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Hedger of Last Resort: Evidence from Brazilian FX Interventions, Local Credit, and Global Financial Cycles

RODRIGO BARBONE GONZALEZ, DMITRY KHAMETSHIN, JOSÉ-LUIS PEYDRÓ, and ANDREA POLO*

ABSTRACT

We show that FX interventions can be effective, particularly in attenuating global financial spillovers. We exploit global financial shocks and Brazilian central bank interventions in FX derivatives using three matched administrative registers: bank credit (to firms), foreign credit to banks, and employer-employees. After the U.S. Taper Tantrum (followed by emerging markets' FX turbulence), Brazilian banks with more foreign debt cut credit supply, reducing firm-level employment. A subsequent large policy intervention supplying derivatives against FX risks —*hedger of last*

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resort— halved the negative effects. A 2008 to 2015 panel exploiting global FX shocks and local FX interventions confirms the results and the hedging channel. However, the FX policy entails fiscal and moral hazard costs.

GLOBAL FINANCIAL SHOCKS, SUCH AS those resulting from U.S. dollar (USD) strength and U.S. monetary policy changes, affect local credit and economic conditions around the world, including foreign exchange (FX) markets (Rey (2013), Shin (2016), Jiang, Krishnamurthy, and Lustig (2021)). In response to such shocks, central banks often intervene in FX markets, despite the fact that the empirical evidence on the effectiveness of FX intervention remains limited (Maggiori (2022)). This may be unsurprising since dynamic macroeconomic models often predict that FX intervention should be irrelevant (for instance, Backus and Kehoe (1989)). However, recent theoretical literature, based on more realistic assumptions of financial market imperfections, shows that FX interventions can be effective (Gabaix and Maggiori (2015), Cavallino (2019), Amador et al. (2020), Davis, Devereux, and Yu (2020), Bianchi and Lorenzoni (2021), Fanelli and Straub (2021), Hassan, Mertens, and Zhang (2023)). Maggiori (2022) further stresses the similarity between quantitative easing (QE) and FX intervention, arguing that the aim of both tools is to transfer risk from the private sector to the central bank. Since a key mechanism is to transfer risk, FX intervention may be implemented with derivatives, instead of the traditional sterilized spot interventions.[1] The International Monetary Fund (IMF), which had traditionally discouraged FX interventions, has changed its policy stance based on the conceptual model of Basu et al. (2020), which includes FX intervention as a stabilization tool.

Our most important contribution to the literature is to show that FX interventions can be effective, in particular attenuating global financial spillovers on local corporate credit and real effects. Despite that central banks around the world have extensively used FX interventions, empirical evidence on their success has been weak (see, for instance, Chang (2018), Maggiori (2022)). Moreover, there has been scant evidence on how local policies in general—and FX interventions, in particular—diminish the negative spillovers of global financial shocks (Maggiori (2022), Miranda-Agrippino and Rey (2022)).

Specifically, we analyze whether central banks can successfully apply FX policies (providing FX insurance via FX derivatives) to reduce global financial spillovers on local corporate credit (including the associated real effects). Since softer local monetary policy in response to global financial tightening shocks has severe limitations, macroprudential and capital account measures have been advocated (Rey (2013), Blanchard (2016), Blanchard et al. (2017), Bianchi and Lorenzoni (2021), Maggiori (2022)). Importantly, given FX markets' reaction during the Taper Tantrum and Covid-19 pandemic, many central banks

[1] Interventions in derivatives markets are becoming more common among central banks. For a transfer of risk from the private to the public sector in other settings, see, for example, Tirole (2012).

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intervened in FX markets to provide the private sector with insurance against FX risks (Domanski, Kohlscheen, and Moreno (2016), International Monetary Fund (2020)). Recently, given the tightening of U.S. monetary policy due to inflation, FX interventions have again been advocated (Georgieva (2022), Gourinchas (2022)).

Brazil provides an excellent setting for investigating global financial spillovers in emerging markets and whether local FX interventions can attenuate these spillovers. In addition to having exceptional administrative microlevel data sets, Brazil is a large, representative emerging economy, it has been subject to large external shocks, and its local central bank—Banco Central do Brasil (BCB)—implemented a large intervention program in the FX derivatives market in August 2013 that has varied over time. The open positions of the BCB in these derivatives amounted to nearly 7% of Brazilian GDP (or 33% of its international reserves). Other emerging market central banks adopted similar programs in subsequent years, for example, Mexico in February 2017, Turkey in November 2017, Chile in November 2019, and several other countries during the Covid-19 pandemic (for instance, Colombia, Dominican Republic, Indonesia, and Mexico (International Monetary Fund (2020)). We construct our sample by matching three administrative registers: register of bank credit to firms from the BCB, the register of foreign credit flows to financial institutions domiciled in Brazil also from the BCB, and the employer-employee data set from the Ministry of Labor and Employment.

The first global shock we exploit was on May 22, 2013, when the Chairman of the U.S. Federal Reserve System, Ben Bernanke, raised the possibility of tapering its security purchases (i.e., QE) in his testimony before the Joint Economic Committee of the U.S. Congress. While unconventional expansionary monetary policies by the Federal Reserve were not expected to be permanent, the tapering speech did surprise the markets. Following this speech, currencies depreciated across emerging markets (for instance, Indonesia and Argentina experienced a 20% depreciation, Turkey 15%, Brazil 14%, India 12%, and South Africa 10% (Sahay et al. (2014)). The market reaction to Bernanke's speech became known as the Taper Tantrum.

In light of high FX volatility and depreciation of the Brazilian real (BRL), FX derivative markets became distressed. On August 22, 2013 the BCB responded by announcing a major program of FX intervention: for a one-year period, the central bank committed to daily sales of USD 500M worth of currency nondeliverable forwards (USD forwards settled in BRL, more widely known as "BCB swaps"). By committing to supply FX derivatives, the BCB provided the markets insurance against further depreciation of the BRL to satisfy excess demand for hedging instruments (BCB (2014)), thus acting as a *hedger of last resort*.[2] Unlike traditional FX interventions in the spot market, this type of intervention does not reduce the country's international reserves, but alters the

[2] This role is consistent with claims by the IMF and the BCB, among others. For example, International Monetary Fund (2015) states that "A FX swap program was put in place in August 2013 to mitigate financial risks arising from monetary policy normalization in the U.S. and has helped preserve financial stability by allowing economic agents to hedge their foreign exchange

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central bank's net FX position. The FX market welcomed the announcement of the BCB's FX program, which caused immediate appreciation of the BRL (see Chamon, Garcia, and Souza (2017)).

We analyze the supply of bank credit in Brazil and the associated real effects at the firm level. For the Taper Tantrum period, we exploit two consecutive events—the U.S. tapering speech and the announcement of the BCB intervention in the FX derivatives market. To verify external validity and robustness, we analyze the effects of quarterly changes in FX market conditions (FX level and volatility of Emerging Market Economies (EME) FX index with the USD) using a panel data set over 2008 to 2015 (at loan or firm level), controlling for other macro variables, both local (for instance, business cycle) and foreign (for instance, capital inflows). We also explore whether the global FX spillovers on local credit change after the BCB intervention via FX derivatives, controlling for other local macroprudential policies (including capital controls). The panel also allows us to exploit periods of mild and strong FX shocks, both before and after the Brazilian FX derivatives program.

For identification, we exploit global shocks, local FX interventions, specific conditions of the Brazilian market, and the granularity of our data sets. First, we analyze domestic banks, which cover most of the Brazilian credit market. Second, we analyze loans in BRL, which represent almost all of the loans extended by Brazilian domestic banks to local firms (less than 1% of the firms in the sample obtain loans indexed to USD, and the results are robust to including these loans). Third, because we have loan-level data from the Credit Registry, and we can follow Khwaja and Mian (2008), and control for firm-level changes in fundamentals (including credit demand) using firm-time fixed effects exploiting firms with at least two banks.[3] Fourth, we focus on changes in credit supply (due to global shocks and FX local programs) across banks with different ex ante foreign debt, as these banks should be differently affected by FX shocks and policies.[4] Finally, the employer-employee data set

positions." The BCB similarly states that "to provide currency hedge to economic agents and liquidity to the foreign exchange market, the Central Bank of Brazil (BCB) announced a program of exchange auctions in which it would conduct daily auctions of currency swaps" (see BCB (2014)). Tony Volpon, ex-deputy governor of the BCB, in explaining the mechanism behind the sale of the Domestic-Nondeliverable Forwards by the BCB, also reports that "The sale of forward FX by the BCB will compress forward points against spot. This will lower the cost of hedging" (see Garcia and Volpon (2014)). Note that the BCB intervened in FX derivatives in the past, but did not commit to a large program in terms of amount or duration.

[3] We exclude from the analysis two foreign banks (with a market share of around 13%) as these banks are likely to be affected by global shocks through different channels. The results continue to hold if we include these banks. Moreover, when we analyze data at the firm level (or the loan level for all firms, including firms with only one bank), we can control for firm-level credit demand by adding industry-location-time fixed effects. We also include the fixed effects estimated in the loan-level regressions as a proxy for time-varying firm demand shocks.

[4] Regarding observables, banks with different ex ante foreign funding are not differently exposed to different firm lending relationships (for instance, firm or loan risk) or bank characteristics (for instance, bank capital, liquidity, or risk). We control (in levels and interactions) for two significant bank variables associated with banks with larger foreign debt (bank size, and private vs.

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allows us to shed light on the real effects of both global financial shocks and FX intervention policies.

We find the following robust results. Exploiting loan-level data, and analyzing changes in lending to the same firm by banks with different levels of foreign debt, we find that after Bernanke's tapering speech, banks with larger ex ante foreign debt reduce credit supply to firms. Specifically, we find that a one-standard-deviation increase in banks' ex ante foreign debt leads to 2.2 percentage points (pp) lower quarterly credit growth. However, this relative reduction in credit supply is partially reversed following the FX intervention: the sensitivity of credit growth to foreign bank funding decreases by half in absolute terms after the BCB intervention. Importantly, placebo tests show that these effects are not present before the shock. The panel results additionally serve as a further placebo check since the panel covers quarters without significant FX shocks.

We further show that the tapering shock and the FX policy both have real effects. The loan-level results also hold at the firm level: firms more exposed ex ante to banks with more foreign debt experience a large reduction in credit after the tapering shock (1.8 pp) and a large partial reversal after the BCB policy intervention (half the size). Moreover, total employment at the firm level follows a similar pattern. After the Bernanke speech, firms more ex ante exposed to banks with more foreign debt reduce employment by 0.4 pp more, while the FX policy decreases by half the reduction in employment by firms more exposed to banks with larger FX debt. Furthermore, the margin of adjustment for employment is on less-tenured workers.

Analyzing the full panel with quarterly data from 2008 to 2015, we find that after EME FX depreciation, banks with larger ex ante foreign debt reduce the supply of credit to firms. We obtain similar results if, instead of the level of the FX rate, we use its volatility (quarterly changes in the level and in volatility of FX have a correlation of 0.8). To focus on global exogenous shocks and to avoid the endogenous effect of the BCB FX intervention on the BRL/USD exchange rate, instead of using the BRL/USD FX, we use an index of the EME currencies excluding Brazil against the USD.[5]

We also show that the effects of changes in the FX rate on the credit supply of banks with larger foreign debt are attenuated after the BCB intervention. Despite large fluctuations in the FX market, both before and after the BCB intervention, changes in global FX shocks after the local FX intervention affect

state-owned bank). Regarding unobservables, following Oster (2019) and Altonji, Elder, and Taber (2005), we find a stable estimate of the main effect accompanied by a very large increase in R^2 due to the inclusion of many observable variables and fixed effects. The evidence therefore suggests that omitted variable and self-selection problems (i.e., unobservables) do not drive our results.

[5] However, results stem from Brazilian FX changes, the correlation with the EME index is very high, and our results hold if we use the bilateral FX rate between Brazil and the United States. Our results also hold if we control for interactions against a set of macroeconomic variables including monetary policy in the United States, monetary policy in Brazil, VIX, economic activity, aggregate foreign debt flows to the Brazilian banking sector or the whole economy, and changes in capital controls and other macroprudential policies.

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credit supply or employment much less. The results therefore suggest that the policy of supplying FX derivatives mitigates global financial spillovers on EMEs.

