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FX funding shocks and cross-border lending: fragmentation matters

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Abstract

This paper provides novel empirical evidence on the existence of a cross-border bank lending channel arising from funding shocks in FX swap markets ('CIP deviations'). Using balance sheet data from UK banks we show that when the cost of obtaining funds in a particular foreign currency increases, banks reduce the supply of cross-border credit in that currency. Notably, this effect is increasing in the degree of banks' reliance on swap-based FX funding. Fragmentation in funding markets appears to play an important role: we find that high access to foreign FX funding in general, and to internal capital markets in particular, shields banks' cross-border FX lending supply from the described channel.

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 zone.[1] This feature of the international financial landscape highlights the importance of FX funding markets, on which banks can rely to fund the global supply of cross-border foreign-currency (FX) loans.

Banks use a variety of funding sources —including local FX deposits, internal capital markets, wholesale funding and FX derivatives— 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). 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.

In this paper, we examine the impact of the fragmentation of global FX funding markets on the stability of cross-border bank credit supply. We explore whether shocks to the cost of FX-swap-based funding affect the cross-border lending supply of banks based in the UK that provide cross-border lending in currencies different than sterling. FX swap markets allow banks with a limited access to foreign currency funding markets to tap FX liquidity by swapping local currency funding without incurring foreign exchange risk. However, we inspect whether banks' reliance on this type of FX funding (usually called 'synthetic') affects the supply of cross-border FX credit in the face of liquidity shocks in FX swap markets. While increased reliance on swap-based funding may itself be a consequence of fragmented funding markets, we investigate further whether access to foreign FX funding markets shields the FX lending supply from the effect of the mentioned liquidity shocks for banks which rely on synthetic funding.[2] The use of data on UK banks provides an ideal vantage point to

[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] Access to foreign FX funding markets and thus the use of the word 'fragmentation' are defined based on the realized balance sheets of banks, acknowledging that a high reliance on synthetic funding or having no internal FX funding from other parts of the group may also be driven by other factors than fragmented FX

answer this question, as the UK is the single largest global originator of cross-border bank credit, a large share of which is denominated in currencies other than sterling.

Why could we expect changes to the costs of FX-swap-based funding 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 commercial paper debt directly in foreign money markets or exploit their internal capital markets to tap FX liquidity abroad. Cetorelli and Goldberg (2011) show, for instance, how global banks manage liquidity from a group-level perspective by exploiting their network of bank branches worldwide when facing liquidity shocks. 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, the fragmentation of banks' FX funding markets may imply that some banks face restrictions in accessing funding sources alternative to FX-swap-based funding, triggering a cross-border lending channel of liquidity shocks to FX swap markets. Temporary stress in one FX funding market may not be easily substituted away by accessing alternative liquidity sources, with consequences for the supply of FX lending.

Potential frictions are particularly important when it comes to banks' reliance on FX swap funding. If market fragmentation was important, and banks had limited access to on-balance-sheet FX funding, then these institutions may resort to FX swap-based funding as a way of overcoming geographical and regulatory barriers. In this scenario, banks with large reliance on FX swap funding could be expected to adjust their balance sheet by more once currency-specific liquidity shocks in FX swap markets occur. In contrast, banks with foreign affiliates and active internal capital markets, and/or swift access to FX funding markets more generally, should see this latter effect being attenuated.

Even though the reliance on FX synthetic funding as a share of total US dollar funding by non-US banks has been significant over the past decades, the implications of liquidity shocks in FX swap markets for cross-border FX credit have not yet been investigated to the best of our knowledge.[3] More generally, the literature on international banking has documented how liquidity shocks in global bank-funding markets can have real effects via

funding markets.

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

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, FX swap markets are likely to 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 liquidity shocks to the FX synthetic funding market.

To proxy for 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 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 liquidity 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'

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

(currency-specific) demand shocks. By observing banks' on-balance-sheet FX liabilities, we can explore heterogeneities in the response to FX synthetic funding shocks depending on banks' access to foreign FX funding markets. We implement this identification strategy on a sample that covers the activities of 106 banks in 69 countries between 2003 and 2016.

Our results suggest that liquidity shocks in global FX synthetic funding markets significantly affect the supply of cross-border FX lending by banks located in the UK. Importantly, the lending channel 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 20 basis points in the sterling-US dollar basis leads the bank in consideration to cut back US dollar lending growth by 1.6 per cent in comparison to a bank with average synthetic funding exposure.

In a second step, we explore the role of the fragmentation of FX funding markets as an underlying mechanism driving our baseline results. We conjecture that banks' access to on-balance-sheet FX funding, particularly if coming from abroad, can shield their supply of FX cross-border lending. Indeed, we find that for banks with high access to foreign FX funding markets in general, and to internal capital markets in particular, greater reliance on synthetic FX funding does not lead to greater effects on cross-border FX lending supply in the face of shocks to the cost of synthetic FX funding. A possible interpretation of this finding is that frictions imposed by fragmented FX funding markets affect banks' capacity to overcome liquidity shocks in FX swap markets.

By shedding light on this mechanism our paper informs discussions on the financial stability implications of international financial markets fragmentation (see for instance Dobler et al., 2016 and ECB, 2016).

Our baseline results are robust to different specifications of the model and alternative definitions of CIP deviations. Moreover, the results also hold when excluding the period of the global financial crisis or the subsample of banks that can be considered to be market makers in the FX swap market.

Finally, by aggregating the data at the destination country-currency level we find that countries cannot substitute away from the lending channel by tapping alternative UK banks.

Our work contributes to three strands in 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 has profusely documented how different types of liquidity shocks can affect bank' lending behavior provided that financial frictions exist. Previous studies have linked adjustments in cross-border credit supply to banking groups internal liquidity conditions (Cetorelli and Goldberg, 2011), 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)). These studies do not address the role of banks reliance on FX synthetic funding or access to fragmented FX funding markets 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 for instance 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. Also, we broaden the scope and not only focus on periods of market distress.

Particularly noteworthy for our analysis is the study of Ivashina et al. (2015). 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 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 —the sterling— as a benchmark. This allows us to compare lending in different currencies in the face of currency-specific synthetic funding shocks in a sample which is not necessarily restricted to crisis periods with big dislocations in financial markets. Notably, while Ivashina et al. (2015) examine the effect of funding shocks originating from US wholesale markets on FX lending abroad (i.e. US dollar), we on the other hand study whether access to such markets can shield UK banks FX lending responses in the face of currency-specific liquidity shocks.

Finally, a third related strand of literature refers to the recent set of studies investigating the occurrence of CIP deviations.[5] In contrast to most of these, we take CIP deviations as given and instead focus 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 and reports our baseline results. Section 4 explores the role of funding markets fragmentation in driving the baseline results. Section 5 discusses further robustness tests and Section 6 presents an extension of the baseline model that accounts for potential lender-substitution effects across borrowers. Section 7 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).

[5] See, e.g., Avdjiev et al. (2016), Du et al. (2017), 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 USD originated outside the US represent around 40 percent of total (world-level) claims. In terms of geographic origin, cross-border banking claims' origination is dominated by the worlds financial centres: Figure 2 shows that the UK is the largest lender by a wide margin, followed by the United States.

