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Global banks and synthetic funding: the benefits of foreign relatives

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Global banks and synthetic funding: the benefits of foreign relatives

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Abstract

This paper provides novel empirical evidence on the effect of dislocations in FX swap markets ('CIP deviations') on bank lending. Using balance sheet data from UK banks we show that when the cost of obtaining swap-based funds in a particular foreign currency increases, banks reduce the supply of cross-border credit in that currency. This effect is increasing in the degree of banks' reliance on swap-based FX funding. Notably, high access to alternative funding sources of (on balance sheet) FX funding shield banks' cross-border FX lending supply from the described channel, but only if such access occurs via internal capital markets. There is evidence of some degree of substitution from banks outside the UK which are not affected by changes in the cost of accessing dollars or euros synthetically.

Key words: Cross-border bank lending, covered interest rate parity deviations, FX swaps, internal capital markets.

JEL classification: F34, G21.

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1 Introduction

The international market for cross-border bank lending is characterised by the widespread origination of claims in currencies which are 'foreign' from the lenders' perspective. As of end-2016, around 82 percent of global cross-border claims in US dollars were originated outside the US, while 35 percent of euro claims came from jurisdictions outside the Euro Area.[1] This feature of the international financial landscape highlights the importance of FX funding markets, on which banks rely to fund the global supply of cross-border foreign-currency (FX) loans.

Banks use a variety of funding sources – including FX deposits, internal capital markets, wholesale funding and FX swaps – to access liquidity in currencies different than the one of the countries in which they are based. Recent evidence suggests that banks' choices of and access to FX funding sources can have important implications for the stability of cross-border banking flows (Bruno and Shin, 2015, Ivashina et al., 2015, Correa et al., 2016).[2]

One of these markets for FX funds, namely the use of FX swaps (usually called 'synthetic'), has seen large dislocations in its pricing since the financial crisis, leading to the emergence of apparent arbitrage opportunities ('CIP deviations'). These dislocations have been the focus of a series of recent studies (Avdjiev et al., 2016, Du et al., 2018, Sushko et al., 2016, Cenedese et al., 2018), which have nevertheless focused on the their causes but not the consequences for other variables of interest.[3]

In this paper, we study the effect of changes in the relative price of swap-based FX funding on cross-border bank lending. FX swap markets allow banks with limited access to foreign currency funding markets to tap FX liquidity by swapping local currency funding without incurring foreign exchange risk. Motivated by the described recent dislocations in these markets, we inspect whether banks' reliance on this type of FX funding affects the supply of cross-border FX credit in the face of the mentioned shocks. We also analyse whether having foreign relatives – i.e. access to FX funding via cross-border internal capital markets– shields banks from the effect of CIP deviations. We use of data on global banks operating from the UK, which provides an ideal vantage point given that the UK is the single largest global

[1]The number for the US is lower (i.e. 75 percent) when counting USD originated in the Cayman Islands towards US originated claims. See Figure 1 for data sources.

[2]Correa et al. (2016) show that US branches of European banks with a higher exposure to US money market funds as a source of funding were more prone to reduce their credit supply during the European debt crisis. Other contributions stress that a larger access to FX emergency liquidity provided by central banks (Correa et al., 2015) and to insured retail FX deposits (Ivashina et al., 2015) can cushion banks against liquidity risk, stabilizing their lending supply.

[3]One exception is Liao (2019), who relates CIP deviations to corporate debt issuance.

originator of cross-border bank credit, a large share of which is denominated in currencies other than sterling.

Why would we expect changes to the cost of swap-based FX funding to affect banks' lending decisions? At first glance, FX swaps are only one of several alternative FX funding channels banks can rely on to access FX liquidity. In principle, banks could still issue debt directly in money markets, raise FX deposits or exploit their internal capital markets to tap FX liquidity abroad. If these alternative FX funding channels are available for banks – i.e. in a world of frictionless and well integrated FX funding markets – changes to the costs of accessing FX swap markets should only alter banks' funding mix, without translating into disruptions in banks' credit supply in different currencies. Liquidity strains affecting one distinct FX funding channel could be compensated by accessing liquidity in other markets. In reality, however, some banks may face restrictions in accessing funding sources alternative to swap-based FX funding, triggering an effect on cross-border lending from funding shocks to FX swap markets.

Potential frictions in the substitution across FX funding sources could be particularly important when it comes to banks' reliance on FX swap funding. If frictions existed and banks had limited access to on-balance-sheet FX funding, then these institutions may resort to swap-based FX funding as a way of overcoming geographical, regulatory or informational barriers. In this scenario, banks with large reliance on FX swap funding could be expected to adjust their balance sheet by more once funding shocks in FX swap markets occur. In contrast, banks with swift access to alternative FX funding markets should see this latter effect being attenuated. We test for this hypothesis by analysing heterogeneities in the reaction of bank lending to shocks to the cost of synthetic funding, particularly as a function of banks' access to alternative funding sources, including internal capital markets.

In order to measure funding shocks in FX swap markets we rely on the time series of deviations from the covered interest rate parity condition (in what follows CIP deviations) between sterling on the one side and US dollar and euro on the other, between 2003 and 2016. We work under the assumption that for banks operating in the UK access to funding in sterling should be easier than that to foreign currencies, so that sterling can be used as a base currency in swap trades aimed at securing dollar and euro funds. CIP deviations measure the difference between the 'cash' or money market interest rate in a given foreign currency and the corresponding synthetic funding rate.[4] The well-established CIP principle

[4]This latter interest rate results from raising funds in banks' domestic currency and using the proceeds to buy foreign currency while hedging the FX risk of repayment by using an FX forward contract. Following convention, a negative CIP deviation of sterling vis-á-vis the US dollar reflects a situation in which direct US

in international finance states that such CIP deviations should tend to zero. We exploit violations in the CIP condition observed most markedly since 2008 to proxy for funding cost shocks – positive and negative – affecting the availability of FX swaps of sterling vis-á-vis US dollars and euros. For this purpose, we build on previous contributions documenting how CIP deviations reflect changing funding conditions in FX swap markets (see Ivashina et al., 2015).

The study of the effect of FX synthetic funding shocks on cross-border bank lending comes with strong data requirements. In particular, we base our analysis on an identification strategy that exploits balance sheet data on global banks operating from the UK, tracing their cross-border assets and liabilities (and other balance sheet characteristics) on a destination country-currency-quarter dimension. Adapting the established literature (i.e. Cetorelli and Goldberg, 2011; Ongena et al., 2015), we define the destination country-currency dimension as banks' relevant markets and estimate the effect of FX synthetic funding shocks on currency-specific cross-border lending, conditional on banks' ex-ante exposure to FX synthetic funding. The richness of the data allows us to saturate the empirical model with country-currency-time fixed effects, absorbing non-observable time-varying confounders such as borrowers' (currency-specific) demand shocks. By observing banks' on-balance-sheet FX liabilities, we can also explore heterogeneities in the response to FX synthetic funding shocks depending on banks' access to alternative FX funding markets. We implement this identification strategy on a sample that covers the activities of 106 banks lending to 70 countries between 2003 and 2016.

Our results suggest that shocks in global synthetic FX funding markets significantly affect the supply of cross-border FX lending by banks located in the UK. Importantly, the effect on lending we document is increasing in the degree of banks' reliance on synthetic funding. Consider a bank that has a ratio of US dollar synthetic funding relative to total dollar assets that is one standard deviation above the sample mean. A widening of the CIP deviation of 14 basis points in the sterling-US dollar basis (i.e., the standard deviation of its changes) leads the bank in consideration to cut back US dollar lending growth by 1.4 per cent in comparison to a bank with average synthetic funding exposure. These results are robust to the exclusion of crisis episodes and big market makers in FX swap markets, to a series of measures of CIP deviations, and importantly not present when replacing currency specific CIP deviations with currency indices that have been found to correlate with CIP deviations (Avdjiev et al., 2016).

dollar funding in cash markets is cheaper than the synthetic alternative.

In a second step, we explore whether banks' access to alternative (on-balance-sheet) FX funding sources shields their supply of FX cross-border lending. Indeed, we find that large access to alternative sources of FX funding shields banks' cross-border FX lending supply from synthetic FX funding shocks, but only if such access occurs via internal capital markets. We corroborate these findings by documenting how banks effectively draw FX funds from their internal (foreign) network in these events; that is, there are *advantages of having foreign relatives* in these instances. By shedding light on this mechanism our paper informs discussions on the financial stability implications of possible institutional frictions and fragmentation in international funding markets (see for instance Dobler et al., 2016, ECB, 2016 and FSB, 2019).

In a final exercise, and in order to estimate the aggregate effect of shocks to the cost of synthetic funding, we explore potential substitution effects from borrowers into unaffected lenders. By aggregating data at the destination country-currency level, we find that banks from the relevant currency areas tend to step in and increase lending in the event of a retreat of UK banks when synthetic funding shocks hit, particularly in the case of the most affected markets. However, this does not typically lead to a full offset of the cut back of UK-originated lending.

Even though the reliance on synthetic FX funding as a share of total FX funding by banks has been significant over the past decades, the implications of funding shocks in these markets for cross-border lending have not yet been investigated to the best of our knowledge.[5] More generally, the literature on international banking has documented how liquidity shocks in global bank funding markets can have real effects via cross-border linkages (Schnabl, 2012, Ongena et al., 2015). Considering the large share of cross-border claims denominated in foreign currencies from source-countries' perspective, shocks to FX swap markets could play an important part in this transmission mechanism. By exploring the conditions under which global banks' reliance on FX swap funding affect their cross-border FX credit supply we are, to the best of our knowledge, the first to document the existence and functioning of a cross-border lending channel of funding shocks to the synthetic FX funding market.

Our work contributes to three strands of the literature. The first relates to studies documenting how market imperfections in bank funding markets affect credit supply in general, and the provision of cross-border credit by globally active banks in particular. Since early contributions by Peek and Rosengren (1997) and Peek and Rosengren (2000), which study the cross-border transmission of financial shocks by Japanese banks in the US, the literature

[5] Borio et al. (2017) come up with a figure for the share of US dollar synthetic funding in the neighborhood of 10 per cent.

has profusely documented how different types of liquidity shocks can affect banks' lending behavior provided that financial frictions exist. Previous studies have linked adjustments in (aggregate) cross-border credit supply to banking groups internal liquidity conditions during the crisis (Cetorelli and Goldberg, 2011, 2012a,b,c), to information asymmetries in the market for syndicated loans (De Haas and van Horen, 2012; Giannetti and Laeven, 2012), and to banking groups' exposure to wholesale interbank markets during the global financial crisis (De Haas and van Lelyveld, 2014). In particular, Cetorelli & Goldberg show how global banks managed liquidity from a group-level perspective during the financial crisis by exploiting their network of bank branches worldwide when facing liquidity shocks. These studies do not focus on the FX composition of such lending and do not address the role of banks' reliance on FX synthetic funding for the stability of cross-border banking flows in particular foreign currencies.

A second strand of literature we relate to focuses specifically on the effect of FX funding costs on banks' credit supply. Acharya et al. (2017) find that after the collapse of the asset-backed commercial paper market in 2007 foreign banks in the US charged higher spreads for syndicated loans denominated in US dollars compared to non-US dollars loans. Correa et al. (2016) show that US branches of European banks were affected by a shock to wholesale deposits from US money market funds around the time of the European sovereign debt crisis and reduced their lending supply to US firms. The affected branches received additional funding from their parent banks, but not enough to offset the lost deposits. While these studies focus on the syndicated loan market within the US, we widen the scope and consider overall lending globally (albeit originated in the UK) with particular attention given to currencies of denomination. Also, our source of shocks is not restricted to periods of wide market dislocations, but have instead happened frequently since 2008. Therefore, and in comparison to previous studies, we concentrate on a different financial friction (namely global banks' reliance on FX synthetic funding as a mean to overcome fragmented FX funding markets) and look at the effect of shocks on a broader set of banks claims, denominated in a range of currencies and reaching a wide range of destinations globally.

Particularly noteworthy for our analysis is the study of Ivashina et al. (2015).[6] This article provides a theoretical framework in which a creditworthiness shock affects foreign banks' US dollar lending as US dollar wholesale funding in US markets is withdrawn. Banks respond to this shock by increasing their reliance on US dollar synthetic funding, putting pressure on the FX swap market, driving up costs and eventually leading to cuts in US dollar

[6] Brauning and Ivashina (2017) also present a model (and related empirics) of banks that can access synthetic funding, but focus on the choice between lending and holding central bank reserves across countries.

lending compared to lending in their domestic currency. In their empirical extension they show that European banks exposed to a creditworthiness shock reduced their supply of US dollar syndicated loans relative to euro loans both in Europe and the US at the height of the European debt crisis. Our work differs from this study in two central dimensions. First, we exploit a setting that allows us to take CIP deviations as given and document a cross-border lending channel of synthetic FX funding shocks, while controlling for banks' alternative FX funding sources. Second, we concentrate the analysis on cross-border lending in multiple FX currencies –US dollar and euro– while using banks' domestic currency – sterling– as a benchmark. This allows us to compare lending in different currencies in the face of currency-specific synthetic funding shocks (rather than bank-specific shocks) in a sample which is not restricted to crisis periods with big dislocations in financial markets.

Finally, our paper is also related to the recent set of studies investigating the occurrence of CIP deviations.[7] In contrast to most of these, we focus on the side of 'liquidity takers' in these markets and take CIP deviations as given, instead focusing on the consequences of these in terms of cross-border bank lending.

The remainder of the paper proceeds as follows. Section 2 provides an overview of currency choice in cross-border banking, describes the dataset and discusses the theoretical framework behind using CIP deviations as a proxy for shocks in the synthetic funding market. Section 3 presents the identification strategy, reports our baseline results and robustness checks to these. Section 4 explores the role of access to alternative FX funding markets (including internal capital markets) in shielding banks from the channel sketched in our baseline results. Section 5 presents an extension of the baseline model that accounts for potential lender-substitution effects across borrowers. Section 6 concludes.

2 Data & Stylised Facts

In this section we first discuss stylised facts on currency choice in cross-border lending (Section 2.1) and describe our dataset containing information on balance sheet data from banks operating in the UK (Section 2.2). We then go on to describe the workings of the FX swap market, and the arbitrage condition linking the various ways in which borrowers can obtain FX funds. We also describe the breakup of that condition and discuss how this phenomenon constitutes currency-specific funding shocks affecting the stability of banks' FX funding (Section 2.3).

[7] See, e.g., Abbassi and Bruning (2018) Avdjiev et al. (2016), Du et al. (2018), Sushko et al. (2016), and Cenedese et al. (2018).

2.1 Currency choice in cross-border bank lending

A distinct feature of the international financial system is the large share of cross-border banking claims denominated in 'foreign' currencies (i.e. not the domestic currency of the originator country). This share has been relatively stable around 60 percent of total cross-border banking claims in the period between 2003 and 2017 (Figure 1). Most significantly, as of end-2016, cross-border flows in US dollars originated outside the US represented around 40 percent of total (world-level) claims. In terms of geographic origin, cross-border banking claims' origination is dominated by the world's financial centres: Figure 2 shows that the UK is the largest lender by a wide margin.