We further investigate the mechanisms driving our results. Basel regulation imposes substantial bank capital requirements on unhedged FX exposures. Consistent with such requirements, we find that the credit supply effects are stronger for less-capitalized banks, and that the unhedged FX exposure is negligible, with the average bank in our Tapering sample having net FX exposure of only −0.2% of its total assets. Since banks comply with this prudential regulation, their net worth is not directly affected by changes in the FX rate. We find that external shocks to the FX market affect the availability and price of hedging,[6] and banks react by changing their credit supply. In particular, we show that banks hedge their FX liabilities primarily by rolling monthly forward contracts and futures, despite the average maturity of their foreign debt being much longer on average (see also Borio, McCauley, and McGuire (2017)). In normal times, large global banks and foreigners take net short FX positions satisfying hedging demand of domestic commercial banks. In fact, we find that before the Tapering episode, the net FX position of the foreign financial companies is on average negative. However, their net FX position is significantly positively correlated with FX rate volatility. This pattern is consistent with these regular suppliers of hedging instruments being less willing to take large short FX positions in times of FX market turbulence, thus decreasing the availability of hedging for local institutions. Indeed, after the jump in FX rate volatility following Bernanke' speech, we show that few (private) market participants were selling FX hedging instruments and taking short USD positions (i.e., exposing themselves to further risks of BRL depreciation, i.e., the net position of foreigners switching from negative to positive). Regarding the price of hedging, we find that after the Taper Tantrum, there is a strong increase in the deviation from covered interest parity (CIP). This reflects a positive relation between CIP deviations and FX volatility, which holds throughout our sample period. This is consistent with Borio et al. (2016), who show that the volatility of the FX market is associated with violations of CIP. Our results therefore suggest that during FX market turbulence, banks with a larger share of foreign debt are more constrained in rolling over their FX derivatives and thus cut credit supply.

An objection to the hedging channel could be that the local credit dynamics are driven exclusively by capital flows. To shed more light on this concern, we run several tests. First, we explore the register of foreign credit claims to Brazilian banks. We show that after the FX intervention, banks with more FX debt ex ante did not experience differential inflows of foreign funding.

[6] Newspaper articles often mention an increase in the cost of hedging after episodes of depreciation/increased volatility in the FX rate for emerging markets. Some examples from Brazil, China, and India: "Brazil Real hedging cost jumps as Latin American currencies sink" September 2016, Bloomberg, "Chinese companies that have borrowed heavily in dollars face sharply higher currency hedging costs at a time when the yuan's rising volatility means they need to hedge more" *Reuters*, January 2015, and "Hedging cost of domestic corporate houses have increased by 1-2 percent due to the ongoing rupee volatility" *Zeenews India*, June 2012.

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Moreover, when we analyze changes in FX hedging around the FX intervention, we find that banks with more FX debt ex ante significantly increase their FX hedging via instruments provided by the BCB, consistent with the hedging channel. Second, in our baseline specifications, estimated coefficients do not change if we exclude the maturing or shorter-term (up to 18 months) share of FX bank debt from our treatment variable. Using only the longer-term FX debt funds is equally representative of hedging demand (since hedging contracts are mostly monthly, all FX bank funding is equally affected), while capital flow stress should affect more short-term (rather than long-term) FX bank funding. Alternatively, we do not change the treatment variable but instead include controls for the FX debt maturity, which may capture more of the effect of the capital flows channel, and, again, our estimated coefficient does not change. Third, when we analyze the panel, we control for capital flows explicitly by including additional double and triple interactions with (lagged or/and contemporaneous) changes in aggregate external debt flows to the Brazilian banking sector or to the whole economy, considering both price and quantity dimensions. Our main coefficients of interest hold and do not decrease in size, which reassures us that our results are not driven by these changes in capital flows. Fourth, we show that, once the hedging policy is in place, shocks in FX of similar size (as before) matter less for credit supply and employment. In other words, our results suggest that the FX intervention attenuates the spillover of global FX shocks by guaranteeing the availability (and affordability) of hedging instruments. Finally, to further separate the capital inflow from the hedging channel, in the panel analysis we control for policy measures on capital inflows (including capital controls) that should directly affect capital flows, as compared to the FX intervention on hedging, which should affect the hedging channel to a greater extent. We show that our key coefficient of interest remains statistically and economically significant.

This strategy of acting as a *hedger of last resort*, which has been recently replicated by several countries, has some limitations. First, it works insofar as economic agents believe they can go from forwards to spot USD, that is, convertibility risk is negligible. This has not been an issue in Brazil because of its large international reserves. Second, the *hedger of last resort* policy, similar to the *lender of last resort* policy, can entail fiscal and moral hazard costs. Because the BCB provides insurance against depreciation of BRL, ex post depreciation leads to payments from the BCB to its counterparties, which affects the country's fiscal balance. At year-end, the BCB paid BRL 2.3B to the market in 2013, BRL 10.6B in 2014, and BRL 102B in 2015 (respectively, 0.05%, 0.19%, and 1.73% of GDP), but in 2016 and 2017, a large part of these losses was offset by the appreciation of the BRL. The second type of cost is associated with moral hazard, where the policy may incentivize fragile banks to take on more risks. To explore these potential costs, we reexamine our baseline results exploiting differential firm risk and bank capital. We find that less-capitalized banks (i.e., banks more prone to moral hazard problems; see, for instance, Holmstrom and Tirole (1997)) with more FX debt increase the supply of credit toward riskier borrowers more after the FX policy intervention.

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Contribution to the Literature. Our main contribution is to show that FX interventions can be effective, in particular, they can attenuate global financial shock spillovers to local credit markets and the economy. Despite central banks around the world extensively using FX interventions, empirical evidence on their success is limited (see, for instance, Chang (2018), Maggiori (2022)). Moreover, despite several papers showing how global financial shocks affect local credit markets, there is scant evidence on how local policies in general—and FX interventions in particular—reduce the negative spillovers (Maggiori (2022), Miranda-Agrippino and Rey (2022)).

A recent theoretical literature shows under which conditions FX interventions can be effective and can be used optimally (see, for instance, Gabaix and Maggiori (2015), Cavallino (2019), Amador et al. (2020), Davis, Devereux, and Yu (2020), Bianchi and Lorenzoni (2021), Fanelli and Straub (2021), Hassan, Mertens, and Zhang (2023)). Recently, international organizations that have traditionally discouraged these types of interventions have changed their policy stance. The IMF's current Integrated Policy Framework includes FX intervention as a stabilization tool. However, empirical evidence on the effectiveness of the FX intervention is limited (Maggiori (2022)). According to Chang (2018), "The dominant view from academia is that sterilized FX intervention has a tiny, if any, impact on real variables, which makes it virtually useless as an independent macroeconomic policy tool." The most recent evidence suggests that sterilized FX interventions in the spot market may have some effects in smoothing and stabilizing exchange rates (Blanchard, Adler, and de Carvalho Filho (2015), Chamon, Garcia, and Souza (2017), Fratzscher et al. (2019)) and on the provision of credit (Hofmann, Shin, and Villamizar-Villegas (2019)). In this paper, we show a potent channel of intervention in the derivative FX market. In particular, using micro administrative matched data sets and different shocks, we show that FX interventions can be effective, in particular, they can attenuate global financial spillovers on local corporate credit and real effects. FX intervention can therefore be successfully used as a policy tool—albeit with fiscal and moral hazard costs.

A substantial number of academic papers argue that global financial shocks affect countries around the world, including a large empirical literature on the bank lending channel associated with global financial conditions (see, for instance, Cetorelli and Goldberg (2011), Schnabl (2012), De Haas and Van Horen (2013), Kalemli-Ozcan, Papaioannou, and Perri (2013), Rey (2013), Paravisini et al. (2015), Shin (2016), Baskaya et al. (2017), Cerutti, Claessens, and Ratnovski (2017), Morais et al. (2019)). We corroborate these findings. However, none of these papers analyze how local policies, such as FX interventions, impact the spillovers of global financial shocks on local markets. We show that interventions in FX derivatives reduce the impact of global spillovers on local credit supply and the related real effects. In the model of Bruno and Shin (2015), who analyze the impact of changes in the FX rate considering the currency mismatch of nonfinancial firms, local banks do not play a significant role as they are assumed to be fully hedged. Despite being fully hedged and compliant with prudential bank capital regulation, episodes of local currency

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depreciation may still be relevant for credit markets of domestic banks in local currency. As we show in this paper, the short-term nature of the average hedging instruments used by commercial banks vis-á-vis the much longer maturities of their foreign debt can imply strong credit supply reductions that are partially mitigated by *hedger of last resort* policies.[7]

The paper proceeds as follows. Section I provides institutional details regarding the derivatives, FX interventions in Brazil, and the Tapering episode. Section II describes the matched data sets and the identification strategy. Section III presents the results. Finally, Section IV concludes.

I. Derivatives, FX Interventions, and Tapering in Brazil

Due to historical restrictions on buying USD in the Brazilian spot market, the country's FX derivative markets developed more and grew larger than the spot market. For example, FX price discovery takes place in the Brazilian derivatives market (Medeiros, Garcia, and Santos (2015)), and participants of the FX derivative markets in Brazil rely on option contracts, futures, forwards, and the on-shore dollar rate on Brazil's main exchange, which is also traded as a contract and known as "*Cupom Cambial*." In addition to these instruments, BCB swaps and comparable over-the-counter (OTC) forwards constitute the core of this market. All of these FX derivatives are settled in BRL.

The BRL emerged as the official Brazilian currency in 1994 as a currency pegged to the USD. Between 1994 and 1999, the BCB intervened in the derivative markets directly, buying or selling futures on the stock exchange, particularly in times of instability such as during the Asian and Russian crises. In 1999, Brazil adopted an inflation targeting regime and to increase transparency with respect to its role in the derivatives markets, the BCB developed its own instrument—"*swaps cambiais*"—that we refer to as BCB swaps, following convention among practitioners in Brazil. As detailed by Garcia and Volpon (2014), the product is technically a domestic nondeliverable forward settled in BRL.[8] BCB swaps are fungible and negotiated daily on the stock exchange, but only the BCB can issue the contract and call auctions on the primary market. There are no restrictions on taking part in the auctions, but financial institutions tend to absorb more than 70% of the volume on the primary market. BCB swaps are structured in such a way that the BCB pays its counterparties the

[7] Borio, McCauley, and McGuire (2017) claim that the practice of rolling short-term hedges "can generate or amplify funding and liquidity problems during times of stress."

[8] During times of market stress, central banks can establish swap lines against each other. The Fed, in particular, created swap lines designed to improve liquidity conditions in USD funding markets and support foreign central banks. In these cases, foreign central banks withdraw USD from the New York Fed (against their currencies) and return USD in the future at a fixed exchange rate, which alleviates pressure against their international reserves. Note that if these central banks want to transfer U.S. liquidity to local financial institutions, they would do so at their own risk using another transaction (for instance, a repo). Fed swap lines became available to the BCB on two occasions, namely, during the great financial crisis in 2007 and during the Covid-19 crisis in 2020, but the BCB did not fall short of reserves on these occasions.

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realized variation in the BRL/USD exchange rate when the BRL depreciates further against the USD, and receives analogous payments from its counterparties when the exchange rate moves in the opposite direction. In return for this swap of cash flows, the counterparties pay to the BCB the overnight money market rate net of an on-shore dollar rate. In other words, the BCB assumes a short position in USD and therefore incurs losses if the BRL depreciates (above the difference between the two interest rates) while it records gains if the BRL appreciates. The BCB can also take the opposite side, auctioning "reverse swaps" and drawing dollar liquidity from the derivatives market. Reverse swaps are also settled in BRL and do not change the level of international reserves, but they increase the BCB net FX position. Auctions of reverse swaps are not common but a few were put forward in 2011 and 2012. Notice that none of these interventions require sterilization since everything is settled in BRL.

The BCB interventions in the FX derivatives market target firms and financial intermediaries that demand FX instruments for hedging, not the market participants who use the currency for actual settlement. The former include institutions with needs to address their balance sheet exposures (for instance, banks that continually rollover foreign debt and related derivatives). "The Forex interventions are not meant to establish a floor for the exchange rate, but to provide the needed liquidity for the depreciation to take place without excess volatility and overshooting — which may entail unnecessary economic costs" (Garcia (2013)). These operations, as we show below, can occur when there is a strong depreciation shock and the private market does not work well. Hence, by supplying the markets with FX risk insurance, a central bank in effect acts as a hedger of last resort. Such intervention is consistent with its standard function as lender of last resort, whereby it aims to mitigate systemic risks by lending to the financial system in times of aggregate liquidity shocks. Both policies can be helpful but can entail fiscal costs for taxpayers (particularly during crises) and moral hazard costs by distorting incentives. In our analysis, we evaluate the policy's implications in terms of its effectiveness in protecting domestic credit markets from global financial shocks, and we assess its potential fiscal and moral hazard costs.