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 on banks' balance sheets is a panel of quarlerly 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 banks balance sheet, including capitalization, funding structure and business model characteristics. Second, we use information reported in form CC, which provides detailed data on banks international claims. 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 US dollars, euros and sterling. Finally, we obtain data on banks international liabilities from form CL. These data have been used in previous papers, such as Aiyar et al. (2014) and Forbes et al. (2017).

Our dependent variable captures the quarter-to-quarter growth rate in currency-specific international claims between bank i and all borrowers located in country j [6]. We therefore 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. Even though our data also provide information on claims in sterling, these positions are not considered as the focus of our paper is on 'foreign currency' lending, given the distinct nature of the relevant funding markets. Further positions in yen, Swiss franc, and 'other currencies' are also 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.[7]

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. This aims at reducing concerns of banks going into and out of the sample driving our results. Moreover, the identification strategy outlined below requires tracing bank-market relationships frequently over time so as to pin-down the effect of liquidity dynamics 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 69 countries, creating a sample of 3,589 bank-country-currency relationships that can be traced over time, including claims in US dollars and euros.[8] Each bank lends to 24 different countries on average. Despite the demands of this procedure, the final sample covers on average 80.5 percent of US dollar and euro cross-border claims originated in the UK over the period of study.

[6] An innovation of our data is that the available currency splits allow us to calculate growth rates based on exchange-rate adjusted changes in stocks. This adjustment makes sure that exchange rate valuation effects do not drive our results. Alternatively, we conduct robustness tests in which we replace our baseline dependent variable (total claims) for the specific amount of cross-border loans outstanding or, alternatively, for a version in which the growth rate in claims is computed as a quarter-to-quarter percentage change.

[7] 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.

[8] A detailed description of the steps required to obtain our final dataset can be found in Appendix A.2

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, see Section 2.3). 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.[9] We can see from Table 1 that banks do indeed use synthetic funding. Their average reliance on this type of funding is approximately 15 percent of total assets in a given foreign currency, and there is heterogeneity across banks (the standard deviation is 38 percent).

Table 1 reports descriptive statistics computed from the resulting baseline sample. The final panel includes 74,363 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 69 destination countries correspond to the US, 13 Euro Zone economies and 55 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 (RSF large) and those below that threshold (RSF low).

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 to 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 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 better observed. We find only little evidence of differences between the main balance sheet features of banks with different RSF ratios. The only statistically

[9] By construction this ratio of synthetic funding exposure can be either positive or negative. The latter case 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 5.

significant difference is that high-RSF banks tend to report a 5 percentage points larger deposit ratio. We do not expect this difference to be a major concern for the analysis, since the liquidity-cushion effect of a larger deposit base would, if anything, compensate for the balance-sheet adjustment due to a large RSF ratio, leading to more conservative results. Most 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 differentially exposed to those shocks.

In terms of the data going into our baseline specifications, both the dependent variable and all control variables are winsorized at the 2.5th and 97.5th percentiles [10]

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:

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

That is, it should be equivalent to borrow one US dollar at time t and pay back $(1+I_{t,t+n}^{USD})^n$ 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, $(1 + I_{t,t+n}^{GBP})^n$). 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

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

Equation 1) is lower than the FX-swap-implied interest rate (RHS of Equation (1)). 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.[11] It can be seen that this is not exclusively true for crisis periods.[12] This breakdown in the CIP condition has been the subject of study of a series of recent papers, including Avdjiev et al. (2016), Du et al. (2017), 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.

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

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

[12] The wedge in funding costs across markets cannot be explained by counterparty risk. Du et al. (2017) document the existence of CIP deviations using risk-free securities denominated in different currencies.

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 (1)), 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 obtain 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. (2017) 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 5).

3 The effect of currency-specific funding shocks on cross-border bank lending

In this section we outline the identification strategy that allows us to estimate the causal effect of currency-specific funding shocks in the swap market on banks' supply of cross-border lending in that currency. We then present our benchmark specification and baseline results.

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 changes in sterling-based CIP deviations with respect to both euros and US dollars. 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 misleading positive correlation between our variables of interest. Additionally, lending growth could as well be driven by changing demand; 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 would be driving both changes, then the correlation should not necessarily be particularly strong 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.[13] On the other hand, demand shocks could in principle constitute another confounding factor. 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. In order to control for this possibility 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

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

us to control for unobserved changes in demand for funds. 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:

$$\Delta L_{i,j,k,t} = \alpha + \beta_1 RSF_{i,k,t-5} + \sum\nolimits_{l=1}^{4} \beta_{2,l} \Delta CIP_{k,t-l} * RSF_{i,k,t-5} \tag{2}$$

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

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. $X_{i,t}$ 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 cross-border lending in the currencies other than the currency under study ($\Delta L^{\neq k}_{i,k,t}$) 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.

Following conventional use in the empirical banking literature (e.g., Kashyap and Stein, 2000), we consider the first four lags our main object of interest: the interaction between ΔCIP and the fifth lag of RSF. We then focus our analysis on the sum of these four interactions terms. This approach allows us to alleviate concerns that RSF may react to the dynamics in ΔCIP, generating a multicollinearity problem. 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 (2) 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 (2).

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. This can be seen in the fact that estimates for β_2 across specifications considering various fixed effects schemes are positive and highly significant.

Column (1) 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 credit supply. The specification underlying results in Column (2) factors in bank heterogeneity in reliance on synthetic funding for identification purposes (as described in Section 3.1), as well as controlling for other bank balance sheet characteristics. Results show 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 (3) we further tighten the specification by adding bank and time fixed effects. This setting allows us to absorb confounding factors related to banks' time-invariant characteristics and aggregate trends in the world economy affecting all banks in the sample. Our results are also robust to this fixed effects setting. Column (4) modifies the fixed effects structure by incorporating bank and country-time fixed effects. This fixed effects structure is more demanding on the data as it absorbs 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. In a final specification (columns 5) we allow these demand shocks (and other potential confounding factors) to be currency-specific by including country-currency-time fixed effects combined with the bank-level 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 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, 37 percentage points above the sample mean of 15 per cent. Based on the results from our benchmark model, a negative CIP deviation of 20 basis points in the sterling-US dollar basis (its post-2008 average) leads the bank in consideration to cut back US dollar lending by 1.6 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 full reliance on synthetic funding and observed CIP deviations above 100 basis points.

These benchmark results are unchanged when considering a battery of robustness checks, described in detail in Section 5.1.

4 Exploring the role of fragmentation

In the previous section we document the existence of a cross-border bank lending channel of funding shocks in FX swap markets. Banks with a high reliance on synthetic FX funding adjust their currency-specific cross-border FX lending particularly strongly in the face of changes in the cost of funds in 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 FX swap-based funding need not necessarily lead to shifts in lending behavior but only to a change in the source of those funds.

Our baseline results can therefore be interpreted as a consequence of banks difficulty in accessing FX funds in general, and of the fragmentation of banks' FX funding markets in particular. Specifically, it could be the case that banks rely on FX swap markets to circumvent frictions that prevent them from swifter access to on-balance-sheet FX funding, both in domestic and foreign markets. If this was the case, when system-wide frictions in FX swap markets arose and funding conditions tightened, the fragmentation of FX funding markets would in effect trigger a cross-border lending channel. Following this logic, our baseline result should then decrease in banks' capacity to tap alternative sources of FX funds. In this section we test for this feature by considering a series of alternatives. We first analyse whether the effect of synthetic funding shocks on cross-border lending is smaller for banks with higher access to on-balance-sheet FX funding, both from domestic (UK) and foreign markets. We then zoom into the role of internal capital markets (and banks' ownership structure) in shielding banks' cross-border lending from the effects of synthetic funding shocks.

