level (Panel A) or clustered at the month level (Panels B and C). ***, **, and * indicate statistical significance at the 1%, 5%, and 10% level, respectively.

	(1)	(2)	(3)	(4) IV: Fed Funds	(5) IV: Policy News
Panel A. Dependent Variable: Net Internal Borrowing					
IOER Difference (pp)	5.049***	9.204***	8.531***	3.201*	4.695
	(3.67)	(3.60)	(3.91)	(1.77)	(1.45)
R^2	0.623	0.657	0.658	0.623	0.543
ON Rate Difference (pp)	3.991***	8.493***	7.856***	2.578*	3.898
	(3.39)	(3.47)	(3.53)	(1.77)	(1.37)
R^2	0.621	0.657	0.658	0.621	0.540
Observations	1,990	1,990	1,990	1,990	1,360
Panel B. Dependent Variable: USD FX Swaps					
IOER Difference (pp)	22.924***	21.626***	21.882***	23.784*	2.833
	(5.75)	(5.52)	(6.28)	(1.90)	(0.17)
R^2	0.778	0.894	0.894	0.779	0.707
ON Rate Difference (pp)	23.815***	25.386***	25.788***	21.400*	0.878
	(5.68)	(5.33)	(5.98)	(1.92)	(0.06)
R^2	0.783	0.899	0.899	0.784	0.703
Observations	85	85	85	85	50
Panel C. Dependent Variable: USD Forward Premium					
IOER Difference (pp)	0.633**	0.638***	0.634***	0.353**	−0.208
	(2.16)	(6.11)	(6.36)	(2.13)	(−0.91)
R^2	0.661	0.904	0.905	0.633	0.478
ON Rate Difference (pp)	0.638**	0.728***	0.726***	0.310**	−0.185
	(2.32)	(8.04)	(8.22)	(2.09)	(−0.91)
R^2	0.683	0.937	0.937	0.638	0.474
Observations	85	85	85	85	50
Fixed Effects:					
Bank/Currency (D_i)	Yes	Yes	Yes	Yes	Yes
Quarter/Month (D_t)	–	Yes	Yes	N/A	N/A
FX Spot Rate	–	–	Yes	Yes	Yes

Table IV

Banks' Claims on Foreign Official Sector

This table presents the mean and standard deviation (in parentheses) of claims by different banking sectors on official sectors of the six major currency areas. Claims are expressed in billions of 2016:Q4 U.S. dollars. The sample period runs from 2005:Q1 through 2016:Q4. The data are compiled from BIS Consolidated Banking Statistics.

	Claims on the Official Sector of:					
Banks from:	US	EA	GB	JP	CH	CA
US	–	139.52	53.57	77.66	13.39	14.38
		(51.36)	(32.70)	(37.45)	(12.72)	(6.81)
EA	241.06	–	75.93	120.04	34.33	26.46
	(140.53)		(36.63)	(45.72)	(21.43)	(12.29)
GB	194.92	170.52	–	45.03	20.89	15.46
	(99.01)	(71.20)		(20.19)	(20.51)	(6.51)
JP	404.74	225.85	38.28	–	0.76	16.76
	(137.24)	(29.61)	(9.32)		(0.19)	(2.58)
CH	174.50	84.75	38.62	N/A	–	3.74
	(68.11)	(27.98)	(16.89)			(1.43)
CA	154.04	24.34	13.41	6.93	0.27	–
	(72.22)	(14.20)	(7.21)	(5.63)	(0.42)	

as measured by the one-year forward premium, but results are similar if we consider the forward premium at other maturities. Recall that the forward premium is the total "cost" of an FX swap (to facilitate the interpretation we have rescaled the forward premium such that a larger forward premium means that the swap becomes more expensive). As Table III shows, the results are robust to alternative measures of interest rate differentials.

B. Aggregate Evidence: Cross-Country Setting

We next show that differences in monetary policy rates impact global banks' portfolio allocations—in particular, credit supply to foreign firms, holdings of foreign reserve assets, and intragroup transfers—in a cross-country setting using BIS data.

Table IV reports the means and standard deviations of claims by different banking sectors on the official sectors of the six major currency areas. As one would expect, there are sizable holdings of claims by foreign banks on the official sector of the United States, with an average volume of USD 1.17 trillion during our sample period. However, Table IV illustrates that claims on the official sector of other currency areas also play an important economic role. For example, claims on the official sector of the Eurozone and Japan amount on average to USD 645 billion and USD 250 billion, respectively. The magnitudes of these holdings as well as the size of their variation suggest that holdings of foreign reserve assets are not exclusively a U.S. dollar phenomenon.