Given the prominence of 'foreign currency' loans in cross-border bank lending, it follows that the supply of these loans depends to a large extent on global banks being able to access FX funding. Borio et al. (2017) discusses how these funding sources can be divided into four main channels: banks' FX deposit liabilities to non-banks, interbank FX liabilities (interbank and intragroup), international bonds, and net FX swaps. As of 2016, out of an estimated 10 trillion of non-US banks' US dollar liabilities, FX deposits were the largest funding source, accounting for 60 percent of the total. Deposits were followed by international bonds (25 percent), FX swaps (10 percent), and interbank liabilities (5 percent). This emphasizes the variety of sources potentially available for banks when choosing a given FX funding mix.

2.2 Banks balance sheet data

In order to explore the effect of liquidity shocks in FX swap markets on cross-border bank lending in 'foreign' currencies we take the perspective of banks operating in the UK and providing cross-border FX loans in currencies different than sterling. In particular, we focus on banks lending abroad in US dollars and euros.

Our main data source is a panel of quarterly banks' balance sheet data constructed from selected regulatory fillings and statistical data forms submitted to the Bank of England by domestic and foreign banks operating in the UK.

We combine data contained in three of these forms. First, we obtain selected balance sheet variables from form BT, which reports a comprehensive picture of the structure of each bank's balance sheet, including capitalization, funding structure and business model characteristics. Second, we use information reported in forms CC and CL, which provide detailed data on banks' international claims and liabilities. These data are reported on a bank-country-currency-quarter basis, tracing the balances outstanding of different types of assets held vis-á-vis borrowers located outside the UK. This source provides us with a currency breakdown for each asset position in sterling and other major currencies. These data have been used in previous papers, such as Aiyar et al. (2014) and Forbes et al. (2017).

Our baseline dependent variable measures the quarter-to-quarter growth rate in currency-specific international claims between bank i and all borrowers located in country j. We focus our analysis on different country-currency markets outside the UK. For each bank i we look at its cross-border claims vis-á-vis country j in two currencies, namely US dollars and euros. Further positions in yen, Swiss franc, and 'other currencies' are not considered given the impossibility to trace back banks' reliance on synthetic funding in those currencies. This latter exclusion should not be problematic given the small size of claims denominated in these currencies.[8]

We start from a raw dataset containing information on 376 banks reporting cross-border claims in at least one quarter over 2003-2016. We implement a sampling procedure to focus on stable bank-country-currency relationships that can be observed throughout the period of analysis, as the identification strategy outlined below requires tracing bank-market relationships over time so as to pin-down the effect of funding shocks in FX swap markets. Also for identification purposes, only country-currency destination markets in which claims are held by at least two different banks in each quarter are considered. Our final quarterly dataset covers 106 banks over the 2003-2016 period. These banks lend to borrowers in 70 countries, creating a sample of 1,315 bank-country-currency relationships that can be traced over time, including claims in US dollars and euros.[9] Each bank lends to 10 different countries on average. Despite the demands of this procedure, the final sample covers on average 71.2 percent of US dollar and euro cross-border claims originated in the UK over the period of study.

Central to our analysis is the need to quantify banks' reliance on 'synthetic' funding in the currencies listed above (that is, funding obtained using FX swaps). Given the lack of detailed data on banks' derivatives positions, we follow Borio et al. (2017) and quantify banks' reliance on synthetic funding by residual; that is, we measure the difference between consolidated assets and liabilities in a given currency (as a share of total assets in that currency), and assume the 'missing' funding comes from FX swaps. [10] Algebraically:

[8]Specifically, the measure of reliance on synthetic funding also requires information on domestic funding from BT forms, which only contain data for assets and liabilities in sterling, euros and 'other', where 'other' is constituted mainly of US dollars.

[9]This dataset is 'final' in the sense that is consistent with the tightest set of fixed effects considered in our specifications. A detailed description of the steps required to obtain our final dataset can be found in Appendix A.2

[10]By construction this ratio of synthetic funding exposure can be either positive or negative. The latter case

$$RSF_{i,k,t-l} = \frac{Claims_{i,k,t-l} - Liabilities_{i,k,t-l}}{Claims_{i,k,t-l}} \tag{1}$$

where $RSF_{i,k,t-l}$ is the reliance on synthetic funding of bank i in currency k at time $t-l$.

We can see from Table 1 that banks do indeed use synthetic funding. Their average reliance on this type of funding is approximately 9 percent of total assets in a given foreign currency, and there is heterogeneity across banks and over time (the standard deviation of this measure is 17 percent).

Table 1 reports descriptive statistics computed from the resulting baseline sample. The final panel includes 62,739 observations at the bank-country-currency-quarter level. Out of the 106 banks in the sample 95 are foreign-owned institutions (both branches and subsidiaries) and 11 correspond to UK-owned banks. The 70 destination countries correspond to the US, 13 Euro Area economies and 56 countries from the rest of the world. The first five columns of Table 1 report information on the whole sample. Thereafter the mean value for each variable in the pre-2008 sample is reported for two groups of banks: those with an average RSF ratio above the sample median ('high RSF') and those below that threshold ('low RSF').[11]

The motivation for analysing descriptive statistics split by reliance on synthetic funding is the need to compare a range of competing balance sheet characteristics that could in principle be suspected of offering alternative explanations to our channel. That is, we look at balance sheet characteristics that could potentially be both correlated with reliance on synthetic funding and, by themselves, explain differences in cross-border lending supply by banks in the face of shocks to the cost of synthetic FX funding. These control variables include measures of banks' size (log of total assets), capitalization (capital-to-assets ratio), liquidity (liquid-to-total assets ratio), and deposits' reliance (total deposits to assets ratio). The final column in Table 1 reports a test of difference in means between both groups which uses the Imbens and Wooldridge (2009) test of normalized differences. We find that none of the

may reflect a situation in which a bank obtains relatively large amounts of foreign currency via deposits or FX money markets without using the proceedings to lend this FX liquidity. Since we are mainly interested in tracing a lending channel of positive synthetic funding exposures, we truncate the RSF variable by replacing negative RSF values by 0. Even though this approach is more consistent with the proposed research question, the main conclusions derived from the empirical analysis are unchanged if the negative values of RSF are included in the sample, as discussed in Section 3.3.

[11] We focus on the pre-2008 period given the lack of large liquidity shocks in FX swap markets, so that structural differences between high and low RSF banks can be observed before major dislocations in FX swap markets take place.

balance sheet items considered are significantly different across the two groups.[12] Importantly, we do not find evidence of both groups of banks reporting a different trend in the growth rate of cross-border claims before 2008. This result indicates that deviations in this growth rate after liquidity shocks in FX swap markets started occurring in 2008 should not be attributed to pre-existent differences in the behavior of banks diferentially exposed to those shocks. In Section 3.3 we complement this analysis by running horse races in which we allow different balance sheet characteristics to 'compete' with RSF in explaining the heterogeneous reaction of bank lending in the face of shocks to the cost of synthetic funding.

In terms of the data going into our baseline specifications, both the dependent variable and all control variables are winsorized at the 1st and 99th percentiles [13]

2.3 The covered interest rate parity condition and *currency-specific* funding shocks

The covered interest rate parity (CIP) condition states that the cost of obtaining funds in a given currency should be equalized across cash and FX swap markets. That is, from the point of view of a borrower looking for funds in a particular currency, it should be equally costly to pay the relevant cash-market interest rate, or, alternatively, to obtain funds in the cash market in a second currency and transform those proceeds into the target currency, locking-in the exchange rate at the moment of repayment via the use of an FX forward contract. Algebraically:

$$(1 + I^{USD}_{t,t+n})^n = \frac{S_t}{F_{t+n}}(1 + I^{GBP}_{t,t+n})^n \tag{2}$$

That is, it should be equivalent to borrow one US dollar at time t and pay back $(1+I^{USD}_{t,t+n})^n$ at time $t+n$, and to borrow instead the S_t sterling needed to buy one dollar, transform those proceeds into one US dollar, and lock-in a given exchange rate (F_{t+n}) in the derivatives market to pay back the sterling debt at time $t+n$ at the relevant interest rate (that is,

[12]If we instead look at the direct correlation between RSF and other balance sheet items in a linear way via the use of plain OLS regressions, we find that the only variable that is (weakly) positively correlated with RSF is total assets. We include this variable as a control in our benchmark specification and also run a robustness test dropping large banks from our sample.

[13]The exact definition of all these variables, and their corresponding entries in the relevant regulatory forms can be found in Appendix A.1

$(1 + I^{GBP}_{t,t+n})^n)$. If this condition did not hold, then an arbitrage opportunity would arise. Let us suppose, for the sake of argument, that the US dollar cash market interest rate (LHS of Equation 2) is lower than the FX-swap-implied interest rate (RHS of Equation (2)). If this was the case, an arbitrageur could make a positive risk-free profit by borrowing US dollars in the cash market and lending them via an FX swap in the derivatives market. It is worth noting that this profit would be risk-free, as all cash-flows (and exchange rates) are locked-in at the time trades are executed simultaneously.

The described CIP condition held remarkably well in the pre-GFC era (Figure 3). However, beginning in 2008, international financial markets witnessed the break-down of this once-thought unbreakable no-arbitrage relation. Figure 3 considers sterling as a base currency and shows that obtaining foreign currency funding in US dollar or euro via the FX swap market has been more expensive than doing so in cash markets during several periods.[14] It can be seen that this is not exclusively true for crisis periods.[15] This breakdown in the CIP condition has been the subject of study of a series of recent papers, including Abbassi and Bruning (2018), Avdjiev et al. (2016), Du et al. (2018), Sushko et al. (2016), and Cenedese et al. (2018).

A deviation from the CIP condition means that there exists a wedge in the cost of obtaining funds in a given currency in cash and FX swap markets. In the absence of frictions, borrowers (including banks) would then turn to the cheapest source of funding, rendering the more expensive alternative irrelevant. However, while FX derivatives can be readily accessible in international markets, access to cash markets (or insured deposits) for certain currencies is not automatic for some borrowers. In the case this fragmentation of funding markets was important, CIP deviations would constitute a funding shock to those borrowers with no access to FX cash markets or insured deposits, while the cost of funds for borrowers with access to both cash and derivatives markets would be unaffected in principle (as they would turn to the cheapest alternative). Throughout the paper we will consider a *negative* change in CIP deviations as a situation in which cash market funding becomes cheaper in relation to synthetic funding via FX swaps. Algebraically:

$$CIP_{k,t} = y^k_{t,t+n} - y^{GBP}_{t,t+n} + \frac{1}{n}\left[log(F_{t,t+n}) - log(S_{t,t+n})\right] \tag{3}$$

where $CIP_{k,t}$ is the sterling-based CIP deviation vis-a-vis currency k at time t; that is, the difference between the cost of obtaining funds in currency k via cash markets (at interest rate

[14]See Figure B.1 in Appendix B for a distinct view of CIP deviations in US dollar and euro markets.

[15]The wedge in funding costs across markets cannot be explained by counterparty risk. Du et al. (2018) document the existence of CIP deviations using risk-free securities denominated in different currencies.

$y^k_{t,t+n}$) and doing so synthetically by borrowing sterling (at interest rate $y^k_{t,t+n}$) and locking in the exchange rate using spot ($S_{t,t+n}$) and forward ($F_{t,t+n}$) markets, as described above. Note that this equation is the wedge in the log version of Equation 2.

An important aspect of these funding shocks is that they are currency-specific. That is, from the point of view of a bank obtaining funds in a range of foreign currencies via FX swaps, differential changes in CIP deviations (when measured with respect to a common base currency) alter the relative cost of these currencies. In a world in which frictions such as the one described above are relevant, one could expect these changes in relative funding costs to have an impact on the FX composition of banks' lending.

It is worth noting that, from the point of view of a bank with no access to foreign currency cash markets, and which therefore obtains its FX funding via swaps, changes in CIP deviations only constitute a proxy of the relevant funding shocks it is subject to. In principle, one could focus on changes in the FX-swap leg of the CIP trade (only the RHS of Equation (2)), as this constitutes the effective funding cost via FX swaps. However, the price of FX swaps can change for two reasons: it can change due to supply and demand considerations (in tandem with some friction in the market), which is the shock we are actually interested in, but in can also change because of revisions to expected exchange rates in the future. The latter does not constitute a net funding shock in principle: the differing cost of obtaining FX funds should be compensated by the fact that those funds are expected to change their value in terms of the domestic currency by the end of the contract. However, there is a way of abstracting from these cases: in principle, revisions to exchange rate expectations should be matched by changes in interest rate differentials across countries, leading to an unchanged CIP condition. Therefore, we use changes in CIP deviations as a proxy for friction-driven currency-specific funding shocks to banks securing foreign currency in swap markets.

Another possible confounding factor is the potential endogeneity of these CIP deviations to the balance sheet management of banks. The structure of the FX derivatives market is such that a relatively small group of big banks act as 'market makers', concentrating a large portion of trades, while the rest of the banks usually operate whenever they have non-speculative needs to borrow or lend foreign currency. Recent papers, including Du et al. (2018) and Cenedese et al. (2018), point to a regulation-driven reduction in the balance sheet capacity of these market makers to engage in FX derivatives trades as one of the main reasons behind the existence of arbitrage possibilities (e.g. of a wedge in the CIP relation). If these big FX derivatives market makers, which balance sheet management could lead to wedges in the CIP relation, engaged in cross-border lending in a systematic way linked in some form to their behaviour in FX derivatives markets, then this would constitute a problem for our specification. To guard against this possibility, we repeat our benchmark exercise excluding these big players from our sample (see Section 3.3). Relatedly, Abbassi and Bruning (2018) study German banks' pricing of dollar-euro forwards and find heterogeneity in prices that reflects underlying balance sheet characteristics, including reliance on this type of funding. Although the effect seems to be small, it can be interpreted as complementary to our findings in that differential pricing would have consequences for cross-border lending, in line with our hypothesis.

3 The effect of FX swap funding shocks on cross-border bank lending

In this section we outline the identification strategy that allows us to estimate the causal effect of funding shocks in the FX swap market on banks' supply of cross-border lending in the currencies in question. We then present our benchmark specification, baseline results and a series of robustness checks.

3.1 Identification and benchmark specification

Our objective is to estimate the effect of currency-specific funding shocks originating in the FX swap market on UK banks' cross-border lending in those specific currencies. Hence, our variable of interest consist of percentage changes in UK banks' cross-border claims, denominated in both US dollars and euros. The 'shock' variable we consider (discussed in more detail in Section 2.3) is defined by quarter-to-quarter changes in sterling-based CIP deviations with respect to both euros and US dollars.[16] The sign convention is as follows: a negative change in this deviation reflects swap-based FX funding costs going up relative to the cash market costs.

The identification of the causal effect of FX funding shocks on banks' supply of currency-specific cross-border lending presents a series of challenges. In particular, a satisfactory specification needs to address two main concerns. First, there could be a third force driving both changes; that is, a third shock could push up on FX-specific funding costs and lead to reduced cross-border lending in that currency at the same time, therefore resulting in a

[16] In the baseline case we use quarterly averages of CIP deviations, but later check robustness to considering end-quarter observations.

misleading positive correlation between our variables of interest. Additionally, lending growth could as well be driven by changing demand. If borrowers increased demand for FX bank loans in the face of funding shocks in the FX swap market, then an increase in lending could just be a reflection of this increased demand and not of changes in banks' supply. Observing quantities is not enough to be able to isolate the effect of supply.