A. The Tapering Speech, the Dollar, and Derivatives' Market

In May 2013, after a prolonged period of (expansive) unconventional monetary policy in the United States, Federal Reserve chairman Ben Bernanke announced in his Congressional speech that the monetary authority was considering tapering QE (tightening) in light of a better economic outlook. This speech immediately triggered a roller-coaster effect in the United States and in global financial markets. In the following months, FX volatility in EMEs increased substantially, accompanied by steep local currency depreciation. Figure A.1 in the Appendix illustrates the macroeconomic conditions prevailing in Brazil during the analysis period.

The steep depreciation of the BRL and increased volatility had several implications for the derivatives market. The following analysis uses data from

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Brazilian clearings (including the Brazilian stock exchange, B3) on the *net* FX position in derivatives of different investor groups (for instance, foreign vs. local financial institutions). Due to data availability, we have information starting from January 2010. We find that before May 2013, large global banks and foreign firms took net short FX positions satisfying the hedging demand of domestic commercial banks. In fact, the net FX position of foreign financial companies was, on average, negative. However, the correlation between foreigners' net FX position and the FX rate volatility was significantly positive (the unconditional correlation is 0.40, increasing to 0.65 when we condition for interest rates in Brazil and the United States). This finding is consistent with the regular suppliers of hedging instruments being less willing to take large short FX positions when FX rate volatility increases. As we show in Figure A.1, Panel C, in the months before the Tapering episode, foreign financial intermediaries and, occasionally, domestic nonfinancial corporations were net providers of FX derivatives, and the market's buying side consisted of domestic financial institutions that took net long positions. This market was balanced almost entirely in the absence of BCB, and when the central bank did intervene, it did so with modest volumes. However, after the jump in the FX rate volatility that followed the Tapering speech, hardly any market participant was selling FX derivatives and taking short USD positions.

The CIP deviation just before the announcement of the FX intervention spiked and reached the level of 150 basis points (bps) (more than double the level of pre-Taper Tantrum normal times). In Table IA.IV, we confirm in a regression framework that after the Taper Tantrum, there is a significant increase in the CIP deviation. In column (1), we regress the CIP deviation on a dummy variable that takes the value of one after the Taper Tantrum speech. The average CIP deviation goes from 71 bps in the pre-Taper Tantrum period (coefficient on the constant in column (1)) to 97 bps in the post-Taper Tantrum period (the coefficient on the post-Taper Tantrum dummy is 26 bps), with an average increase in CIP deviation of 36% (26/71). This evidence is in line with evidence of Cerutti and Zhou (2024) showing that, in emerging markets, there is a significant increase in CIP deviations after the Taper Tantrum. In the remaining columns of Table IA.IV, we show that the result above reflects the positive relation between CIP deviations and FX volatility. In columns (2) and (3), we replace the post-Taper Tantrum dummy with the volatility of the bilateral BRL/USD FX (column (2)) or the volatility of the FX index with EME (column (3)). These two variables are highly statistically significant. Finally, in columns (4) and (5), we show that the positive relation between FX volatility and CIP deviations holds throughout our full sample period (2008 to 2015). This result is consistent with Borio et al. (2016), who show the implied volatility of the FX is associated with the CIP violations. The external shock to the FX market associated with the Taper Tantrum therefore affected the availability and price of hedging.

The BCB started to offer swaps immediately after the Tapering speech, and domestic banks were the main buyers. By the end of June 2013, the BCB also offered currency repo lines. However, uncertainty about interventions' volume

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and duration did not alleviate the distress in the FX markets, which forced the BCB to move from irregular injections of FX liquidity to announcing a regular program of daily auctions of BCB swaps in August.

B. The Intervention Program

On August 22, 2013, three months after Bernanke's Tapering speech, a formal program was announced whereby the BCB committed to daily swap sales of USD 500M from Monday to Thursday over the following year. The volume of swaps offered by the BCB after the announcement did not increase significantly (see Figure A.1, Panel C), but the announcement resolved the uncertainty regarding the provision of FX derivatives, which led to an appreciation of the BRL against the USD. Chamon, Garcia, and Souza (2017) adopt a synthetic control approach to prove the causal relationship between the FX interventions announcement by the BCB and the level and volatility of the exchange rate. Their counterfactual results, based on the exchange rates of other emerging markets, show that the August 22, 2013 announcement led to an appreciation of the BRL in excess of 10% and to a decline in the option-implied volatility. Before the FX intervention announcement, the BRL and its synthetic control have similar patterns, but they diverge sharply after August 22, 2013 and remain different for several weeks.

Later in 2013, depreciation resumed and, on December 18 the BCB announced the second round of interventions. In the second round, the BCB auctioned USD 200M in swaps daily and repo auctions by demand. The impact of this second announcement had more modest effects on the BRL (Chamon, Garcia, and Souza (2017)). In December 2014, the BCB announced auctions between USD 50M to 100M. The program effectively resumed on March 31, 2015 (BCB (2015)). In his testimony to the Senate on March 24, 2015, the Governor of the BCB, Alexandre Tombini, stated that "the swap program is an important instrument to smooth FX rate effects […] it allows the private sector to navigate in safety when the dollar spikes from [BRL] 2.85 to 3.20" (Portal Brasil (2015)). This intervention program in the FX derivatives market was the largest of its kind, reaching 7% of Brazilian GDP at its peak. During this intervention by the BCB, all private sectors stayed net long in USD making the central bank the hedger of last resort (Figure A.1, Panel C). In explaining the mechanism behind the BCB FX intervention Tony Volpon, ex-deputy governor of the BCB, stated that "the sale of forward FX by the BCB will compress forward points against spot. This will lower the cost of hedging" (Garcia and Volpon (2014)). Similarly, in the Country Report for Brazil of 2015, the IMF Executive Director claims that "A FX swap program was put in place in August 2013 to mitigate financial risks arising from monetary policy normalization in the U.S. and has helped preserve financial stability by allowing economic agents to hedge their foreign exchange positions."

How can the FX hedging policy affect local commercial banks? Prudential regulation in Brazil (stemming from Basel capital regulations) imposes

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additional charges on large unmatched FX exposures.[9] On-balance-sheet hedging (via foreign-denominated assets) is limited to a few Brazilian banks with off-shore operations. In addition, FX-denominated lending is limited to the trade sector and comprises a small part of the total assets of domestic commercial banks. As a result, banks hedge their foreign debt predominantly using off-balance-sheet (short-term) instruments. In particular, domestic commercial banks mostly use FX forwards and futures that they roll over every month. It is worth noting the large maturity mismatch between banks' foreign debt and the derivatives they use for balance sheet hedging (see Figure A.2 in the Appendix). In April 2013, almost 70% of the derivatives held by banks were due in less than 30 days, whereas 70% of their foreign debt was due in more than one year. With the announcement of the swap program on August 22, the BCB effectively promised to promote the supply of FX derivatives selling BCB swaps as much as needed. Relative to other sectors, domestic financial institutions used by far this central bank hedging facility.

The level of international reserves is considered an indicator of EMEs' economic health, and preserving reserves by deploying derivatives that settle in the local currency is at the heart of this policy. The BCB had large international reserves at the time of the Taper Tantrum. Technically, reserves represent a long FX position that insures the country against global shocks. During the intervention, the BCB shared a fraction of this FX exposure (up to one-third in notional value) via swaps with the markets. When the BCB sold the swaps, it reduced its net FX position (to two-thirds of international reserves). Yet this figure was large enough to mitigate market participants' concerns about convertibility risk. To a certain extent, the intervention policy was possible only because the high level of reserves assured all players that convertibility was not an issue (Garcia and Volpon (2014)).

II. Data and Identification Strategy

In this paper, we match three data sets: the credit register of corporate loans, a register of foreign debt claims against institutions domiciled in Brazil (both administered by the BCB), and the formal employment registry (from the Brazilian Ministry of Labor and Employment). In the Internet Appendix, we describe in detail the matching process as well as firm and bank financing in Brazil.[10] We augment these data with bank balance sheet and macroeconomic variables. Our final panel sample spans all calendar quarters from 2008 through the middle of 2015.

Financial regulation in Brazil instructs every financial institution to submit comprehensive information on each credit exposure larger than BRL

[9] At the time of the Taper Tantrum, the regulation in Brazil (Circular 3,389 of June 25, 2008 and Circular 3,568 of December 21, 2012) imposed punitive capital charges on FX exposures larger than a minimum value of regulatory capital. The same regulation waves unhedged positions of less than 2% of capital requirements and introduces progressively higher charges.

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

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5,000[11] (equivalent to 2,500 USD at the April 2013 exchange rate) to the Credit Registry of the BCB (*Sistema de Informações de Créditos*). These data contain detailed characteristics on the underlying credit contracts, including credit volumes (committed or drawn), interest rates, and maturity, as well as monthly information on each loan's performance matched by the borrower fiscal id. We further aggregate loan-level credit exposure at the firm-bank level to calculate total committed credit provided by each bank to each firm. We perform this aggregation at the bank holding company level to mitigate any concerns about credit supply dependence of banks within the same group.

The sample is constructed as follows. We first identify all firms that were recorded in the credit registry in at least one quarter during the sample period. From this group of firms, we randomly select 30% of the firms to form our initial sample. For this subset of firms, we gather information on their credit relationships with all banks during the sample period (loan-level data). The randomization is conducted at the firm level, not at the loan level, which implies that we randomly select firms and keep *all* loans of these selected firms with *all* banks.

Since we aim to control for unobservable credit demand shifts using a firm-time fixed effect estimator, we further restrict the sample to include firms with at least two bank lenders in a given quarter (85% of the total credit goes to firms with relationships with more than one bank). However, we also report results with all firms, including those with only one lender. Because we focus on credit supply in the local currency, we drop firm-bank observations with at least one loan indexed in currencies other than BRL. In our sample, as of the end of April 2013, fewer than 1% of firms have a liability indexed to a foreign currency.[12] We also exclude from the loan-level analysis nonprofit organizations and financial firms, as well as loans not originated by commercial banks. Importantly, we exclude from our baseline analysis credit claims of foreign banks. With the exception of two larger institutions, most foreign banks in Brazil are involved in investment banking rather than in commercial activity. As of the end of April 2013, the two largest foreign banks involved in commercial activity accounted for 13% of corporate credit in the economy. We focus on domestic commercial banks in the baseline sample because we want to identify the impact of global financial shocks and the effect of FX intervention via banks' foreign debt; results do not change, however, when we include the two large foreign banks.

Our main dependent loan-level variable is the growth rate of firm-bank credit exposures (in log terms) winsorized at the 1% and 99% percentiles. For robustness, we also adopt the Davis and Haltiwanger (1992) definition of growth rate, which includes both the intensive and extensive margins and is calculated as the net flow of credit provided by each bank to each firm over one

[11] This threshold was progressively reduced during our sample. We keep the BRL 5,000 threshold while constructing the full sample for consistency.

[12] This number corresponds to 0.2% in terms of number of loans, 2.6% in terms of the market value of corporate loans, and 0.7% in terms of the market value of bank assets in our sample.

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quarter relative to the average credit outstanding over the same period. We also analyze changes in loans at the firm level, with potential substitution at the firm level between different banks and sources of credit (including foreign banks, investment banks, and all remaining financial institutions).

We quantify our main bank treatment variable using data on banks' foreign debt. The original data on banks' foreign debt come from the BCB register of foreign claims (*Registro de Operaçôes Financeiras* (ROF)) and comprises contract-level data on bonds and loans issued by institutions domiciled in Brazil with the corresponding claims extended by identified foreign investors. We further recast the foreign debt variable in terms of BRL using end-of-quarter exchange rates. More than 93% of banks' foreign debt is nominated in USD. We calculate our main bank treatment variable, *Bank FX Debt*, as the ratio of total foreign claims to total liabilities at the end of each quarter. The foreign debt variable captures the exposure of each bank in our sample to time-varying FX (or global financial) risks. Part of these FX risks (stemming from a bank's foreign debt) may be offset using security holdings or credit claims denominated or indexed in the corresponding foreign currency, that is, using on-balance-sheet hedging. However, we find that Brazilian commercial banks have very small FX exposures on their asset side. As a consequence, most FX risks are indeed hedged using off-balance-sheet instruments, obtained in the derivatives markets. Hence, bank-level foreign debt is a good proxy for hedging demand.