In Table V, we look at the relationship between interest rate differentials and banks' cross-border claims broken down by currency and sector. In columns

Table V

Cross-Border Claims and FX Swap Volumes by Banking Sector

FX Claims on Firms, *FX Claims on Official Sector*, and *FX Intragroup Claims* refer to cross-border claims denominated in foreign currency f by a banking sector headquartered in currency area d on either private nonbank entities, the foreign official sector (including central bank deposits and government debt holdings), and related offices, respectively. *FX Swap Volume* (in USD billions) of a banking sector in currency area d is computed as total assets minus total liabilities in each foreign currency f. *FX Forward Premium* is the one-year forward premium in percentage points. All data are quarterly. There are two specifications for each dependent variable. For example, specification (2) corresponds to

$$Log(FX\ Claims\ on\ Firms)_t{}^{fd} = D_d + D_f \times D_t + \beta(r_t^f - r_t^d) + \delta FX\ Spot\ Rate_t^{d/f} + \epsilon_t{}^{fd},$$

where D_d are fixed effects for the currency area of the banking sector, and $D_f \times D_t$ are currency interacted with quarter fixed effects. *FX Spot Rate* is the spot exchange rate between the foreign investment currency and the banking-sector currency. Columns (7) and (8) include Banking-Sector*Currency*Post-2012Q1 fixed effects (unreported) to account for a structural break (level shift) in some data series in 2012:Q2. The change in the number of observations is due to data availability. Robust t-statistics are in parentheses. Standard errors are clustered at the quarter*currency level. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% level, respectively.

	FX Claims on Firms		FX Claims on Official Sector		FX Intragroup Claims		FX Swapping Volume		FX Forward Premium	
Dependent Variable:	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
IOER Difference (pp)	−0.073***	−0.046**	0.536***	0.578***	0.048	0.076**	38.145***	38.836***	0.740***	0.720***
	(−3.27)	(−1.98)	(5.81)	(6.31)	(1.57)	(2.35)	(4.46)	(4.19)	(37.20)	(27.72)
R^2	0.934	0.939	0.820	0.825	0.898	0.900	0.987	0.987	0.952	0.954
ON Rate Difference (pp)	−0.132***	−0.102***	0.453***	0.488***	0.116***	0.171***	32.626***	34.011***	0.850***	0.841***
	(−4.02)	(−3.13)	(5.06)	(5.63)	(3.09)	(4.93)	(3.56)	(3.23)	(61.34)	(57.06)
R^2	0.935	0.940	0.816	0.821	0.899	0.901	0.986	0.986	0.981	0.982
Fixed Effects										
Banking Sector	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Currency*Quarter	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
FX Spot Rate	–	Yes	–	Yes	–	Yes	–	Yes	–	Yes
Observations	1,361	1,361	1,036	1,036	1,276	1,276	1,017	1,017	1,017	1,017

(1) and (2), we estimate the effect of the interest rate differential between the foreign-currency area and the domestic currency area on the domestic banking sector's foreign currency cross-border claims on foreign firms. In line with our previous findings for the United States, we find that banks from currency areas with a lower interest rate hold fewer claims against (nonbank) firms in the foreign currency area with a higher interest rate.[23] This result holds after controlling for currency-quarter fixed effects, that is, when we look at the variation of claims in a given foreign currency *within* the same quarter. Consistent with our theoretical prediction, column (1) shows that the total effect of an interest rate change is larger (in absolute value) than the direct (partial) effect shown in column (2), where we control for the spot exchange rate. In column (2), our estimates indicate that banks from a currency area with a 25-basis-points-lower IOER rate than the foreign-currency area hold 1.2% less in foreign currency claims on foreign firms (total effect in column (1) indicates a reduction of about 2%). The results based on the overnight rate difference are quantitatively larger.

In columns (3) and (4), we look at the claims of domestic banks on the foreign official sectors. Consistent with our model and our previous findings for foreign banks' reserve holdings at the Fed, we find that banks from currency areas that face a higher interest rate differential with respect to the foreign currency area of the counterparty hold more foreign currency claims on the foreign official sector, including the central bank and the government. Again, the total effects in column (3) are smaller than the direct effects in column (4). In column (4), we estimate that a 25-basis-point increase in the IOER rate difference increases the claims on the foreign official sector by about 14.4%. This result, like all results obtained using the BIS data, holds when we exclude U.S. dollar activity from the sample, which increases confidence that we are not measuring an effect that is specific to the U.S. dollar. Our finding is also again robust to using alternative interest rate differentials, for example, based on the overnight interbank lending rate.

In columns (5) and (6), we show that, consistent with our analysis of the U.S. Call Reports, global banks reallocate capital to high-interest-rate currencies within their global banking organization. Column (6) shows that a 25-basis-point increase in the IOER rate difference leads to a 1.9% increase in internal cross-border capital transfer into the foreign. Estimates based on the overnight rate differential suggests an increase of about 4%. As before, and consistent with our theoretical framework, we find that the direct (partial) effects are larger than the total effects.

We next analyze the role of FX swaps in funding assets denominated in foreign currency through synthetic funding. Following McGuire and von Peter (2012), we combine BIS Consolidated Banking Statistics and BIS Locational Banking Statistics to compute FX swap volumes for each currency as the

[23] In line with the analysis in Tables II and III, in this analysis we limit attention to claims on and by the United States from 2008:Q4 onward, when the Fed started paying interest on reserves. Results are similar, however, if we include them.

difference between total assets and total liabilities held in each foreign currency by the banking sector of each domestic currency area. These data are therefore at the banking-sector*currency*quarter level. For instance, we compute for all Eurozone banks the difference between their USD assets and their USD liabilities in a given quarter.[24]

