The currency dimension of the bank lending channel in international monetary transmission*

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Abstract

We investigate how the use of a currency transmits monetary policy shocks in the global banking system. We use newly available unique data on the bilateral cross-border lending flows of 27 BIS-reporting lending banking systems to borrowers in over 50 countries, broken down by currency denomination (USD, EUR and JPY). We have three main findings. First, monetary shocks in a currency significantly affect cross-border lending flows in that currency, even when neither the lending banking system nor the target country uses that currency as their own. Second, this transmission works mainly through lending to non-banks. Third, this currency dimension of the bank lending channel works similarly across the three currencies, suggesting that the cross-border bank lending channel of liquidity shock transmission may not be unique to lending in USD.

JEL classification: E5; F42; G21

Keywords: Cross-border bank lending, bank lending channel, monetary transmission, currency denomination

* Acknowledgements: We would like to thank the Bank for International Settlements for providing the data and financial resources for the completion of this project. We thank Stijn Claessens, Dietrich Domanski, Ingo Fender, Steven Ongena, Adrian van Rixtel, Rebecca Zarutskie and seminar participants at the WEAI and IBEFA 2017 summer meetings, the 4th Bank of Canada-Bank of Spain Workshop on International Financial Markets, the INFINITI 2017 summer conference, the IFABS Oxford 2017 conference, the CUNY Graduate Center, the University of Kent, the Central Bank of Hungary and the Bank for International Settlements for valuable comments. All remaining errors are our own. The views expressed in this paper are solely those of the authors and shall not be interpreted as reflecting the views of the Board of Governors of the Federal Reserve System or the views of the Bank for International Settlements.

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1. Introduction

Major advanced economies, such as the United States, the Euro Area and Japan have engaged in extraordinary unconventional monetary policies after the global financial crisis. Evidence is accumulating that these monetary policies indeed affect broad monetary and credit conditions elsewhere (Cetorelli and Goldberg, 2012; Ongena et al, 2015, Miranda-Agrippino and Rey, 2015; Forbes and Warnock, 2012), and that cross-border bank lending is a major channel of such transmission (Temesvary et al, 2016; Rey, 2015; Bruno and Shin, 2015a, 2015b; Alper et al, 2016). The concentrated currency exposure adds another, little investigated dimension to the analysis of these cross-border transmission effects. The three major currencies, the US dollar (USD), the euro (EUR) and the Japanese yen (JPY), dominate cross-border bank lending globally with shares of around 47 percent, 32 percent and 5 percent of the total volumes at end-2014 (Avdjiev and Takats, 2016). This raises several questions: How does monetary policy in the United States, the euro area and Japan affect cross-border bank lending denominated in USD, EUR and JPY around the world? Which target sectors' borrowing is most affected by the monetary shocks? And, is the strength of monetary transmission different across these three major currencies?

We answer these questions by using a new unique dataset on the bilateral cross-border lending flows of 27 BIS-reporting banking systems to borrowers in over 50 countries, broken down by currency denomination (USD, EUR and JPY) and target sector of borrowers (banks and non-banks). As Avdjiev and Takats (2016) discuss, this

dataset is the first to offer information simultaneously on three key dimensions: (1) the currency composition of the claims, (2) the location, or residence, of the borrower and (3) the nationality of the lending banking system. The dataset is available from Q2 2012 to Q4 2015. Given that in this period most advanced economies relied on unconventional policies with policy interest rates hovering around zero, we use the shadow interest rates from Krippner (2016) to measure monetary conditions.

Our main hypothesis focuses on how the currency denomination of cross-border loans might affect the workings of the bank lending channel: We investigate whether the currency denomination of loans transmits monetary policy internationally. As an example: we ask whether the Federal Reserve's (or the European Central Bank's) monetary policy affects the US dollar (or euro) denominated cross-border bank lending of UK banks to Malaysia – even if neither the UK nor Malaysia is directly using the US dollar (or the euro). The underlying economic logic is similar to the working of the "traditional" bank lending channel. Namely, we posit that monetary policy shocks induced by the issuing country of a given currency affect the amount of funding that is available to foreign banking systems in that currency.[3] These funding shocks will then impact the lending of these foreign banking systems to other countries. We call this effect the currency dimension of the bank lending channel.

[3] For instance, monetary shocks induced by the issuing country of a currency impact the amount of that currency available to foreign banks through central bank liquidity swaps. Large-scale corporate deposits and FX swap markets are further examples of channels through which monetary shocks can affect banks in foreign countries.

A challenge is to disentangle the supply (funding) side lending effects of currency-specific monetary shocks from their indirect impact on credit demand by borrowers around the world. In our identification strategy, we isolate the monetary effects on the supply (funding) side by comparing the differential lending responses of banking systems with various levels of short-term international liquidity to changes in monetary policy (Kashyap and Stein, 2000; Jimenez et al, 2012; Cetorelli and Goldberg, 2012). In order to control for unobservable credit demand shocks, we saturate the model with fixed effects (Jimenez et al, 2014; Ongena et al, 2015). The results of our instrumental variables regressions are robust to alternative specifications, including weighted estimations.

We obtain three main results. First, we find that monetary shocks in a currency significantly affect cross-border lending flows in that currency, across all lending banking systems and host countries of borrowers. For instance, easing monetary conditions in the US, as measured by a lower short-term shadow US interest rate, increases cross-border bank lending denominated in US dollars. The effect holds even when the United States is neither the lending banking system nor the host country of borrowers. As an example, US monetary policy significantly affects US dollar-denominated bank lending from the UK banking system to borrowers in Malaysia. Therefore, we find evidence for the operation of the currency dimension of the bank lending channel in international monetary transmission, which we defined above.

Second, we find that this currency dimension of the bank lending channel works primarily through cross-border lending to non-bank borrowers, while we do not find

significant transmission into cross-border lending flows to banks.[4] This finding lends our results additional policy relevance, as credit to the non-financial sector is important for real economic growth (Kashyap and Stein, 2000; Peek and Rosengren, 2000).

Third, we find that this currency dimension of the bank lending channel works similarly across the three major currencies. We do not find detectable differences in the lending responses of banking systems to USD, EUR and JPY monetary shocks. This would suggest that the working of the USD network in this transmission might not differ substantially from the working of other major currencies.

Our results on the international transmission of monetary policy shocks are relevant for policy. They suggest that policymakers should pay attention not only to the source of cross-border bank lending but also to its currency denomination when analysing the impact of cross-border monetary and liquidity spillovers. For instance, cross-border bank lending denominated in euros and dollars will behave differently if the underlying monetary policies in the US and the euro area diverge, even if these loans are targeted at the same borrowers in the same host country and originate from the same lending banking system. These differences are likely to get more pronounced, as monetary policies have started to diverge since the taper tantrum: the Federal Reserve has led the way, ahead of the the European Central Bank and the Bank

[4] The counterparty sector "banks" includes "[f]inancial institutions whose business it is to receive deposits or close substitutes for deposits and to grant credits or invest in securities on their own account…"banks" excludes central banks and multilateral development banks…[m]oney market funds, investment funds and pension funds…" (BIS Banking Statistics Glossary).

of Japan, in removing policy accommodations. Hence, understanding the workings of the currency dimension of the bank lending channel that we identify in this paper is becoming increasingly more relevant.

The rest of the paper is organized as follows. The second section discusses the related literature. The third section describes our data. The fourth section introduces the estimation methodology and the fifth section presents the results. The final section concludes with policy implications.

2. Related Literature

Our work is related to the literature on drivers of cross-border bank lending, especially recent work which focuses on the newly available currency dimension and the (absence of) the triple coincidence in international finance.

Our paper adds to the strand of literature that examines the drivers of cross-border lending during and after the financial crisis (De Haas and Van Lelyveld, 2011; Rose and Wieladek, 2011; Cetorelli and Goldberg, 2012a; Giannetti and Laeven, 2012; De Haas and Van Horen, 2012; Buch et al, 2014; Cerutti et al, 2014; Cerutti et al, 2015). In this context, Cetorelli and Goldberg (2012) and Temesvary et al (2016) find that US monetary policy has a significant effect on US banks' cross-border lending abroad before the crisis.