We augment our database using the following bank observables: *Size* (log of bank assets), *Capital* (bank capital to total assets), *NPL* (share of nonperforming loans in a bank's credit portfolio), a *State Ownership* indicator, and the bank's *Exposure to Trade*. The latter controls for potential effects of terms of trade on a bank's balance sheet mediated via exporting and importing firms.[13] In addition, to capture compositional effects of foreign debt, we condition the estimates on the bank-level share of external debt structured as loans versus bonds (*FX Debt in Loans*), which also comes from the foreign claims registry. Finally, we account for a bank's unhedged net FX exposure (including all on- and off-balance-sheet FX exposures normalized by total assets).[14] Banks unhedged FX exposures are subject to strong capital requirements under Basel. Accordingly, we find that net FX exposures are close to zero, with the average bank having an FX exposure of −0.2% of total assets. Furthermore,

[13] Variation in the FX rate can affect these firms' net worth and impact the bank's overall credit supply, provided that the share of loans to these firms in its total portfolio is significant. *Exposure to Trade* is a time-varying bank variable calculated as the share of credit to net exporters minus the share of credit to net importers. A firm's net exports/imports are calculated for each quarter in the sample as the difference between its total exports and total imports over the preceding 12 months. Data on exports and imports come from *Sistema Cambio*, a special register for FX spot transactions. Firms in the trade sector, like any other firms, are required to file requests through *Sistema de Câmbio* in order to conduct FX transactions with the BCB or authorized FX dealers.

[14] The data come from *Demonstrativo de Risco de Mercado* (DRM), a regulatory form filed by all financial institutions in Brazil that provides details about underlying market risk factors to the BCB.

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at the firm-bank level, we control for the (log of) beginning-of-period credit exposure, the share of unused (undrawn) credit to total exposure, and a default indicator that captures bank-firm-specific determinants of the credit outcomes. We explicitly account for the maturity structure of the foreign bank debt by conditioning on the share of foreign debt with remaining maturity of less than one year or greater than three years (*FX Debt < 1y* and *FX Debt > 3y*). The inclusion of these controls alleviates concerns about the correlation of debt maturity with the level of foreign debt. Tables IA.II in the Internet Appendix reports summary statistics for the Tapering shock. The sample contains 46 banks (with nonzero credit claims on firms) just before the tapering shock. The average corporate loan is extended by a bank with 5% of foreign debt in its total liabilities. At the end of April 2013, 23% of this foreign debt was short-term and 56% were loans (rather than bonds issued by the bank).

Finally, we augment the data with information on firms' employment, from the employer-employee database of the Brazilian Ministry of Labor and Employment. The original data file collects information on each job spell defined by work start and end dates matched by employer-employee tax numbers. We calculate the stock of the active firm-level formal labor force as of the end of each quarter between April 2013 and April 2014. We use the (log of) the number of employees and their average (log) wage and tenure as of the end of April 2013 (Table IA.II).

We analyze the supply of credit by domestic banks in Brazil that differ in their ex ante reliance on foreign debt. First, we examine how banks with larger preshock FX debt react to the QE tapering shock (May 22, 2013). In particular, the dependent variable is credit growth at the bank-firm level over the April to July 2013 event window. A cross-sectional specification in first differences eliminates a time-invariant component of firm credit as well as macroeconomic effects common to all firms and banks. Because we can introduce firm fixed effects that absorb firm-level credit demand shifts, the coefficient on *Bank FX debt* is due to banks' supply decisions (Khwaja and Mian (2008)). We provide a placebo test by running the same specification in the same quarter of the Taper Tantrum but over the previous three years.

Note that before the Taper Tantrum, there is no systematic relationship between bank FX debt and a comprehensive set of firm and loan observables that capture different aspects of riskiness and size: unused credit line, bank share in firm credit, default indicator, log of total employment, average log tenure, average log wages, small firm and high interest rate firm indicators (see Table IA.V). We report average values computed by tercile of bank FX debt at the loan level. Following Imbens and Wooldridge (2009), we report (in parentheses) the normalized differences across pairs of averages: the difference between the tercile average and the average of the two other terciles, normalized by the square root of the sum of the corresponding variances. According to the rule of thumb proposed by Imbens and Wooldridge (2009) and Imbens and Rubin (2015), two variables are different when the normalized difference is greater than 0.25. In the context of lending relationships, we find that the characteristics of the firms to which banks with more FX debt lend

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are not different. Moreover, in Table IA.X we show that bank size and the state-owned indicator vary across banks with more versus less foreign bank debt (we control for these bank variables in interactions; see Section III).

To estimate the effect of the BCB FX intervention program, the regressions examine credit growth over the following quarter. To do so, we expand the data set such that each bank-firm pair contains two observations, one corresponding to the quarter around the Tapering shock (April 2013 to July 2013) and the other to quarter after the BCB interventions (July 2013 to October 2013). To trace the policy effect, we augment the explanatory variables with a dummy variable indicating the period after the policy announcement (the second quarter) and with the interaction between this indicator and bank FX debt. To allow for conservative inference, we calculate standard errors under two-way bank and industry clustering, with the latter defined by the first three digits of a firm's National Classification of Economic Activity (Classificação Nacional de Atividades Econômicas, CNAE) attribute.[15]

We complement loan-level regressions with regressions at the firm level where the dependent variable is the change in total credit. Moreover, we use the firm-employment growth rate (defined as the change in the number of employees over the average number of firm employees during the quarter) and the change in average tenure as dependent variables to trace the real effects of changes in credit supply. In these regressions, we cannot include firm-time fixed effects to control for demand, but we can include the fixed effects estimates in the loan-level analysis from the within-firm regressions as well as granular industry-location-time fixed effects. Nevertheless, as we discuss below, in the within-firm regressions, the coefficients do not change significantly across specifications with and without firm-time fixed effects (despite large changes in R^2), which suggests that further unobservables do not drive our results (Oster (2019)).

We next analyze the full panel. In particular, we examine whether outside the Tapering shock, banks with larger preshock foreign debt change their credit supply in response to global FX shocks, and if FX interventions by the central bank can attenuate these effects. To this end, we estimate a series of panel regressions at the firm-bank level where the dependent variable is credit growth and the key explanatory variable is the interaction between lagged bank foreign debt and lagged FX global shocks. The latter are the changes in the currency index of EMEs or their implied volatility.[16] We construct these EME FX indexes as the average of 20 local currency indices. To focus on global financial shocks, we do not include the BRL in the calculation of the EME FX

[15] The CNAE is the classification officially used by the Brazilian Statistics National System to classify industrial sectors. It closely resembles NAICS.

[16] We use option-implied volatility with at-the-money options (delta equal to 0.5). The implied three-month volatility Bloomberg code for Brazil-U.S. FX rate is usdbrlv3mcurncy. When we construct the FX volatility index, we calculate the average of the bilateral option implied volatilities for a list of countries.

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index. [17] We calculate quarterly index changes as the difference in the average log of its daily values (with positive differences indicating a strengthening of the USD), and changes in EME FX implied volatility are constructed similarly. As the recent literature documents a noticeable dependence of the local credit supply on the global financial cycle, in particular, on money market rates in the United States, we also consider changes in the Wu-Xia short shadow (federal funds) rate (Wu and Xia (2016)). The panel setup allows us to account for the effect of capital flows (the capital flow channel) by controlling for changes in the aggregate foreign debt of Brazilian banks (or the whole economy) and the cost of this foreign funding. Furthermore, we control for an index of macroprudential policies, some related to capital controls. The panel results also serve as a further placebo check since the panel covers quarters without significant FX shocks.

Finally, by adding a triple interaction between FX debt, changes in FX, and a central bank intervention variable, we analyze whether the impact of FX shocks is attenuated when the central bank intervenes. To capture interventions of the BCB in the derivatives markets, we use the ratio of the gross swaps position (notional value) of the BCB relative to its international reserves.[18] This measure ranges up to 30% by the end of our sample. It is also worth noting that before 2013, the BCB also issued reverse swaps, taking the opposite position of the one explored after the Tapering shock (i.e., drawing instead of introducing dollar liquidity in the derivatives markets), so the period during which the BCB used this instrument can be identified by negative values of the variable *FX Intv* (see also Figure A.1, Panel C). A higher positive level of the BCB interventions measure indicates the BCB's increasing role as a hedger of last resort. We can also analyze whether the central bank intervention can attenuate the impact of FX shocks on the Brazilian economy as there are large fluctuations in FX market conditions both before and after the BCB FX announcement.[19] Table IA.I in the Internet Appendix describes all variables used in the paper and Table IA.III presents summary statistics for the panel data.

III. Results

A. The QE Tapering Shock and the FX Intervention

Table I reports the baseline estimates of the credit supply dependence on foreign debt around the QE tapering shock (May 22, 2013).

The estimates in Table I consistently indicate that the ex ante dependence on foreign debt negatively affects credit supply in the aftermath of the

[17] Some of the currencies in our index are highly correlated with the BRL (see Figure A.3), which is crucial for identification as long as the BCB policies do not influence the FX between the United States and other EME, which is a mild assumption.

[18] Alternatively, in the Internet Appendix we use a dummy variable equal to one for the quarters following the policy announcement (2013Q3 onward).

[19] Before and after the FX announcement in Brazil, there are similar (strong) fluctuations in FX for both USD/BRL and USD/EME index.

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Table I
QE Tapering: Credit Supply, Firm-Bank Level

The table reports estimates of the equation

$$\Delta Credit_{f,b} = \beta_1 Bank\ FX\ Debt_b + \gamma X_{f,b} + \theta_f + e_{f,b},$$

where $\Delta Credit_{f,b}$ is log growth rate of credit provided to firm f by bank b, over one quarter after Tapering Speech (end of April '13–end of July '13), $Bank\ FX\ Debt_b$ is bank's ex ante share of foreign debt in its total liabilities, θ_f is firm fixed effect, and $X_{f,b}$ is a set of controls; all explanatory variables are measured as of the end of April '13. In column (7), credit growth rate is calculated as the net flow of credit provided by each bank to each firm during the quarter relative to the average credit over the period. Constant in column (1) is omitted. Weights in column (6) are proportional to (log of) firm employment. Standard errors (in parenthesis) are calculated under two-way clustering by bank and firm industry ($^{*}p < 0.1, ^{**}p < 0.05, ^{***}p < 0.01$).

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Bank FX Debt	−1.06***	−0.92***	−1.07***	−0.77***	−0.89***	−0.83***	−1.20***
	(0.26)	(0.20)	(0.19)	(0.22)	(0.24)	(0.27)	(0.41)
Loan-level controls:							
Unused Credit Line			0.16***	0.14***	0.13***	0.13***	−0.43***
			(0.01)	(0.01)	(0.01)	(0.01)	(0.02)
Default			−0.05***	−0.04***	−0.04***	−0.04***	−0.24***
			(0.01)	(0.01)	(0.01)	(0.01)	(0.02)
Bank Share			−0.03	−0.08***	−0.08***	−0.07***	−0.54***
			(0.02)	(0.02)	(0.02)	(0.02)	(0.04)
Bank-level controls:							
Size				0.03***	0.02***	0.02***	0.05***
				(0.00)	(0.00)	(0.00)	(0.01)
Capital				0.49**	0.46***	0.49***	1.33***
				(0.18)	(0.11)	(0.13)	(0.36)
NPL				0.13	−0.08	−0.17	−1.21***
				(0.17)	(0.10)	(0.12)	(0.26)
FX Debt in Loans				0.04***	0.08***	0.06***	0.15***
				(0.01)	(0.01)	(0.02)	(0.02)
State owned				0.03	0.00	0.01	0.03
				(0.02)	(0.02)	(0.02)	(0.04)
Exposure to Trade				0.16**	0.17***	0.16**	0.15
				(0.08)	(0.06)	(0.06)	(0.14)
Net FX Exposure				3.54**	1.16	1.46	3.17
				(1.44)	(1.00)	(1.16)	(3.10)
FX Debt < 1y					−0.17***	−0.16***	−0.50***
					(0.03)	(0.04)	(0.07)
FX Debt > 3y					0.03	0.02	−0.01
					(0.03)	(0.03)	(0.05)
Firm FE	no	yes	yes	yes	yes	yes	yes
WLS	no	no	no	no	no	yes	no
R^2	0.01	0.41	0.42	0.43	0.43	0.41	0.45
N	114,182	114,182	114,182	114,182	114,182	114,182	131,077

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tapering talk. The coefficient on foreign debt is negative and statistically different from zero at conventional levels. The estimated economic effect of a one-standard-deviation increase in foreign debt is a −2.2 pp change in quarterly credit growth. This estimate is robust to the inclusion of firm fixed effects (column (2)), which absorb approximately 60% in the variation of the dependent variable. In columns (3) to (5), we incrementally add control variables that can potentially influence credit outcomes. In column (3), we include loan-level controls (*Unused Credit Line*, *Default*, *Bank share of Firm Credit*), and in column (4) we also add bank-level controls (*Size*, *Capital*, *NPL*, *FX Debt in Loans*, *FX Debt < 1y*, *FX Debt > 3y*, *State owned*). In column (5) we further saturate the model with two additional bank-level variables: *Exposure to Trade* and *Net FX Exposure*. The coefficients on *Bank FX Debt* are statistically significant and quantitatively similar in all specifications. The stability of the coefficients accompanied by a large increase in R^2 due to the inclusion of control variables suggests that omitted variable and self-selection problems do not drive our results (Altonji, Elder, and Taber (2005), Oster (2019)). In column (6), we report weighted least squares (WLS) estimates of the model of column (5) to give more weight to larger firms, where we use the size of firm employment as weights. Finally, in column (7) we show that this result is robust to credit growth to including both the intensive and the extensive margin.[20] Moreover, we run placebo tests by reproducing column (5) of Table I changing the time period: we analyze the same quarter of the Taper Tantrum but during the previous years (2012, 2011, and 2010). In this placebo exercise, the coefficient on *Bank FX Debt* is not significant either economically or statistically (Table IA.VI).