Consistent with our theoretical prediction, columns (7) and (8) show an increase in the interest rate differential between the foreign currency and the home currency area of the banking sector leads to a higher FX swap volume into the high-yield, carry-trade currency. Our strongest result in column (8), where we include the spot exchange rate, indicates that a 25-basis-point increase in the interest rate differential increases FX swap volume by a sizable USD 9.7 billion. Total effects are somewhat smaller, in line with our model prediction. In columns (9) and (10), we show that the increase in banks' demand for FX swaps is accompanied by an increase in the forward premium. Specifically, we find that the one-year forward premium increases by about 18 basis points per 25-basis-point increase in the IOER differential. (Leaving aside the maturity mismatch, this finding shows that CIP roughly holds.) Results are qualitatively similar if we use the forward premium at other maturities. As before, we have rescaled the forward premium for ease of interpretation, such that a higher forward premium means that the swap becomes more expensive. All findings are robust to other measures of interest rate differentials, for example, the overnight rate differential presented in the bottom panel.

In line with the model's predictions, these results confirm that our findings for the United States hold in a cross-country setting: Domestic banks from currency areas with a lower interest rate (that is, a higher interest rate differential vis-à-vis the foreign currency area) increase their cross-border claims on the foreign official sector (central bank and government), move capital into the foreign currency, and reduce their cross-border credit to foreign firms.

Our key finding that cross-border lending decreases after an increase in the interest rate differential is also illustrated in Figure 3, which shows the quarterly change in claims on foreign firms by domestic banks in the periods surrounding an increase in the IOER rate difference between the currency area of the foreign firms and the currency area of the domestic banks. As the figure highlights, after an increase in the IOER rate difference, the mean cross-border credit growth declines 6 percentage points from the preshock level of 2% by, leading to a contraction of credit of 4%.

C. Micro Evidence on Monetary Policy and Foreign Lending Activities

To improve the identification of the impact of international monetary policy differences on global banks' lending activities in a cross-country setting, we

[24] We thank Swapan-Kumar Pradhan from BIS for pointing out that data on the currency breakdown of total assets and liabilities exhibit a structural break in 2012:Q2 for some reporting banking sectors and currencies. To account for the level shift, we include in our regressions in columns (7) and (8) include banking-sector*currency*post-2012:Q1 fixed effects, which allowi for a different intercept before and after 2012:Q2 for each banking-sector-currency pair.

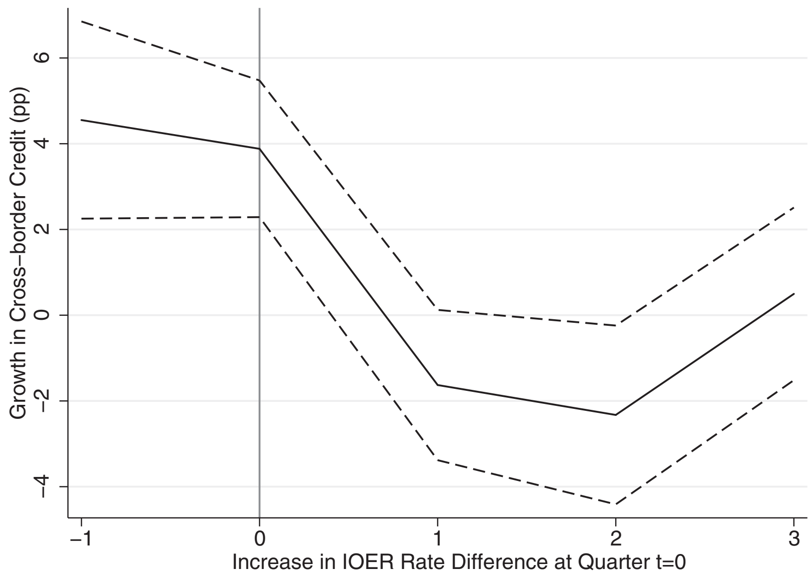

Figure 3. Cross-border credit after increase in IOER rate difference. *Growth in Cross-border Credit* is the percentage change in cross-border claims on private nonbank entities (firms). The sample covers the period from 2000:Q1 to 2016:Q4 and includes banks and nonbank firms from the United States, the Eurozone, the United Kingdom, Japan, Switzerland, and Canada. The solid line is the mean of the conditional distribution of *Growth in Cross-border Credit* (conditional on the time after an IOER rate differential increase), and the dashed lines indicate the conditional interquartile range.

next analyze DealScan loan issuance data. Loan-level data allow us to better control for confounding effects of loan demand, which is particularly important given that no homogeneous monetary policy shock series are available in a multi-country setting. Our main identification in this section is based on loan-level data together with borrower-quarter and bank-quarter fixed effects. In particular, following convention in the monetary policy transmission literature based on loan-level data (e.g., Jimenez et al. (2012)), we exploit within-borrower-quarter variation in foreign banks' commitments to control for loan demand, and within-bank-quarter loan volumes across currencies to control for general credit supply by individual banks.

C.1. Bank-Level Evidence

In Table VI, we look at the share of a bank's lending in a given foreign currency as a fraction of the sum of its lending in the domestic currency and its lending in the given foreign currency.