Closest to our work are the papers which investigate how monetary policy in a given currency transcends national borders. Ongena et al (2016) uses variation across currencies to identify the bank lending channel of monetary policy into foreign currency lending in Hungary. Alper et al (2016) document significant cross-border lending effects of crisis-induced unconventional US monetary policy in the lending of international banks to borrowers in Turkey. Avdjiev and Takats (2016) show that exposure to the USD had significantly reduced cross-border bank lending during the taper tantrum and Avdjiev, Subelyte and Takats (2016) show similarly that exposure to the EUR during the European Central Bank's Quantitative Easing significantly increased cross-border bank lending. This latter result strongly suggests that currency denomination can affect international spillovers more systematically.

Furthermore, our empirical work builds on the insight that national borders and economically relevant decision-making units often diverge. Fender and McGuire (2010) and Cecchetti et al (2010) have shown that the lending bank's nationality tends to be more relevant than its residence in identifying the decision-making unit. This insight and its policy implications were developed further in CGFS (2011). Building on these findings, Avdjiev, McCauley and Shin (2015) coined the term of the (absence of) triple coincidence in international finance. This term refers to the phenomenon that national borders, the conventional units of international economic analysis, often do not coincide with the economically relevant decision-making unit. Following these lessons, we focus on "lending banking systems" as opposed to "lending countries", so that we can follow the decision-making unit as precisely as possible.

Finally, it is also important to highlight that the cost savings achievable in the (foreign exchange) FX derivatives markets might contribute to the observed working of the currency dimension of the bank lending channel. This is because conditions in FX markets can affect the costs of, and thereby the demand for, borrowing in certain currencies.[5] This channel arises because in recent periods we see large and persistent deviations from the covered interest rate parity (Sushko et al, 2016; Avdjiev et al, 2016). However, our findings are robust to including extensive sets of controls and fixed effects to account for such credit demand-side shocks – which greatly limits concerns that the impact that we identify as the currency dimension of the bank lending channel might originate from derivative market conditions and "opportunistic borrowing".

3. Data

In order to answer our research question precisely, we need three data dimensions: (A) the currency composition of cross-border claims; (B) the residence of the borrower and (C) the nationality of the lending banking system (see CGFS (2012) for further details and Avdjiev and Takats (2016) for a more detailed discussion).

[5] As an example, borrowers might consider direct euro borrowing versus borrowing in US dollars and then swapping the received funds to euros in derivatives markets. For instance, Ivashina et al (2015) and later Romo Gonzalez (2016) show that for European banks covered parity violations and the resulting costs explain US dollar borrowing. Furthermore, this channel may be relevant specifically to Japanese banks with large US dollar denominated claims which are financed through FX swap markets.

The first dimension, currency composition (A) enables us to map the relevant currency networks and flows in each selected currencies, that is, to map bilateral claims in USD, EUR, and JPY and their evolution over time, purged of valuation effects.

Dimension (B), the lender's nationality identifies the home country of the highest-level banking entity in the corporate chain, of the lending banking systems. As Fender and McGuire (2010) and Cecchetti et al (2010) have shown, nationality tends to be much more relevant than residence for identifying the decision-making unit when thinking about credit supply. This is because nationality better captures the factors that influence a bank's lending decisions, such as the performance or equity constraints of the bank as a whole.

Furthermore, using nationality as opposed to residence is also necessary due to the presence of financial centers. To see this, consider a German bank that lends to a borrower in Malaysia via its London branch in the United Kingdom. The nationality-based data establishes a link between the German banking system (as the lender) and Malaysia (as the country of the borrower). The alternative residence-based data would identify two cross-border bank lending links: one from Germany to the UK and another between the UK and Malaysia. This classification would mistakenly identify two economic relationships: one with the UK as the country of the borrower, and another with the UK banking system as the lender – whereas the loan is just intermediated through the UK and not materially linked to local conditions there.

Dimension (C), the residence of the borrower, allows us to account for the country-specific borrowing drivers of cross-border bank lending, such as credit demand.

The recently implemented Enhancements to the BIS International Banking Statistics (IBS) provide the three necessary dimensions simultaneously.[6] That is we are able to tell the currency composition (dimension A), the nationality of the lender bank (dimension B) and the residence of the borrower (dimension C) of the claims. This is a newly available unique dataset on the bilateral cross-border exposures of 27 BIS-reporting countries to borrowers in 51 host countries over the Q2 2012 – Q4 2015 period, broken down by currency denomination (USD, EUR and JPY) and target sector of borrowers (banks and non-banks). The data described below are summarized in Table 1.[7]

3.1 Data on Bank Claims and Flows

We focus on cross-border bank flows, i.e. changes in claims, in three currencies: the US dollar (USD), the euro (EUR) and the Japanese yen (JPY). These three reserve currencies dominate cross-border bank lending globally with shares of around 47

[6] It is important to note that the data is based on nationality, i.e. not based on the consolidated dataset. This implies, that our cross-border claim data includes interoffice exposure (whereas they would not be reported in the consolidated dataset).

[7] The 27 lending banking systems are Austria; Australia; Belgium; Brazil; Canada; Chinese Taipei; Denmark; Finland; France; Germany; Greece; India; Ireland; Italy; Japan; Korea; Luxembourg; Mexico; the Netherlands; Norway; Portugal; Spain; Sweden; Switzerland; Turkey; United Kingdom; United States. The 51 target countries are Angola; Austria; Australia; Belgium; Brazil; Bulgaria; Canada; Chile; China; Chinese Taipei; Croatia; Cyprus; Czech Republic; Denmark; Finland; France; Germany; Greece; Hungary; Ireland; Israel; Italy; Japan; Korea; Liberia; Lithuania; Luxembourg; Malta; Marshall Island; Mexico; Morocco; the Netherlands; New Zealand; Nigeria; Norway; Poland; Portugal; Romania; Russia; Slovakia; Slovenia; South Africa; Spain; Sweden; Switzerland; Turkey; Ukraine; United Kingdom; United States; Vietnam.

percent, 32 percent and 5 percent of the total volumes at end-2014, respectively.[8] We measure bilateral cross-border bank flows from source banking system *i* to borrowers in target country *j* as the quarterly percent change in bilateral cross-border bank claims. The median bilateral cross-border flows (across currencies and sectors) is –0.59 percent per quarter.

Bilateral cross-border claims vary substantially depending on the target sector and currency denomination (Table 1). The median bilateral cross-border claims on banking sectors in host countries amount to 414 million US dollars, while the median volume of claims is lower on the non-bank sector at 304 million US dollars. Looking at flows rather than claims, bilateral cross-border flows are similar across the two sectors, with averages of 0.25 percent quarterly increase in flows to banks and 0.58 percent increase in flows to non-banks. The median flows show a 0.19 percent quarterly decline in lending to both sectors.

We see some variation in the magnitudes of bilateral cross-border bank claims across currencies. Converted to US dollars, the median bilateral euro-denominated cross-border claims on banks amount to 498 million US dollars (median of 394 million US dollars in claims on the non-bank sector). The median US dollar-denominated cross-border claims is 539 million US dollars (median of 338 million US dollars in claims on the non-bank sector). The median yen-denominated cross-border claims

[8] The fourth largest currency network, the British Pound (GBP), constitutes less than 5 percent of total cross-border bank claims.

are substantially smaller, amounting to only 132 million US dollars in claims on the banking sector (median of 91 million US dollars in claims on the non-bank sector).[9]

Variation is also present in cross border bank flows. The median quarterly decline in euro-denominated cross-border claims is 0.43 percent in lending to the banking sector and at 0.01 percent in lending to the non-bank sector (–1.12 and 0.05 percent, respectively, if claims are measured in US dollars). The comparable median declines in yen-denominated flows are 0.65 percent and 0.86 percent in lending to the bank and non-bank sectors, respectively (3.41 and 4.29 percent declines if measured in US dollars, respectively). The median US dollar-denominated cross-border flows are at zero percent in lending to the banking sector, but show a 0.12 percent quarterly decline in lending to the non-bank sector.[10]

[9] Converted to US dollars, the mean bilateral euro-denominated cross-border claims on banks amount to 28,483 million US dollars (mean of 24,823 million US dollars in claims on the non-bank sector), compared to the mean US dollar-denominated cross-border claims of 11,717 million US dollars (mean of 6,004 million US dollars in claims on the non-bank sector). The mean yen-denominated cross-border claims are smaller, amounting to an average of 2,007 million US dollars and 1,683 million US dollars in claims on the banking and non-bank sectors, respectively.