While the baseline results suggest that banks' ex ante dependence on foreign debt negatively affects credit supply, a firm could offset this shock in part by replacing more affected banks by less affected or unaffected lenders. To check whether this is the case in practice, we run firm-level regressions with total credit growth as the dependent variable. The corresponding estimates are reported in Table IA.VII in the Internet Appendix, where the left panel (columns (1) to (4)) presents estimates for total credit growth of banks included in the sample, while the right panel (columns (5) to (8)) reports analogous regressions with total credit including credit provided by all financial intermediaries (local and foreign, commercial and investment, and nonbank financial institutions) as the dependent variable. All bank and loan-level explanatory variables are calculated as weighted averages of the ex ante bank-firm credit exposure. In each panel, we start by including *Bank FX Debt* without additional variables (columns (1) and (5)). We then add industry-location fixed effects (columns (2) and (6)), and all series of firm and bank controls as in Table I (columns (3) and (7)), including some firm-level controls such as log of total credit, log of

[20] Regarding additional variables, we note that firms that were in default or more indebted with the bank ex ante have lower credit growth. Banks with foreign debt structured mostly under loan agreements (rather than bonds) have a lower contraction of their credit supply. Shorter maturities of foreign debt, in contrast, affect bank credit supply negatively. The variables exposure to trade and net FX exposure variables are not robust. Larger banks or banks with more capital provide more loans.

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total employment, average log wage, and average log tenure, plus a proxy for firm demand (the estimated value of firm fixed effects obtained in the previous bank-firm level regressions). Finally, in columns (4) and (8), we report WLS estimates. We calculate standard errors under two-way clustering (firm-industry, main bank).

The estimates suggest that the change in credit supply is only partially offset: the estimated coefficient of bank FX debt is negative and statistically significant in all specifications. A one-standard-deviation increase in (weighted) bank reliance on foreign debt corresponds to 1.8 pp lower quarterly credit growth. Furthermore, resorting to unaffected or less affected banks does not insulate firms from the shock. The estimates reported in the right panel are smaller but still statistically and economically significant. This last result also suggests that neither foreign banks nor nonbank lenders were able to offset the credit supply decrease of the domestic banks.

To trace the effect of the FX hedging policy, we add to the regressions the following quarter of credit growth dynamics and we augment the explanatory variables with a dummy variable indicating the period after the policy announcement (the second quarter) and with the interaction between this indicator and bank foreign debt.[21] The interaction indicates whether the loan growth dynamics of the exposed banks change significantly after the BCB policy is announced. We fix all other explanatory variables at their ex ante levels. Table II reports the regression results. The first column does not include any controls, the second column includes firm-time fixed effects to address potential demand shifts, the third column includes a large number of loan- and bank-level controls, and the fourth column reports WLS estimates.

According to the estimates, FX interventions positively affect credit supply. Before the policy announcement, banks with high levels of foreign debt supply less credit to firms in comparison to less or nonexposed banks. In the first quarter following the policy announcement, this difference is partially mitigated, that is, more exposed banks increase credit supply. In particular, in the first postpolicy quarter, the sensitivity of credit supply to foreign debt is estimated to be half that of the posttapering quarter. In other words, the BCB policy reduces the credit supply growth differential across differently exposed banks, although FX policy does not completely offset the original shock.

The right panel of Table II reports results of a similar exercise but with three-quarters of credit growth observations in the "postpolicy" period. The estimates are quantitatively and statistically similar to those discussed above, which suggests that the effect of the BCB intervention is persistent.[22]

[21] The coefficients on *Bank FX Debt* are the same as in Table I since they represent the impact of having greater foreign debt exposure when the *Post* dummy is equal to zero (i.e., around the QE tapering shock).

[22] In the regressions, we restrict the sample to firms with relationships with more than one bank to be able to control for unobservable credit demand shifts using a firm-time fixed effect estimator (Khwaja and Mian (2008)). However, if we also include single-bank firms and control for firm fixed effects and industrial sector × location × time fixed effects instead of firm × time fixed effects, results are very similar (Table IA.VIII). In addition, in Table IA.IX, we include in our

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Table II

QE Tapering versus FX Interventions: Credit Supply, Firm-Bank Level

The table reports estimates of the equation

$$\Delta Credit_{f,b,t} = \beta_1 Bank\ FX\ Debt_b + \beta_2 FX\ Intv(0/1)_t \times Bank\ FX\ Debt_b + \gamma X_{f,b} + \theta_{f,t} + e_{f,b,t},$$

where $\Delta Credit_{f,b,t}$ is quarterly log growth rate of credit provided to firm f by bank b, $Bank\ FX\ Debt_b$ is bank's ex ante share of foreign debt in its total liabilities, $\theta_{f,t}$ is firm-quarter fixed effect, and $X_{f,b}$ is a set of controls. $FX\ Intv_t$ is equal to one for periods t of active BCB FX intervention program, and zero otherwise. The left panel spans the period of end of April '13–end of October '13 (two quarters with one quarter of the postpolicy period). The right panel spans the period of end of April '13–end of April '14 (four quarters with three quarters of the postpolicy period). Constants in columns (1) and (5) are omitted. The set of control variables is identical to that in Table I. All explanatory variables are measured as of the end of April' 13. Weights in columns (4) and (8) are proportional to (log of) firm employment. Standard errors (in parenthesis) are calculated under two-way clustering by bank and firm industry ($^{*}p < 0.1, ^{**}p < 0.05, ^{***}p < 0.01$).

	+1 Policy Quarter				+3 Policy Quarters			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Bank FX Debt	−1.06***	−0.92***	−1.14***	−1.13***	−1.06***	−0.92***	−1.18***	−1.19***
	(0.26)	(0.20)	(0.23)	(0.26)	(0.26)	(0.20)	(0.20)	(0.24)
Bank FX Debt × *FX Intv* (0/1)	0.48**	0.42***	0.44***	0.40**	0.57***	0.51***	0.52***	0.47***
	(0.22)	(0.16)	(0.16)	(0.18)	(0.16)	(0.11)	(0.12)	(0.14)
FX Intv (0/1)	−0.03**				−0.04***			
	(0.01)				(0.01)			
Firm × Time FE	no	yes	yes	yes	no	yes	yes	yes
Controls	no	no	yes	yes	no	no	yes	yes
WLS	no	no	no	yes	no	no	no	yes
R^2	0.01	0.41	0.43	0.41	0.004	0.41	0.43	0.41
N	229,327	229,327	229,327	229,327	462,677	462,677	462,677	462,677

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Table III presents firm-level evidence on total credit. We concentrate on the period spanning the quarter of the tapering speech and the three quarters following the FX intervention program. The estimates on the sensitivity of credit supply to foreign bank debt during the period immediately after the U.S. monetary tightening shock are close to those obtained in Table IA.VII. Also at the firm level, we find a positive effect of the FX interventions, suggesting that the FX policy is binding (columns (1) and (2)). This effect holds if we consider total credit of other lenders not in our sample (columns (3) and (4)). In Table IA.XI, we show that the results do not change if we include additional interactions between the postpolicy dummy and the two bank observables that are correlated with bank FX debt in cross-sectional regression: bank size and the state owned indicator (see Table IA.X).[23]

To quantify the transmission to the labor market, we run a similar set of firm-level regressions but instead of using total credit growth as the dependent variable, we analyze the employment growth rate (columns (5) and (6) of Table III). We show that firms that experience lower credit growth due to their ex ante exposure to banks with larger foreign debt also experience lower labor force growth (−0.4 pp) after the tapering shock. However, this effect is halved after the BCB intervention. Finally, in columns (7) and (8) of Table III, the dependent variable is the change in the average tenure of firm employees. We find that average tenure increases for firms more exposed to banks with large FX debt after the Taper Tantrum but decreases after the intervention. This result suggests that the margin of adjustment on firm employment (during both the Taper Tantrum and the FX intervention) is on less-tenured workers.

The results are consistent with the hedging channel. However, one may be concerned that the results are driven by capital inflows and outflows. To alleviate this concern, we rely on the register of foreign credit claims to Brazilian banks to analyze the change in foreign funding around the central bank announcement in terms of ex ante bank characteristics. At the bank level, we show that banks with more or less FX debt ex ante do not experience a different change in foreign funding around FX intervention (columns (1) and (2) of Table IA.XII). Moreover, we find that banks with more FX debt ex ante significantly increase their FX hedging via instruments provided by the BCB (columns (3) and (4) of Table IA.XII). In addition, in our baseline loan-level specifications, the results do not change if we exclude the share of FX debt maturing in the quarter following the Taper Tantrum from our treatment variable (Table IA.XIII). Using only the debt not maturing may be equally representative of hedging demand, as most foreign debt is hedged with short-term maturity instruments, while for capital inflow stress, the most

sample those bank-firm observations with at least one loan indexed in currencies other than BRL, observations that we do not include in our main sample. We also control for a dummy identifying FX loans and we further interact our main variables (and interactions) with the FX loan dummy. We find that these additional variables are not significant and the coefficients on our variables of interest do not change.

[23] We also control for exposure to trade, as this variable, while statistically insignificant, is also related to foreign economic activity and hence is affected by FX shocks.

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Table III

QE Tapering versus FX Interventions: Firm-Level Evidence

The table reports estimates of the equation

$$\Delta Y_{f,t} = \beta_1 Bank\ FX\ Debt_f + \beta_2 FX\ Intv(0/1)_t \times Bank\ FX\ Debt_f + \gamma X_f + \theta_{i,t} + e_{f,t},$$

where $\Delta Y_{f,t}$ is either the log growth rate of total credit of a firm f (from all banks included in the sample, columns (1) to (2), or from all credit institutions, columns (3) to (4)), or the log growth rate of firm employment, or the change in the average (log of) tenure of firm's employees, $Bank\ FX\ Debt_f$ is a weighted average of firm lenders' ex ante share of foreign debt in their total liabilities, $\theta_{i,t}$ is industry-location-time fixed effect, and X_f is a set of controls. The set of control variables include those reported in Table I as well as *log of Total Credit*, *log of Total Employment*, *Average log of Wage*, and *Average log of Tenure*. Bank-firm and bank-level variables are aggregated to the firm level by taking the weighted average of the corresponding variables with weights proportional to the bank's share in firm total ex ante credit liabilities. All explanatory variables are measured as of the end of April'13. *Proxy for Credit Demand* refers to estimated firm fixed effect from the firm-bank regression. Weights in columns (2), (4), (6), and (8) are proportional to (log of) firm employment. Standard errors (in parenthesis) are calculated under two-way clustering by main bank and firm industry ($^{+}p < 0.11$,$^{*}p < 0.1$,$^{**}p < 0.05$,$^{***}p < 0.01$).