In terms of the notation used in the previous section, here we are looking at $L^f/(L^f + L^d)$. Hence, the regressions in Table VI are based on observations at the bank-currency-quarter level. For example, for a Japanese bank lending in

Table VI

Share of Foreign Currency Lending at Bank Level

The dependent variable is the share of lending (in percent) in a given foreign currency relative to the sum of lending in the domestic currency and the foreign currency. The unit of observation is bank i × foreign currency f × quarter t. *IOER Difference* is the difference (in percentage points) between the IOER rates in the foreign currency, r^f, and the rate of the currency of the country in which the bank is headquartered, r^d. Specification (1) corresponds to

$$L_{it}^{f}/(L_{it}^{f}+L_{it}^{d}) = D_i + D_t \ + \beta(r_t^f - r_t^d) + \delta FX\ Spot\ Rate_t^{d/f} + \varepsilon_{it}^{f},$$

where D_i and D_t are bank and quarter fixed effects. *Equity* is a bank's equity over total assets (in percent) measured as of the preceding quarter. *Dollar Lending* is a dummy variable that is equal to one for dollar lending and zero otherwise. *FX Spot Rate* is the spot exchange rate between the foreign lending currency and the lender-country currency. In addition, columns (1) through (5) include the dollar exchange rate (unreported) given that all loan volumes are expressed in U.S. dollars. The sample used in columns (5) and (10) includes only those observations in the period after a decrease in each bank's domestic IOER rate, that is, we look exclusively at the effects of monetary policy abroad. The independent variables in columns (2) and (7) are demeaned. Robust t-statistics are in parentheses. Standard errors are two-way clustered at the bank and quarter*currency level. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% level, respectively.

	Share of Foreign Currency Lending (Loan Volume)					Share of Foreign Currency Lending (Number of Loans)				
	All Markets			Foreign Market Spillover		All Markets			Foreign Market Spillover	
					Drop in r^d					Drop in r^d
Dependent Variable:	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
IOER Difference (pp)	−2.968***	−3.225***	−0.727**	−2.663***	−6.128***	−2.421***	−2.597***	−1.090***	−1.920***	−1.941*
	(−6.41)	(−5.07)	(−2.39)	(−5.91)	(−4.54)	(−6.07)	(−4.63)	(−3.39)	(−4.88)	(−1.70)
IOER Difference × Equity	–	0.505***	–	–	–	–	0.578***	–	–	–
		(3.24)					(4.03)			
Equity (% of Assets)	–	−0.859*	–	–	–	–	−0.110	–	–	–
		(-2.07)					(−0.26)			
IOER Difference × Dollar Lending	–	–	−1.483*	–	–	–	–	−1.195	–	–
			(−1.75)					(−1.49)		
Dollar Lending	–	–	23.594***	–	–	–	–	21.550***	–	–
			(10.68)					(10.30)		
Fixed Effects:										
Bank (D_i)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Quarter (D_t)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
FX Spot Rate	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	10,695	5,661	10,695	8,915	1,755	10,695	5,661	10,695	8,915	1,755
R^2	0.666	0.599	0.734	0.747	0.511	0.666	0.599	0.753	0.747	0.511

U.S. dollars, the dependent variable is lending in U.S. dollars as a fraction of the sum of lending in U.S. dollars and lending in yen. The explanatory variable in this case would be ($IOER^{USD} - IOER^{JPY}$). We analyze the share based on the volume of lending in columns (1) to (5), and the share based on the number of loans in columns (6) to (10). Given the focus on the cross-section, we include quarter fixed effects in all specifications. We also include bank fixed effects, which control for time-invariant differences in the cross-section of banks. Moreover, in all regressions we include the spot exchange rate between the bank's home currency area and the currency of lending to isolate the partial effect of a change in the interest rate differential.

Consistent with our hypothesis, we find that global banks lend less (more) in foreign currencies that are associated with a higher (lower) interest rate. The coefficients in Table VI, column (1) indicate that a 25-basis-point increase in the IOER rate difference is associated with a 0.74-percentage-point reduction in the lending volume share. The effect is economically significant: relative to the average lending share in foreign currencies of 41.1 percentage points, this implies a reduction of about 2%. The effect on the number of loans, reported in column (6), is equally sizable: global banks cut down the share of loans in a given currency by about 0.6 percentage points in response to an increase in the IOER rate differential of 25 basis points (or a decline of about 2% relative to the average share of 35 percentage points).[25]

In columns (2) and (7), we examine the effect of bank capital on the international monetary policy transmission mechanism through interest rate differentials. Our model predicts that the IOER rate difference has a stronger impact on the foreign lending of banks with lower capital. Indeed, for a bank that is not capital-unconstrained, our proposed channel does not bind and foreign lending does not depend on domestic monetary policy. In columns (2) and (7) we therefore include an interaction term between the variables *IOER difference* and *Equity*, defined as the bank's equity-to-assets ratio (in percent) in the previous reporting year.[26] In line with our model prediction, we find that the IOER rate difference has a larger effect on the foreign lending of banks with low capital. For example, in response to an increase in the IOER rate differential of 25 basis points, a bank with an equity ratio of 2.5 percentage points (one standard deviation) below the sample mean of 5.7% cuts down the share of lending in a given currency by an additional 39% (an additional reduction of 0.31 percentage points on top of the average reduction of 0.81 percentage points); see column (2). In contrast, the effect of the interest rate differential is significantly muted for banks with an equity ratio above the mean. Indeed, for a bank with an equity ratio two standard deviations above the mean, the IOER rate differential has no significant impact on its foreign lending.