We exploit the richness of our dataset in a series of ways to address the concerns outlined above. In the hypothetical case an omitted third variable was driving both changes, then the correlation should not necessarily be stronger for banks with a higher exposure to our sketched mechanism. That is, banks with a high reliance on synthetic funding (i.e. relying on FX swaps) would have no reason to adjust lending particularly strongly in the face of shocks. We are able to test for this feature explicitly by incorporating balance sheet information on individual banks' reliance on synthetic funding.[17]

To control for demand constituting a confounding factor we leverage on the fact that we observe the lending of several banks in a particular currency into a particular destination country. This panel structure allows for adding currency-destination-time fixed effects, which allow us to control for unobserved changes in demand for funds in the spirit of Khwaja and Mian (2008).

A final consideration is that our results are driven by differences in bank-specific cross-border lending in different currencies (in the face of differential shocks to their funding costs in FX swap markets). Therefore, there are no grounds to expect that shocks at the bank level could be driving our results, as they would need to imply a differential reaction across the different currencies in a bank's lending portfolio. Despite this consideration, we add a series of time-varying bank level controls in our main specification, and also explore bank-time fixed effects in the robustness section to absorb relevant time-varying bank characteristics.

These design features result in the following benchmark specification:

$$\Delta L_{i,j,k,t} = \alpha + \beta_1 RSF_{i,k,t-5} + \sum_{l=1}^{4} \beta_{2,l} \Delta CIP_{k,t-l} * RSF_{i,k,t-5} \quad (4)$$

$$+ \beta_3 \Delta L^{\neq k}_{i,k,t} + \beta_4 X_{i,t-1} + \gamma_{i,j,k} + \delta_{j,k,t} + \epsilon_{i,j,k,t}$$

[17] Additionally, we have shown in Section 2.2 that a range of other balance sheet characteristics are not correlated with banks' reliance on synthetic funding.

where $\Delta L_{i,j,k,t}$ represents the percentage change in the cross-border claims of bank i to recipient country j in currency k at time t, $\Delta CIP_{k,t}$ is the first difference in the sterling-based CIP deviation of currency k at time t and $RSF_{i,k,t}$ is the reliance on synthetic funding of bank i in currency k at time t (see Equations (3) and (1), respectively). $X_{i,t}$ represent bank-time specific controls and $\gamma_{i,j,k}$ and $\delta_{j,k,t}$ are bank-country-currency and country-currency-time fixed effects, respectively. The former allows us to control for time-invariant unobserved characteristics of banks lending to a particular country in a given currency, while the latter allow us to control for potential changes in country-specific demand for funds in a particular currency (hence constituting a key control variable). The bank-time controls include total assets, deposits ratio, liquidity ratio and capital ratio. We also consider the average cross-border lending in the currencies other than currency k ($\Delta L^{\neq k}_{i,k,t}$) which works as a benchmark and controls for banks overall lending behavior which might respond to factors other than changes in currency-specific synthetic funding costs.[18]

Following conventional use in the empirical banking literature (e.g., Kashyap and Stein, 2000), we consider the first four lags of our main object of interest: the interaction between ΔCIP and the fifth lag of RSF. This approach allows us to alleviate concerns that RSF may react to the dynamics in ΔCIP. We then focus our analysis on the sum of these four interactions terms. Moreover, the focus on the sum of the coefficients is important to trace banks' lending adjustment to ΔCIP over a time horizon of four quarters, recognizing the fact that this adjustment is likely to take place with a certain delay.

If higher synthetic funding costs in a particular currency resulted in reduced cross-border lending in that currency, and particularly so for banks with high reliance on this type of funding, we would expect coefficient β_2 to be positive and significant. This is our main coefficient of interest.

3.2 Benchmark results

In this section we test whether banks with high reliance on synthetic FX funding adjust cross-border lending particularly strongly in the face of currency-specific synthetic funding shocks. Table 2 shows the results from bringing the benchmark specification outlined in Equation (4) to the dataset described in Section 2.1. For each regression we report the sum of the coefficients corresponding to the lags considered in Equation (4).

[18] Variable $L^{\neq k}_{i,k,t}$ includes lending in sterling, which is not analysed specifically in our baseline model because CIP deviations are measured with respect to Sterling (i.e., the CIP deviation of Sterling equals 0). We test the robustness of our results to including sterling lending on the dependent variable, matched with null CIP deviations to help improve the pinning down of the intercepts. Results are virtually unchanged.

We find strong evidence that banks adjust currency-specific cross-border lending in the face of funding shocks to the same currency in the FX swap market.

Column I in Table 2 reports the results of a plain specification that does not factor in bank heterogeneity in terms of reliance of synthetic funding, but instead looks at average common variation in cross-border bank lending in the face of changes in CIP deviations. This estimation, although lacking a sharp identification, allows us to get a first idea of the empirical relationship between the growth rate in cross-border claims and currency-specific funding shocks in FX swap markets. It can be seen that an increase in the funding cost of using FX swaps is associated with a decrease in banks' currency-specific lending growth. In the remainder of the analysis we do incorporate bank heterogeneity in their exposure to shocks to the cost of FX swaps by considering their reliance on this type of funding (as described in Section 3.1).

The specification underlying results in column II factors in this bank heterogeneity, and delivers results which are in line with the unconditional correlation reported in column I. That is, the table shows that in the face of, say, an increase in the cost of synthetic funding, it is banks with a high reliance on this type of funding that cut back currency-specific lending particularly sharply. In column III we add a series of bank balance sheet items as further controls, and in column IV we further tighten the specification by adding bank and country-time fixed effects. This setting allows us to absorb confounding factors related to banks' time-invariant characteristics and country-specific trends affecting banks operating in that market, which are then ruled-out as a driver of our results. For instance, this setting captures borrowers' demand shocks that are homogeneous across currencies but specific to each destination country. Our results are robust to this fixed effects setting. In our final specification (column V) we allow these potential demand shocks (and other potential confounding factors) to be currency-specific by including country-currency-time fixed effects combined with the bank-country-currency time-invariant fixed effects. Our main findings hold after saturating the model with this structure. It is reassuring to see that the joint coefficient of the four lags of the interaction between ΔCIP and RSF (β_2) remains fairly stable across the different specifications of the model, working as evidence of the regularity of the empirical relationship documented in this paper.

The effect of currency-specific funding shocks on banks' cross-border credit supply is not only statistically significant but also economically meaningful. Consider the case of a bank that has a ratio of US dollar synthetic funding relative to total US dollar assets that is one standard deviation above the sample mean; that is, 17 percentage points above the sample mean of 9 per cent. Based on the results from our benchmark model, a negative CIP deviation of 14 basis points in the sterling-US dollar basis (i.e., the standard deviation of its changes) leads the bank in consideration to cut back US dollar lending by 1.4 per cent in comparison to the behaviour of a bank with average synthetic funding exposure. These estimates are conservative considering the existence of banks with 70 per cent reliance on synthetic funding and observed changes CIP deviations above 40 basis points.

Another useful exercise to calibrate the economic magnitude of our baseline effect is to focus on a particular point in time and develop an alternative hypothetical scenario.[19] Consider the second quarter of 2012, when the sterling-US dollar basis widened by 7 basis points.[20] In this quarter, the group of banks in our sample with positive reliance on synthetic funding cut back cross-border US dollar lending (to all destinations) by 184 billion US dollars. By making use of our benchmark results, we can estimate the hypothetical lending behaviour of these banks had they not been exposed to the shock to the cost of synthetic funding; i.e., if these banks had not relied on synthetic funding at all. In order to do this we calculate a bank-specific lending adjustment that arises from mapping a hypothetical reduction of their reliance on synthetic funding to zero into their lending behaviour, in the context of the observed shock.[21] By doing this we calculate that, had these banks had zero reliance on synthetic funding, they would have cut back lending by 160 billion US dollars instead; that is, the fall in lending would have been 24 billion US dollars (i.e. 13%) smaller.

Our benchmark results are unchanged when considering a battery of robustness checks, described in detail in the next section.

3.3 Robustness tests

In this section we run a number of robustness tests to assess the sensitivity of our findings to different specifications of the model.

We first examine whether our baseline findings can respond to or be biased by important individual events which in turn are time-clustered with the CIP deviations we use to quantify funding shocks in the FX swap market. Figure 3 shows that, although CIP deviations do occur at different periods throughout our sample, these are particularly large during the

[19] This exercise is an adaptation of a calculation presented in Cornett et al. (2011) in the context of liquidity risk in the global financial crisis.

[20] We consciously avoid using the global financial crisis and the height of the European debt crisis as case studies, despite larger widenings in the relevant basis, given potential confounding factors taking place at those times.

[21] The calculation we do for each bank is: $\Delta CIP * \Delta RSF * \beta_2$, where ΔRSF is the distance between their observed reliance on synthetic funding and zero. We then add up these adjustments across banks.

2008-2009 global financial crisis, and later during the euro area crisis. Our results may therefore be driven by the fact that banks largely exposed to FX synthetic funding are also generally more exposed to international financial markets, which were hit severely during these crises. In order to address this concern, we re-estimate our benchmark specification after alternatively dropping the 2008-2009 and 2011-2012 periods from our sample. Results, reported in columns (1) and (2) in Table B.1, confirm that excluding the potential biases induced by crisis periods does not alter our findings. Moreover, the size of the coefficient of interest remains fairly stable.

One additional potential issue is that CIP deviations could be contemporaneous to (or even a reflection of) other market-wide dynamics, which could be the 'true shocks' bank lending is reacting to. We conduct two robustness checks to address these concerns. First, we emphasise the currency specific nature of our story by considering a 'placebo' FX swap funding shock by assigning US dollar CIP deviations to euro lending and euro deviations to US dollar lending. The fact that we do not find any results when performing this experiment (column 3 in Table B.1) is reassuring and addresses concerns that CIP deviations only reflect tensions in financial markets. Relatedly, we also explore the possibility of CIP deviations being a reflection of US dollar strength (Avdjiev et al., 2016), which could in turn affect bank lending via alternative channels. When replacing CIP shocks with changes in the US dollar index (col. 4), we see that results cease to be significant. This result lends additional support to our hypothesis relating bank lending to specific shocks in the synthetic FX funding market.

Another concern relates to the workings of the FX swap market. So far we have analysed banks as 'liquidity takers' which tap FX swaps markets when in need of (synthetic) FX funds. However, some institutions necessarily have to 'make markets' and take the other side of the trades. If these 'market makers' engage in cross-border lending, while also having the capacity to influence the price of FX swaps given the relative concentration of the market, then our results could be biased if their behaviour differed from the mechanisms sketched so far. In order to guard our results against such possibility, we estimate our benchmark specification after excluding the top-5 banks in FX derivatives' trading volume.[22] Results, reported in column (5) and (6) in Table B.1, show that our findings remain in place when excluding this group of 'market makers'.

A further concern relates to a potential correlation between reliance on synthetic funding and other bank traits. For example, a high value of RSF may also reflect a relatively high

[22] We identify these banks from *Euromoney 2016 FX rankings* . We consider the top 5 banks in overall market share.

exposure to short-term interbank market debt. Provided that this latter type of liabilities was especially affected during periods of financial distress in our sample, the channel that we identify may capture banks' overall exposure to financial contagion. Even though both (i) the time-varying controls and fixed-effects included in Equation (4) and (ii) the curreny-specific nature of our results should prevent a bias via such confounding factors, we implement a set of further robustness tests that shed light on the role of bank characteristics. First, we run a set of regressions in which we replace the fixed-effects structure in Equation (4) by alternative structures including bank-quarter fixed effects. This test aims at changing the dimension of the identification from within (country-currency) relevant markets to a within bank estimation that absorbs both observed and unobserved bank traits that could be correlated with RSF. The results, reported in Table B.2 in the Appendix, show that our findings remain in place once we control for both observed and unobserved time-varying bank characteristics captured by bank-quarter fixed effects under different specifications.[23]

A related exercise entails running 'horse races' in which we replace our quantification of banks' exposure to shocks to synthetic funding markets with other balance sheet characteristics which are in principle unrelated to our story. It is reassuring to see that shocks to the cost of synthetic funding particularly affect the lending of banks with high reliance on this type of funding, but not that of banks with particularly high values of other balance sheet characteristics considered (see Table B.3 in the Appendix).

Finally, we also test the robustness of our results to more mechanical modifications of our baseline setup (all tables reported in Online Appendix). Our results are robust to (i) considering alternative swap maturities and end-of-quarter observations for measuring CIP deviations, (ii) truncating our left-hand-side variable, increasing the winsorisation threshold and replacing aggregate lending with a narrower measure of loan growth, (iii) modifying the clustering of standard errors to bank and currency-time units, (iv) considering alternative measures of banks' reliance on synthetic funding, (v) dropping the largest banks in our sample, (vi) adding sterling flows to our panel with corresponding null CIP deviations to help anchor the baseline, and (vii) excluding the US and euro area as destination countries and, separately, US and euro area banks lending from the UK as originators. The robustness of our results and stability of the magnitudes involved across this battery of checks speak to the tightness of our identification strategy.

[23] We run this exercise both with and without our preferred set of credit-demand controls via fixed-effects. In the latter case we find the coefficients of Joint ΔCIP x RSF_{t-5} to be slightly smaller than in the benchmark model. These smaller coefficients reflect that currency-specific credit supply and demand shocks are negatively correlated, so that not controlling for credit demand leads to an underestimation of the actual size of the (credit-supply-driven) coefficient. This latter fact further underpins the validity of our identification.

4 The benefits of foreign relatives

In the previous section we document an effect on cross-border bank lending arising from funding shocks in FX swap markets. Banks with a high reliance on synthetic FX funding adjust their currency-specific cross-border lending particularly strongly in the face of changes in the cost of funds in FX swap markets. This feature is by no means obvious: if banks had access to alternative sources of funding at similar cost, then changes in the cost of swap-based FX funding need not necessarily lead to shifts in lending behavior, but only to a change in the source of those funds.

In this section, we extend our baseline model to test whether the documented effect of synthetic funding shocks on bank lending reflects banks' capacity to access alternative FX funding. We test for this hypothesis by considering a series of alternative measures that could shed light on banks' capacity to tap FX funds. We first analyse whether the effect of synthetic funding shocks on cross-border lending differs across banks' organisational structures, focusing on the differences between branches, which have frictionless access to their parents abroad, and other banks. We then consider effective access to alternative sources of on-balance-sheet FX funding in general, and internal capital markets (ICM) in particular, and test whether this access shields banks' lending from synthetic funding shocks. Finally, we also analyse whether banks' actual liability management in the event of synthetic funding shocks goes in line with our hypothesis.