	$\Delta Credit$		$\Delta Total\ Credit$		$\Delta Employment$		$\Delta Tenure$	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Bank FX Debt	-1.11^{***}	-1.17^{***}	-0.80^{***}	-0.83^{***}	-0.11^{*}	-0.20^{***}	0.23^{*}	0.25^{**}
	(0.20)	(0.19)	(0.22)	(0.21)	(0.07)	(0.07)	(0.12)	(0.11)
Bank FX Debt × *FX Intv* (0/1)	0.78^{***}	0.77^{***}	0.67^{***}	0.65^{***}	0.10^{*}	0.11^{**}	-0.13^{*}	-0.14^{+}
	(0.07)	(0.08)	(0.10)	(0.10)	(0.05)	(0.05)	(0.08)	(0.08)
Proxy for Credit Demand	0.90^{***}	0.90^{***}	0.77^{***}	0.75^{***}	0.02^{***}	0.02^{***}	-0.02^{***}	-0.02^{***}
	(0.01)	(0.01)	(0.01)	(0.01)	(0.00)	(0.00)	(0.00)	(0.00)
Industry × Location × Time FE	yes	yes	yes	yes	yes	yes	yes	yes
Controls	yes	yes	yes	yes	yes	yes	yes	yes
WLS	no	yes	no	yes	no	yes	no	yes
R^2	0.80	0.79	0.67	0.66	0.13	0.15	0.14	0.15
N	180,679	180,679	180,679	180,679	180,679	180,679	180,679	180,679

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problematic part is short-term foreign bank debt. To push further, in Table IA.XIV, we rerun our main regressions but this time we exclude not only the part of the FX debt maturing during the post-Taper Tantrum quarter but also other debt instruments with increasing residual maturities. We exclude the share of FX debt with a residual maturity up to 6 months in columns (1) and (4), 12 months in columns (2) and (5), and 18 months in columns (3) and (6). In Table IA.XIV, we again show that the results on the effect of the FX policy on hedging remain similar across the different bank FX debt variables. We control for capital flows directly in Section III.B using the panel setup.

An alternative channel at play could be the net worth channel, through which our results on *FX Intv (0/1)* × *Bank FX Debt* may simply be capturing the balance sheet effects of currency appreciation, a "net worth effect." As explained above, due to prudential bank capital regulation, unhedged FX exposure is very small (−0.2% of total bank assets), so this channel is unlikely to play a significant role. However, for robustness, in Table IA.XV we include the interaction between the net FX exposure and the contemporaneous change in the EME FX Index (columns (1) and (3)) or in the BRL/USD exchange rate (columns (2) and (4)). While these interactions are not significant, the coefficient on the interaction between bank FX debt and the postintervention dummy is always statistically and economically significant.

An additional potential concern relates to the announcement of other policy measures within our event windows. While there were no noteworthy policy measures in the window after the FX intervention announcement, prior to the FX intervention announcement there was another announcement concerning the removal of reserve requirements (RR) on open FX positions, which Brazil had adopted earlier. On January 6, 2011, Brazil introduced (Circular BCB, n. 3520) RR of 60% on open short positions in the FX spot market (or simply open FX positions) to curb carry trading, which was materially relevant only to some foreign banks (these positions are used by FX dealers (foreign banks) to operate the FX spot market). On June 25, 2013, this RR was officially removed (Circular BCB, n. 3659). Using proprietary data from the Open Market Department of the BCB, we can calculate these open FX positions.[24] We find that only eight foreign banks were ever subject to this particular RR and after

[24] It is important to note that these open FX positions targeted by RR relate to short cash positions, and thus are very short-term and are used to operate on the FX spot market, and hence became subject to liquidity requirements. They are very different from positions targeted by capital requirements, and thus hedged by banks, that we exploit in this paper. The main explanatory variable in our paper, *Bank FX Debt*, includes each bank's FX financing (loans and bonds issued) for all maturities, not just very short-term positions. Moreover, due to very strong capital requirements on unhedged FX positions, a bank's FX debt is basically fully hedged—net (unhedged) FX exposure is only −0.2% of a bank's total assets. Hence, the variable associated with the above RR (open FX positions) is also different from our net FX exposure variable, which we control for in all regressions and is based on balance sheet data (DRM), including spot and derivative instruments of all maturities. Consistent with this discussion, the correlation between *Bank FX Debt* and *Open FX Positions* is very close to zero (0.01 at the loan level and −0.03 at the bank level), and the correlation between *Net (unhedged) FX Exposure* and *Open FX Positions* is also very close to zero (−0.013 at the loan level and −0.01 at the bank level).

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December 2012 no bank met the threshold of this RR (i.e., the policy was not binding for any bank). Importantly, for identification, we always exclude foreign banks from our analysis, so this policy did not affect any of the banks in our sample. Put differently, this RR policy was already not binding in June 2013 for any bank in Brazil, and it was never binding for the national banks in our sample. In any case, we control for the underlying open FX positions in Table IA.XVI (even if our banks never met the threshold that triggered this particular RR tool). As Table IA.XVI shows, our results continue to hold.

To push the mechanism underlying our findings further, we note that there are two types of costs associated with the Taper Tantrum: an immediate cost due to capital charges, and the expected cost due to the risk of further BRL depreciation. If a bank leaves the FX debt unhedged, punitive capital charges will be applied as we explain in Section II. In addition, there is the expected cost due to the risk of further depreciation. Because the average domestic bank in Brazil is hedged at the time of the Taper Tantrum, the immediate depreciation of 14% does not affect the net worth of the bank. However, FX derivatives mature in the following weeks, and assuming that banks are not able to roll over the hedges and they face further FX depreciation, then without any hedging, the average bank would lose significantly and this loss would be relatively high given the bank capital ratios. Consistent with the analyzes above, we find that our results are larger for banks with less capitalization, for which the two types of additional costs are more relevant. We show this in Table IA.XVII by including in our main specification the triple interaction: *FX Intv (0/1)* × *Bank FX Debt* × *Capital*, as well as the double interactions, *Bank FX Debt* × *Capital*, and *Capital* × *FX Intv (0/1)*, where capital refers to bank capital. We find that the negative effects of the tapering speech for banks with more FX debt are larger for less-capitalized banks (i.e., a positive and significant coefficient on the double interaction *Bank FX Debt* × *Capital*), and that the positive effects of the FX intervention for banks with more FX debt are larger for less-capitalized banks (i.e., a negative and significant coefficient on the triple interaction *FX Intv (0/1)* × *Bank FX Debt* × *Capital*).

B. Full Panel Data Analysis

In this section, we use a full panel between 2008 and 2015 to analyze whether, outside the two episodes of May and August 2013, the credit supply of banks with larger foreign debt changes more in response to global shocks (shocks in the FX rate), and whether FX interventions can attenuate these effects.

For this analysis, we first run a series of panel regressions on quarterly data, where the dependent variable is growth of credit (at the firm-bank level) and the key independent regressor is the interaction between the lag of bank foreign debt and the lag of changes in the EME index or its implied volatility. To attribute our results to FX shocks, we introduce additional interactions between bank foreign debt and several other explanatory variables. Recent literature documents a dependence between credit supply and the global

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financial cycle, in particular to the Fed funds rate and the Fed balance sheet expansion in the United States (for instance, Morais et al. (2019)). We interact the Wu-Xia shadow federal funds rate with banks' foreign debt to capture this latter effect. Since the correlation between quarterly changes in U.S. monetary policy and quarterly changes in the FX conditions is not very high, we are able to estimate the effects of the two. Since an EME's currency devaluation can have a significant effect on firm credit demand, we use firm-time fixed effects to identify changes in credit supply. Analogous to the previous analysis, we include the same time-varying lagged bank and firm-bank controls to account for other drivers of credit outcomes and capture any potential confounding factors.

Table IV reports the baseline results for the panel data specifications. Column (1) indicates that the EME's FX rate is an important stand-alone factor for the credit supply of the domestic banks that rely on foreign debt. Column (2) shows that this result is robust to the inclusion of the U.S. monetary policy interacted with the banks' foreign debt. As expected, tighter monetary policy in the United States negatively affects the domestic banks that borrow more in dollars. The baseline results show that global financial shocks are relevant determinants of local credit supply. The strengthening of the USD against EME currencies has economically and statistically significant negative effects on credit supply. A positive shock in the FX index of one standard deviation accounts for a drop in subsequent local credit growth of approximately 2.1 pp (in annualized terms) for a domestic bank with the average level of foreign debt. The effect is more than twice as high when estimated conditionally on other macroeconomic variables interacted with bank foreign debt dependence (column (3)).

In column (4), we control explicitly for capital flows. We include additional double interactions between FX debt and lagged changes in the (log) foreign debt of Brazilian banks and lagged changes in the cost of these flows (calculated as the ratio of interest payments over aggregate foreign debt of the banking sector). The effects of the FX rate are robust to the inclusion of these additional interactions, which reassures us that our results are not driven solely by changes in capital flows. The results do not change if instead we use aggregate external debt flows to the whole economy, which is additional evidence in favor of the hedging channel since banks with more FX debt also react negatively to an FX shock when we control for capital inflows. For robustness, in Table IA.XVIII we also include interactions with both lagged and contemporaneous changes in capital flows (both price and quantity dimensions) and the results remain very similar. Specifically, in columns (1), (2), (5), and (6), we include four double interactions between *Bank FX Debt* and contemporaneous and lagged changes in (log) foreign debt and contemporaneous and lagged changes in the cost of these flows (calculated as the ratio of interest payments over aggregate foreign debt). In columns (3), (4), (7), and (8), we add again four double interactions, but this time, instead of considering capital flows directed toward the full economy, we consider only the capital flows directed toward the banking sector alone.

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Table IV

GFC Shocks, Full Panel

The table reports estimates of the equation

$$\Delta Credit_{f,b,t} = \beta_1 Bank\ FX\ Debt_{b,t-1} + \beta_2 Bank\ FX\ Debt_{b,t-1} \times \Delta EME\ FX_{t-1} + \gamma X_{f,b,t-1} + \theta_{f,t} + e_{f,b,t},$$

where $\Delta Credit_{f,b,t}$ is quarterly log growth rate of credit provided to firm f by bank b, $Bank\ FX\ Debt_{b,t}$ is bank's share of foreign debt in its total liabilities, $\theta_{f,t}$ is firm-quarter fixed effect, and $X_{f,b,t}$ is a set of controls. The sample period is 2008Q1 to 2015Q2. In all columns, the estimates are conditioned on lagged bank- and loan-level control variables (the set of control variables is identical to that in Table I). *Capital Flows (Quantity)* stands for change in (log of) end-of-quarter levels of aggregate external debt of the banking sector in Brazil. *Capital Flows (Price)* stands for change in interest payments on external debt to be paid during the following year normalized by the end-of-quarter levels of aggregate external debt of the banking sector in Brazil. Additional macroeconomic variables interacted with *Bank FX Debt* in columns (3) and (7) include: changes in *BRA Money Rate*, *Inflation*, *IBC BR*, and *VIX*. Standard errors (in parenthesis) are calculated under two-way clustering by bank and quarter-industry ($^{*}p < 0.1, ^{**}p < 0.05, ^{***}p < 0.01$).

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Bank FX Debt × Δ*EME FX Index*	−3.34***	−3.34***	−8.50***	−3.73***				
	(1.11)	(0.90)	(2.57)	(0.94)				
Bank FX Debt × Δ *EME FX iVol*					−0.36*	−0.70***	−1.89***	−0.71***
					(0.18)	(0.16)	(0.58)	(0.18)
Bank FX Debt × Δ *US Shadow Rate*		−0.27***	−0.05	−0.24***		−0.38***	−0.37***	−0.37***
		(0.07)	(0.11)	(0.06)		(0.08)	(0.08)	(0.07)
Bank FX Debt × Δ *Capital Flows* (*Quantity*)				−0.37				−0.01
				(0.40)				(0.43)
Bank FX Debt × Δ *Capital Flows* (*Price*)				0.06				0.05
				(0.08)				(0.08)
Firm × Quarter FE	yes	yes	yes	yes	yes	yes	yes	yes
Controls	yes	yes	yes	yes	yes	yes	yes	yes
Macro interactions	no	no	yes	no	no	no	yes	no
R^2	0.43	0.43	0.43	0.43	0.43	0.43	0.43	0.43
N	3,900,653	3,900,653	3,900,653	3,900,653	3,900,653	3,900,653	3,900,653	3,900,653

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In columns (5) to (8) of Table IV, we report similar specifications but instead of using the change in the level of FX, we use the change in the implied volatility of EME currencies. Rising uncertainty typically accompanies local currency depreciation (quarterly changes in the level of FX and in the volatility of FX have a 0.8 correlation), and this can affect investors' hedging costs. We find that, following positive shocks to FX volatility, the credit growth rates of banks with higher foreign debt are lower than those of the banks with less exposure. After a one-standard-deviation shock to the FX volatility index, the credit growth of a bank with an average level of foreign debt contracts by an additional annualized 2 pp relatively to the same firm-time. The economic effect is twice as high in the specification controlling for other local and global macroeconomic conditions (column (7)).[25]