[25] Our results are similar if we consider (the logarithm of) the amount of foreign lending in a given currency instead of the relative share of foreign lending.

[26] Due to data availability, we were not able to collect balance sheet information for all bank-quarters in the sample. We therefore have different number of observations in columns (1) and (2).

In columns (3) and (8), we show that the results are not driven by USD-denominated loans. To this end, we include an interaction term between the interest rate differential and a dummy variable that equals one if the lending currency is the U.S. dollar and zero otherwise. The coefficient on the interest rate differential thus measures the effect for all other currencies (excluding the U.S. dollar), while the coefficient on the interaction term measures the differential effect of the U.S. dollar relative to all other currencies. In columns (3) and (8), we find a significant negative coefficient estimate on the interest rate differential. Hence, the mechanism is not confined to the United States but rather is a broader phenomenon across major currency areas, although the economic effects are somewhat stronger for USD-denominated lending as indicated by the negative interaction term in column (3), which is significant at the 10% level.

We are ultimately interested in the monetary spillover to lending of global banks in foreign markets, rather than currencies. In columns (4), (5), (9), and (10), we condition our sample on borrowers headquartered in the foreign currency area (e.g., a U.S. firm borrowing in USD from a Japanese bank). This analysis therefore excludes lending in a foreign currency to borrowers in the same location as the bank (i.e., excluding USD lending to Japanese firms). We find that global banks also reduce their lending to foreign borrowers in response to a negative IOER rate difference. Economically, in column (4) we estimate that a 25-basis-point increase in *IOER difference* is associated with a 0.67-percentage-point decrease in the lending volume share. Relative to the average share of 37.23 percentage points, this is a reduction of about 2%. Column (7) points to a reduction of 1.8% (relative to the average share of 37.23 percentage points), due to an increase in the interest rate differential of 25 basis points.

Finally, in columns (5) and (10), we condition the sample on lending to foreign borrowers, but consider only those quarters after a change in the IOER rate difference triggered by a monetary policy change in the IOER rate paid in the domestic currency of the banks (e.g., a U.S. firm borrowing in USD from a Japanese bank after a monetary policy change in Japan). While this leads to a substantial decrease in the number of observations, the estimated coefficient on *IOER difference* remains negative and significant. In addition, as column (4) suggests, the economic magnitude of the estimated effect increases strongly, with a reduction in the lending volume share of 1.5 percentage points per 25-basis-point increase in the interest rate differential (which equals 4.5% when compared with the mean share of 33.21 percentage points).

C.2. Loan-Level Evidence: Foreign-Bank Lending

The results presented so far are consistent with the novel channel proposed in this paper, but they could also reflect a shift in demand for credit if investment opportunities of foreign borrowers are correlated with the monetary policy movements in banks' home countries. For example, if U.S. global banks tend to lend to foreign firms that export goods to the United States, improving macroeconomic conditions in the United States—and a subsequent rise in $IOER^{USD}$ (decrease in *IOER difference*)—would increase the investment opportunities of such foreign borrowers and lead to an expansion in foreign credit by U.S. banks.[27] Alternatively, to the degree that easing monetary policy (increase in *IOER difference*) is a response to a negative shock to the domestic banking sector, we would expect retrenchment of foreign lending activities similar to that shown in Peek and Rosengren (1997, 2000), and potentially substitution toward domestic lending as in Giannetti and Laeven (2012). To strengthen the identification of the proposed channel, we look at lending to individual borrowers (Table VIII) and at differential lending behavior of banks within a given loan (Table VII). This analysis addresses credit-demand concerns. Moreover, to separate our channel from other aggregate forces that might be at work, we also control for effects at the bank-quarter level, and focus exclusively on across-currency (and currency-zone) variation in a given bank's lending behavior within the same quarter.

In Table VII, the unit of observation is the borrower-lender-quarter. In the tightest specification, we control for time-varying, bank-specific characteristics by including bank-quarter fixed effects (D_{it}). These fixed effects are identified from different loan commitments in the same quarter by the same bank. In addition, we control for time-varying firm characteristics by including firm-quarter fixed effects (D_{jt}), that is, we compare the lending behavior in the same quarter to the same borrower across banks from different currency areas. Inclusion of these fixed effects is possible because loans are syndicated, and there are multiple lenders to the same firm in the same quarter.[28] Again, we look at two margins of credit: the probability of lending (extensive margin) and the volume of loan commitment (intensive margin). To estimate the effects on the extensive margin of credit (loan probability), we take any borrower-lender-currency combination for which we observe at least one loan in the sample and construct a dummy variable that is equal to one in quarters when the borrower-lender pair has a loan origination in the given currency and zero otherwise. For the intensive margin of credit, we consider (the logarithm of) the total volume of loans in a given currency provided by the lender to the borrower in the given quarter. As before, we focus on estimating the partial effect of an interest rate change and therefore include the spot exchange rate between the borrower and lender county in all specifications.

[27] Note that it would also increase investment opportunities of U.S. firms and thus the overall effect in this case is actually not clear.