One possible interpretation of these tests is that they are suggestive of traces of institutional frictions in international FX funding markets, which can help to explain the dynamics of cross-border FX credit supply. Previous literature suggests that a reallocation of FX funding sources may be impaired by such institutional frictions (Buraschi et al., 2014). Banks with limited institutional access to alternative FX markets are arguably less able to prevent the credit supply effects documented in Section 3.2. Relevant institutional frictions in international capital markets may relate, for instance, to ring-fencing regulations and capital controls that prevent banks from efficiently reallocating internal liquidity from a consolidated perspective when they benefit from a local presence via bank affiliates in foreign funding markets (see, i.e., Allen and Gale, 2004; Cetorelli and Goldberg, 2012a; Acharya et al., 2017). More generally, market segmentation and differences in regulatory regimes may impair global banks' capacity to pledge future cash flows when issuing paper abroad, further limiting their access to foreign FX markets even in an arms'-length fashion (see, i.e., Darrell et al., 2007; Brunnermeier and Pedersen, 2009.)

4.1 Banks organisational structure

At first glance, the hypothesis that alternative FX funding sources can provide a cushion against synthetic funding shocks seems easily testable *a priori*; however, measuring access to funding sources is not straightforward: banks could have access in case of need, without this ever materializing in the balance sheet data we observe. One alternative is to consider banks' organisational structure, relying on the idea that UK-regulated banks and foreign branches could in principle have differential access to FX markets given different intragroup links, regulatory arrangements and, more generally, different informational frictions. Therefore, as a first step in exploring heterogeneities in the effect of synthetic funding shocks on bank lending we test whether there are differential effects for UK-regulated banks on the one hand and foreign branches on the other.

Foreign-owned branches providing cross-border FX credit from the UK are especially interesting for our analysis. It has been profusely documented that branches tend to have tighter links with their banking groups (see, e.g., Cerutti et al., 2007; Dell'Ariccia and Marquez, 2010). This phenomenon relates to the fact that branches have no separate legal standing but form an integral part of the parent's balance sheet, thus in most cases enjoying a more direct and frictionless access to intragroup funding. This stylized fact is also present in our sample of UK-based banks. Figure 5 depicts the share of branches in each quartile of the distribution of banks by their ratio of internal capital market funding (ICM) to assets. This figure reveals a clear pattern in which higher quartiles of the ICM distribution report a higher presence of branches. However, branches are not special in terms of their reliance on synthetic funding (RSF), the key dimension of heterogeneity behind our identification strategy. Replicating the same exercise for the quartiles of the RSF distribution (Figure 4) shows that branches are evenly distributed across quartiles. These charts highlight the distinctive aspects of banks' FX liquidity management captured by RSF and ICM.[24]

The pattern outlined above suggests that branches can be used as a quasi-control group in the context of our analysis, considering that they typically share a similar RSF exposure but, simultaneously, a larger access to ICM on average compared to other banks.[25] Considering

[24] In our sample, branches report on average a higher ratio of on-balance-sheet FX funding to total assets (0.42) compared to the group of UK-regulated banks (0.29). Most importantly, this difference stems mostly from internal capital markets (ICM) funding from abroad (ratio to total assets is 0.13 versus 0.04). On the contrary, the ratio of non-ICM FX funding from abroad to assets does not vary much between these two groups (0.29 vs. 0.24). Despite these differences, branches report on average a similar RSF compared to other banks, suggesting that synthetic funding reliance and access to ICM represent two distinct dimensions of banks' FX liquidity management. These descriptive statistics are reported in Table A.2 in the Online Appendix.

[25] In unreported results, we find that benchmark results can be replicated both for the subsamples of

this setup we test whether non-branches' low institutional access to alternative markets via ICM affects the adjustment of their credit supply following synthetic funding shocks. To operationalise this test we adjust Eq. (4) by adding a triple-differences' term which equals 1 if a bank in the sample is a branch and 0 otherwise. We then focus the analysis on the joint coefficient of the triple interaction (ΔCIP x RSF_{t-5} x $Branch_{t-5}$) after saturating the model with our preferred fixed-effects structure.

Results are reported in Table 3. We find that, for the same level of dependence on synthetic funding, foreign branches adjust their cross-border FX lending by around two-thirds less than other banks (col. II). In cols. III and IV we tighten the analysis by identifying those foreign branches owned by banking conglomerates headquartered in the Euro Area and the US. The rationale for this exercise is that, in the event of system-wide shocks to the cost of obtaining a particular foreign currency using FX swap markets, branches of banking groups headquartered in the relevant currency area will have more direct access to cash funding in that particular currency than other banks. With this in mind, we replicate the previous exercise by defining a new dummy variable that takes the value of 1 if a bank is (i) a foreign branch and (ii) owned by a bank headquartered in one of these currency areas. This test, reported in column IV in Table 3, shows that these particular branches are behind the 'shielding' effect identified in column III. On the contrary, when we define as branches only those entities owned by banks headquartered in regions different than the Euro Area or the US, the branches do not seem to be shielded any more (see column V in Table 3).

Taken together, these results show that branches – a group of banks that we would expect to be less exposed to the institutional frictions affecting FX funding access – are less affected by synthetic funding shocks. Most importantly, the capacity of branches to compensate for the loss in synthetic funding seem to be fueled by their advantage to obtain liquidity via their headquarters abroad, as long as these headquarters operate in the relevant currency areas. These findings highlights how banks' organisational structures can shape the dynamics of cross-border credit flows in a world of synthetic funding shocks.

4.2 Alternative FX funding sources: internal capital markets

Starting from the differential effect of synthetic funding shocks on branches' cross-border FX lending, in this subsection we explore a dimension that could be expected to be behind this

branches and UK-regulated banks. This finding confirms that a large heterogeneity in the use of synthetic funding exists, even within the group of the arguably well integrated' branches. These results are available upon request.

finding; namely, their differential access to alternative sources of FX funding. We conjecture that if institutional frictions related to banks' capacity to tap alternative FX funding markets matter, then wide access to these alternative sources should indeed lead to a smaller effect of synthetic funding shocks on cross-border lending, both for branches and non-branches. In particular, we look at banks' on-balance-sheet FX funding in general, and the split between ICM and non-ICM funding in particular. Looking at effective access to on-balance-sheet FX funds provides a complementary intensive margin angle to the extensive margin view represented by branches' organisational structure. In fact, we may expect also subsidiaries and especially UK-owned banks – given their role as bank headquarters – also to benefit from access to alternative sources of FX funds.

In order to test for this conjecture, we compute a ratio of on-balance-sheet FX funds to total assets at the bank-currency-quarter level. We then zoom into the type of funds by computing the ratios of foreign ICM and non-ICM funds to total assets over the same panel dimension. ICM funds represent FX-specific intrabank liabilities from abroad vis-à-vis related entities within the same banking conglomerate. [26] For completeness, we compute non-ICM funds as the net liabilities when subtracting ICM from total FX funds.[27] In order to arrive at a proxy for large and small access to intragroup funding that can be compared with the branch dummy calculated in the previous section, we assign observations above the 75th percentile of the respective ratio to a group of 'high access' banks and use a dummy based on this categorization to introduce a triple interaction term in Eq. (4).[28] These dummies enter the model with the same 5-lag structure as the RSF variable. Making use of this structure we assess whether the effect of synthetic funding shocks on lending is smaller for those banks with large access to alternative funding sources. [29]

The results from this exercise are reported in Table 4. We find that the aggregate access

[26]Ideally we would have bilateral intragroup links to specific currency areas; however, such data starts only in 2014 and is hence too short for our analysis

[27]Note that the level of on-balance-sheet funding is not mechanically correlated with the reliance on synthetic funding: a bank with a given level of reliance on synthetic funding can have low or high on-balance-sheet funding (if overall FX operations are small or large, respectively). In effect, the correlation of these two variables in our sample is negative but low.

[28]We split observations at the 75th percentile to properly capture the skewness of the ICM ratio distribution. As it can be seen in Figure A.1 in the Online Appendix, the low median (red vertical line) in the ratio's distribution implies that many low-ICM observations would be assigned to the high ICM group if using a median split. For consistency, we follow the same definition when generating splits in the other relevant ratios throughout the analysis.

[29]Due to data limitations we restrict this analysis to the period from 2008Q1 to 2016Q1, as the information on banks' internal capital markets' funding is not available for earlier periods. This does not impose a big constraint on the exercise given that we are left with the period of non-negligible synthetic funding shocks in any case.

to on-balance-sheet FX funding *per se* does not shield banks' lending from the effect of dislocations in synthetic funding markets (col. II). However, when zooming in into the different types of on-balance-sheet funding (cols. III and IV) we see that a high ex-ante ICM ratio does indeed reduce the effect of synthetic funding shocks on FX credit supply. On the contrary, access to non-ICM funds does not have a similar shielding effect. We therefore conclude that, for the full set of banks in the sample, a large access to ICM does shield banks' FX lending from the effect of shocks to the cost of synthetic funding.

Interestingly, when we replicate the exercise separately for the subsamples of branches and UK-regulated institutions (columns V and VI), we find the effect of a higher marginal ICM-access to be stronger in the case of non-branches. This is consistent with the fact that branches have a generally high level of ICM (see Figure 5) and hence it is difficult to tease out differential effects. For non-branches of course the relevance of ICM access will capture to a great extent the access of banks to their branches located in key currency areas. [30]

We interpret these latter results as providing further evidence that access to funding markets via intragroup links helps banks offset shocks arising in synthetic funding markets. This also points to the possible role played by institutional frictions to the extent that they may prevent some banks from making full use of their internal capital markets.

4.3 Zooming-in: changes in banks' FX foreign liabilities.

The results above are suggestive of the notion that UK-based banks that are less constrained by institutional frictions can tap intragroup FX liquidity sources which, in turn, reduces the pass-through of synthetic funding shocks to FX cross-border lending. However, it is still to be seen whether banks actually increase their internal FX funding when institutional frictions are low, or whether the findings described above merely reflect that better connected banks have an overall better market perception that allows them to raise FX liquidity when needed.

We explore this angle by analysing whether branches and UK-regulated banks with large ICM-access do indeed increase their internal funding in the face of synthetic funding shocks. To implement this test, we adjust the structure of our panel as follows. First, we compute the quarterly growth rate in (exchange rate adjusted) ICM liabilities at the bank-currency-quarter level given data on intragroup liabilities from specific countries are only available for a short period. Therefore, we exclude the destination country dimension used in the previous regressions. The resulting panel can be used to test whether high-RSF banks with a better

[30] Reinhardt and Riddiough (2015) show that intragroup funding to parent banks from foreign affiliates has been most stable during the global financial crisis and in the face of increases in the VIX index.

ICM-access ex-ante do indeed increase their ICM liabilities in the context of synthetic funding shocks. The new structure of our panel means that we cannot implement our preferred set of country-currency-time fixed effects as in Eq. 4. We therefore run regressions saturated with bank and currency-time fixed effects.

Results are reported in Table 5. In a first exercise (cols. II and III), we look at whether branches are more active in using their ICM funding networks in the event of synthetic funding shocks. Results show that this is indeed the case, as branches draw more ICM funding when compared to non-branches, even though the coefficient of interest losses statistical significance when including currency-time fixed effects. The latter may not be surprising given data limitations, namely that we observe intragroup funding from related entities across the rest of the world rather than directly from the parent entity. We then turn to the subsample of UK-regulated banks, for which intragroup links were found to be particularly important, and explore whether those with high ex-ante access to ICM do make use of this channel conditional on the occurrence of synthetic funding shocks. The results, reported in columns IV and V, confirm that within this group of banks a larger ICM-access ex-ante allows banks to draw more liquidity from internal sources abroad in the event of shocks.

In sum, the exercises in this subsection allow us to link the role of ex-ante access to ICM in shaping the effect of synthetic funding shocks on bank lending, with an active management of internal FX liabilities in the event of a shock. The important role played by internal capital markets reveals how geographical funding market structures can shape the stability of cross-border banking flows worldwide, especially in the presence of institutional frictions potentially preventing the reallocation of funding sources when liquidity conditions change.

5 The macroeconomic dimension: substitution across banks and countries

The results of our analysis provide compelling evidence of an effect on cross-border bank lending from shocks to the cost of synthetic funding. However, this does not necessarily mean that such dynamics should have aggregate consequences: borrowers in the recipient countries could in principle offset this credit supply shock by shifting their demand for credit to less affected banks, either based in the UK or in other countries. Exploring this question is important both to calibrate the macroeconomic consequences of shocks to the cost of synthetic funding and, relatedly, to assess whether stronger access to global (intrabank) liquidity channels helps limit the pass-through of the identified effect on lending to the real economy.

In this section we analyse whether this substitution across banks or originator countries indeed takes place. We divide this analysis in two steps. We first assess the existence of substitution in credit supply in the cross-section of UK-based banks, as less affected banks could step in when affected banks cut back their lending in the face of synthetic funding shocks. However, a more potent source of substitution might be banks outside the UK which are less affected by synthetic funding shocks. We thus assess secondly substitution of borrowers shifting demand out of affected UK banks into banks outside the UK, importantly into banks located in the US or the Euro Area. Taken together, these tests can shed light on the potential consequences for aggregate credit volumes of shocks to the cost of synthetic funding, and whether banks' access to internal capital markets has a role in these considerations.

To conduct these tests, we adjust our baseline empirical setting as follows. First, we aggregate our left-hand side variable at the country-currency level and compute the aggregate growth rate in cross-border credit by all UK-based banks. Then, we re-compute all bank-level variables as the market-share-weighted average of all banks within a country-currency market. For example, the synthetic funding reliance variable (RSF) is computed as the average RSF of all banks in a country-currency pair weighted by their respective market shares in that specific market.[31]

To explore the substitution of credit across origination countries we implement a second set of tests in which we replace the dependent variable by the (exchange rate adjusted) growth rate in total cross-border credit to the country-currency pair in consideration from the 'rest of the world' (i.e. world ex UK) or from the currency areas of the currencies we consider; that is, the US and Euro Area. We compute these series using data from the BIS Locational Banking Statistics.

In order to operationalise this setting, we run an adjusted version of Equation (4) using a panel at the country-currency-quarter level. This adjusted empirical model is formalized by Equation (5):

[31]For this exercise we employ the full dataset without the filters imposed on the data in our baseline specification to allow for a potential substitution across all UK-based banks active in a given market abroad.

$$\Delta L_{j,k,t} = \alpha + \beta_1 RSF_{j,k,t-5} + \sum_{l=1}^{4} \beta_{2,l} \Delta CIP_{k,t-l} * RSF_{j,k,t-5} \qquad (5)$$

$$+ \beta_3 X_{j,t-1} + \gamma_{j,k} + \delta_t + \epsilon_{j,k,t}$$

In Equation (5) we study the cross-border lending growth rate in country j and currency k during quarter t ($\Delta L_{j,k,t}$). As in our baseline specification, the variable of interest is the interaction between a country-level proxy for the exposure to synthetic funding in currency k by banks operating in country j (RSF) and the deviations in the CIP condition (ΔCIP). We consider country-currency and time fixed effects. Although this specification does not allow for the type of credit demand control implemented in Equation (4), we can still absorb demand shocks that spread similarly across countries and currencies.[32] To ensure consistency, the country-currency level panel used to run the estimation of Eq. (4) is matched to this country-currency specification, including the same group of 70 countries.