Finally, we explore the effects of BCB interventions in the panel setup. Since there are large fluctuations in FX market conditions before and after the BCB intervention, we can assess whether the negative impact of global financial shocks is attenuated when the central bank intervenes. To do so, we introduce a triple interaction between FX debt, changes in FX, and the level of central bank intervention in the derivatives market, which we measure as the ratio of the bank's swap notional amount relative to its international reserves (see Section III). The estimates reported in the first four columns of Table V show that the coefficient on the triple interaction of bank foreign debt, the FX rate, and FX interventions is positive and statistically significant. In columns (5) to (8), we instead use changes in the volatility of the FX index. The results suggest that, when there is a higher level of FX intervention by the BCB, changes in FX global shocks matter less for the local credit supply cycle in Brazil. In Table IA.XXI, we show that we obtain similar results if we interact FX debt and the FX rate with a dummy equal to one for the months after the BCB FX announcement.[26]

[25] Results are further robust to other controls or sample periods. All our results do not stem from the two large episodes of depreciation and appreciation of the QE Tapering and initial FX Intervention, as we find similar results when we rerun the baseline regression omitting the second and the third quarters of 2013 (columns (1) and (2) of Table IA.XIX). Furthermore, we include additional interactions of FX shocks with those bank variables which are correlated with FX debt or are directly affected by FX shocks (columns (3) and (4) of Table IA.XIX), and estimates are similar. Moreover, to minimize concerns about a net worth channel influencing the results, in Table IA.XX we control for the *Net FX Exposure* interacted with the lagged changes in the FX index and find that the coefficient of this interaction is not significant; instead, our variable of interest (*Bank FX Debt* $\times$ Δ *EME FX Index*) remains strongly significant. In columns (2) to (4), we replicate the results but using, respectively, the contemporaneous change in the *EME FX Index*, and the lagged and contemporaneous change in the BRL/USD exchange rate. Results are similar: not robust for *Net (unhedged) FX Exposure* and significant for *Bank FX Debt*.

[26] In the baseline results, we consider an FX index of EMEs excluding Brazil. In robustness tests, we show that our results do not depend on the specific definition of the FX index used. In Table IA.XXII, we include only the EME currencies with the lowest correlation with the BRL from countries outside the American continent (India, Philippines, Taiwan, Russia, and Thailand). We show that our results are robust to using this alternative index. Despite the lower correlation, it is important to note that this alternative FX index remains significantly correlated with the Brazil-USD FX (correlation of 0.73), which is crucial for our channel.

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Table V

GFC Shocks and FX Interventions, Full Panel

The table reports estimates of the equation

$$\Delta Credit_{f,b,t} = \beta_1 Bank\ FX\ Debt_{b,t-1} + \beta_2 Bank\ FX\ Debt_{b,t-1} \times \Delta EME\ FX_{t-1} + \beta_3 Bank\ FX\ Debt_{b,t-1} \times FX\ Intv_{t-1} + \beta_4 Bank\ FX\ Debt_{b,t-1} \times \Delta EME\ FX_{t-1} \times FX\ Intv_{t-1} + \gamma X_{f,b,t-1} + \theta_{f,t} + e_{f,b,t},$$

where $\Delta Credit_{f,b,t}$ is quarterly log growth rate of credit provided to firm f by bank b, $Bank\ FX\ Debt_{b,t}$ is bank's share of foreign debt in its total liabilities, $\theta_{f,t}$ is firm-quarter fixed effect, and $X_{f,b,t}$ is a set of controls. $FX\ Intv_{t-1}$ is equal to the end-of-quarter notional amount of BCB swap intervention program over FX reserves. The sample period is 2008Q1 to 2015Q2. In all columns, the estimates are conditioned on the interaction of lagged *Bank FX Debt* and changes in the *US Shadow Rate*, as well as on lagged bank- and loan-level control variables (the set of control variables is identical to that in Table I). Additional macroeconomic variables interacted with *Bank FX Debt* include: changes in *BRA Money Rate*, *Inflation*, *IBC BR*, and *VIX*. In columns (2), (4), (6), and (8), *Bank FX Debt* is additionally interacted with *Capital Flows (Quantity)* and *Capital Flows (Price)*. Standard errors (in parenthesis) are calculated under two-way clustering by bank and quarter-industry ($^{*}p < 0.1, ^{**}p < 0.05, ^{***}p < 0.01$).

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Bank FX Debt × Δ*EME FX Index*	−6.40***	−6.79***	−11.06***	−12.22***				
	(2.11)	(2.26)	(3.33)	(3.98)				
Bank FX Debt × Δ*EME FX Index* × *FX Intv*	25.07**	25.45**	23.35***	22.40***				
	(10.02)	(10.34)	(7.26)	(6.99)				
Bank FX Debt × Δ *EME FX iVol*					−1.30***	−1.29***	−2.50***	−3.49***
					(0.35)	(0.35)	(0.73)	(1.07)
Bank FX Debt × Δ *EME FX iVol* × *FX Intv*					5.65***	5.66***	7.55***	9.51***
					(2.07)	(2.09)	(2.21)	(2.64)
Firm × Quarter FE	yes	yes	yes	yes	yes	yes	yes	yes
Controls	yes	yes	yes	yes	yes	yes	yes	yes
Macro interactions	no	no	yes	yes	no	no	yes	yes
Interactions with capital flows	no	yes	no	yes	no	yes	no	yes
R^2	0.43	0.43	0.43	0.43	0.43	0.43	0.43	0.43
N	3,900,653	3,900,653	3,900,653	3,900,653	3,900,653	3,900,653	3,900,653	3,900,653

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One potential concern is that our FX intervention variable may capture other policy interventions. To address this concern, we control explicitly for other policy interventions in our regressions. Since the coefficient of interest in this setting is the coefficient on the triple interaction *Bank FX Debt* $\times$ Δ *EME FX Index (or iVol)* $\times$ *FX Intv*, in the same regression we add a triple interaction that considers other policy interventions—*Bank FX Debt* $\times$ Δ *EME FX Index (or iVol)* $\times$ *Macroprudential tool*—so we can horserace different policy tools. We also include all of the lower-level interactions. To proxy for the intensity of other policy interventions, we use Gambacorta and Murcia (2017) index of macroprudential policies, which covers some heterogeneous macroprudential tools, assigning $+1$ (-1) to each active tightening (easing) policy. We also construct two subindexes for capital inflow/outflow policies, one containing measures introduced by the BCB (columns (3) to (4) of Table IA.XXIII), such as RR on open FX positions, and one containing taxes on capital flows introduced by the tax authority, as described in Chamon and Garcia (2016) (columns (5) to (6) of Table IA.XXIII). We multiply these Gambacorta and Murcia (2017) indexes and subindexes by minus one, so we can interpret the coefficient similarly as our BCB FX intervention variable—in both cases, positive values of the policy variable mean easing of the policy (softening of the macroprudential tools or more FX interventions). In Table IA.XXIII, we show that even when we include the triple interaction with other policy tools, our key coefficient of interest remains statistically and economically significant. This reassures us that our *BCB FX intervention* variable is not just proxying for other policy tools. Rather, these alternatives policies are not robust as seen in columns (2), (4) and (6).

Analogous to the previous analysis, in the panel setting we analyze whether the results that we find at the bank-firm level translate into aggregate results at the firm level. In Table IA.XXIV, we report estimates from firm-level regressions in which the dependent variable is the growth of firm total credit in columns (1) and (2) and the change in employment growth in columns (3) and (4). We include industry-quarter and firm fixed effects in addition to a series of firm and bank characteristics. We find that firms borrowing from banks with larger FX debt experience a reduction in total credit after an FX shock (quarterly changes in the level or volatility of FX), and that these effects are attenuated after the intervention of the central bank. This result suggests that firms cannot fully replace the changes in credit supply by affected banks by borrowing more from less affected lenders. Furthermore, these changes in total credit translate into real effects since we show that employment at the firm level follows a similar pattern: the double interaction between *Bank FX Debt* and changes in FX is negative and significant, while the triple interaction between *Bank FX Debt*, FX shocks, and BCB intervention is positive and statistically significant. In columns (5) to (8), we replicate the analysis using the alternative measure of the BCB intervention variable and find similar results. The results above suggest that, after the local FX intervention, global financial shocks matter less for credit and employment outcomes. That is, the *hedger of last resort* policy has been effective in decreasing local economy exposure to global financial conditions.

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C. Limitations of the Policy

The empirical evidence in the paper shows that the *hedger of last resort* policy attenuates spillovers of the global financial cycle, but what are the limitations of this policy? First, the central bank's credibility is likely to depend on the level of its international reserves, although it does not employ them in its interventions directly. Thus, the policy works insofar as economic agents believe they can go from forwards to spot USD, that is, convertibility risk is negligible. This has not been an issue in Brazil because of its large international reserves. Second, the *hedger of last resort* policy, similar to the *lender of last resort* policy, can entail fiscal and moral hazard costs.

This policy affects the fiscal balance of the country. USD appreciation creates mark-to-market gains in the BCB's international reserves. Similarly, USD depreciation leads to losses to the BCB balance sheet in BRL. The BCB incurs losses from its derivatives portfolio in the first case and gains in the second. Thus, the notional amounts committed in BCB swaps directly reduce FX exposure from its international reserves.[27] The BCB's payments to its swap counterparties are treated as government interest rate payments, worsening the country's fiscal balance in times of global distress. At year-end, the BCB paid BRL 2.3B (0.05% of GDP) to the market in 2013, BRL 10.6B (0.19% of GDP) in 2014, and BRL 102B (1.73% of GDP) in 2015. In 2015, the BCB has its largest position in swaps (and its lowest "net FX position"), which is mostly rolled over each period and decreases slowly over time as contracts expire. In the two following years, when the BRL mostly appreciates, cash transfers from the stock exchange to the BCB worth BRL 83.8B (1.34% of GDP) in 2016 and 6.3B (0.1% of GDP) in 2017 offset part of the related fiscal costs from the previous years. While in the long run, the intervention policy is likely to have a zero net effect on the fiscal balance, it reduces the fiscal space in economic downturns associated with local currency depreciation.

The second type of costs is associated with moral hazard, where the policy may incentivize more risky behavior, particularly among more fragile banks. To explore this possibility, in Table VI we reexamine the baseline results of the paper adding an interaction with bank capital and splitting the sample between ex ante riskier versus safer firms. We use bank capital since it is an established measure of the intensity of the agency conflict that besets banks' own borrowing from their financiers (Holmstrom and Tirole (1997), Freixas and Rochet (2008)). In column (1), we include the triple interaction between *Bank FX Debt*, the intervention dummy and bank capital. We find that the expansion of credit supply by banks with more FX debt after the FX

[27] Note that the FX policy we analyze is characterized by a commitment to intervene in the market for a very long period of time (and without necessarily using reserves (dollars)). Even though the central bank does not deploy international reserves as in the case of spot intervention using actual reserves, the credibility of the commitment still depends on the level of its international reserves. The FX policy in the derivatives market works only insofar as economic agents believe they can go from forwards to spot USD, that is, convertibility risk is negligible. This has not been an issue in Brazil because of its large international reserves.

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Table VI
QE Tapering versus FX Interventions: Risk Taking

The table reports estimates of versions of the equation

$$\Delta Credit_{f,b,t} = \beta_1 Bank\ FX\ Debt_b \times FX\ Intv(0/1)_t + \beta_2 Bank\ FX\ Debt_b \times Capital_b \times FX\ Intv(0/1)_t + \beta_3 Capital_b \times FX\ Intv(0/1)_t + \gamma X_{f,b} + \theta_{f,t} + \phi_b + e_{f,b,t},$$

where $\Delta Credit_{f,b,t}$ is quarterly log growth rate of credit provided to firm f by bank b, $Bank\ FX\ Debt_b$ is bank's ex ante share of foreign debt in its total liabilities, $Capital_b$ is bank's ex ante capital, $\theta_{f,t}$ is firm-quarter fixed effect, ϕ_b is bank fixed effect, and $X_{f,b}$ is a set of controls. $FX\ Intv(0/1)_t$ is equal to one for the period t of active BCB FX intervention program, and zero otherwise. All regressions are estimated using the end of April '13–end of October '13 sample (two quarters with one quarter of the postpolicy period). Controls include the following variables: *Unused Credit Line*, *Default*, and *Bank Share*. All explanatory variables are measured as of the end of April '13. Columns (2) and (3) report the estimates obtained on a subsample of firms with ex ante average interest rates below the sample median (column (2)) and above the sample median (column (3)). Columns (4) and (5) report the estimates obtained on a subsample of firms with greater than 10 employees (column (4)) and not more than 10 employees (column (5)). Standard errors (in parenthesis) are calculated under two-way clustering by bank and firm industry ($^{*}p < 0.1, ^{**}p < 0.05, ^{***}p < 0.01$).