4.1 Access to on-balance-sheet FX funding

If banks had swift access to on-balance-sheet FX funding at similar cost to synthetic alternatives, then funding shocks in swap markets would just lead to a change funding sources, with no consequence for currency-specific cross-border lending. In order to test for this prediction we proxy for banks' access to on-balance-sheet FX funding by assigning them to one of two 'buckets' depending on whether they report (normalised) on-balance-sheet FX funding above or below the sample median.[14] [15] We then estimate our baseline specification for the resulting subsamples, and compare the main coefficients of interest. We do this exercise separately for domestic (UK) and foreign funding motivated by the fact that sterling-based CIP deviations constitute system-wide shocks, and hence access to foreign funds might prove more important in shielding banks' supply of cross-border credit.[16]

[14] There is a case to be made that some banks might have access to foreign funds in case of need but not use them frequently and hence be assigned to the bucket of 'low access' banks. As a partial safeguard against this possibility in Section 4.2 we consider other proxies of access to alternative sources of funding not based directly on balance sheet data, such as banks' (foreign) ownership structure.

[15] Note that the level of on-balance-sheet funding is not mechanically related to 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: Depending on the on-balance-sheet FX item considered the correlation with the RSF ratio lies between -0.15 and -0.2.

[16] We repeated the exercise considering the US and EA in particular as funding sources for US dollar and euro funding respectively, but results do not differ from specifications that consider foreign funds from the rest of world.

Result are reported in Table 3. Column (1) replicates our preferred baseline result from Table 2 to serve as a benchmark. Focusing first on access to FX funds from within the UK system, columns (2)-(3) show that, although the effect of synthetic funding shocks is only significant for banks with low access to on-balance-sheet domestic FX funds, coefficients are not significantly different across buckets. Hence, there is not conclusive evidence that access to on-balance-sheet FX funds from the domestic market shields banks' cross-border lending from funding shocks in FX swap markets. In contrast, columns (4)-(5) show that above-median access to foreign on-balance-sheet FX funding does indeed result in synthetic funding shocks having no effect on cross-border lending, with the resulting coefficient being significantly smaller than that corresponding to the group of banks with low access.

These results suggest that banks with large access to *foreign* on-balance-sheet FX funding are shielded from the effect of currency-specific synthetic funding shocks on their cross-border lending, while this is not necessarily the case for banks with access to the domestic UK market. This is intuitive to the extent that sterling-based CIP shocks conform to system wide shocks, and hence FX funding might dry up for a large share of UK market participants in sync.

4.2 Internal capital markets and ownership structure

Having uncovered a role for access to on-balance-sheet FX funding coming from abroad in shielding banks from the effect of synthetic FX funding shocks on their cross-border lending, we now turn to analysing the role played by banks' access to internal capital markets and, relatedly, their ownership structure (and regulation). It is clear that these two sets of mechanisms could be related: access to foreign on-balance-sheet funding might take the form of internal funds for global banks that manage their liquidity on a global scale, and this might be more likely to take place under certain ownership structures (and, consequently, regulatory arrangements).[17]

We begin by analysing whether the effect of synthetic funding shocks on cross-border lending differs for UK banks and foreign subsidiaries on the one hand (that is, UK-regulated entities) and foreign branches on the other. This is interesting by itself, but can also be taken as a proxy measure for banks' ease of access to internal funds from foreign headquarters. Results, displayed in columns (2)-(3) of Table 4, show that synthetic funding shocks do have an effect on cross-border lending for UK-regulated entities but they do not affect lending of

[17]Although it would be interesting to test which of the two variables –access to on-balance-sheet funding in general, or to internal capital markets in particular– is the most relevant, banks tend to be on either the 'high' or 'low' access buckets in both dimensions, making this comparison difficult.

foreign branches. The difference in coefficients (which is statistically significant), tells us that foreign branches do not alter their FX cross-order lending in the face of synthetic funding shocks even when relying on synthetic funding. One interpretation is that branches can access (internal) funds from abroad more easily, and hence are shielded from the mechanism studied here.

In order to test for the hypothesis of relevance of the access to internal funding more directly, we repeat the 'buckets' exercise described above but using the ratio of intra-group FX funding to total assets as a sorting variable. It can be seen (in columns (4)-(5) of Table 4) that it is indeed the case that synthetic funding shocks do have an effect on the cross-border lending of banks with low intra-group funding, but they do not affect lending of banks that have access to internal funds (the difference between coefficients being highly statistically significant).

These findings are consistent with previous literature showing that global banks are prone to manage liquidity on a global scale exploiting their affiliated banks' networks (Cetorelli and Goldberg, 2011) and that internal capital markets play a central role in this consolidated liquidity management scheme (De Haas and van Lelyveld, 2010). The emphasis on institutional linkages supports the idea that, by having access to FX liquidity from their parent entities, these type of banks manage to isolate their supply of cross-border lending from shocks to the FX swap market, even when they were relying on it heavily in the first place.

The results reported in this section provide supporting evidence for the role of international financial market fragmentation in explaining our findings. In the presence of fragmented FX money markets, banks that can circumvent this market friction by accessing on-balance-sheet FX funding (either from the market or using internal capital markets) are able to shield their supply of cross-border FX lending in the face of shocks to the cost of synthetic funding.

5 Robustness tests and additional exercises

5.1 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 2008-2009 global financial 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 the crisis. In order to address this concern, we re-estimate our benchmark specification after dropping the 2008-2009 period from the sample. Results, reported in Table B.1, confirm that excluding the potential biases induced by the crisis period does not alter our findings. Moreover, the size of the coefficient of interest remains fairly stable.

Another potential 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 implement two empirical tests. First, we compute a size rank considering banks' average total assets and estimate our benchmark specification separately for banks above and below the median of this rank. Results, reported in Columns (4) and (5) of Table B.2 in the Appendix, show that our baseline effect holds for both sub-groups of banks. Against the described concern, we find that the effect is stronger for smaller banks. Second, we estimate our benchmark specification after excluding the top-5 banks in FX derivatives' trading volume.[18] Results, reported in Columns (6) and (7) in Table B.2 in Appendix B, 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 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 the time-varying controls and fixed-effects included in Equation (2) should prevent a bias via such confounding factors, we implement a further test that sheds light on the role of bank characteristics. For this purpose, we run a set of regressions in which we replace the fixed-effects structure in Equation (2) by alternative structures including bank-quarter FE. This test aims

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

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.3 in Appendix B, show that our findings remain in place once we control for both observed and unobserved time-varying bank characteristics captured by bank-quarter FE under different specifications.[19]

Finally, we also test the robustness of our results to more mechanical modifications of our benchmark specification, such as using FX swaps of alternative maturities to measure CIP deviations and relying on alternative definitions of our credit variable. We also estimate Equation (2) by computing RSF as a continuous variable including its negative values under different fixed-effects specifications. Results, reported in Table B.1 and Columns (2) and (3) in Table B.2 in Appendix B, show that findings are robust to these various robustness tests.

5.2 Additional exercises

In this section, we report two additional exercises that shed further light on the link between FX synthetic funding shocks and UK banks' cross-border lending. First, we explore potential heterogeneities in the reaction of banks with different levels of liquidity holdings. Secondly, we look into potential differential effects of positive and negative funding shocks.