Table 6 reports the results of testing for substitution of credit across UK-based banks with different exposures to synthetic FX funding. Column I reports a positive and statistically significant joint coefficient for the interaction term of interest, suggesting that markets with a large presence of UK-based banks largely exposed to synthetic funding experience a drop in aggregate credit from the UK when synthetic funding shocks occur. We interpret this result as evidence against a potential substitution of credit across UK-based banks with different exposures to synthetic funding. Interestingly, despite not speaking directly to substitution dynamics, columns II-V show that, in periods of synthetic market strain, aggregate lending from the UK does not fall in destination markets with large share of lending originated from UK-based branches (cols. II-III) or UK banks with large use of internal capital markets (cols. IV-V). [33] This result - which goes in line with our findings from Section 3.2 at the bank-level - could imply that either there is more active substitution or that the original credit supply does not fall initially given the large presence of banks that can undo the effect of synthetic

[32] Richer fixed effect structures such as receiving country-time fixed effects are difficult to implement in our core specification measuring substitution across originator countries. This is because of stronger data restrictions in the cross-country BIS International Banking Statistics compared to the UK micro-banking data used in our baseline specification: for reasons for confidentiality or an actual lack of data there are often for example no observations on lending in euros to countries in Latin America or for lending in dollars to countries in Central or Eastern Europe.

[33] For this exercise we split the sample according to the 75th percentile of the pre-2008 distribution of the share of UK-based branches in total claims from the UK.

funding shocks by relying on their internal capital markets.[34]

Next, we re-estimate Eq. (5) by replacing the dependent variable $\Delta L_{j,k,t}$ by the growth rate in cross-border claims from the 'rest of the world' (all countries ex-UK) in general, and, alternatively, from the corresponding currency areas of the flows in consideration (i.e., the US and Euro Area). The latter is motivated by these regions being the 'home areas' for the currencies we consider, i.e. the US dollar and the euro, and hence less exposed to shocks to the cost of obtaining these currencies synthetically. The results from this analysis are reported in Table 7. While in these regressions we keep the focus on the joint coefficient of the interaction term ($\Delta CIP_{k,t-l} * RSF_{j,k,t-5}$), which still reflects the weighted reliance of synthetic funding of UK banks active in the relevant market, we would expect, in contrast to our baseline results, a negative sign if a substitution across origination countries takes place; that is, we would expect lending from these areas to increase in the face of shocks to sterling-based synthetic FX funding in their respective currencies (which we have seen to reduce UK lending).

Given the change in the dataset used to measure cross-border lending from Bank of England regulatory data to BIS Locational Statistics, in Column I we report a repeat of the exercise on UK lending shown in Table 6, but estimated on BIS data. Reassuringly, results hold and the magnitudes of effects are very similar. Turning to cross-country substitution, column II shows that this does not take place between the UK and the world considered as a whole, as the rest of the world does not increase lending to affected countries in the event of sterling-based synthetic funding shocks. However, the result changes when considering only cross-border flows originated in the US and the Euro Area (column III), in which case estimating Eq. (5) results in a negative and statistically significant coefficient. This is intuitive if synthetic funding shocks are not exclusive to sterling but also shared across other non-US dollar/euro currencies. As a further exercise we look separately at markets with a high and low market share of UK-based banks, as a proxy for their exposure to sterling-based synthetic funding shocks (columns IV and V).[35] It can be seen that it is indeed the case that the increase in credit supply from US and Euro Area based banks only happens in those markets particularly affected by our shock, that is, in markets where UK-based banks have a larger presence ex-ante and where a larger share of them is largely exposed to synthetic funding.

How large is such cross-country substitution? The answer is nuanced. We indeed see currency area banks increasing lending to affected markets, but it is yet to be determined

[34] As in Section 4.3 and due to data limitations, this exercise is restricted to the period 2008-2016.

[35] This sample split follows the same definition as in Table 4.

whether that increase in lending is enough to offset the fall in lending coming from the UK. This net effect will depend on the relative importance of lending from UK banks and lending from currency area banks and has to be considered on a case-by-case basis. As an illustrative example, we can go back to the case study considered in Section 3.2. During the second quarter of 2012, the sterling-based US dollar basis widened by 7 basis points (making it more expensive to secure US dollars synthetically). In order to illustrate heterogeneities in the degrees of substitution in cross-border lending let us consider two cases: Singapore, which receives around 30% of its US dollar funding from the UK, and South Africa, for which the share of dollars coming from UK is close to 50%. The market-weighted reliance on synthetic funding of UK banks active in these markets is very similar, at around 20%. Using the coefficients displayed in Table 7, it can be calculated that, in the face of the CIP shock considered, the increase in cross-border lending from the US offsets around two-thirds of the fall in UK lending for Singapore, but that this figure was smaller, at around one third, for South Africa, given the larger reliance on the UK for its US dollar funding.

In sum, the analysis of credit supply from affected and non-affected banks in the event of synthetic funding shocks suggests that (i) substitution does not take place within the sample of UK-based banks, but (ii) other banks, namely those based in the US and Euro Area, do step in and increase their lending to particularly affected recipient countries. The net effect depends on initial levels of lending coming from the UK and the respective currency area. This result highlights the effects on the geographical distribution of cross-border lending that arise as a consequence of global banks' limited access to alternative FX funds in a context of significant dislocations in synthetic FX funding markets.

6 Conclusion

This article documents the existence of a cross-border bank lending channel arising from funding shocks in FX swap markets. By looking at balance sheet data from banks operating in the UK we show that banks cut cross-border lending in specific foreign currencies whenever the cost of obtaining funds in these currencies goes up in FX derivatives markets. These instances are reflected in deviations in the covered interest rate parity (CIP) condition, which have drawn much attention in the post financial crisis era.

By exploiting the richness of our dataset we are able to control for a series of confounding factors, and to tightly identify a causal link going from the cost of 'synthetic' FX funding to the supply of cross-border FX loans. When further dissecting these results we find that banks with higher reliance on synthetic funding cut back lending by a greater extent in the face of synthetic funding shocks, and that the effect is alleviated for those banks that have access to on-balance-sheet FX funds coming from abroad via internal capital markets. The effects we find are highly statistically significant and economically meaningful. We interpret our results as evidence of the relevance of institutional frictions in the workings of global banking activities.

When exploring the degree of borrower substitution towards other lenders, we do not find evidence of an increase in lending from unaffected UK banks, but do see an increase in lending originating from the corresponding currency areas, particularly towards destination countries with initial high reliance on UK lending. However, this increased lending does not work as a full offset in many cases, pointing to the macroeconomic consequences of the mechanisms outlined in the paper.

Our results could inform policy discussions related to international financial fragmentation and the need for regulatory cooperation to tackle the drivers of fragmentation. Specifically, it may contribute to the debate on the future of global banking and potential restrictions on global bank operations. Since the outset of the latest financial crisis several countries have introduced policies aimed at restricting the ability of domestic banks and foreign bank affiliates to participate in internal (and external) capital markets, including geographic ring-fencing policies.[36] These policies attempt to protect the interests of domestic stakeholders, limiting the transmission of foreign shocks.[37] Our analysis highlights a potential unintended drawback of this drive: by restricting global banks' capacity to manage internal liquidity on a global scale, these policies may entail the risk of reducing banks' access to FX liquidity, affecting thereby the stability of cross-border banking flows. In this context, international regulatory cooperation may be important in addressing the financial stability concerns behind potentially fragmenting policies.

[36]See OECD (2017) for a recent survey of the structural banking reform measures implemented in most of the countries surveyed in the aftermath of the crisis. This report highlights that a key issue being increasingly monitored since the crisis concerns liquidity and many financial requirements are liquidity related.

[37]Previous studies have argued that these policies may provide a cushion against financial contagion (Anginer et al., 2017) at the cost of increasing banks' capital and liquidity needs (Makarova et al., 2010). See also Beck et al. (2015). See Fiechter et al. (2011) for a discussion on the financial stability implications of branches vs. subsidiary based models of international banking.

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Figures and tables

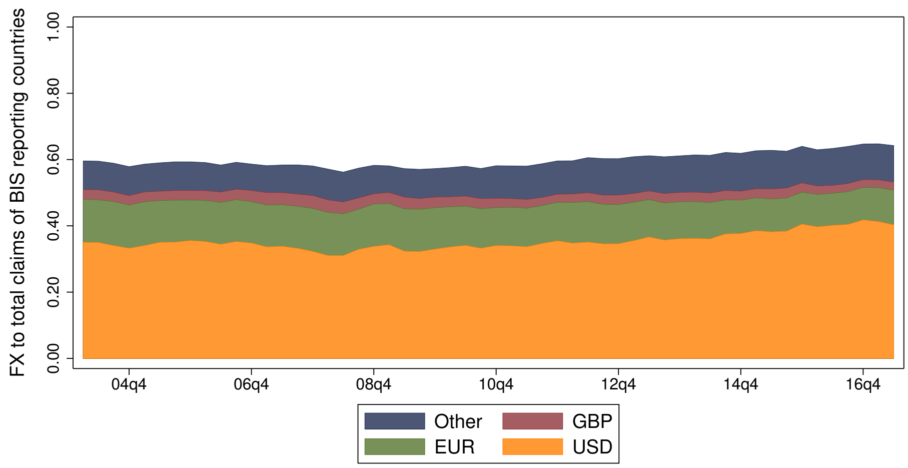

Figure 1 Cross-border bank claims in currencies other than originator home currency

Notes: Authors' calculations based on the BIS Locational Banking Statistics. The figure shows the share of cross-border claims originated outside the currencies' domestic countries with respect to total currency-specific claims originated in all BIS reporting countries. The figure reports the breakdown for US dollar (USD), sterling (GBP), euro (EUR) and other currencies (Other). The figure shows that around 60 percent of cross-border claims originate outside the home countries of their currencies of denomination. Cross-border flows in US dollar originated outside the US represent around 40 percent of total (world-level) claims.

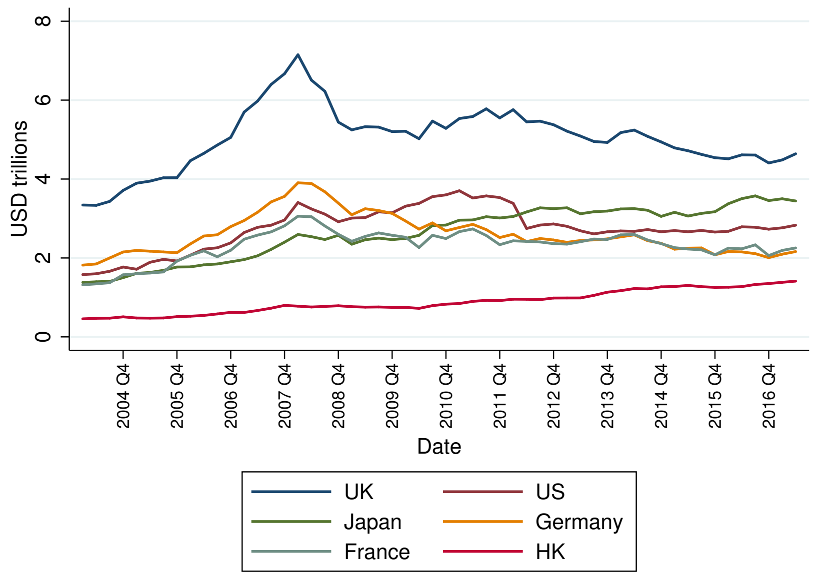

Figure 2 Cross-border bank claims by country of origination

Notes: This figure depicts aggregate cross-border claims in US dollar trillions from 2004 to 2016 on a quarterly basis. The figure is based on data from the BIS Locational Banking Statistics. Each line represents the aggregate claims originated by banks located in the UK, the US, Japan, Germany, France and Hong Kong (HK). German data are interpolated when missing. These countries represent the major sources of cross-border banking claims.

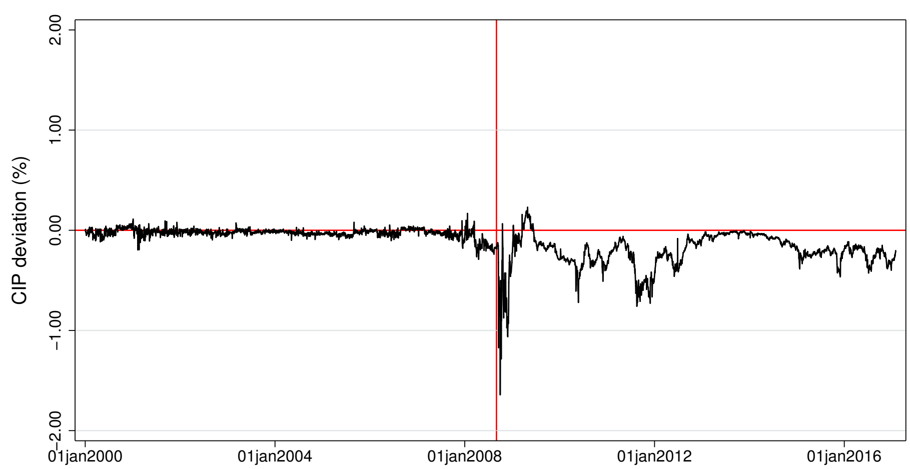

Figure 3 Sterling-based CIP deviations (average across currency pairs)

Notes: Authors' elaboration based on data from Bloomberg. The figure shows the average cross-currency basis between sterling (GBP) and four major currencies: US dollar (USD), Japanese yen (JPY), Swiss franc (CHF) and euro (EUR). The red vertical line marks September 1st 2008. A negative CIP deviation denotes a situation in which foreign currency funding is more expensive in FX swaps markets compared to cash markets.

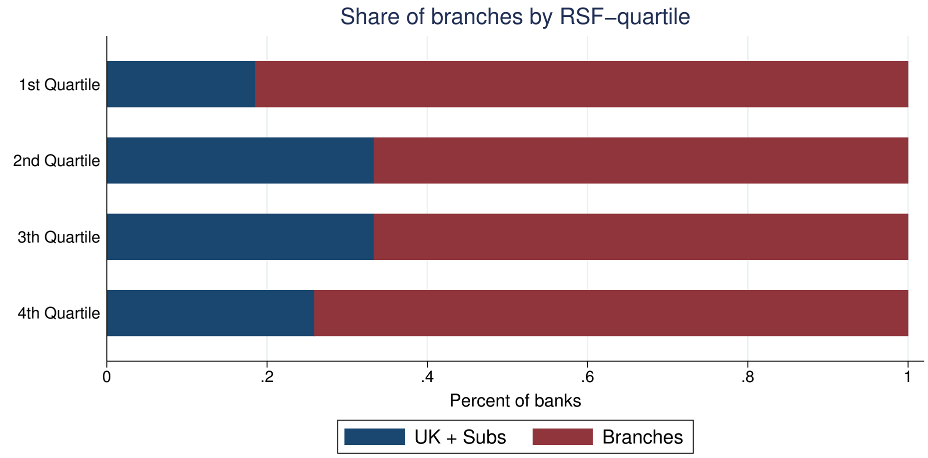

Figure 4 Share of branches by RSF-quartile

Notes: The figure shows the share of foreign branches (red area) and UK-regulated banks (blue area) as a share of the total number of banks in the four quartiles of the RSF distribution. RSF represents the ratio of synthetic funding to assets. The figure is constructed from the working sample used for the econometric analysis and based on regulatory data from the Bank of England.