[28] As background, this setting is comparable to analysis using credit registry data commonly employed in the empirical banking literature to identify credit supply effects. In both cases, the idea is to use within-borrower variation in behavior across creditors. While a credit registry has complete coverage of loans, it cannot be used in a cross-country setting. The additional advantage of the syndicated loan data is that we know for a fact that all banks in the syndicate receive exactly the same terms in and out of bankruptcy. Of course, this is still not a randomized setting, but, to the degree that there some remaining effects from borrower-lender selection remain, such borrower-lender matching would need to line up with the evolution of interest rate differentials.

Table VII

Loan Participation and Amount at the Borrower-Lender Level

The dependent variable in columns (1) though (4) is a dummy variable that is equal to one if borrower j obtains a loan in currency f (recall that d is the domestic currency of the lender) during quarter t from bank i, and zero otherwise. The dependent variable in columns (5) to (10) is the log of the amount of loans in currency f that borrower j obtains during quarter t from bank i. Lenders from the same currency area as the loan are excluded from the sample; for example, U.S. banks are excluded when looking at lending in U.S. dollars. As before, the central explanatory variable is *IOER Difference*, defined as the difference (in percentage points) between the IOER rates of the currency of lending, r^f, and the currency of the country in which the bank is headquartered, r^d. Specifications (4) and (8) include the tightest set of controls, corresponding to

$$I(Loan^f)_{jit} = D_{it} + D_{jt} + \beta(r_t^f - r_t^d) + \delta FX\ Spot\ Rate_t^{d/f} + \gamma Macro\ Controls_t^{d/f} + \varepsilon_{jit}^f,$$

where D_{it} are bank × quarter fixed effects and D_{jt} are borrower × quarter fixed effects. *FX Spot Rate Control* is the spot exchange rate between the foreign loan currency and the lender country currency. *Macro Controls* are the difference between the industrial production growth and CPI growth of the loan currency area, f, and the lender currency area, d. In addition, all regressions with volumes as the dependent variable include the dollar exchange rate (unreported) given that all loan volumes are expressed in U.S. dollars. Standard errors are two-way clustered at the borrower*lender and quarter*currency level. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% level, respectively.

	Probability of Getting a Loan (in%)				Log(Amount)			
Dependent Variable:	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
IOER Difference (pp)	−0.114***	−0.110***	−0.156*	−0.164*	−0.005**	−0.010**	−0.142*	−0.147*
	(−5.82)	(−5.38)	(−1.77)	(−1.82)	(−1.97)	(−2.20)	(−1.69)	(−1.73)
Fixed Effects:								
Bank (D_i)	Yes	Yes	–	–	Yes	Yes	–	–
Quarter (D_t)	Yes	Yes	–	–	Yes	Yes	–	–
Borrower (D_j)	Yes	Yes	–	–	Yes	Yes	–	–
Bank × Quarter (D_{it})	–	–	Yes	Yes	–	–	Yes	Yes
Borrower × Quarter (D_{jt})	–	–	Yes	Yes	–	–	Yes	Yes
FX Spot Rate	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Macro Controls	–	–	–	Yes	–	–	–	Yes
Observations	3,052,180	2,675,968	2,675,968	2,675,968	70,486	58,000	58,000	58,000
R^2	0.010	0.010	0.601	0.601	0.753	0.784	0.977	0.977

In Table VII, columns (1) through (4), we report results of linear probability models for the extensive margin of credit. We estimate linear probability models due to the presence of a large set of fixed effects. In column (1), where we control for borrower, lender, and time fixed effects, we find that a 25-basis-point increase in the IOER rate difference is associated with a 2.8-basis-point-lower probability of lending (1.2% decline relative to the mean lending probability of 2.5 %). In columns (2) through (4), we condition the sample to comply with the restrictions needed to identify the strongest set of fixed effects, that is, banks with multiple loans in foreign currency per quarter and borrowers with more than one top-tier lender in the lending syndicate.[29] While this changes the sample, the estimated effect does not change under the same set of fixed effects (column (2)).

In column (3), we add bank-quarter fixed effects, that is, we analyze within-bank variation in the same quarter. By analyzing within-bank variation, we control for any time-varying heterogeneity at the bank level, such as changes in domestic monetary policy, bank size, or bank health that might affect the bank's overall lending in a given quarter. In addition, we control for borrower-quarter fixed effects to control for time-varying borrower characteristics. Given that the vast majority of borrowers have only one loan per quarter, borrower-quarter fixed effects effectively resemble loan fixed effects. If a given firm's investment opportunities increase as a result of macroeconomic conditions in a foreign country, this should affect all senior secured lenders' willingness to lend (all first-lien lenders in the syndicate) and hence would not explain variation across lenders at the borrower level. Borrower-quarter fixed also control for other time-varying firm heterogeneity, such as differential loan demand by firms with currency imbalances on their balance sheets. With this strongest set of fixed effects, we estimate that a 25-basis-point increase in the interest rate differential leads to a reduction in the probability of lending of about 3.9 basis points (a decline of 1.6% relative to the sample mean). The result is also robust if we directly control for differences in macroeconomic conditions between the borrower and lender countries; see column (4), where we include the differences in industrial production (IP) growth and CPI growth between the borrower country and the bank country as additional variables.