We begin by investigating the link between banks' liquidity holdings and the effect of synthetic funding shocks on their cross-border lending. Previous literature suggests a link might be present: Cetorelli and Goldberg (2011) show for instance that during the global financial crisis global banks with a higher liquidity risk reduced their cross-border positions by more than other banks. In order to test for this potential mechanism, we compute banks' pre-2008 average ratio of liquidity to total assets, both in aggregate and in terms of specific currencies. We then follow the approach of the previous tests and split the sample according to the median of these ratios. We conjecture that, in the event of funding shocks in FX swap markets, lower (currency-specific) liquidity ratios could impair banks' capacity to raise alternative funding by signaling a higher funding and liquidity risk to other banks and depositors, as well as by increasing the regulatory pressure as regulatory ratios become binding. Also, banks could simply rely on their liquid buffers to shield their lending in the face of these synthetic funding shocks. Columns (2) and (3) in Table 5 report the results of this extension.

[19] 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.

We find that the synthetic funding shocks result in changes in cross-border lending only for banks with relatively low liquidity ratios in the respective currencies.[20]

In terms of our second exercise, in principle one could expect the effect of synthetic FX funding shocks on cross-border lending to be symmetric. Present frictions that prevent banks from accessing on-balance-sheet FX funding at ease, changes in the cost of funds obtained via FX swaps should be directly linked to lending in both directions: as funding becomes cheaper banks should increase lending in that particular currency, while they should cut back on lending as funds become more expensive. This is indeed what we find in column 4 of Table 5: the coefficient corresponding to a potential differential effect of negative CIP changes (that is, synthetic FX funding becoming more expensive) is not significantly different from zero.

6 Substitution effects and macroeconomic dimension

The results of our analysis provide compelling evidence of a cross-border lending channel of FX swap funding shocks, potentially driven by a geographical fragmentation of global FX funding markets. However, borrowers could in principle substitute away the affected lending by accessing alternative funding sources, limiting the real effects of such dynamics. This section discusses a set of analyses which attempt to provide insights on borrowers' capacity to offset the consequences of cross-border credit supply adjustments.

To look at substitution effects from borrowers' perspective we adjust our empirical strategy to allow for a within-sample substitution of funding sources across the UK-based banks operating in a given country-currency pair. To conduct this test, 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 bin. For example, the synthetic-funding reliance variable becomes the average RSF variable of all banks in a country-currency pair weighted by their respective market shares in that specific relevant market. For this exercise we employ the full dataset without the filters imposed on the data in our baseline specification to maximise the number of available observations. This approach allows us to measure whether borrowers can substitute away credit-supply shocks by tapping liquidity from other (less affected) UK banks operating in the country. If borrowers could

[20] The results are similar independently of whether we consider aggregate or currency-specific liquidity ratios. Unreported results of the former case are available upon request.

turn to unaffected low RSF banks in the face of synthetic funding shocks, then aggregate lending from the UK might not change.

In order to operationalise this setting, we run an adjusted version of Equation (2) using a panel at the currency-country-quarter level. This adjusted empirical model is formalized by Equation (3):

$$\Delta L_{j,k,t} = \alpha + \beta_1 RSF_{j,k,t-5} + \sum_{l=1}^{4} \beta_{2,l} \Delta CIP_{k,t-l} * RSF_{j,k,t-5} \tag{3}$$

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

In Equation (3) we analyse 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 currency-time fixed effects. Although this specification does not allow for the type of credit demand control implemented in Equation (2), we can still absorb currency-specific demand shocks spread similarly across countries.

Table 6 reports the results. In Column (1) we estimate our approach including bank control variables aggregated at the country-level and considering country and time fixed-effects. In Column (2) we replace the fixed-effects setting by country-currency and currency-time fixed-effects, resembling the structure our preferred bank-level specification. The results show a positive and statistically significant effect of the interaction term between CIP deviations and the country-currency proxy for banks' synthetic funding exposure. This result implies that borrowers cannot substitute away the lending channel within the group of UK-based banks in our sample.

Future work could look into the possibility of foreign debtors substituting away credit from UK suppliers and tapping banks from other nationalities instead.

7 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 in general, and to internal capital markets in particular. The effects we find are highly statistically significant and economically meaningful. We interpret our results as evidence of the relevance of fragmentation of FX funding markets.

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.[21] These policies attempt to protect the interests of domestic stakeholders, limiting the transmission of foreign shocks.[22] 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.

[21] 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.

[22] 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

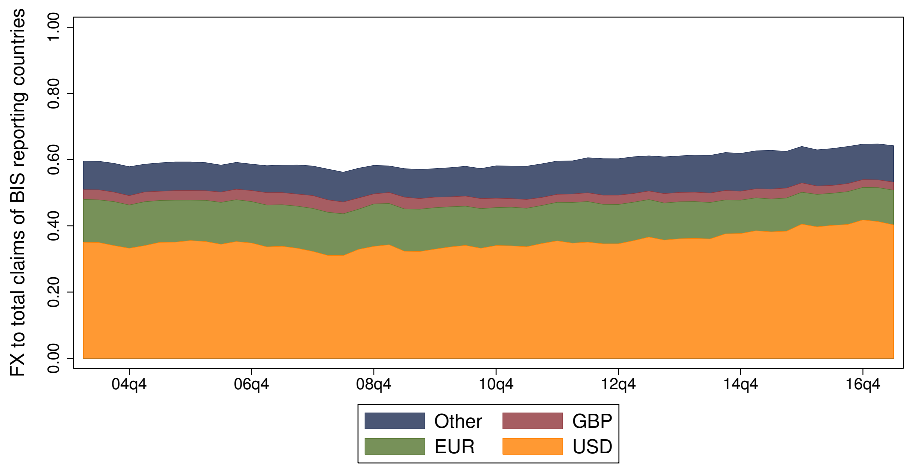

Figure 1 Cross-border bank claims in currencies other than originator home currency

Notes: Authors' calculations based on the Locational Banking Statistics of the Bank of International Settlements. The figure shows the share of cross-border claims originated outside the currencies' domestic countries with respect to total currency-specific claims originated in the BIS reporting countries. The graph 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.

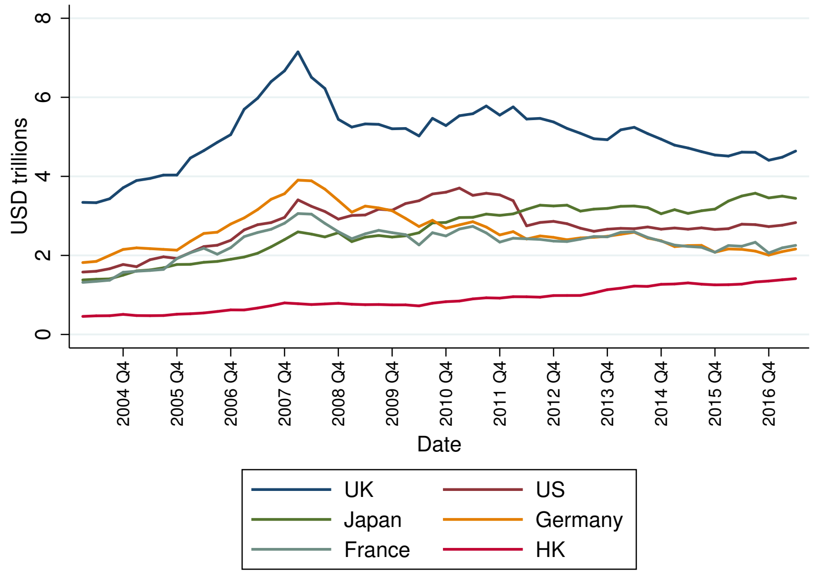

Figure 2 Cross-border bank claims by country of origination

Notes: This figure depicts aggregate cross-border claims in US dollar trillions from 2004 to 2017 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.