[10] The mean quarterly decline in euro-denominated cross-border claims is 0.13 percent in lending to the banking sector and at 0.86 percent in lending to the non-bank sector (0.97 and 0.13 percent, respectively, if measured in US dollars). The comparable mean declines in yen-denominated flows are 0.29 percent and 1.32 percent in lending to the bank and non-bank sectors, respectively (1.94 and 4.23 percent declines if measured in US dollars, respectively). The mean US dollar-denominated cross-border flows are at 1.25 percent in lending to the banking sector, and show a 0.82 percent increase in lending to the non-bank sector.

Descriptions and Summary Statistics of Variables — Table 1

Variables	Unit	Description	Notes	N	mean	sd	min	p25	p50	p75	max
Dependent Variables											
Quarterly Change in Total Bilateral Cross-border Claims	%	$\Delta \ln(Y)_{j,t} = \left(\ln(Y)_{j,t} - \ln(Y)_{j,t-1}\right) * 100$ where *Y* is the stock of bilateral cross-border bank claims	*Total*	25,441	0.61	31.35	–149.76	–9.55	–0.21	10.21	149.66
			By Sector:								
			To Banks	18,916	0.25	38.72	–149.70	–14.57	–0.19	14.03	149.66
			To Non-banks	22,902	0.58	28.46	–149.39	–7.65	–0.19	8.10	149.64
			By Currency:								
			U.S. Dollar	10,723	0.91	32.27	–149.39	–10.18	–0.01	11.61	149.55
			Euro	11,102	0.68	28.05	–149.19	–8.47	–0.22	8.95	149.64
			Yen	3,616	–0.51	37.56	–149.76	–12.34	–0.62	9.78	149.66
Main Explanatory Variables											
Quarterly change in the Short-term Shadow Interest Rate of the Currency of Lending	%	Quarterly change in the short-term shadow interest rate associated with the currency of lending, in 100 bps, based on Krippner (2013)	*U.S. Dollars*	27,000	0.11	0.62	–1.46	–0.26	0.05	0.63	1.25
			Euro	27,000	–0.26	0.60	–1.12	–0.75	–0.30	0.10	1.08
			Yen	27,000	–0.12	0.75	–0.89	–0.66	–0.28	0.04	2.32
Short-term International Liquidity Ratio	%	Ratio of the source (lending) country's banking sector's short-term FX claims to their total FX claims, times 100		24,100	47.67	15.53	0.00	39.67	49.26	59.36	83.90
Short-term to Long-term International Liquidity Ratio	%	Ratio of the source (lending) country's banking sector's short-term international claims to their long-term international claims, denominated in foreign currencies. Used as instrument for short-term international liquidity ratio in IV estimations		24,100	1.27	0.82	0.00	0.76	1.08	1.72	5.21

The breakdown by major lenders and borrowers shows that a few countries dominate the currency networks (Table A1, upper panels). Among USD lenders (left panel) Japanese, US and UK banks dominate. French and German banks are the top EUR lenders (centre panel). On a much smaller scale, Japanese banks dominate among JPY lenders (right panel). Looking at the countries of borrowers shows a similar picture (Table A1, lower panels). The country with the highest USD borrowing is the United States, and the country with the most JPY borrowing is Japan. Reflecting its role as a financial center, the UK is home to the largest amount of cross-border borrowing in euros and the second largest in USD and JPY as well.

3.2 Data on Banking Sector Controls

Our main banking sector characteristic of interest is a banking system's *International Liquidity Ratio,* defined as the ratio of country *j*'s banks' short-term international claims (with remaining maturity less than one year) to their total international claims. International claims denote cross-border claims and local claims denominated in foreign currency. We collect the data from the BIS IBS consolidated banking statistics on intermediate counterparty basis. This measure is our proxy for a banking system's ability to replace and fund shortfalls in cross-border or FX claims emanating from monetary shocks to their balance sheets. In other words, this short-term international liquidity ratio measures a banking system's ability to buffer international liquidity shortfalls by reallocating short-term international claims within the banking system.

Furthermore, this variable also proxies for the extent to which a banking system has built-up channels to replace monetary shock-induced international claim shortfalls. The average source banking system in our sample has a short-term international liquidity ratio of around 48 percent.

In our differential estimation strategy, an important consideration is the extent to which the *International Liquidity Ratio* may be endogenous. While several features of our analysis help to alleviate concerns about the confounding effects that the potential endogeneity of this measure may have, we employ Instrumental Variable specifications in all our regressions, as we detail later in our methodology description.

While our diff-in-diff estimation strategy ensures the identification of credit supply-side shocks, we take additional steps to control for (potentially unobservable) features of and shocks to the credit demand of target countries. We do so by including target country*time fixed effects in almost all our specifications, which fully control for time-varying unobservable credit demand-side conditions. In a few (less saturated) specifications, we include macro controls for the country of the source banking system, and target country or time fixed effects.

3.3 Data on Macro Controls

We collect data on macro controls from the Economist Intelligence Unit (EIU)'s Country Data-base. Our macro controls include the *quarterly change in the exchange rate* between the currencies of the source banking system's country and the target

country, in order to account for potential valuation effects in the bilateral bank flows. The median and mean quarterly changes in the exchange rate between country pairs are zero and 0.5 percent, respectively. Based on Kashyap and Stein (2000) and Cetorelli and Goldberg (2012), we also include the *real GDP growth rate* of the country of the source banking system as a control variable. The median and mean real GDP growth rates in our sample of these source countries are both 1.5 percent. In some specifications, we also control for the monetary policy shocks (measured as quarterly percentage point changes in the short-term interest rate) associated with the source banking system's currency.

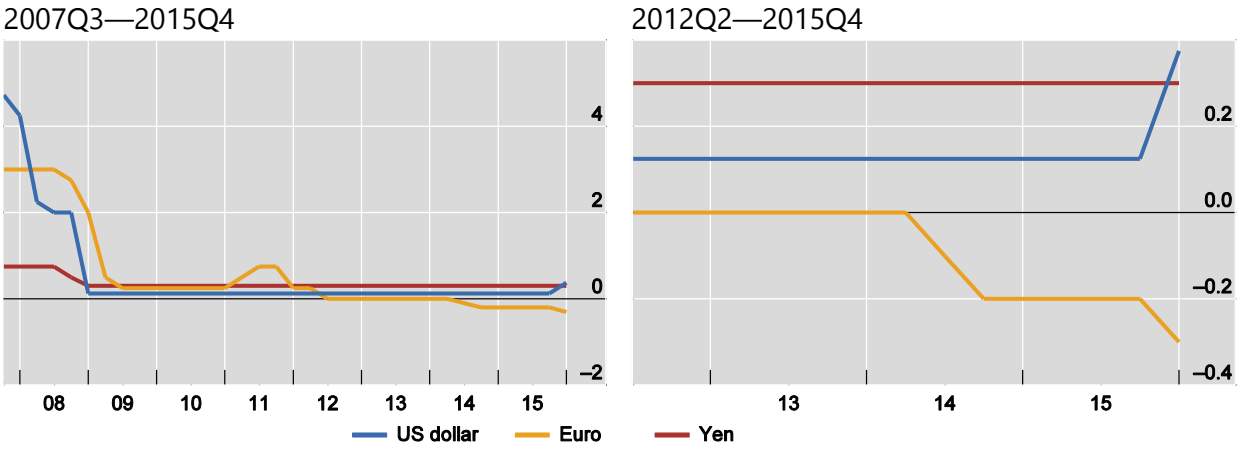
Our main macroeconomic variable of interest is our measure of monetary policy shocks affecting the three reserve currencies of lending. We define the monetary shock as the quarterly change (from $t-1$ to t, in percentage points) in the short-term shadow interest rate that corresponds to the monetary conditions determined by the central bank that issues currency c. We use this measure because our sample spans the 2012–2015 period, which covers the period of "unconventional" expansionary monetary policy actions by the Federal Reserve, the European Central Bank and the Bank of Japan.[11] As a result of these steps, the short-term policy target interest rates set by these three central banks hit the zero lower bound in early 2009, rendering further "conventional" monetary policy easing infeasible from then on (Figure 1).