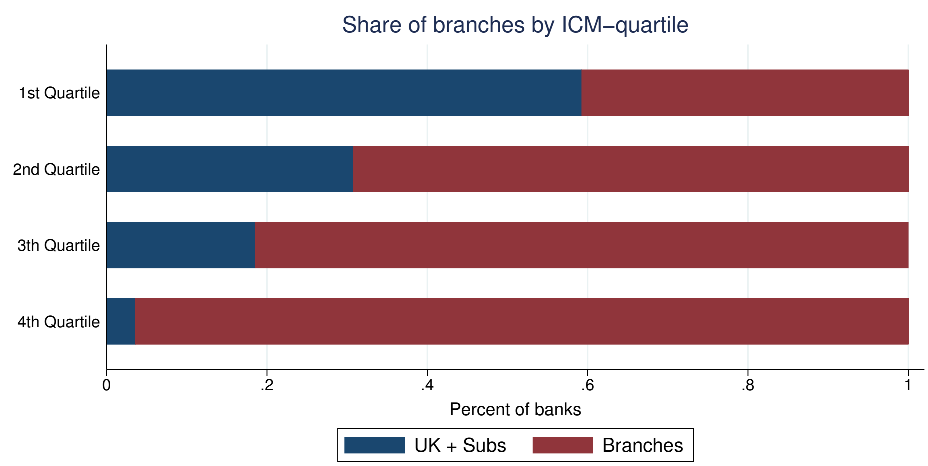

Figure 5 Share of branches by ICM-quartile

Notes: The graph shows the share of foreign branches (red area) and UK-regulated banks (blue area) as a share of the total number of banks in the four quartiles of the distribution of the ratio of ICM liabilities to assets. ICM stands for the ratio of internal capital market liabilities from abroad (currency-specific) to total bank assets. The figure is constructed from the working sample used for the econometric analysis and based on regulatory data from the Bank of England.

Table 1 Bank level dataset – Descriptive statistics

	mean	median	S.D.	min	max	***RSF*** large	low	Dif
	I	II	III	IV	V	VI	VII	VIII
Dep. var.								
$\Delta L_{i,j,k,t}$	0.01	0.00	0.77	-3.15	3.30	0.05	0.05	0.01
Exposure var.								
RSF_{t-5}	0.09	0.00	0.17	0.00	0.70	0.09	0.01	0.081*
Control var.								
$Log\, assets_{t-1}$	17.68	17.78	1.83	13.33	19.83	17.47	17.52	-0.05
$Dep.\, ratio_{t-1}$	0.76	0.75	0.32	0.03	1.75	0.77	0.68	0.10
$Liq.\, ratio_{t-1}$	0.39	0.34	0.22	0.01	0.96	0.38	0.35	0.03
$Cap.\, ratio_{t-1}$	0.08	0.04	0.09	-0.06	0.38	0.08	0.06	0.03
$\Delta L^{\neq k}_{i,k,t}$	0.01	0.01	0.27	-0.90	0.95	0.06	0.06	0.00
CIP deviation								
GBP-CB	-0.07	-0.08	0.18	-0.76	0.41			
ΔCIP	0.00	0.00	0.14	-0.74	0.46			

Note: This table reports descriptive statistics for our main variables of interest. The dependent variable $\Delta L_{i,j,k,t}$ is computed as the quarter-to-quarter change in log total claims of bank i in country j, currency k and quarter t. The variable RSF represents the ratio of synthetic funding to assets at the bank-currency-quarter level. The table reports descriptive statistics for the following control variables: Banks' size ($Log\, Assets_{t-1}$), deposit-to-assets ratio ($Dep.\, ratio_{t-1}$), liquid-to-total assets ratio ($Liq.\, ratio_{t-1}$), and capital-to-assets ratio ($Cap.\, ratio_{t-1}$). The variable $\Delta Claims_{\neq k}$ represents the average change in log total claims of bank i in all currencies different than k. The table reports for each variable its sample average (mean), median, standard deviation (S.D.), and the minimum (Min.) and maximum (Max.) values. Columns VI and VII report the pre-2008 average for each variable for two subsamples: Banks with an average pre-2008 RSF ratio above (VI) and below (VII) the sample median. Column VIII shows the difference in means between large and low RSF banks. * indicates whether this difference is statistically significant by normalized differences (Imbens and Wooldridge, 2009). The last two rows report summary statistics for two measures of CIP deviations: GBP currency basis (level, GBP-CB) and the quarter-to-quarter change in the GBP currency basis (ΔCIP).

Table 2 Benchmark results

	I	II	III	IV	V
Joint ΔCIP x RSF_{t-5}		0.745**	0.678***	0.617***	0.605***
		(0.287)	(0.251)	(0.195)	(0.176)
Joint ΔCIP	0.108**	0.0259	0.0224	-0.0241	
	(0.0506)	(0.0912)	(0.0836)	(0.0811)	
RSF_{t-5}		-0.022	-0.024	0.007	0.020
		(0.015)	(0.017)	(0.021)	(0.031)
Interaction terms:					
ΔCIP_{t-1} x RSF_{t-5}		0.306**	0.287**	0.204*	0.192**
		(0.127)	(0.122)	(0.110)	(0.087)
ΔCIP_{t-2} x RSF_{t-5}		0.278*	0.257*	0.271**	0.261**
		(0.142)	(0.137)	(0.122)	(0.107)
ΔCIP_{t-3} x RSF_{t-5}		0.190	0.178	0.192	0.170
		(0.117)	(0.118)	(0.130)	(0.126)
ΔCIP_{t-4} x RSF_{t-5}		-0.029	-0.045	-0.050	-0.018
		(0.116)	(0.105)	(0.098)	(0.083)
Controls:					
$Log\, assets_{t-1}$			0.001	-0.013	-0.013
			(0.002)	(0.010)	(0.010)
$Dep.\, ratio_{t-1}$			-0.002	0.004	0.008
			(0.012)	(0.014)	(0.017)
$Liq.\, ratio_{t-1}$			-0.016	-0.033	-0.037
			(0.018)	(0.044)	(0.046)
$Cap.\, ratio_{t-1}$			0.035	-0.096	-0.093
			(0.041)	(0.088)	(0.087)
$\Delta L^{\neq k}_{i,k,t}$			0.107***	0.076***	0.084***
			(0.022)	(0.023)	(0.022)
Constant	0.011***	0.012*	0.001	0.262	0.256
	(0.003)	(0.007)	(0.023)	(0.180)	(0.183)
No. of Banks	106	106	106	106	106
Fixed effects	None	None	None	i	i,j,k
				j,t	j,k,t
Obs	62,739	62,739	62,739	62,739	62,739
R^2	0.000	0.000	0.002	0.060	0.108

Note: This table reports the results from estimating Equation (4) for different specifications of the model. All constitutive terms of the interactions are included in the regressions. Coefficients for $\Delta CIP_{k,t}$ are not reported. Col. I reports the results of regressing $\Delta L_{i,j,k,t}$ only on the four lags of $\Delta CIP_{k,t}$, showing the respective joint coefficient in the upper row (Joint ΔCIP). In Col. II we add the four lags of the interaction term between $\Delta CIP_{k,t}$ and $RSF_{i,k,t-5}$. Column III further includes our set of control variables. Column IV adds both bank (i) and country-quarter (j,k) fixed effects. Finally, Column V reports our preferred benchmark specification including both bank-country-currency (i,j,k) and country-currency-time fixed effects (j,k,t). This latter model absorbs any variation that is specific to banks serving a particular country-currency market, as for instance borrowers' credit demand in that currency. Robust standard errors clustered at the bank- and quarter-level are reported between parentheses. Variables are winsorized at the 1st and 99th percentiles. Variables' definitions are reported in Table A.1 in the Appendix. *** indicates significance at the 1% level; ** at the 5%; * at the 10%.

Table 3 Access to FX funding: Foreign Branches

	Triple interaction term ($Trait_{t-5}$):			
	None	Branch	CA Branch	Non-CA Branch
	I	II	III	IV
Joint ΔCIP x RSF_{t-5} x $Trait_{t-5}$		-0.522**	-0.795**	0.194
		(0.246)	(0.390)	(0.479)
Joint ΔCIP x RSF_{t-5}	0.605***	0.813***	0.793***	0.594***
	(0.176)	(0.227)	(0.238)	(0.170)
Joint ΔCIP x $Trait_{t-5}$		0.0379	0.0800	-0.0445
		(0.107)	(0.0761)	(0.108)
RSF_{t-5} x $Trait_{t-5}$		0.061	0.005	0.124*
		(0.066)	(0.072)	(0.069)
$Trait_{t-5}$		0.000	0.211***	-0.228***
		(0.000)	(0.035)	(0.030)
RSF_{t-5}	0.020	-0.012	0.019	-0.003
	(0.031)	(0.043)	(0.040)	(0.032)
Controls:				
$Log\,assets_{t-1}$	-0.013	-0.013	-0.022**	-0.020**
	(0.010)	(0.011)	(0.009)	(0.009)
$Dep.\,ratio_{t-1}$	0.008	0.010	0.010	0.013
	(0.017)	(0.018)	(0.017)	(0.018)
$Liq.\,ratio_{t-1}$	-0.037	-0.031	-0.031	-0.024
	(0.046)	(0.046)	(0.045)	(0.046)
$Cap.\,ratio_{t-1}$	-0.093	-0.075	-0.138*	-0.119*
	(0.087)	(0.082)	(0.081)	(0.071)
$\Delta L^{\neq k}_{i,k,t}$	0.084***	0.084***	0.082***	0.083***
	(0.022)	(0.023)	(0.022)	(0.022)
Constant	0.256	0.245	0.333**	0.428**
	(0.183)	(0.190)	(0.154)	(0.169)
Observations	62,739	62,739	62,739	62,739
R^2	0.108	0.108	0.108	0.108

Note: This table reports the results from estimating Equation (4) by adding an interaction term between ΔCIP x RSF_{t-5} and variables measuring banks' different organizational structure and access to global FX funding. All constitutive terms of the interactions are included in the regressions. The variable $Trait_{t-5}$ represents the respective interaction term in each column lagged in five quarters. Col. I replicates the benchmark results from Col. V in Table 2. Columns II to IV include triple interactions with a foreign branch dummy (Branch, Col. II); a dummy for foreign branches from the US or Euro Area (CA Branch, Col. III); and a dummy for foreign branches with a headquarter in currency areas different than the US or the Euro Area (Non-CA Branch, Col. IV). Robust standard errors clustered at the bank and quarter level are reported between parentheses. All regressions include the full set of fixed effects at the bank-country-currency and country-currency-time level. Variables are winsorized at the 1st and 99th percentiles. Variables' definitions are reported in Table A.1 in the Appendix. *** indicates significance at the 1% level; ** at the 5%; * at the 10%.

Table 4 ACCESS TO FX FUNDING: ON-BALANCE-SHEET FX-FUNDING

	Triple interaction term ($Trait_{t-5}$):					
	Branch	Total FX	ICM rat.	Non-ICM rat.	ICM rat.: Branches	ICM rat.: UK-regulated
	I	II	III	IV	V	VI
Joint ΔCIP x	-0.522**	-0.795	-1.263***	2.367	-1.720	-2.574**
RSF_{t-5} x $Trait_{t-5}$	(0.246)	(1.783)	(0.395)	(3.318)	(1.364)	(1.231)
Joint ΔCIP x RSF_{t-5}	0.813***	0.693**	1.059***	0.518**	0.726**	1.013*
	(0.227)	(0.299)	(0.328)	(0.223)	(0.327)	(0.535)
Joint ΔCIP x $Trait_{t-5}$	0.0379	0.0101	0.0979	-0.175**	-0.00375	1.083**
	(0.107)	(0.108)	(0.174)	(0.0825)	(0.192)	(0.391)
RSF_{t-5} x $Trait_{t-5}$	0.061	-0.070	0.039	0.108	0.078	-0.011
	(0.066)	(0.226)	(0.055)	(0.262)	(0.113)	(0.120)
$Trait_{t-5}$	0.000	-0.018	-0.009	-0.055***	-0.014	-0.000
	(0.000)	(0.025)	(0.022)	(0.013)	(0.022)	(0.080)
RSF_{t-5}	-0.012	0.056	0.038	0.042	0.004	0.142*
	(0.043)	(0.039)	(0.032)	(0.037)	(0.054)	(0.077)
Controls:						
$Log\,assets_{t-1}$	-0.013	-0.019	-0.019	-0.023*	-0.018	-0.059
	(0.011)	(0.014)	(0.014)	(0.012)	(0.016)	(0.065)
$Dep.\,ratio_{t-1}$	0.010	0.030	0.029	0.020	0.055**	-0.028
	(0.018)	(0.025)	(0.023)	(0.023)	(0.024)	(0.055)
$Liq.\,ratio_{t-1}$	-0.031	-0.045	-0.049	-0.041	-0.082*	-0.018
	(0.046)	(0.041)	(0.040)	(0.037)	(0.048)	(0.116)
$Cap.\,ratio_{t-1}$	-0.075	-0.022	-0.019	-0.036	-0.111	0.017
	(0.082)	(0.139)	(0.133)	(0.139)	(0.167)	(0.272)
$\Delta L_{i,k,t}^{\neq k}$	0.084***	0.062**	0.063**	0.060**	0.065*	0.059
	(0.023)	(0.026)	(0.026)	(0.025)	(0.035)	(0.044)
Constant	0.245	-0.070	0.039	0.108	0.078	-0.011
	(0.190)	(0.226)	(0.055)	(0.262)	(0.113)	(0.120)
Observations	62,739	36,573	36,573	37,887	21,318	14,503
R^2	0.108	0.112	0.112	0.112	0.138	0.227

Note: This table reports the results from estimating Equation (4) by adding an interaction term between ΔCIP x RSF_{t-5} and variables measuring banks' different degree of access to on-balance-sheet FX funding. The sample period is restricted to 2008Q1 to 20016Q1. The variable $Trait_{t-5}$ represents the respective interaction term in each column lagged in five quarters. For comparison, col. I replicates the exercise using triple differences with the branch dummy reported in col. III in Table 3. Columns II to IV report triple interaction regressions with dummies equal to one for banks above the 75th percentile of the respective variable. The variables of interest (i.e. $Trait_{t-5}$) are the ratio of (FX-specific) FX funding to total assets (Total FX, col. II); the ratio of (FX-specific) internal FX funding (ICM) to total assets (ICM rat., col. III); and the ratio of non-ICM funding to total assets (Non-ICM rat., col. IV). Columns V and VI replicate the exercise from col. III for the subset of foreign branches (col. V) and UK-regulated banks (col. VI). Robust standard errors clustered at the bank and quarter level are reported between parentheses. All regressions include the full set of fixed effects specified in Eq. (4). Variables are winsorized at the 1st and 99th percentiles. Variables' definitions are reported in Table A.1 in the Appendix. *** indicates significance at the 1% level; ** at the 5%; * at the 10%.