In columns (5) through (8), we analyze the effect of the monetary policy differential on (the logarithm of) the loan amount provided at the borrower-lender level in a given currency in a given quarter. Again, we start by controlling for lender, borrower, and time fixed effects in column (5) for the full sample and then restrict the sample to comply with the identification of the fixed effects in columns (6) through (8). In all specifications and samples, we find that the IOER difference has a negative effect on the loan amount. This finding is robust to the inclusion of both lender-quarter fixed effects and borrower-quarter fixed effects, which represents our benchmark result (column (7)). The estimated economic effect in column (7) equals a reduction in the lending amount

[29] Circumstances in which the same borrower obtains more than one syndicated loan per quarter are rare. In such circumstances, we aggregate the loan volume.

of about 3.6% for a change in the IOER rate differential of 25 basis points. Once again, the lender-quarter and borrower-quarter fixed effects control for any observed and unobserved heterogeneity across lenders and borrowers. In particular, these fixed effects control for macroeconomic conditions in the borrower or lender country that may be correlated with the IOER rate difference and could also affect loan demand and supply. In column (8), we control directly for differences in macroeconomic conditions between the borrower and lender countries by using the differences in IP growth and CPI growth. Our finding is quantitatively robust to the inclusion of these additional macroeconomic controls.

C.3. Borrower-Level Evidence: Overall Effect

Previous results indicate a substantial contraction in credit from foreign banks in response to a decrease in the foreign IOER rate and/or an increase in a borrower's domestic IOER rate. We show that for a given borrower, lenders facing a higher IOER rate differential with respect to the currency of the loan are more likely to cut lending at the extensive margin (the decision to grant a loan) and reduce the loan amount for granted loans. However, it is plausible that borrowers substitute away to other lenders. To measure the potential substitution effect directly, we look in this section at whether banks' responses to monetary policy actually impair the funding conditions of firms.

To study the effects at the firm level, we compare the extensive and intensive margins of credit for a given firm after a monetary policy shock. For the extensive margin, for each firm-quarter borrowing in a given currency, we construct a dummy variable that equals one if the firm obtains a loan and zero otherwise. For the intensive margin, we construct the percentage change (first difference of the logarithm) of the amount of the loan in the quarter and the amount of the last loan in the same currency. We then estimate the probability of a loan and the change in the loan amount provided to a firm after a foreign monetary policy shock that increases the interest rate differential with respect to the currency of the loan. As a key explanatory variable of interest, we use the share of foreign global banks participating in the last loan prior to the change in monetary policy, *Past Foreign Bank Reliance*. We base the share only on those foreign banks that are subsequently subject to the monetary policy shock. For instance, if a U.S. firm borrowed a USD loan from two Eurozone banks and one Japanese bank, the variable *Past Foreign Bank Reliance* would take the value of one-third if the Bank of Japan lowered its interest rates and the ECB did not change its rate. If the ECB alone cut its rate, the variable would take the value of two-thirds. However, if both the ECB and the Bank of Japan lowered their IOER rates, *Past Foreign Bank Reliance* would take the value of one.[30] This variable captures the idea that if a given firm relies more on credit from foreign global banks that are subject to a foreign monetary policy change, then

[30] In the example, if the Fed increased the IOER rate, all three banks would be affected, as we are looking at U.S. dollar lending, and the variable *Past Foreign Bank Reliance* would again be equal to one.

Table VIII
Loan Issuance and Growth at the Firm Level after a Positive Shock to the IOER Rate Difference

The dependent variable in columns (1) to (3) is a dummy variable that is equal to one if borrower j obtains a loan in currency f after a positive shock to an IOER rate differential and zero otherwise. Note that the sample is *conditional* on changes in IOER for a given currency pairing. The IOER rate differential is defined as the difference between the IOER rates of the currency of lending abroad, r^f, and the currency of the country in which the bank is headquartered, r^d. The dependent variable in columns (4) to (6) is the change in the log amount of granted loans in currency f relative to the last loan in the same currency before the monetary shock. The central explanatory variable is *Past Foreign Bank Reliance*, the share of foreign banks from currency area d in the last lending syndicate to borrower j. For example, for an increase in $(r^{USD} - r^{JPY})$, we look only at the share of Japanese banks in the last dollar-denominated loan received by the same borrower. In columns (2) to (3) and (5) to (6), the sample is constrained to quarters in which the IOER difference increases due to a drop in r^d. Specifications (1) to (3) correspond to

$$I(Loan^f)_{jt} = D_j + D_t + \beta Past\ Foreign\ Bank\ Reliance^f_{jt} + \gamma Firm\ Controls_{jt} + \varepsilon^f_{jt},$$

where D_j are firm fixed effects and D_t are quarter fixed effects. *Time-Varying Firm Controls* include log total assets, return on assets, total debt over assets, and property, plant, and equipment over assets. In addition, all regressions with volumes as the dependent variable include the dollar exchange rate given that all loan volumes are expressed in U.S. dollars. Standard errors are two-way clustered at the firm and quarter*currency level. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% level, respectively.