[11] We differentiate these unconventional monetary policy actions (characterized by quantitative easing and large-scale asset purchases) from "conventional" policy, which is expansionary monetary policy through open market operations.

Short-term target interest rates

In per cent

Figure 1



These graphs present the paths of the short-term policy target interest rates set by the Federal Reserve (blue), the European Central Bank (yellow) and the Bank of Japan (red).

Source: Central bank websites.

In order to get a measure of monetary policy stance and liquidity shocks in the post-2009 period, we use the currency-specific short-term shadow interest rates (as described in Krippner (2013, 2015 and 2016)) as our measures of monetary conditions for the United States, the euro-zone and Japan (Figure 2).[12] By construction, these

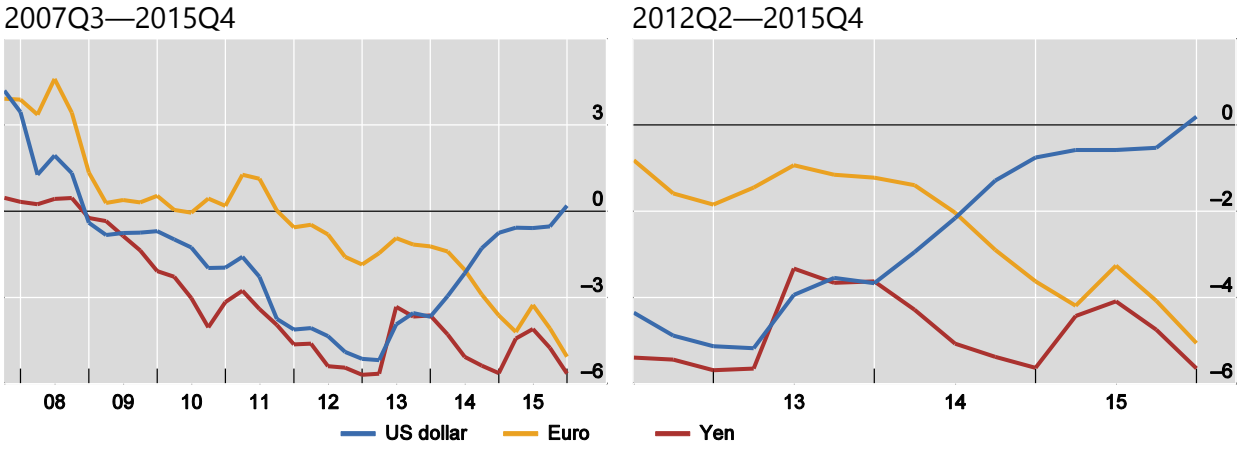
[12] Regarding the short-term shadow interest rate, Krippner (2016) describes: "The SSR is the shortest maturity rate from the estimated shadow yield curve. It is essentially equal to the policy interest rate in non-LB/conventional monetary policy environments (eg August 2008), but the SSR can freely evolve to negative values in LB/unconventional environments (eg July 2011) to indicate an overall stance of policy that is more accommodative than a near-zero policy rate alone. In particular, the SSR reflects the effects that unconventional policy actions (such as quantitative easing and forward guidance) have on longer-maturity interest rate securities, because it is estimated from yield curve data. *SSRs have therefore become a popular and intuitive indicator of the stance of monetary policy across conventional and unconventional environments* (emphasis added)." (page 4). Furthermore, Krippner describes: "…an in-principle issue with SSRs is that negative values do not represent interest rates at which economic agents can transact. Therefore, the levels and changes in SSRs when they are negative should not necessarily be expected to influence the economy in the same way as policy rate levels and changes in conventional policy periods…… *However, the results for the United States in Krippner (2015) indicate that SSR estimates from K-ANSM(2) models do provide useful quantitative indicators of unconventional monetary policy, and hence I think it is useful to retain them in the suite of unconventional monetary policy indicators.* (emphasis added)" (page 4). In other words, since declines in the short-term shadow interest rate are designed to correspond to quantitative easing and large-scale asset purchase (LSAP) actions, they, reflect a flattening of the yield curve on banks' portfolio. The additional balance sheet liquidity induced by a relative increase in short-term rates (induced by unconventional monetary policies) is a potent way through which declines in shadow rates may correspond to higher lending (investment) by banks, even in the absence of changing bank funding costs.

short-term shadow interest rates are not subject to the zero bound, and are therefore able to capture expansionary monetary policy actions by dipping into the negative range. As expected, all three shadow rates fall below zero when monetary conditions continue to ease and the nominal policy interest rates in Figure 1 hit the zero lower bound. The US and Japanese short-term shadow rates continued their steep decline through March 2013, dropping as low as –5 to –6 percent. The euro-zone shadow interest rate displayed a more gradual decline. After the first quarter of 2013, the US short-term shadow interest rate started to rise corresponding to the Federal Reserve's reduction of the pace of policy accommodations, while the euro-zone shadow rate continued to decline and approached the Japanese shadow rate at –5 to –6 percent. Data on these shadow interest rates are compiled, described and provided by Krippner (2013, 2015, 2016).

Short-term shadow interest rates

In per cent

Figure 2



These graphs present the paths of the short-term shadow interest rates for the US dollar (blue), the euro (yellow) and the yen (red).

Source: Krippner (2016)

4. Estimation methodology

We aim to test our main hypothesis, that is, whether the currency denomination of a bilateral lending relationship transmits the monetary policy shocks of the country that issues the currency. For instance, we aim to test whether UK banks' lending to borrowers in Malaysia denominated in euros responds to the monetary policy of the European Central Bank, and whether the lending denominated in US dollars responds to the monetary policy of the Federal Reserve.

Technically, we estimate a panel regression where the dependent variables are cross-border claim changes (flows) denominated in the three largest currencies. Formally, let $Y_{j,t}^{i,c}$ denote the stock of claims held by the source banking system *j*'s in (target) country *i* at time *t*, denominated in currency *c* (where *c* is one of USD, EUR or JPY). Then $\Delta \ln(Y)_{j,t}^{i,c}$ denotes the quarterly bilateral bank flows between the source banking system and target country, from time *t–1* to time *t*, defined as the difference in the natural logarithm of claims between a given quarter and the previous one.

Our basic econometric formulation takes the following form:

$$\Delta \ln(Y)_{j,t}^{i,c} =$$

$$= \alpha + \sum_{k=1}^{4}\beta_k MP_{t-k}^{c} + \sum_{k=1}^{4}\gamma_k MP_{t-k}^{c} \times L_{j,t-k} + \sum_{k=1}^{4}\delta_k L_{j,t-k} + \sum_{k=1}^{4}\zeta_k \begin{pmatrix} Source \\ Controls \end{pmatrix}_{j,t-k}$$

$$+ \sum_{k=1}^{4}\eta_k \begin{pmatrix} Target \\ Controls \end{pmatrix}_{t-k}^{i} + \varepsilon_{j,t}^{i,c}$$

In Equation (1), $\Delta \ln(Y)_{j,t}^{i,c}$ denotes quarterly bilateral cross-border bank flows, as described above. We include four lags of the following explanatory variables. The monetary shock MP_t^c is defined as the quarterly change (from *t–1* to *t*) in the short-term shadow interest rate corresponding to the monetary conditions set by the central bank that issues currency *c*.[13] Furthermore, $L_{j,t}$ denotes country *j*'s banking system's *International Liquidity Ratio,* which we define as the ratio of country *j*'s banks' short-term FX claims to their total FX claims. The sets of *Source* and *Target Controls* contain macroeconomic characteristics of source banking system *j* and target country *i*. We add target country*time fixed effects in some specifications, in order to capture any unobservable time-varying shocks (macro, regulatory, and so on) at the target country level. In the set of Source Controls, we include the annualized quarterly GDP growth rate, the quarterly change in the short-term *policy* interest rate, and the annualized quarterly change in the exchange rate between the country of the source banking system and the target country. These sets of source and target variables account for "outside" factors that may impact the country-level supply and demand of credit, respectively.