Table 5 ACCESS TO FX FUNDING: INTERNAL FUNDING GROWTH

	Triple interaction term ($Trait_{t-5}$):				
	None	Branch	Branch	ICM rat.	ICM rat.
	I	II	III	IV	V
Joint ΔCIP x		-3.532**	-2.161	-2.085*	-3.258*
RSF_{t-5} x $Trait_{t-5}$		(1.859)	(2.087)	(1.216)	(1.852)
Joint ΔCIP x RSF_{t-5}	-0.624	1.519	0.522	1.334	0.850
	(1.694)	(1.093)	(1.432)	(1.447)	(1.662)
Joint ΔCIP x $Trait_{t-5}$		-0.0269	-0.460	0.784*	1.132*
		(0.166)	(0.435)	(0.445)	(0.600)
RSF_{t-5} x $Trait_{t-5}$		-0.449***	-0.490***	-0.112	-0.125
		(0.142)	(0.143)	(0.146)	(0.213)
RSF_{t-5}	0.138	0.510***	0.541***	0.467**	0.480**
	(0.139)	(0.122)	(0.123)	(0.182)	(0.202)
Controls:					
$Log\, assets_{t-1}$	-0.020	-0.020	-0.024	0.008	-0.008
	(0.036)	(0.036)	(0.039)	(0.008)	(0.008)
$Dep.\, ratio_{t-1}$	-0.064*	-0.067*	-0.071	-0.026	-0.036
	(0.035)	(0.038)	(0.042)	(0.061)	(0.083)
$Liq.\, ratio_{t-1}$	-0.135	-0.144	-0.144	-0.508	-0.452
	(0.142)	(0.141)	(0.146)	(0.350)	(0.378)
$Cap.\, ratio_{t-1}$	0.021	-0.037	0.019	0.890	0.621
	(0.322)	(0.311)	(0.330)	(0.633)	(0.759)
$\Delta L^{\neq k}_{i,k,t}$	0.089**	0.089**	0.084**	0.157	0.156
	(0.036)	(0.036)	(0.035)	(0.120)	(0.131)
Constant	0.492	0.416	0.493	-0.168	0.131***
	(0.585)	(0.558)	(0.591)	(1.564)	(0.039)
Fixed effects	None	i+k	i + k,t	i+k	i + k,t
Observations	4,214	4,214	4,214	1,019	1,019
R^2	0.018	0.021	0.034	0.037	0.082

Note: This table reports the results from estimating an adjusted version of Equation (4) with a panel structured at the bank-currency-quarter dimension. The dependent variable is the quarterly growth rate in internal FX funding liabilities. Col. I reports the result of a simple model replicating the double interaction structure of Equation (4). Columns II to V report the results of triple-interaction models in which ΔCIP x RSF_{t-5} is further interacted with variables measuring banks' ex-ante access to internal funding from abroad (i.e. $Trait_{t-5}$). Columns II and III use a branch dummy, while columns IV and V use a dummy equal to one for banks with a ratio of (currency-specific) FX internal liabilities to total assets (ICM rat.) above the 75th percentile. Columns II and IV include bank and currency fixed effects ($i + k$), whereas columns III and V include bank and currency-quarter fixed effects ($i + k, t$). Robust standard errors clustered at the bank and quarter level are reported between parentheses. Variables are winsorized at the 1st and 99th percentiles. Variables' definitions are reported in Table A.1 in the Appendix. *** indicates significance at the 1% level; ** at the 5%; * at the 10%.

Table 6 Macroeconomic dimension – Substitution across UK banks

		Share of UK branches in total claims:		Share of large ICM ratio:	
Sample:	Full	Low	High	Low	High
	I	II	III	IV	V
Joint ΔCIP x RSF_{t-5}	1.159**	1.326**	0.646	1.688*	-1.096
	(0.461)	(0.618)	(0.936)	(0.848)	(1.181)
RSF_{t-5}	-0.057	-0.099**	0.081	-0.110	0.047
	(0.037)	(0.041)	(0.065)	(0.078)	(0.095)
Controls:					
$Log\, assets_{t-1}$	0.008	0.007	0.009*	0.009	-0.007
	(0.006)	(0.007)	(0.005)	(0.011)	(0.014)
$Dep.\, ratio_{t-1}$	-0.021	-0.059	0.080*	-0.019	0.222*
	(0.036)	(0.045)	(0.046)	(0.062)	(0.114)
$Liq.\, ratio_{t-1}$	0.244***	0.316***	0.119	0.309**	-0.093
	(0.066)	(0.080)	(0.106)	(0.136)	(0.137)
$Cap.\, ratio_{t-1}$	0.434***	0.503***	0.039	0.013	1.185***
	(0.151)	(0.184)	(0.204)	(0.207)	(0.279)
Constant	-0.237**	-0.227*	-0.275**	-0.266	-0.157
	(0.102)	(0.120)	(0.108)	(0.196)	(0.202)
Obs	6,576	4,896	1,680	2,856	980
R^2	0.036	0.041	0.061	0.038	0.064

Note: This table reports the results from estimating Equation (5) at the country-currency level. The dependent variable is the quarterly change in log total claims to country j in currency k by all UK-based banks in the original sample ($\Delta L_{j,k,t}$), before including sample filters. The independent variables (with the exception of ΔCIP) are computed as market-share weighted averages of the respective underlying bank-level variables in each country-currency pair. Column I reports the results for the full sample. Columns II and III report a sample split exercise according to the 75th percentile of the pre-crisis average share of UK-based branches in total claims to each j, k pair. Columns IV and V replicate the sample split exercise according to the 75th percentile of the pre-crisis share of large ICM-ratio banks in total claims in each j, k pair. Large ICM-ratio banks are those with a ratio of (currency-specific) FX internal liabilities to total assets (ICM ratio) above the 75th percentile of the banks' distribution. All constitutive terms of the interactions are included in the regressions. Regressions include country-currency and time fixed effects. Standard errors (in parentheses) are clustered at the currency and quarter level. Variables are winsorized at the 1st and 99th percentiles. *** indicates significance at the 1% level; ** at the 5%; * at the 10%.

Table 7 MACROECONOMIC DIMENSION – SUBSTITUTION ACROSS SOURCE COUNTRIES

Claims from:	UK	Rest of world	Home CA		
			Share UK claims:		
Sample:	Full	Full	Low	High	Full
	I	II	III	IV	V
Joint ΔCIP x RSF_{t-5}	1.039**	-0.499	-0.959*	-0.651	-1.694**
	(0.415)	(0.403)	(0.541)	(0.661)	(0.769)
RSF_{t-5}	-0.084	-0.048	0.021	-0.041	0.079
	(0.052)	(0.033)	(0.041)	(0.051)	(0.069)
Controls:					
$Log\, assets_{t-1}$	0.013**	-0.001	0.003	0.002	0.004
	(0.005)	(0.002)	(0.002)	(0.003)	(0.006)
$Dep.\, ratio_{t-1}$	-0.008	-0.006	0.052	0.034	0.035
	(0.087)	(0.035)	(0.074)	(0.080)	(0.134)
$Liq.\, ratio_{t-1}$	0.239***	0.019	0.097*	0.119*	0.083
	(0.062)	(0.033)	(0.050)	(0.063)	(0.086)
$Cap.\, ratio_{t-1}$	0.434**	-0.050	-0.270*	-0.290*	-0.329
	(0.176)	(0.089)	(0.141)	(0.151)	(0.271)
Constant	-0.334***	0.025	-0.072	-0.045	-0.088
	(0.073)	(0.032)	(0.049)	(0.061)	(0.103)
Obs	6,546	6,546	5,695	2,999	2,696
R^2	0.039	0.076	0.035	0.043	0.048

Note: This table reports the results from estimating Equation (5) at the country-currency level. The dependent variable is the quarterly change in log total claims to country j in currency k computed using data from the BIS Locational Banking Statistics ($\Delta L_{j,k,t}$). The independent variables (with the exception of ΔCIP) are computed as market-share weighted averages of the underlying bank-level variables in each country-currency pair. The table reports regressions in which we compute $\Delta L_{j,k,t}$ using flows originated in three regions: UK (col. I), all countries different than the UK (Rest of world, col. II); and the US and Euro Area as the home currency areas of the currencies in which claims are denominated (Home CA, cols. III to V). In columns IV and V we report a sample split exercise according to the median of the pre-crisis average share of claims from the UK in total claims to each j, k market. All constitutive terms of the interactions are included in the regressions. Regressions include country-currency and time fixed effects. Standard errors are clustered at the currency and quarter level. Variables are winsorized at the 1st and 99th percentiles. *** indicates significance at the 1% level; ** at the 5%; * at the 10%.

A Appendix: Data

A.1 Variable definitions

Table A.1 describes the variables used in the analysis. These variables are divided into the following categories: dependent variables, main variables of interest, bank-level controls, and additional variables.

Table A.1 VARIABLES DEFINITIONS

Variable	Definition	Source
Dep. vars:		
$\Delta L_{i,j,k,t}$	Exchange-rate adjusted growth rate in cross-border claims of bank i to country j in currency k at time t in percent.	BoE
$\Delta L_{j,k,t}$	Aggregated exchange-rate adjusted growth rate in cross-border claims of all UK banks to country j in currency k at time t in percent. Alternatively, the variable is computed from total cross-border claims originated in the BIS reporting countries from the BIS Locational Banking Statistics.	BoE,BIS
Main vars:		
$\Delta CIP_{k,t-l}$	Quarter-to-quarter change in the cross-currency basis between sterling and currency k.	BBG
$RSF_{i,k,t-l}$	Ratio of synthetic funding in currency k by bank i relative to total liabilities in currency k. Synthetic funding in k is proxied by the difference between total assets and liabilities denominated in currency k.	BoE
Joint ΔCIPxRSF_{t-5}	Joint coefficient of 4-lags of interactions betweeen RSF and CIP for lags t=-1 to t=-4.	BoE& BBG
Dif_{t-5}	Dummy equal to 1 if the respective claims are denominated in EUR. Alternatively, the variable equals to 1 if ΔCIP is negative.	BBG
Control vars:		
$Log\, assets_{t-1}$	Log of total assets at the UK-bank level (excludes assets of foreign affiliates).	BoE

NOTES: This table reports the definitions and sources of the variables used in the analysis. The sources include the Bank of England (BoE), Bloomberg (BBG), the Claessens and Van Horen (2014) Bank Ownership Database (C&VH), the Locational Banking Statistics reported by the Bank of International Settlements (BIS), and the authors' own construction (own).

Table A.1 VARIABLES DEFINITIONS (CONTINUED)

Variable	Definition	Source
$Dep. ratio_{t-1}$	Ratio of total retail (sight + savings) deposits to total assets at the bank level.	BoE
$Liq. ratio_{t-1}$	Ratio of liquid assets (cash + BoE deposits) to total assets at the bank level.	BoE
$Cap. ratio_{t-1}$	Ratio of total equity to total assets	BoE
$\Delta L_{i,k,t}^{\neq k}$	Average growth rate of bank i's claims in non-k currencies to all countries but j.	BoE
Additional vars:		
Branch	Dummy variable equal to one if a bank in the sample is a branch of a foreign banking conglomerate operating in the UK.	C&VH
CA branch	Dummy variable equal to one if a foreign bank branch in the sample is owned by a bank headquartered either in the US or the Euro Area. These jurisdictions represent the home currency areas (CA) of the currencies in which cross-border claims are denominated (i.e. USD and EUR).	C&VH
Non-CA branch	Dummy variable equal to one if a foreign bank branch in the sample is owned by a bank headquartered outside the US or the Euro Area. These jurisdictions represent the home currency areas (CA) of the currencies in which cross-border claims are denominated (i.e. USD and EUR).	C&VH
Total FX	Ratio of total on-balance-sheet liabilities in a given FX currency to total bank assets. FX currencies are represented by either USD or EUR. In the analysis the variable enters the empirical model as a dummy equal to one for banks with a ratio above the 75th percentile, and 0 otherwise.	BoE

NOTES: This table reports the definitions and sources of the variables used in the analysis. The sources include the Bank of England (BoE), Bloomberg (BBG), the Claessens and Van Horen (2014) Bank Ownership Database (C&VH), the Locational Banking Statistics reported by the Bank of International Settlements (BIS), and the authors' own construction (own).

Table A.1 Variables definitions (continued)

Variable	Definition	Source
Additional vars:		
ICM ratio	Ratio of foreign internal liabilities in a given FX currency to total bank assets. FX currencies are represented by either USD or EUR. Internal liabilities represent liabilities vis-à-vis correspondent entities within the same banking conglomerate located outside the UK. In the analysis the variable enters the empirical model as a dummy equal to one for banks with a ratio above the 75th percentile, and 0 otherwise. This variable is only available for the period 2008-2016.	BoE
Non-ICM ratio	Ratio of Non-ICM liabilities in a given FX currency to total bank assets. FX currencies are represented by either USD or EUR. Non-ICM liabilities correspond to total on-balance-sheet liabilities minus ICM liabilities as described in the variable ICM rat.. In the analysis the variable enters the empirical model as a dummy equal to one for banks with a ratio above the 75th percentile, and 0 otherwise. This variable is only available for the period 2008-2016.	BoE
Rest of World	Dummy variable equal to one for countries different than the UK, and 0 otherwise.	Own
Home CA	Dummy variable equal to one for the US and the Euro Area countries, and 0 otherwise. These countries represent the home currency area (CA) of the currencies in which cross-border claims are denominated (i.e. USD and EUR).	Own

Notes: This table reports the definitions and sources of the variables used in the analysis. The sources include the Bank of England (BoE), Bloomberg (BBG), the Claessens and Van Horen (2014) Bank Ownership Database (C&VH), the Locational Banking Statistics reported by the Bank of International Settlements (BIS), and the authors' own construction (own).

Table A.1 VARIABLES DEFINITIONS (CONTINUED)

Variable	Definition	Source
Additional vars:		
Share of UK branches	Average pre-2008 (2003-2007) share of UK branches in total claims from banks operating in the UK to a given country-currency market i, j. In the analysis the variable is used as a dummy equal to one for markets with a share above the 75th percentile of the distribution, and 0 otherwise.	BoE
Share of large ICM rat.	Share of large-ICM ratio banks in total claims from banks operating in the UK to a given country-currency market i, j. Large-ICM ratio banks are banks with a ratio of internal liabilities from abroad (ICM) to assets above the 75th percentile of the variable's distribution. The share is computed as of 2008Q1, the first available observation. In the analysis the variable is used as a dummy equal to one for markets with a share above the 75th percentile of the distribution, and 0 otherwise.	BoE
Share of UK claims	Average 2003-2007 share of UK-originated cross-border claims in total claims to a given country-currency market i, j originated in the BIS reporting countries. In the analysis the variable is used as a dummy equal to one for markets with a share above the sample median, and 0 otherwise.	BIS

NOTES: This table reports the definitions and sources of the variables used in the analysis. The sources include the Bank of England (BoE), Bloomberg (BBG), the Claessens and Van Horen (2014) Bank Ownership Database (C&VH), the Locational Banking Statistics reported by the Bank of International Settlements (BIS), and the authors' own construction (own).