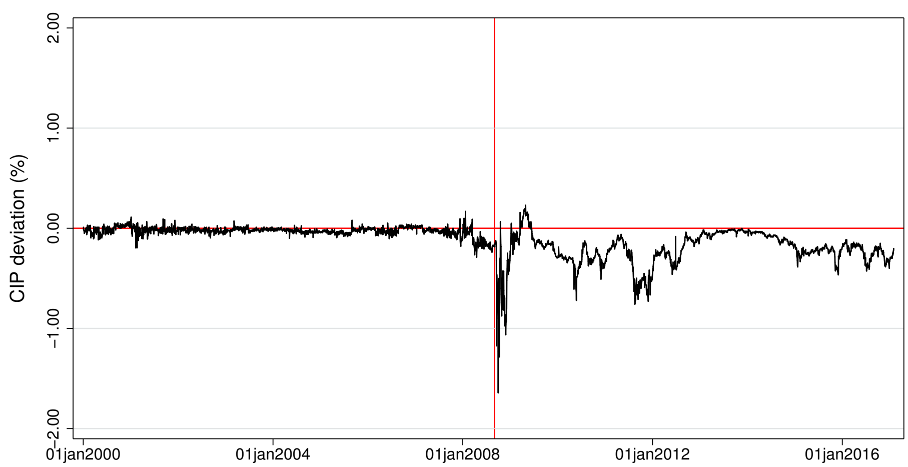

Figure 3 Sterling-based CIP deviations (average across currency pairs)

Notes: Authors' elaboration based on data from Bloomberg. The graph 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.

Table 1 BANKING DATASET – DESCRIPTIVE STATISTICS

	mean	median	S.D.	min	max	RSF large	RSF low	Dif
	(1)	(2)	(2)	(3)	(4)	(5)	(6)	(7)
Dependent variable								
$\Delta L_{i,j,k,t}$	0.01	0.00	0.67	-1.87	1.96	0.04	0.04	-0.000
Exposure variable								
RSF_{t-5}	0.15	0.00	0.38	0.00	1.80	0.14	0.01	0.1310*
Independent variables								
$Total\,assets_{t-1}$	17.66	17.89	1.84	13.57	19.83	17.44	17.45	-0.007
$Deposit\,ratio_{t-1}$	0.27	0.22	0.21	0.00	0.75	0.26	0.20	0.0579*
$Liquidity\,ratio_{t-1}$	0.38	0.34	0.22	0.04	0.92	0.39	0.34	0.0582
$Capital\,ratio_{t-1}$	0.09	0.06	0.09	0.00	0.34	0.09	0.07	0.0218
$\Delta L^{\neq k}_{i,k,t}$	0.02	0.02	0.24	-0.64	0.69	0.05	0.06	-0.010
CIP deviations								
GBP currency basis (CIP deviation)	-0.06	-0.06	0.17	-0.76	0.41			
Δ GBP currency basis (CIP deviation)	0.00	0.00	0.13	-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 banks' exposure to synthetic FX funding via FX swaps as it is defined in the paper. The control variables if interest are the following: Banks' size (log of total assets), deposit base (ratio of total deposits to assets), liquid-to-total assets ratio, and capital-to-assets ratio. The variable $\Delta Claims_{\neq k}$ represents the change in log total claims of bank i in all currencies different than k. The table reports for each variable its sample average (mean), its median, its standard deviations (S.D.), and the minimum (Min.) and maximum (Max.) values. Columns (5) and (6) report the average pre-2008 for each variable for two subsamples: Banks with an average pre-2008 RSF ratio above (5) and below (6) the sample median. Columan (7) 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) and Δ GBP currency basis (quarter-to-quarter first differences).

Table 2 Benchmark results

	(1)	(2)	(3)	(4)	(5)
Joint ΔCIP x RSF_{t-5}	0.271***	0.250***	0.252***	0.235***	0.221***
	0.0587	0.0590	0.0557	0.0550	0.0588
Joint ΔCIP	0.0525	0.0461	0.0203	-0.0127	
	0.0390	0.0376	0.0630	0.0779	
RSF_{t-5}	-0.011*	-0.011	0.004	0.004	0.007
	(0.006)	(0.007)	(0.008)	(0.008)	(0.011)
Interaction terms:					
ΔCIP_{t-1} x RSF_{t-5}	0.100***	0.093***	0.090***	0.072**	0.070**
	(0.035)	(0.035)	(0.031)	(0.033)	(0.033)
ΔCIP_{t-2} x RSF_{t-5}	0.103***	0.098***	0.102***	0.095***	0.092***
	(0.029)	(0.029)	(0.027)	(0.031)	(0.027)
ΔCIP_{t-3} x RSF_{t-5}	0.066*	0.062	0.061	0.070	0.060
	(0.037)	(0.038)	(0.039)	(0.045)	(0.046)
ΔCIP_{t-4} x RSF_{t-5}	0.001	-0.004	-0.001	-0.001	-0.001
	(0.039)	(0.036)	(0.036)	(0.041)	(0.039)
Controls:					
$Total\,assets_{t-1}$		0.002	-0.014	-0.012	-0.012
		(0.002)	(0.009)	(0.009)	(0.009)
$Deposit\,ratio_{t-1}$		-0.012	-0.061	-0.054	-0.054
		(0.014)	(0.038)	(0.039)	(0.040)
$Liquidity\,ratio_{t-1}$		-0.015	-0.018	-0.024	-0.027
		(0.015)	(0.034)	(0.036)	(0.039)
$Capital\,ratio_{t-1}$		0.035	-0.128	-0.101	-0.086
		(0.037)	(0.078)	(0.075)	(0.077)
$\Delta L_{i,k,t}^{\neq k}$		0.108***	0.079***	0.075***	0.083***
		(0.021)	(0.019)	(0.021)	(0.021)
No. Banks	106	106	106	106	106
Observations	64,986	64,890	64,890	63,829	62,759
R-squared	0.000	0.002	0.007	0.066	0.109

Note: This table reports the results from estimating Equation (2) 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. First, Column (1) reports the results of regressing $\Delta L_{i,j,k,t}$ only on the four lags of the interaction term between $\Delta CIP_{k,t}$ and $RSF_{i,k,t-5}$. This regression omits all control variables and fixed effects. Column (2) further includes our set of control variables. Column (3) adds both bank and time (quarter) fixed effects. Column (4) replaces the fixed effects structure by a combination of bank and country-time fixed effects. Finally, Column (5) report our preferred baseline specification include both bank-country-currency and country-currency-time fixed effects. This latter model absorbs then 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-level are reported between parentheses. Variables are winsorized at the 2.5th and 97.5th 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 ON-BALANCE-SHEET FX FUNDING