As there is a valid concern that the *International Liquidity Ratio* may be endogenous, we employ Instrumental Variable specifications in all our regressions. Several features of our analysis help to alleviate concerns about the confounding

[13] This refers to the Federal Reserve Bank in the case of the US dollar, the European Central Bank in the case of the Euro, and the Bank of Japan in the case of the Yen.

effects that the potential endogeneity of this measure may have.[14] Nonetheless, in all our specifications we instrument the short-term *International Liquidity Ratio* using source banking system *j*'s banks' *Short-to-long-term* international liquidity *Ratio* (defined as short-term international claims over long-term international claims).[15]

We expect that monetary tightening by the central bank that issues currency *c* reduces all lending flows in currency *c*. Therefore, we expect to find that the cumulative effects of monetary policy shocks on bilateral cross-border lending from that country are negative: $\sum_{k=1}^{4}\beta_k < 0$. Our identification strategy is based on Kashyap and Stein (2000) and Cetorelli and Goldberg (2012). Accordingly, we identify the bank lending channel of monetary policy from the *differential* response of the lending of source banking systems with less vs. more international liquidity to monetary policy shocks. The idea is that banking systems with less short-term international liquidity may find it more difficult to maintain previous levels of lending flows after a monetary tightening-induced liquidity shortage, as they have less buffer than banking systems with more international liquidity. Therefore, we expect to find that banking systems with less international liquidity reduce their currency *c*-denominated lending flows

[14] First, our identification strategy is to compare the *differential* impact of monetary shocks on cross-border bank lending originating from banking systems of various international liquidity *levels*. Therefore, any *level* effect that a liquidity shock in the euro-zone, for instance, might have on foreign banking systems' international liquidity ratios does not jeopardize our identification strategy as long as this level effect is the same across all foreign banking systems. In this case, the *difference* in lending response across any two banking systems will not be affected, even if both banking systems' funding ratios change by the same amount. Second, we include four lagged values of the international liquidity measure.

[15] This *Short-to-long-term International Liquidity Ratio* is a valid instrument in that it is highly and significantly correlated with the short-term international liquidity ratio (correlation coefficient of over 0.90, significant at the 1% level), but uncorrelated with changes in the short-term shadow interest rates (our measures of monetary shocks, correlation coefficient of 0.02, insignificant) associated with the three reserve currencies.

more in response to monetary tightening in currency *c* than banking systems with abundant international claims.[16] If this is the case, the cumulative sum of coefficients on the interaction of the international liquidity ratio with interest rate shocks is positive: $\sum_{k=1}^{4}\gamma_k > 0$.

Next, we examine the extent to which the strength of the transmission of monetary shocks may vary across different banking systems and countries. We examine monetary transmission by adding country/banking system specific dummies as shown in the following specification.

$$\Delta \ln(Y)_{j,t}^{i,c} =$$

$$= \varphi + \sum_{k=1}^{4}\beta_k L_{j,t-k} + \sum_{k=1}^{4}\varphi_k MP_{t-k}^{c} + \rho \mathrm{F}_{j,t}^{i,c} + \sum_{k=1}^{4}\sigma_k MP_{t-k}^{c} \times \mathrm{F}_{j,t}^{i,c} + \sum_{k=1}^{4}\ddot{\iota}_k MP_{t-k}^{c}$$
$$\times L_{j,t-k} + \sum_{k=1}^{4}\Psi_k L_{j,t-k} \times \mathrm{F}_{j,t}^{i,c} + \sum_{k=1}^{4}\vartheta_k MP_{t-k}^{c} \times L_{j,t-k} \times \mathrm{F}_{j,t}^{i,c}$$
$$+ \sum_{k=1}^{4}\varpi_k \begin{pmatrix} Source \\ Controls \end{pmatrix}_{j,t-k} + \sum_{k=1}^{4}\mathfrak{f}_k \begin{pmatrix} Target \\ Controls \end{pmatrix}_{t-k}^{i} + \mu_{j,t}^{i,c}$$

In addition to the terms presented in Equation 1, Equation 2 also contains the interaction of the monetary shock MP_t^c with the dummy variable $\mathrm{F}_{j,t}^{i,c}$, as well as the double interaction of this dummy variable with the monetary shock MP_t^c and international liquidity ratio $L_{j,t}$.[17]

[16] As discussed in Section 3 above, we consider our international liquidity measure to be representative of the extent to which a banking system is able to fund/replace FX losses, as it proxies for a banking system's current access to international liquidity from its balance sheet or built-up channels (such as FX swap contracts, and so on).

[17] Also included in the estimations, but not reported in the equation or the tables in the interest of space, are the interactions of this dummy variable with *all* of the covariates in the model.

Depending on the specification, the dummy variable $F_{j,t}^{i,c}$ captures two types of monetary transmission sensitivities. First, we analyze if the transmission of monetary shocks depends on whether the bank flows under study are "return flows", that is, if the country of the source banking system and the target country is the same. This allows for the possibility, for instance, that US banks' lending to borrowers in the US may respond differently to monetary policy shocks than their lending to non-US borrowers. In this analysis, $F_{j,t}^{i,c}$ is a dummy variable that takes on a value of 1 if the source and the target are the same (i=j), and 0 otherwise.

Second, we examine whether the transmission of currency c-specific monetary shocks is different in bank lending flows to borrowers in countries which use currency c as their own currency. If this is the case, for instance, an increase in the euro short-term shadow rate would affect EUR-denominated lending inflows from all banks to borrowers in countries in the euro-zone differently than USD or JPY-denominated inflows into the euro-zone. In this analysis, $F_{j,t}^{i,c}$ is a dummy variable that takes on a value of 1 if currency c is the (borrowers' host) country j's own currency, and 0 otherwise.

5. Estimation results

Tables 2 through 6 present our main estimation results. We begin by examining the transmission of monetary policy-induced monetary shocks into *aggregate* bilateral

bank flows to uncover the currency dimension of the bank lending channel (Table 2). Next, we analyse transmission by sector of borrowers to see how transmission into lending to banks and non-banks differs (Tables 3 and 4). Finally, we examine transmission by currency denomination, to see how transmission into lending in USD, EUR or JPY may differ (Tables 5 and 6). As described above, in all our estimations we instrument the *Short-term International Liquidity Ratio* with the *Short-to-long-term International Liquidity Ratio* (defined as short-term FX claims over long-term FX claims).

5.1 Shock transmission in aggregate bilateral cross-border flows

We examine monetary transmission into *aggregate* bilateral cross-border flows, aggregated (summed) across target sectors (bank and non-bank borrowers) in Table 2. We start by estimating Equation 1 to see the differential role of the source banking system's *International Liquidity Ratio* in the strength of monetary transmission. First, we estimate the equation in its simplest form with target country fixed effects (Column 1). We find evidence of the currency dimension of the bank lending channel: Following a change in monetary policy associated with the currency of lending, international liquidity-constrained banking systems reduce their bilateral cross-border lending flows in that currency significantly *more* than their international liquidity-abundant counterparts (see second row, showing $\sum_{k=1}^{4}\gamma_k > 0$). Furthermore, the results also suggest a significant direct negative effect of monetary tightening in

a currency on the lending denominated in the same currency (first row, showing $\sum_{k=1}^{4}\beta_k < 0$). In sum, the first results confirm our expectations.