	All Firms	Interest Rate		Firm Size	
	(1)	(2)	(3)	(4)	(5)
		Low	High	Large	Small
Bank FX Debt × *FX Intv* (0/1)	0.32***	0.26**	0.30**	0.41***	0.03
	(0.10)	(0.11)	(0.13)	(0.11)	(0.13)
Bank FX Debt × *Capital* × *FX Intv* (0/1)	−9.71***	−3.31	−16.18***	−6.52*	−16.72***
	(3.01)	(2.04)	(3.65)	(3.30)	(2.49)
Capital × *FX Intv* (0/1)	0.03	−0.04	0.12	0.03	0.17
	(0.08)	(0.08)	(0.12)	(0.10)	(0.12)
Firm × Time FE	yes	yes	yes	yes	yes
Bank FE	yes	yes	yes	yes	yes
Controls	yes	yes	yes	yes	yes
R^2	0.43	0.43	0.43	0.41	0.46
N	229,327	113,746	115,580	129,242	100,080

intervention is stronger for less-capitalized banks. In columns (2) and (3), we split the sample between firms with a low versus high ex ante interest rate, and in columns (4) and (5) we split the sample between large and small firms. We consider a high interest rate and small size as proxies for firm risk. Consistent with the moral hazard hypothesis, we find that the expansion of credit supply following the FX intervention by less-capitalized and more-FX-affected banks is stronger for riskier firms.

IV. Conclusion

The key contribution of this paper is to show that FX interventions can be effective, in particular by attenuating global financial spillovers on local

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corporate credit markets and the associated real effects. Despite the fact that central banks around the world have made significant use of FX interventions, empirical evidence on their success is limited (see, for instance, Chang (2018), Maggiori (2022)). Moreover, despite several papers showing how global financial shocks affect local credit markets around the world, there is scant evidence of how local policies in general—and FX interventions in particular—mitigate negative global financial spillovers (see, for instance, Miranda-Agrippino and Rey (2022), Shin (2016)).

Central banks may intervene in either the spot markets or the derivatives markets. We focus on the latter case in Brazil, where, following the Taper Tantrum shock, a large local FX intervention program with daily auctions was announced in August 2013 (with subsequent variation over time). Central banks in other EMEs adopted similar programs in the following years, for example, Mexico in February 2017, Turkey in November 2017, Chile in 2019, and other countries during the Covid-19 pandemic (International Monetary Fund (2020)). This *hedger of last resort* type of intervention allows local commercial banks (in demand for hedging) to adjust to the new (and negative) macroeconomic conditions by transferring part of these FX risks to the balance sheet of the local central bank (see also Gabaix and Maggiori (2015)).

In addition to the FX interventions in derivatives in Brazil, we exploit three administrative registers (credit, foreign credit flows to banks, and employer-employee) in conjunction with the U.S. Taper Tantrum (inducing strong FX depreciation and volatility in EMEs) in a difference-in-difference setting, as well as in a panel exploiting FX global shocks.

We find that after the U.S. Federal Reserve Taper Tantrum, Brazilian banks with larger ex ante reliance on foreign debt cut credit supply more, thereby reducing firm-level employment. We find that external shocks to the FX market affect the availability and price of (their mostly short-term) hedging, and banks react by changing their credit supply (due to bank capital regulation, banks have to hedge their FX debt, so their net worth is not directly affected by FX changes). Moreover, the subsequent announcement by the BCB of an intervention program consisting of supplying FX derivatives against FX risks—*hedger of last resort*—reduces by half the negative credit and employment effects. The 2008 to 2015 panel exploiting FX global shocks and FX local interventions confirms these results, including the hedging channel. However, we also provide evidence that this local FX policy—*hedger of last resort*—entails both fiscal and moral hazard costs.

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Appendix

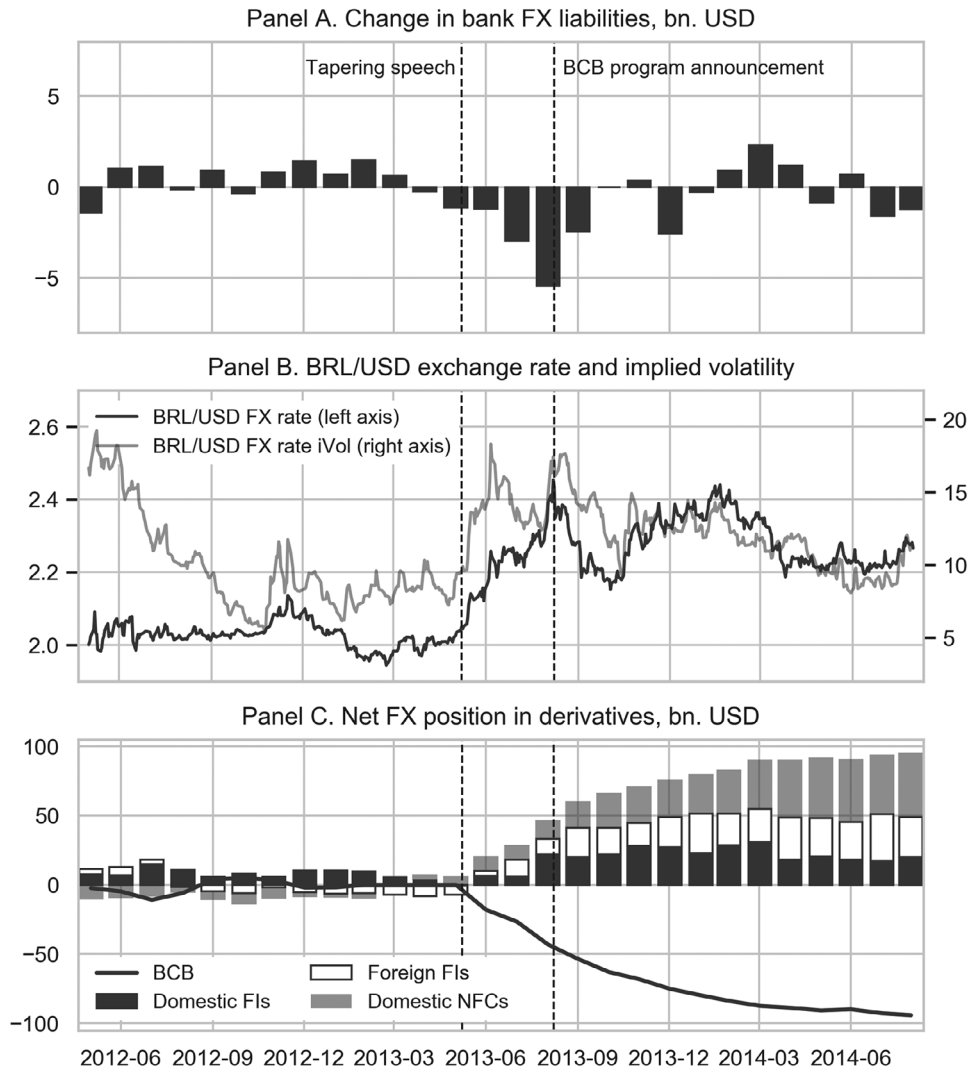

Figure A.1. Bank FX Debt, the BRL/USD exchange rate, and the intervention by the Central Bank of Brazil. Changes in the bank FX liabilities (upper panel, monthly series) are calculated based on the register of foreign claims on domestic financial institutions (ROF). Net FX positions in derivatives (lower panel, from Brazil stock exchange, monthly series) are aggregated by sector over all instruments with FX exposure, including BCB swaps. Vertical grid lines indicate middle-of-month dates. Net FX positions are end-of-month.

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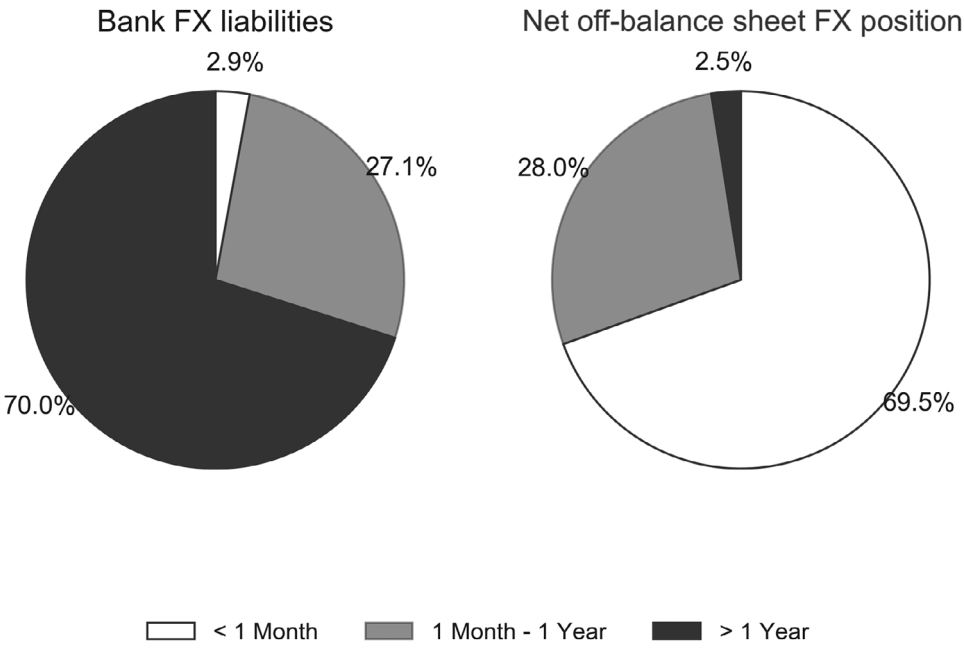

Figure A.2. Maturity composition of foreign debt and FX derivatives. The maturity structure of bank FX liabilities is based on the register of foreign claims on domestic financial institutions (ROF). The maturity structure of off-balance-sheet FX positions is based on *Demonstrativo de Risco de Mercado* (DRM). DRM is a regulatory form filed by all financial institutions in Brazil, that provides details about underlying market risk factors to the Bank Supervision of the BCB. Off-balance FX positions are net long exposures. The graphs reflect the aggregate values for the banks in our sample in April 2013.

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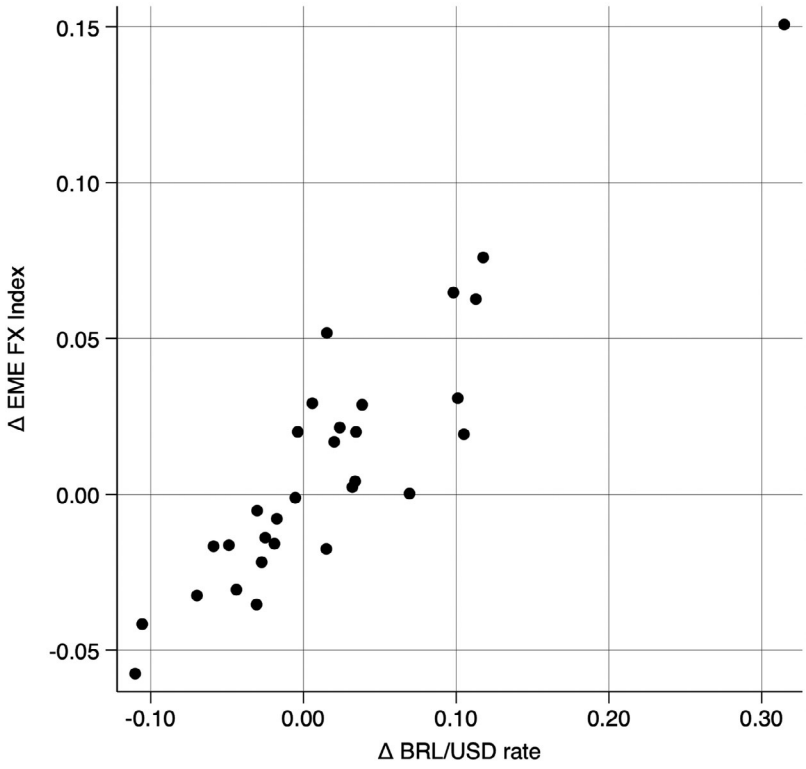

Figure A.3. Correlation between the BRL/USD exchange rate and EME FX index. Quarterly log growth rates, 2008Q1 to 2015Q2.

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