	Benchmark	On-balance-sheet FX funding			
		From UK		From abroad	
		Large	Low	Large	Low
	(1)	(2)	(3)	(4)	(5)
Joint ΔCIP x RSF_{t-5}	0.221***	0.267	0.246***	-0.237	0.285***
	0.0588	0.331	0.0642	0.233	0.0672
RSF_{t-5}	0.007	0.005	0.001	-0.024*	0.004
	(0.011)	(0.020)	(0.013)	(0.014)	(0.020)
Interaction terms:					
ΔCIP_{t-1} x RSF_{t-5}	0.070**	-0.090	0.104***	-0.048	0.101***
	(0.033)	(0.189)	(0.036)	(0.111)	(0.036)
ΔCIP_{t-2} x RSF_{t-5}	0.092***	0.277*	0.089***	0.070	0.075**
	(0.027)	(0.163)	(0.031)	(0.118)	(0.031)
ΔCIP_{t-3} x RSF_{t-5}	0.060	0.260	0.048	0.015	0.076
	(0.046)	(0.216)	(0.042)	(0.146)	(0.056)
ΔCIP_{t-4} x RSF_{t-5}	-0.001	-0.180	0.005	-0.275***	0.032
	(0.039)	(0.146)	(0.037)	(0.095)	(0.032)
Controls:					
$Total\,assets_{t-1}$	-0.012	-0.043***	-0.004	-0.007	-0.023
	(0.009)	(0.014)	(0.009)	(0.012)	(0.015)
$Deposit\,ratio_{t-1}$	-0.054	-0.073	-0.047	-0.117**	-0.029
	(0.040)	(0.070)	(0.047)	(0.047)	(0.060)
$Liquidity\,ratio_{t-1}$	-0.027	-0.024	-0.001	-0.062	0.002
	(0.039)	(0.075)	(0.038)	(0.043)	(0.065)
$Capital\,ratio_{t-1}$	-0.086	-0.235**	-0.056	-0.025	-0.197
	(0.077)	(0.104)	(0.106)	(0.110)	(0.120)
$\Delta L^{\neq k}_{i,k,t}$	0.083***	0.055**	0.117***	0.041**	0.152***
	(0.021)	(0.023)	(0.032)	(0.021)	(0.044)
IW test		Non-different		Different	
Observations	62,759	14,909	46,831	23,570	38,088
R^2	0.109	0.160	0.145	0.126	0.166

Note: This table reports the results from estimating Equation (2) for sub-samples of banks with a different type of access to foreign money markets. All constitutive terms of the interactions are included in the regressions. Coefficients for $\Delta CIP_{k,t}$ are not reported. Column (1) replicates the baseline results from column (5) in Table 2. Columns (2) and (3) split banks according to whether they belong to a bank holding company headquartered in the US or the Euro Zone or not. Columns (4) and (5) split banks according to whether they report receiving internal funding from these two jurisdictions. Robust standard errors clustered at the bank-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 2.5th and 97.5th 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 Internal capital markets

	Benchmark	Type of regulation		Intra-group FX funding	
		Subsidiary + UK	Branch	Low	Large
	(1)	(2)	(3)	(4)	(5)
Joint ΔCIP x RSF_{t-5}	0.221***	0.269***	0.164	0.254***	0.0510
	0.0588	0.0632	0.173	0.0614	0.219
RSF_{t-5}	0.007	-0.009	0.013	-0.001	-0.001
	(0.011)	(0.014)	(0.015)	(0.015)	(0.022)
Interaction terms:					
ΔCIP_{t-1} x RSF_{t-5}	0.070**	0.058**	0.090	0.097***	-0.098
	(0.033)	(0.025)	(0.078)	(0.033)	(0.114)
ΔCIP_{t-2} x RSF_{t-5}	0.092***	0.146***	0.007	0.080**	0.315
	(0.027)	(0.039)	(0.071)	(0.034)	(0.195)
ΔCIP_{t-3} x RSF_{t-5}	0.060	0.055	0.133	0.069	-0.072
	(0.046)	(0.039)	(0.091)	(0.056)	(0.146)
ΔCIP_{t-4} x RSF_{t-5}	-0.001	0.011	-0.066	0.009	-0.094
	(0.039)	(0.025)	(0.071)	(0.039)	(0.086)
Controls:					
$Total\, assets_{t-1}$	-0.012	-0.003	-0.024***	-0.026**	0.003
	(0.009)	(0.020)	(0.008)	(0.012)	(0.011)
$Deposit\, ratio_{t-1}$	-0.054	-0.108**	-0.051	-0.040	-0.145**
	(0.040)	(0.051)	(0.058)	(0.053)	(0.058)
$Liquidity\, ratio_{t-1}$	-0.027	0.041	-0.055*	0.004	-0.102**
	(0.039)	(0.068)	(0.032)	(0.055)	(0.045)
$Capital\, ratio_{t-1}$	-0.086	-0.002	-0.191*	-0.125*	-0.084
	(0.077)	(0.132)	(0.106)	(0.073)	(0.168)
$\Delta L^{\neq k}_{i,k,t}$	0.083***	0.080**	0.070***	0.109***	0.054**
	(0.021)	(0.034)	(0.022)	(0.033)	(0.027)
IW test		Different		Different	
Observations	62,759	26,512	36,305	45,153	16,030
R^2	0.109	0.162	0.142	0.148	0.119

Note: This table reports the results from estimating Equation (2) for sub-samples of banks with a different type of access to FX retail deposits in the home countries of the two currencies analyzed, the US dollar and the euro. All constitutive terms of the interactions are included in the regressions. Coefficients for $\Delta CIP_{k,t}$ are not reported. Column (1) replicates the baseline results from Column (5) in Table 2. Columns (2) and (3) split banks according to whether they reported a higher or lower ratio of FX deposits to total FX funding compared to the sample median in the pre-2008 period. Columns (4) and (5) split banks within the group with access to internal FX funding from abroad according to whether they report a high or low ratio of FX deposits to total FX funding relative to the median in the pre-2008 period. Robust standard errors between parentheses. Robust standard errors clustered at the bank-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 2.5th and 97.5th 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 ADDITIONAL EXERCISES

	Benchmark	Liquidity ratio		Symmetry effect
		Low	High	
	(1)	(2)	(3)	(4)
Joint ΔCIP x RSF_{t-5}	0.221***	0.223***	-0.313	0.473***
	(0.0588)	(0.0651)	(0.217)	(0.181)
Joint ΔCIP x RSF_{t-5} x I_{CIP}				-0.185
				(0.160)
RSF_{t-5}	0.007	0.006	0.024	-0.0184
	(0.011)	(0.014)	(0.017)	(0.0505)
Controls:				
$Total\,assets_{t-1}$	-0.012	-0.004	-0.051***	-0.044*
	(0.009)	(0.009)	(0.011)	(0.026)
$Deposit\,ratio_{t-1}$	-0.054	-0.036	-0.077	-0.103
	(0.040)	(0.053)	(0.081)	(0.090)
$Liquidity\,ratio_{t-1}$	-0.027	-0.049	0.056	0.009
	(0.039)	(0.035)	(0.070)	(0.059)
$Capital\,ratio_{t-1}$	-0.086	0.002	-0.306**	-0.052
	(0.077)	(0.101)	(0.141)	(0.209)
$\Delta L^{\neq k}_{i,k,t}$	0.083***	0.115***	0.041*	0.001
	(0.021)	(0.028)	(0.022)	(0.000)
IW test		Different		
Observations	62,759	42,607	18,566	62,759
R^2	0.109	0.149	0.163	0.146