	Probability of Getting a Loan			ΔLog(Amount)		
	All Markets	All Markets Shock to r^d	Foreign Market Shock to r^d	All Markets	All Markets Shock to r^d	Foreign Market Shock to r^d
Dependent Variable:	(1)	(2)	(3)	(4)	(5)	(6)
Past Foreign Bank Reliance	−0.023***	−0.022***	−0.026***	−0.251***	−0.339***	−0.304***
	(−4.32)	(−2.75)	(−3.13)	(−2.71)	(−3.12)	(−2.73)
Fixed Effects:						
Firm (D_j)	Yes	Yes	Yes	Yes	Yes	Yes
Quarter (D_t)	Yes	Yes	Yes	Yes	Yes	Yes
Firm Controls	Yes	Yes	Yes	Yes	Yes	Yes
Observations	217,173	178,658	169,011	10,772	9,554	9,326
R^2	0.056	0.061	0.062	0.145	0.152	0.149

after a decrease in foreign banks' domestic IOER rate (an increase in the IOER rate differential), these borrowers should experience a credit contraction.

The firm-level results are reported in Table VIII. In columns (1) to (3), we examine the probability of a loan during the same quarter as a positive shock to an IOER rate differential. In column (1), we find that the past share of global banks that lent to the firm has a negative effect on the probability of obtaining a loan after a positive monetary policy shock. As we observe such multiple shocks during our sample period, we also add firm and time fixed effects to control for unobserved factors that may be correlated with our variable of interest. Moreover, we include time-varying firm characteristics—total assets, return on assets, total debt (relative to assets), as well as property, plant, and equipment (relative to assets)—to account for time-varying firm heterogeneity. Compared with the mean loan probability of 3.65%, our coefficient estimate suggests that a one-standard-deviation (17.1-percentage-point) change in past foreign bank reliance corresponds to a relative change in the probability of a loan of 11%. Our results remain robust and economically similar in column (2), where we consider only periods where the IOER rate differential increase was triggered by a foreign central bank that cut its IOER rate (located in a currency area other than that of the firm). In column (3), we further restrict the sample to firms that are located in the currency area associated with the loan (e.g., U.S. firms borrowing in USD) and analyze how the foreign global bank share affects credit to those domestic firms after a foreign monetary policy change. Hence, in this specification, we precisely estimate the spillover of monetary policy shocks to other markets. A one-standard-deviation change in past foreign bank reliance corresponds to a change in the probability of a loan of 12% relative to the average loan probability.

In columns (4) to (6), we analyze the change in (the logarithm of) the amount of the loans granted in the quarter of an IOER rate shock, compared with (the logarithm of) the volume of the last loan of the same borrower before the shock. Again, all specifications include firm and time fixed effects as well as time-varying firm controls. In column (4), we find a negative effect of the past share of global banks after controlling for time and firm fixed effects. Economically, our estimate implies that a one-standard-deviation (18.1-percentage-point) larger past foreign bank reliance corresponds to a relative reduction in the loan amount of granted loans of 4.5%. This result is quantitatively robust if conditioned on periods after a positive IOER rate change that is triggered by a foreign monetary policy change (column (5)), and also if we additionally restrict the sample to those firms that are located in the currency area associated with the loan (e.g., U.S. firms borrowing in USD); see column (6).

IV. Conclusion

Multinational banks play a prominent role in economies around the world. Not surprisingly, a growing literature studies the cross-border propagation of different shocks through the balance sheets of global banks. In this paper, we study the role that global banks play in the cross-border effects of monetary policy. The existing academic and policy view postulates that easing (tightening) monetary policy in one country has positive (negative) spillovers on the global lending of multinational banks more broadly. For example, tightening monetary actions by the ECB would lead to a contraction in credit by Eurozone banks in Mexico (Morais et al. (2019)), but would also make these global banks' responses at home more muted (Cetorelli and Goldberg (2012)). In many respects, the mechanism affecting the transmission of the monetary policy shock in this setting is similar to the way in which large U.S. banks transmit shocks from one geographic region to another (see, e.g., Bord, Ivashina, and Taliaferro (2015)).

In this paper, we emphasize that a capital-constrained bank will need to consider the allocation of a fix amount of equity capital to back lending in multiple currencies. This links a global bank's lending decisions in different currencies, with the equilibrium lending portfolio composition depending on the opportunity cost of lending in each currency. Because monetary policy affects these opportunity costs by setting the interest rate on reserve assets, local policy rate changes will have international spillover effects to loan supply in other currencies. For example, domestic policy easing will lead to an increase in domestic lending at the expense of a reduction in foreign credit. Thus, the cross-border spillover effects of monetary policy go in the opposite direction than the channel postulated by the internal markets view.

We test our prediction in the context of changes in the IOER rate in six major currency areas between 2000 and 2016. We show that, for foreign banks, there is substantial cross-bank variation in their response to monetary policy—banks facing a larger IOER rate differential abroad (vis-à-vis their home country) tend to lend less abroad. This result holds within borrowers, and even within lending syndicates, across groups of banks from different currency areas. In aggregate, we show that borrowers exposed to this type of shock from foreign banks are less likely to receive a loan or, conditional on getting a loan, are more likely to receive a smaller loan, as compared with unaffectedxbrk borrowers.

Initial submission: March 2, 2018; Accepted: January 17, 2020
Editors: Stefan Nagel, Philip Bond, Amit Seru, and Wei Xiong

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Supporting Information

Additional Supporting Information may be found in the online version of this article at the publisher's website:

Appendix S1: Internet Appendix.
Replication Code.