We continue by saturating the model with increasingly extensive sets of fixed effects in order to control for unobservable time-varying credit demand-side shocks. First, we add time fixed effects (Column 2). Next, we add target country*time fixed effects (Column 3) to fully control for unobservable time-varying demand-side shocks at the level of borrowers' host countries. Throughout these estimations, we continue to confirm the initial results from Column 1. We find strong and robust evidence of the currency dimension of the bank lending channel of monetary transmission.

Next, we allow banking system/country-specific effects on transmission by estimating the model specified in Equation 2, while continuing to include target country*time fixed effects throughout (Table 2, Columns 4 and 5). Specifically, in Column 4 we allow for the possibility that the presence of "return flows" in the data (where the source banking system and target country are the same) may affect the strength of monetary transmission.[18] Our main results, both the statistical significance and the size of the coefficient estimates, remain almost identical to earlier results. Furthermore, transmission into "return flows" appear somewhat weaker, as implied by the double interaction term (Row 4 of Column 4). In Column 5, we allow for the

[18] We do so motivated by the hypothesis that "return flows" may increase if parent banks in the source banking system recall loans from abroad, in order to mitigate the impact of monetary tightening at home (Cetorelli and Goldberg, 2012). Furthermore, monetary policy shocks in such cases are highly endogenous as they directly respond to domestic developments – thereby setting these "same source-target" pairs aside from the rest of the sample.

possibility that the strength of monetary transmission may differ if the currency of lending is the same as the currency of the (target) country of borrowers, by including interactions with a dummy variable.[19] Our main results in the first two rows remain significant and similar in magnitude to earlier estimates. This same currency effect does not significantly affect our main estimates (see interaction terms in the sixth and seventh row).

Finally, we show that the monetary transmission results remain significant even when we explicitly exclude data on "return flows" (Columns 6 and 7). Excluding return flows could matter in the strength of transmission, as the coefficient on the double interaction with the return flows dummy in Columns 4 was marginally significant. In Column 6 we re-estimate the target country*time fixed-effect model of Column 3, excluding data on flows where the source and target are the same. The results remain very similar. In Column 7 we repeat the estimation of Column 5 (according to Equation 2) while we exclude return flows. Again, we find that excluding observations where the currency of lending is the target country's own currency yields transmission results similar to the previous estimates, both in magnitude and significance.

[19] For instance, monetary easing in the US would result in real economic effects via more abundant liquidity conditions. These changes would then alter the inflow of bank claims into the US. Alternatively, in other (non-US) countries that use the USD, easing USD liquidity conditions would alter the strength of the USD in international financial markets, leading to real economic effects in any USD-using country. These real effects could then change bank lending inflows into the country.

Total bilateral bank flows - Instrumental Variable Estimations — Table 2

Quarterly change in total bilateral cross-border bank claims across countries and currencies for banking systems with different short-term international liquidity ratios during the 2012:Q1-2015:Q4 period

	[1]	[2]	[3]	[4]	[5]	[6]	[7]
Type of Bilateral Flows	*All Bilateral Flows*	*All Bilateral Flows*	*All Bilateral Flows*	*All Bilateral Flows*	*All Bilateral Flows*	*Excluding Return Flows*	*Excluding Return Flows*
Independent Variables							
ΣΔ Shadow Interest Rate {t-1 to t-4}	–13.63 [4.023]***	–12.15 [4.054]***	–11.46 [4.021]***	–12.43 [4.122]***	–10.36 [4.149]**	–12.29 [4.15]***	–10.67 [4.25]**
ΣΔ Shadow Interest Rate*International Liquidity Ratio {t-1 to t-4}	0.276 [0.0927]***	0.229 [0.0927]**	0.22 [0.0911]**	0.245 [0.0941]***	0.208 [0.0946]**	0.241 [0.0946]**	0.217 [0.0977]**
Σ International Liquidity Ratio {t-1 to t-4}	–0.146 [0.127]	–0.149 [0.13]	–0.149 [0.128]	–0.0994 [0.133]	–0.159 [0.14]	–0.136 [0.134]	–0.137 [0.145]
Source-Target Same Dummy*ΣΔ Shadow Interest Rate*International Liquidity Ratio {t-1 to t-4}				–0.675 [0.368]*			
Source-Target Same Dummy*ΣΔ Shadow Interest Rate {t-1 to t-4}				27.359 [16.764]			
Target Country's Currency Dummy*ΣΔ Shadow Interest Rate*International Liquidity Ratio {t-1 to t-4}					–0.0416 [0.298]		0.0543 [0.327]
Target Country's Currency Dummy*ΣΔ Shadow Interest Rate {t-1 to t-4}					–2.303 [14.19]		–6.634 [15.52]
Constant	7.547 [7.347]	10.75 [7.579]	8.205 [7.449]	9.307 [7.483]	10.31 [7.45]	7.471 [7.766]	5.639 [7.839]
Four lags of Dependent Variable	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Target-Source Same Pairs Included	Yes	Yes	Yes	Yes	Yes	No	No
Source Banking System Macro Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Target Country - Time Fixed Effects	No	No	Yes	Yes	Yes	Yes	Yes
Time Fixed Effects	No	Yes	--	--	--	--	--
Target Country Fixed Effects	Yes	No	--	--	--	--	--
Number of Observations	12598	12598	12598	12598	12598	12072	12072
Differential response of International Liquidity-abundant banking systems (at the 75th ptile) vs. international liquidity-constrained banking systems (at the 25th ptile) to a 100bps decline in the policy interest rate							
	5.428 [1.825]***	4.505 [1.825]**	4.338 [1.793]**	4.572 [1.821]**	4.047 [1.795]**	4.741 [1.863]**	4.318 [1.857]**

Note: The table reports estimates from Arellano-Bond dynamic panel IV estimations. The dependent variable is the quarterly change in total bilateral cross-border bank claims across countries and currencies [i.e., claims denominated in U.S. dollars, Euro and Japanese Yen]. The Short-to-long international liquidity ratio is the instrument for the short-term international liquidity ratio. Table 1 contains the definition of all variables and the summary statistics for each included variable. Coefficients are listed in the first row, robust standard errors are reported in the row below, and the corresponding significance levels are placed adjacently. Σ indicates that the sum of the four coefficients on the indicated lag terms [and corresponding robust standard errors and significance level] is reported. The Source-Target Same Dummy takes on a value of 1 if the source banking system and the target country is the same, and zero otherwise. The Target Country's Currency Dummy takes on a value of 1 if the target country uses the given denomination as their own currency, and zero otherwise. In addition to the reported variables, four lags of the two-way interactions of the Source-Target Same Dummy with the shadow rate change and International Liquidity Ratio as well as the Target Country's Currency Dummy and International Liquidity Ratio are also included in the specifications. "Yes" indicates that the set of characteristics or fixed effects is included. "No" indicates that the set of characteristics or fixed effects is not included. "--" indicates that the indicated set of characteristics or fixed effects are comprised in the wider included set of fixed effects. *** Significant at 1%, ** significant at 5%, * significant at 10%.

The currency dimension of the bank lending channel has statistically and economically significant effects on cross-border lending flows. A 1 percentage point increase in a source banking system's *Short-term International Liquidity Ratio* mitigates the positive impact of a 100 basis points (bps) decrease in the short-term shadow interest rate associated with the currency of lending by around 0.25 percentage points (Table 2, coefficient estimates in the second row). The economic impact is also significant. The first two rows in Table 2 imply that for a source banking system at the sample average *International Liquidity Ratio* (48 percent), a 100 bps decrease in the short-term shadow rate of the currency of lending raises total bilateral cross-border lending flows by 0.49 to 15.68 percentage points. Taking into account the overall bilateral claims on the average target country, these percentage changes correspond to an increase of 72 billion USD in overall cross-border inflows. This effect is much stronger for liquidity-constrained banking systems. As we calculate in the bottom row of Table 2, banking systems at the 25th percentile of the distribution of *International Liquidity Ratios* increase their bilateral cross-border lending 4.05 to 5.43 percentage points more in response to a 100 bps decrease in the short-term shadow rate of the currency of lending than banking systems at the 75th percentile of the international liquidity ratio distribution.