NOTE: This table reports the results from estimating Equation (2) for sample splits according to banks' ex-ante balance-sheet strenghts and by including a triple interaction term with the sign of the level of CIP deviations. All constitutive terms of the interactions are included in the regressions. Coefficients for $\Delta CIP_{k,t}$, for its single interactions with RSF, and for the constitutive terms of the triple interaction are not reported. Column (1) replicates the baseline results from Column (5) in Table 2. Columns (2) and (3) split banks according to the sample median of the liquid assets to total assets ratio. This ratio is computed as a bank-currency-specific average for the period pre-2008. Column (4) reports the results of a regression that adds to the benchmark model a triple interaction term between ΔCIP, RSF and the variable I_{CIP}. I_{CIP} is a dummy variable equal to 1 if at a given quarter the level of the CIP deviation is positive, an zero otherwise. Therefore, this regression tests whether the effect of [ΔCIP x RSF] varies depending whether synthetic funding shocks are positive or negative. Robust standard errors clustered at the bank-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 2.5th and 97.5th 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 SUBSTITUTION EFFECTS

	Within sample substitution	
Specification:	Quarter FE	Country-Currency & Currency-Quarter FE
	(1)	(2)
Joint ΔCIP x RSF_{t-5}	0.451***	0.367**
	(0.169)	(0.161)
RSF_{t-5}	-0.036*	-0.035*
	(0.020)	(0.020)
Controls:		
$Total\,assets_{t-1}$	0.002	0.002
	(0.005)	(0.005)
$Deposit\,ratio_{t-1}$	-0.159**	-0.158**
	(0.066)	(0.065)
$Liquidity\,ratio_{t-1}$	0.176***	0.182***
	(0.048)	(0.048)
$Capital\,ratio_{t-1}$	0.365**	0.364**
	(0.149)	(0.146)
$\Delta L_{i,k,t}^{\neq k}$	-0.062	-0.062
	(0.049)	(0.049)
Observations	6,576	6,576
R^2	0.036	0.044

NOTE: This table reports the results from estimating Equation (3) in which our baseline bank-level sample is aggregated at the country-currency level. Columns (1) and (2) report reggressions where the dependent variable is the growth rate in aggregated cross-border credit by all UK-based banks in our original sample, before screening the data, to a given country j in currency k. The independent variables (with the exception of ΔCIP) are computed as market-share weighted averages of the respective underlying bank-level variables. We consider as a relevant market each country-currency pair. While regression on Column (1) only includes quarter FE, Column (2) reports the results from a specification with country-currency and currency-quarter FE. Standard errors clustered at the country level. All constitutive terms of the interactions are included in the regressions. Coefficients for $\Delta CIP_{k,t}$ are not reported. Variables are winsorized at the 2.5th and 97.5th 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, independent variables of interest, bank-level control variables and country-level financial development indices used in Section 5.

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

Table A.1 Variables definitions

Variables	Definition	Source
Dependent variables:		
$\Delta L_{i,j,k,t}$	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.	BoE
Variables of interest:		
$\Delta CIP_{k,t-l}$	Quarter-to-quarter change in the deviation from the currency basis between sterling and currency k.	Bloomberg
$RSF_{i,k,t-l}$	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 ΔCIP x RSF_{t-5}	Joint coefficient of 4-lags of interactions betweeen RSF and CIP for lags t=-1 to t=-4.	BoE & Bloomberg
I_{CIP}	Dummy equal to 1 if at a given quarter the level of the CIP deviation is positive, an zero otherwise.	Bloomberg
Controls:		
$Total\,assets_{t-1}$	Log of total assets at the UK-bank level (excludes assets of foreign affiliates).	BoE
$Deposit\,ratio_{t-1}$	Ratio of total retail (sight + savings) deposits to total assets at the bank-level.	BoE
$Liquidity\,ratio_{t-1}$	Ratio of liquid assets (cash + BoE deposits) to total assets at the bank-level.	BoE
$Capital\,ratio_{t-1}$	Ratio of total equity to total assets	BoE
$\Delta L^{\neq k}_{i,k,t}$	Average growth rate of bank i's claims in non-k currencies to all countries but j.	BoE

Note: This table reports the definitions and sources of the variables used in the analysis.

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 (2). 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 (2) 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

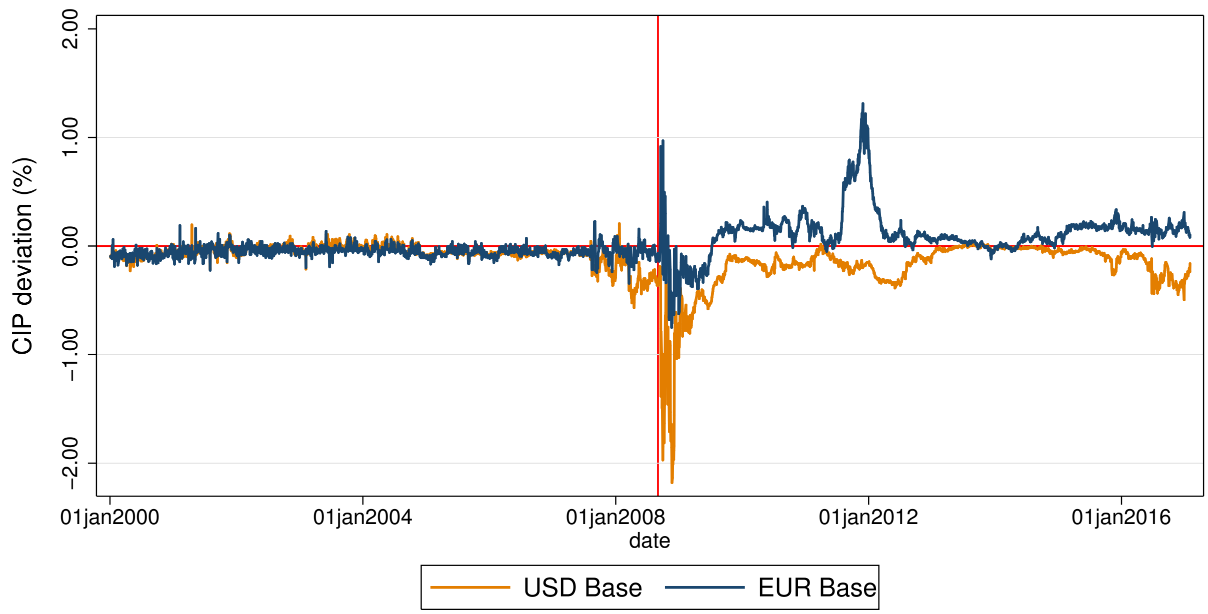

Figure B.1 Sterling-based CIP deviations by currency

Notes: Authors' elaboration based on data from Bloomberg. The graph 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