A.2 Dataset cleaning

To explore the effect of liquidity shocks in FX swap markets on cross-border credit supply we rely on regulatory data provided by the Bank of England covering the cross-border operations of all banks active in the UK. Both domestics as well as foreign-owned banks are included in the sample. We merge bank-level data from two main different sources. The first one reports balance-sheet information for banks located on the UK irrespective of whether they perform cross-border lending operations or not. These data reports the balance sheet of those banks as a UK jurisdictional entity. Therefore, it does not include the assets and liabilities of affiliated banks abroad. For each item in the balance sheet we can observe banks' positions in US dollar, euro and sterling. The second source provides us with information on banks' cross-border assets and liabilities for the aforementioned currencies. These data reports banks' cross-border positions per country and currency on a quarterly basis, following a panel with a bank-country-currency-time structure. For the purpose of our study we merge these two sources of data to generate a panel that reports banks' cross-border assets and liabilities in each country-currency pair (i.e. the relevant market in our setting) together with the domestic balance-sheet characteristics of banks in the UK.

We implement several filters to ensure that the structure of the dataset fulfills the identification requirements of our research question. This screening procedure is as follows. First, we restrict the original sample of 376 banks reporting some cross-border to those banks active throughout the sample period. This filter leaves us with 115 banks which represent the largest and historically more established banks provided cross-border banking services from the UK. We implement this first filter avoid the confounding effect of banks entering and exit the sample and to ensure that we compare the same banks over time. Moreover, focusing on the large players in the cross-border lending market reduces the within-bank volatility in the sample, which is important considering our focus on the intensive margin of the cross-border transmission of FX swap liquidity shocks. For instance, banks only seldomly active in cross-border lending can lead to abnormal growth rates in our left-hand side variable, polluting the sample with outliers.

As a second step we focus on our sample of relevant markets and keep for each bank only country-currency pairs that are reported throughout the sample period. This filter rules-out the effect of entries and exits from these markets and allows us to center the analysis on cross-border flows' disruptions affecting otherwise rather stable funding channels between banks in the UK and borrowers abroad. This filter leaves us with a sample of 3,589 bank-country-currency pairs (i.e. our unit of observation) out of the original 13,722 pairs. Despite of this drop in the number of observations, the sample still covers 80.5% of global cross-border claims in US dollar and euro from UK-based banks on average during the sample period. This latter filter also drops 9 banks that do not report a constant cross-border relationship with any of the country-currency bins in which they report some degree of activity. Therefore, the final sample comprises 106 banks active in 69 countries between 2003Q1 and 2016Q4.

This filtering process is important in order to fulfill the identification requirements imposed by the fixed effects structure of Equation (4). The country-currency-time fixed effects imply that we need to observe at least two banks holding cross-border claims in US dollar and euro in a given country over time. Since this feature of Equation (4) represents the core of our identification strategy – as it absorbs borrower demand confounders that can bias our estimates – we require the data to ensure that sufficient variation within each country-currency bin exists. Moreover, this setting is consistent with our focus on the intensive rather than on the extensive margin of the FX swap lending channel.

B Appendix: Additional Results

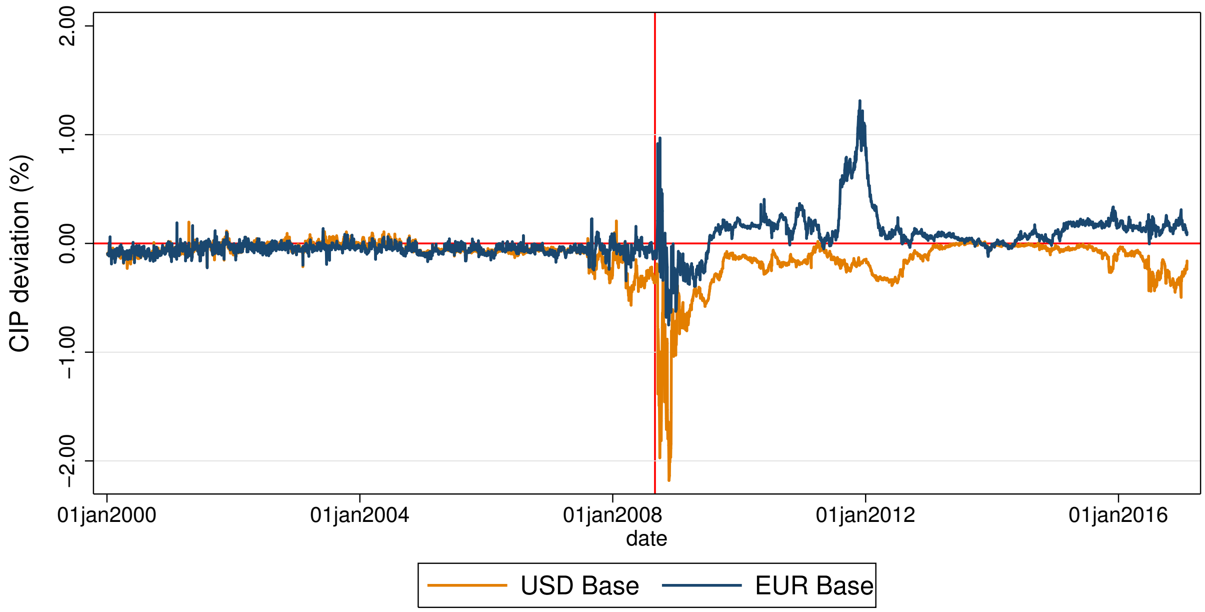

Figure B.1 Sterling-based CIP deviations by currency

Notes: Authors' elaboration based on data from Bloomberg. The figure depicts the cross-currency basis between GBP, on the one hand, and USD and EUR, on the other. A negative CIP deviation denotes a situation in which foreign currency funding is more expensive in FX swaps markets compared to cash markets.

Table B.1 ROBUSTNESS TESTS – EMPIRICAL SETTING

Specification:	Base	Exclude 08-09	Exclude 11-12	Placebo: ΔCIP	Placebo: ΔUSD	Top 5 trader: Yes	Top 5 trader: No
	I	II	III	IV	V	VI	VII
ΔCIP x RSF_{t-5}	0.605***	0.588**	0.744***	0.395	-1.805	1.248	0.475**
	(0.176)	(0.261)	(0.224)	(0.339)	(1.223)	(0.884	(0.232)
RSF_{t-5}	0.020	-0.003	0.012	0.021	0.027	0.159*	-0.012
	(0.031)	(0.030)	(0.035)	(0.032)	(0.029)	(0.069)	(0.032)
Controls:							
$Log\, assets_{t-1}$	-0.013	-0.004	-0.014	-0.013	-0.014	-0.080**	-0.009
	(0.010)	(0.013)	(0.011)	(0.010)	(0.010)	(0.026)	(0.011)
$Dep.\, ratio_{t-1}$	0.008	0.017	-0.002	0.007	0.006	0.009	0.010
	(0.017)	(0.019)	(0.022)	(0.017)	(0.017)	(0.073)	(0.020)
$Liq.\, ratio_{t-1}$	-0.037	-0.032	-0.024	-0.036	-0.037	-0.218	-0.024
	(0.046)	(0.054)	(0.057)	(0.045)	(0.046)	(0.129)	(0.045)
$Cap.\, ratio_{t-1}$	-0.093	-0.012	-0.062	-0.093	-0.096	0.276	-0.049
	(0.087)	(0.087)	(0.103)	(0.087)	(0.087)	(0.420)	(0.084)
$\Delta L_{i,k,t}^{\neq k}$	0.084***	0.082***	0.077***	0.085***	0.084***	0.302**	0.063***
	(0.022)	(0.025)	(0.026)	(0.023)	(0.023)	(0.085)	(0.022)
Constant	0.256	0.087	0.276	0.257	0.268	1.590**	0.165
	(0.183)	(0.233)	(0.188)	(0.184)	(0.184)	(0.472)	(0.184)
Obs	62,739	48,348	47,057	62,739	62,739	11,015	50,032
R^2	0.108	0.110	0.112	0.108	0.108	0.343	0.110

NOTE: This table reports the results from estimating Equation (4) under alternative specifications. All constitutive terms of the interactions are included in the regressions. Coefficients for $\Delta CIP_{k,t}$ and for its interactions with RSF_{t-5} are not reported. Column I replicates the benchmark results from column V in Table 2. Column II excludes the years 2008 and 2009 (i.e. global financial crisis) from the analysis, whereas column III excludes the years 2011 and 2012 (i.e. European sovereign debt crisis). In column IV we replace ΔCIP by a 'placebo' FX swap funding shock by assigning US dollar CIP deviations to euro lending and euro deviations to US dollar lending. In column IV we replace ΔCIP by a 'placebo' FX swap funding shock defined by quarterly changes in the BIS USD price index. In columns VI and VII we report regressions of sample splits according to whether banks belong to the group of top-5 banks in FX swaps' trading volume in the sample. Banks on column VI are within that group, whereas banks on column VII are outside the group. Robust standard errors clustered at the bank and quarter level are reported between parentheses. All regressions include a set of fixed effects at the bank-country-currency and country-currency-time level. Variables are winsorized at the 1st and 99th percentiles. Variables' definitions are reported in Table A.1 in the Appendix. *** indicates significance at the 1% level; ** at the 5%; * at the 10%.

Table B.2 Robustness tests – Alternative FE specifications

	I	II	III	IV	V	VI
Joint ΔCIP x RSF_{t-5}	0.605***	0.347**	0.365**	0.408*	0.499**	0.499**
	(0.176)	(0.178)	(0.178)	(0.239)	(0.227)	(0.230)
RSF_{t-5}	0.020	0.011	0.022	0.033	0.045	0.045
	(0.031)	(0.016)	(0.028)	(0.032)	(0.033)	(0.034)
Controls:						
$Log\,assets_{t-1}$	-0.013					
	(0.010)					
$Dep.\,ratio_{t-1}$	0.008	0.010	0.019**	0.022**	0.026**	0.026**
	(0.017)	(0.007)	(0.010)	(0.010)	(0.010)	(0.010)
$Liq.\,ratio_{t-1}$	-0.037					
	(0.046)					
$Cap.\,ratio_{t-1}$	-0.093					
	(0.087)					
$\Delta L^{\neq k}_{i,k,t}$	0.084***	-1.886***	-1.888***	-1.894***	-1.901***	-1.901***
	(0.022)	(0.076)	(0.076)	(0.076)	(0.073)	(0.074)
Constant	0.256	0.025***	0.017**	0.014*	0.010	0.010
	(0.183)	(0.005)	(0.007)	(0.007)	(0.007)	(0.008)
Fixed effects:	i,j,k j,k,t	i,t	i,j,k i,t	i,j,k i,t j,t	i,j,k i,t j,k,t	i,j,k i,t j,k,t HC,t
Obs.	62,739	62,355	62,355	62,355	62,355	62,355
R^2	0.108	0.154	0.158	0.213	0.255	0.255

Note: This table reports the results from estimating Equation (4) using alternative fixed effects (FE) specifications. All constitutive terms of the interactions are included in the regressions. Coefficients for $\Delta CIP_{k,t}$ and for its interactions with RSF_{t-5} are not reported. Column I replicates the benchmark results from Column V in Table 2 without changes to the empirical setting. This regression includes bank-country-currency (i,j,k) and country-currency-time (j,k,t) FE. The regression reported in column II includes only bank-time (i,t) FE. Columns III and IV add to column II bank-country-currency (i,j,k) and country-time (j,t) FE. Column V further adds country-currency-time (j,k,t) FE. In column VI we further add to the regression on column V home country-time FE (HC,t). We define home country as the country in which a given bank operating from the UK is headquartered. Robust standard errors clustered at the bank and quarter level are reported between parentheses. In columns II and VI only the coefficients for the control variables $Dep.\,ratio_{t-1}$ and $\Delta L^{\neq k}_{i,k,t}$ are reported, which vary over the bank-currency-time dimension. Other control variables are absorbed by bank-time FE. All regressions include a set of fixed effects at the bank-country-currency and country-currency-time level. Variables are winsorized at the 1st and 99th percentiles. Variables' definitions are reported in Table A.1 in the Appendix. *** indicates significance at the 1% level; ** at the 5%; * at the 10%.

Table B.3 Robustness tests – Horse-race against RSF

	Triple interaction term (Int_{t-5}):				
	None	Asset	Dep.	Liq.	Cap.
	I	II	III	IV	V
ΔCIP x RSF_{t-5}	0.605***	0.577**	0.706***	0.588***	0.608***
	(0.176)	(0.254)	(0.273)	(0.210)	(0.183)
ΔCIP x Int_{t-5}		0.00377	-0.153	-0.0579	-0.103
		(0.0193)	(0.137)	(0.115)	(0.472)
RSF_{t-5}	0.020	0.018	0.011	0.002	0.017
	(0.031)	(0.032)	(0.032)	(0.033)	(0.029)
Int_{t-5}		-0.015	0.018	0.015	-0.043
		(0.010)	(0.021)	(0.039)	(0.098)
Controls:					
$Log\,assets_{t-1}$	-0.013		-0.012	-0.014	-0.012
	(0.010)		(0.011)	(0.010)	(0.010)
$Dep.\,ratio_{t-1}$	0.008	0.008		0.006	0.008
	(0.017)	(0.018)		(0.017)	(0.017)
$Liq.\,ratio_{t-1}$	-0.037	-0.039	-0.038		-0.037
	(0.046)	(0.045)	(0.045)		(0.046)
$Cap.\,ratio_{t-1}$	-0.093	-0.084	-0.095	-0.096	
	(0.087)	(0.080)	(0.088)	(0.092)	
$\Delta L^{\neq k}_{i,k,t}$	0.084***	0.083***	0.084***	0.085***	0.085***
	(0.022)	(0.022)	(0.022)	(0.023)	(0.022)
Constant	0.256	0.281	0.235	0.257	0.230
	(0.183)	(0.178)	(0.196)	(0.186)	(0.183)
Obs.	62,739	62,739	62,738	62,739	62,739
R^2	0.108	0.108	0.108	0.108	0.108

Note: This table reports the results from estimating Equation (4) by including a second interaction term between ΔCIP and other bank-level characteristics (Int_{t-5}). These variables enter the model with a five-lag period. All constitutive terms of the interactions are included in the regressions. Coefficients for $\Delta CIP_{k,t}$ and for its interactions with RSF_{t-5} and Int_{t-5} are not reported. Column I replicates the baseline results from Column V in Table 2. Int_{t-5} represents the following variables: log assets (Asset, col. II), deposit ratio (Dep., col. III), liquidity ratio (Liq., col. IV), and capital ratio (Cap., col. V). In columns II to V the single component Int_{t-5} replaces the respective control variable. Robust standard errors clustered at the bank and quarter level are reported between parentheses. All regressions include a set of fixed effects at the bank-country-currency and country-currency-time level. Variables are winsorized at the 1st and 99th percentiles. Variables' definitions are reported in Table A.1 in the Appendix. *** indicates significance at the 1% level; ** at the 5%; * at the 10%.