The results we presented thus far show that currency-specific monetary shocks have generally strong effects on bilateral cross-border lending in that given currency, across all source banking systems. These shocks can exert real economic effects not

only domestically (as implied by Kashyap and Stein, 2000), and not only in countries that receive credit from the source country of the monetary shock (as implied by Peek and Rosengren, 2000), but also in unrelated (third) country relationships, where the currency is used. For instance, US monetary policy can affect lending by UK banks to borrowers in Malaysia denominated in USD. In other words, the monetary policy actions associated with the three reserve currencies have lending effects, and therefore potential real economic effects, in *all* countries that receive lending flows in that currency, irrespective of the source banking system of lending.[20]

5.2 Transmission in lending to banks and non-banks

In the analysis so far we focused on aggregate (summed across target sectors) bilateral cross-border bank lending among country pairs and pooled them across different currencies. Now, we turn our attention to lending to bank and non-bank borrowers separately.

In the first step of the investigation, in Table 3 we pool data on claims to banks and to non-banks across currencies and calculate marginal transmission effects for each target sector separately. In the second step of the sector-specific analysis, we estimate the model for each target sector separately (Table 4). The results in both tables strongly support the following conclusion: The monetary transmission effects

[20] In specifications not presented here, we also examine whether the transmission of currency c-specific monetary policy is stronger into the lending of banking systems whose country uses currency c as its own currency. If this is the case, we would find that monetary easing in the United States would affect the cross-border lending of US-based banks more than the USD-denominated cross-border lending of banks from other countries. However, we do not find a significant difference.

are highly significant into lending to target countries' non-bank sectors, while there is no evidence of significant monetary transmission into cross-border lending to target countries' banking sectors.

In more detail on non-bank lending, the first three columns of Table 3 (which correspond to the Columns 3, 4 and 7 from Table 2) show that a 1 percentage point increase in the *International Liquidity Ratio* of a source banking system reduces the boosting effect of a 100 bps decline in the short-term shadow rate of the currency of lending by 0.40 to 0.43 percentage points on non-bank lending (bottom row). The economic significance of these results is great: Liquidity-constrained banking systems' cross-border lending flows to non-banks increase around 9 percentage points more than that of liquidity-abundant banking systems. Overall, these results imply that for a banking system at the sample average of *International Liquidity Ratio*, a 100 bps decline in the shadow rate of the currency of lending raises lending flows to non-banks by 2.02 to 3.54 percentage points, amounting to an increase of 15.32 billion USD for the average target country.

However, similar estimations for lending to banks in the same pooled dataset show that none of the transmission results are significant (Columns 4 through 6).

Bilateral bank flows by sector - Instrumental Variable Estimations — Table 3

Quarterly change in total bilateral cross-border bank claims on banks and non-banks, pooled specification, for banking systems with different short-term international liquidity ratios during the 2012:Q1-2015:Q4 period

	[1]	[2]	[3]	[4]	[5]	[6]
Type of Bilateral Flows	*Flows to the Non-bank Sector*	*Flows to the Non-bank Sector*	*Flows to the Non-bank Sector*	*Flows to the Bank Sector*	*Flows to the Bank Sector*	*Flows to the Bank Sector*
Independent Variables						
ΣΔ Shadow Interest Rate {t-1 to t-4}	–22.64 [5.443]***	–23.66 [5.415]***	–21.87 [5.475]***	–2.181 [7.875]	–2.16 [8.085]	–5.625 [8.109]
ΣΔ Shadow Interest Rate*International Liquidity Ratio {t-1 to t-4}	0.401 [0.117]***	0.443 [0.118]***	0.427 [0.121]***	0.0796 [0.177]	0.0885 [0.181]	0.142 [0.186]
Σ International Liquidity Ratio {t-1 to t-4}	0.28 [0.318]	0.271 [0.32]	0.333 [0.353]	–0.602 [0.456]	–0.658 [0.462]	–0.777 [0.513]
Target's Currency Dummy*ΣΔ Shadow Interest Rate*International Liquidity Ratio {t-1 to t-4}			0.267 [0.468]			–0.358 [0.635]
Target's Currency Dummy*ΣΔ Shadow Interest Rate {t-1 to t-4}			0.267 [0.468]			–0.358 [0.635]
Constant	7.158 [12.29]	2.974 [12.24]	4.241 [12.53]	7.158 [12.29]	2.974 [12.24]	4.241 [12.53]
Four lags of Dependent Variable	Yes	Yes	Yes	Yes	Yes	Yes
Target-Source Same Pairs Included	Yes	Yes	No	Yes	Yes	No
Source Banking System Macro Controls	Yes	Yes	Yes	Yes	Yes	Yes
Target Country - Time Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Time Fixed Effects	--	--	--	--	--	--
Target Country Fixed Effects	--	--	--	--	--	--
Number of Observations	17147	17147	17147	17147	17147	17147
Differential response of International Liquidity-abundant banking systems (at the 75th ptile) vs. international liquidity-constrained banking systems (at the 25th ptile) to a 100bps decline in the policy interest rate						
	7.888 [2.313]***	9.694 [2.333]***	9.368 [2.373]***	1.567 [3.478]	2.705 [3.567]	3.764 [3.672]

Note: The table reports estimates from Arellano-Bond dynamic panel IV estimations. The dependent variable is the quarterly change in bilateral cross-border bank claims across countries and currencies [i.e., claims denominated in U.S. dollars, Euro and Japanese Yen], with the marginal effects for claims to non-banks (Columns 1 through 3) and claims to banks (Columns 4 through 6) calculated separately from pooled regressions. The Short-to-long international liquidity ratio is the instrument for the short-term international liquidity ratio. Table 1 contains the definition of all variables and the summary statistics for each included variable. Coefficients are listed in the first row, robust standard errors are reported in the row below, and the corresponding significance levels are placed adjacently. Σ indicates that the sum of the four coefficients on the indicated lag terms [and corresponding robust standard errors and significance level] is reported. The Source-Target Same Dummy takes on a value of 1 if the source and target countries are the same, and zero otherwise. The Target Country's Currency Dummy takes on a value of 1 if the target country uses the given denomination as their own currency, and zero otherwise. In addition to the reported variables, four lags of the two-way interactions of the Target-Source Same Dummy with the shadow rate change and International Liquidity Ratio as well as the Target Country's Currency Dummy and International Liquidity Ratio are also included in the specifications. "Yes" indicates that the set of characteristics or fixed effects is included. "No" indicates that the set of characteristics or fixed effects is not included. "--" indicates that the indicated set of characteristics or fixed effects are comprised in the wider included set of fixed effects. *** Significant at 1%, ** significant at 5%, * significant at 10%.

In Table 4, we estimate the same IV specifications as in Table 3, now for lending to banks and non-banks separately (rather than Table 3's pooled specification). We continue to find substantial differences in the strength of monetary transmission across target sectors: The monetary transmission results are highly significant in lending to the non-bank sector, but insignificant in lending to the banking sector of target countries. In terms of economic significance, international liquidity-constrained banking systems (at the 25th percentile of the short-term international liquidity distribution) increase their bilateral lending to non-bank borrowers in response to a 100 bps decrease in the short-term shadow rate of the currency of lending by 4.57 to 5.60 percentage points more than international liquidity-abundant banking systems (at the 75th percentile of the short-term international liquidity distribution). A monetary easing of similar magnitude would increase the lending flows to non-banks of a source banking system at the sample average of the *International Liquidity Ratio* (48 percent) by 1.08 to 9.89 percentage points. These changes correspond to an increase of 30.61 billion USD in overall inflows to the average target country's non-bank sector. As in Table 3, the monetary transmission effects in lending to banks are insignificant throughout (Columns 4 through 6 of Table 4).[21]

In summary, we find important differences in how the bank-lending channel transmits monetary shocks into lending to target countries' non-bank vs. bank

[21] Our IV specifications are particularly important in validating the insignificance of the transmission results into lending to banks. The IV formulation eliminates the concern that the lack of significance could be due to the possible endogeneity of our international liquidity measure.

sectors.[22] The insignificance of the "interbank" lending results makes sense insofar as cross-border interbank flows are driven by many other, non-monetary policy-related considerations, such as payments systems, liquidity management, hedging activities, and so on. Conceptually, these results also suggest that cross-border interbank lending is *not* the initial channel through which monetary policy shocks in a currency's issuing country transmit to foreign banking systems. Large-scale corporate deposits, FX swap markets or central bank liquidity swap lines may play a more prominent role in this initial transmission instead.