Specification	Baseline	1-month rates	Pre-2008	Post-2008	Exclude 08-09	Loan growth
	(1)	(2)	(3)	(4)	(5)	(6)
Joint ΔCIP x RSF_{t-5}	0.221***	0.213***	-1.601	0.261***	0.230***	0.522***
	(0.0588)	(0.0866)	(4.237)	(0.0779)	(0.0676)	(0.149)
RSF_{t-5}	0.007	0.008	0.041	0.013	0.004	0.029
	(0.011)	(0.011)	(0.035)	(0.020)	(0.012)	(0.036)
Controls:						
$Total\,assets_{t-1}$	-0.012	-0.012	-0.136***	-0.015	-0.004	-0.029
	(0.009)	(0.009)	(0.034)	(0.015)	(0.011)	(0.030)
$Deposit\,ratio_{t-1}$	-0.054	-0.053	-0.301***	-0.038	-0.052	-0.136
	(0.040)	(0.041)	(0.109)	(0.046)	(0.041)	(0.103)
$Liquidity\,ratio_{t-1}$	-0.027	-0.027	0.028	-0.027	-0.011	-0.173*
	(0.039)	(0.039)	(0.103)	(0.039)	(0.037)	(0.088)
$Capital\,ratio_{t-1}$	-0.086	-0.087	0.053	0.003	-0.018	-0.248
	(0.077)	(0.077)	(0.363)	(0.130)	(0.074)	(0.264)
$\Delta L_{i,k,t}^{\neq k}$	0.083***	0.083***	0.086**	0.055**	0.076***	0.000
	(0.021)	(0.021)	(0.039)	(0.022)	(0.023)	(0.000)
Observations	62,759	62,759	19,616	36,593	49,674	60,333
R^2	0.109	0.109	0.126	0.113	0.112	0.150

Note: This table reports the results from estimating Equation (2) under alternative specifications. All constitutive terms of the interactions are included in the regressions. Coefficients for $\Delta CIP_{k,t}$ and for its single interactions with RSF are not reported. Column (1) replicates the baseline results from Column (5) in Table 2. Column (2) replicates the analysis when computing ΔCIP from 1-month interest rates instead of 3-month rates. Column (3) estimates the model for the pre-2008 period, whereas Column (4) does it for the post-2008 period. Column (5) excludes the years 2008 and 2009 from the analysis. Column (6) replaces the dependent variable $\Delta L_{i,j,k,t}$ for the growth rate in cross-border loans instead of total claims. Robust standard errors clustered at the bank-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 2.5th and 97.5th 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 Further robustness and role of market makers

Specification:	Benchmark	Alternative RSF		Above median in banks' size rank		Top-5 in trading volume	
		Partial FE	Full FE	Yes	No	Yes	No
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Joint ΔCIP	0.213***	0.197***	0.180***	0.186*	0.475**	0.578*	0.147**
x RSF_{t-5}	(0.0588)	0.0639	(0.0670)	(0.105)	(0.233)	(0.348)	(0.0766)
RSF_{t-5}	0.007	0.007	0.011	0.003	0.019	0.059*	0.002
	(0.011)	(0.007)	(0.010)	(0.020)	(0.020)	(0.031)	(0.009)
Controls:							
$Total\ assets_{t-1}$	-0.012	-0.012	-0.011	-0.008	-0.025*	-0.080***	-0.007**
	(0.009)	(0.009)	(0.009)	(0.009)	(0.014)	(0.026)	(0.004)
$Deposit\ ratio_{t-1}$	-0.054	-0.057	-0.057	-0.055	-0.021	-0.082	-0.062**
	(0.040)	(0.040)	(0.041)	(0.052)	(0.082)	(0.096)	(0.030)
$Liquidity\ ratio_{t-1}$	-0.027	-0.028	-0.031	-0.005	-0.005	-0.195**	-0.012
	(0.039)	(0.037)	(0.040)	(0.038)	(0.058)	(0.094)	(0.017)
$Capital\ ratio_{t-1}$	-0.086	-0.106	-0.092	-0.102	-0.132	0.281	-0.042
	(0.077)	(0.074)	(0.076)	(0.109)	(0.135)	(0.374)	(0.067)
$\Delta L_{i,k,t}^{\neq k}$	0.083***	0.075***	0.083***	0.111***	0.437***	0.267***	0.061***
	(0.021)	(0.021)	(0.021)	(0.021)	(0.065)	(0.053)	(0.015)
Observations	62,759	63,829	62,759	51,500	8,674	11,015	50,052
R^2	0.109	0.066	0.109	0.130	0.223	0.344	0.114

Note: This table reports the results from estimating Equation (2) under alternative specifications. All constitutive terms of the interactions are included in the regressions. Coefficients for $\Delta CIP_{k,t}$ and for its single interactions with RSF are not reported. Column (1) replicates the baseline results from Column (5) in Table 2. In Columns (2) and (3) we compute RSF as a continuous variable including its negative values. Column (2) reports a regression with bank-country and time FE ('Partial FE'), whereas the regression on Column (3) uses the full specification with bank-country-currency and country-currency-quarter FE. In Columns (4) and (5) we report regressions of sample splits according to the median of banks' size rank computed from average total assets. Banks on Column (4) are above that threshold, whereas banks in Column (5) lie below the threshold. In Columns (6) and (7) 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 (6) are within that group, whereas banks on Column (7) are outside the group. Robust standard errors clustered at the bank-level are reported between parentheses. All regressions besides of Column (2) include the full set of fixed effects at the bank-country-currency and country-currency-time level. Variables are winsorized at the 2.5th and 97.5th 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 Alternative fixed-effects specification

FE Specification:	Benchmark	Bank-Quarter	Bank-Country-Currency & Bank-Quarter	Benchmark & Bank-Quarter
	(1)	(2)	(3)	(4)
Joint ΔCIP x RSF_{t-5}	0.221***	0.158***	0.156***	0.173*
	(0.0588)	(0.0416)	(0.0433)	(0.0883)
RSF_{t-5}	0.007	0.001	-0.001	0.010
	(0.011)	(0.006)	(0.010)	(0.013)
Interaction terms:				
ΔCIP_{t-1} x RSF_{t-5}	0.070**	0.061**	0.059**	0.059
	(0.033)	(0.024)	(0.025)	(0.044)
ΔCIP_{t-2} x RSF_{t-5}	0.092***	0.016	0.017	0.003
	(0.027)	(0.024)	(0.024)	(0.039)
ΔCIP_{t-3} x RSF_{t-5}	0.060	0.009	0.009	0.040
	(0.046)	(0.020)	(0.019)	(0.041)
ΔCIP_{t-4} x RSF_{t-5}	-0.001	0.071***	0.071***	0.072***
	(0.039)	(0.017)	(0.016)	(0.025)
Controls:				
$\Delta L^{\neq k}_{i,k,t}$	0.083***	-1.622***	-1.623***	-1.655***
	(0.021)	(0.068)	(0.068)	(0.066)
Observations	62,759	64,504	64,504	62,371
R^2	0.109	0.145	0.150	0.248

Note: This table reports the results from estimating Equation (2) under alternative specifications. All constitutive terms of the interactions are included in the regressions. Column (1) replicates the baseline results from Column (5) in Table 2. In Column (2) we report a regression in which Equation (2) is only estimated with control variables and bank-quarter FE. Column (3) includes bank-quarter-currency and bank-quarter FE. Column (4) adds to the benchmark specification bank-quarter FE. Robust standard errors clustered at the bank-level are reported between parentheses. Note that in regressions reported in Columns (2) to (4) the non-currency-specific control variables are absorbed by the fixed-effects. In Column (1) these later controls are included but not reported. Variables are winsorized at the 2.5th and 97.5th percentiles. Variables' definitions are reported in Table A.1 in the Appendix. *** indicates significance at the 1% level; ** at the 5%; * at the 10%.