Yet, while we find that transmission into interbank lending is insignificant in a global setup, our result does not necessarily imply that interbank transmission is insignificant in all cross-border relationships. For instance, Alper et al (2016) found significant evidence of US monetary policy transmission into cross-border bank lending to Turkish banks, suggesting that interbank lending might also be affected by monetary policy shocks, at least in some locations.

[22] Based on Column 2 of Table 3, we tested for the joint significance of the monetary transmission coefficients across the two target sectors. That is, we tested whether $\sum_{k=1}^{4}\gamma_{k\ non-bank} = \sum_{k=1}^{4}\gamma_{k\ bank} = 0$. The Chi-square test indicates that we can reject this null hypothesis at the 90% confidence level, but not at the 95% level (prob=0.91). Tests on this specification also show that the bank and non-bank results are jointly significant at the 1% level.

Bilateral bank flows by sector - Instrumental Variable Estimations — Table 4

Quarterly change in bilateral cross-border bank claims on non-banks and banks separately, for banking systems with different short-term international liquidity ratios during the 2012:Q1-2015:Q4 period

Type of Bilateral Flows	[1]	[2]	[3]	[4]	[5]	[6]
Independent Variables	*Flows to the Non-bank Sector*	*Flows to the Non-bank Sector*	*Flows to the Non-bank Sector*	*Flows to the Bank Sector*	*Flows to the Bank Sector*	*Flows to the Bank Sector*
ΣΔ Shadow Interest Rate {t-1 to t-4}	–13.77 [5.291]***	–15.72 [5.425]***	–11.2 [5.605]**	–9.465 [7.189]	–9.577 [7.431]	–7.998 [7.591]
ΣΔ Shadow Interest Rate*International Liquidity Ratio {t-1 to t-4}	0.266 [0.113]**	0.303 [0.116]***	0.236 [0.119]**	0.159 [0.155]	0.177 [0.161]	0.122 [0.163]
Σ International Liquidity Ratio {t-1 to t-4}	–0.0497 [0.135]	–0.0272 [0.138]	–0.00517 [0.149]	–0.0698 [0.235]	–0.00605 [0.242]	–0.121 [0.269]
Source-Target Same Dummy*ΣΔ Shadow Interest Rate*International Liquidity Ratio {t-1 to t-4}		50.617 [18.327]***			4.072 [23.504]	
Source-Target Same Dummy*ΣΔ Shadow Interest Rate {t-1 to t-4}		–0.978 [0.382]**			–0.243 [0.502]	
Target's Currency Dummy*ΣΔ Shadow Interest Rate*International Liquidity Ratio {t-1 to t-4}			–0.0809 [0.321]			0.00511 [0.405]
Target's Currency Dummy*ΣΔ Shadow Interest Rate {t-1 to t-4}			–4.265 [14.97]			0.526 [19.75]
Constant	7.137 [8.147]	6.161 [8]	4.67 [8.142]	–1.393 [14.09]	–2.788 [13.92]	–3.968 [14.37]
Four lags of Dependent Variable	Yes	Yes	Yes	Yes	Yes	Yes
Target-Source Same Pairs Included	Yes	Yes	No	Yes	Yes	No
Source Banking System Macro Controls	Yes	Yes	Yes	Yes	Yes	Yes
Target Country - Time Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Time Fixed Effects	--	--	--	--	--	--
Target Country Fixed Effects	--	--	--	--	--	--
Number of Observations	11290	11290	11290	9161	9161	9161
Differential response of International Liquidity-abundant banking systems (at the 75th ptile) vs. international liquidity-constrained banking systems (at the 25th ptile) to a 100bps decline in the policy interest rate						
	5.243 [2.219]**	5.599 [2.246]**	4.57 [2.254]**	3.127 [3.055]	3.399 [3.104]	2.403 [3.09]

Note: The table reports estimates from Arellano-Bond dynamic panel IV estimations. The dependent variable is the quarterly change in bilateral cross-border bank claims across countries and currencies [i.e., claims denominated in U.S. dollars, Euro and Japanese Yen], with the claims to non-banks (Columns 1 through 3) and claims to banks (Columns 4 through 6) analysed separately. The Short-to-long international liquidity ratio is the instrument for the short-term international liquidity ratio. Table 1 contains the definition of all variables and the summary statistics for each included variable. Coefficients are listed in the first row, robust standard errors are reported in the row below, and the corresponding significance levels are placed adjacently. Σ indicates that the sum of the four coefficients on the indicated lag terms [and corresponding robust standard errors and significance level] is reported. The Source-Target Same Dummy takes on a value of 1 if the source and target countries are the same, and zero otherwise. The Target Country's Currency Dummy takes on a value of 1 if the target country uses the given denomination as their own currency, and zero otherwise. In addition to the reported variables, four lags of the two-way interactions of the Target-Source Same Dummy with the shadow rate change and International Liquidity Ratio as well as the Target Country's Currency Dummy and International Liquidity Ratio are also included in the specifications. "Yes" indicates that the set of characteristics or fixed effects is included. "No" indicates that the set of characteristics or fixed effects is not included. "--" indicates that the indicated set of characteristics or fixed effects are comprised in the wider included set of fixed effects. *** Significant at 1%, ** significant at 5%, * significant at 10%.

Our result showing that monetary shocks affect lending flows to non-bank borrowers suggests potentially substantial real economic effects. Kashyap and Stein (2000) and Peek and Rosengren (2000) have shown that monetary policy affects the real economy through bank lending to the non-bank sector. We find that the currency dimension of bank lending channel operates through exactly this type of lending to non-banks.

5.3 Transmission across different currencies

In this subsection we turn to compare how different currencies transmit their respective monetary policy-induced monetary shocks. Following the logic of our sector-specific analysis, first we pool the three reserve currencies and calculate marginal effects by currency (Table 5), then we examine each currency separately (Table 6). In light of the previous section, where we established that the currency dimension of the bank lending channel works primarily through lending to non-banks, we focus our attention on lending to the non-bank target sector exclusively.

In Table 5, we employ a pooled IV specification across currencies and examine currency-specific transmission effects by calculating marginal effects for each currency separately. Columns 1 and 2 show the results for the USD, 3 and 4 for the EUR and Columns 5 and 6 for the JPY. For each currency, we run two specifications: A baseline estimation based on Equation 1, and a specification based on Equation 2 which also

allows for the possibility that monetary transmission is different if the target country uses the denomination of lending as their own currency.

Bilateral bank claims pooled across currencies - Instrumental Variable Estimations — Table 5

Quarterly change in total bilateral cross-border bank claims on non-banks, pooled across currencies, across countries for banking systems with different short-term international liquidity ratios during the 2012:Q1-2015:Q4 period

Currency Denomination of Bilateral Flows	[1] *USD*	[2] *USD*	[3] *EUR*	[4] *EUR*	[5] *JPY*	[6] *JPY*
Independent Variables						
ΣΔ Shadow Interest Rate {t-1 to t-4}	–32.44 [12.56]***	–9.15 [6.841]	–21.67 [7.751]***	–11.39 [7.53]	–17.48 [8.142]**	–11.44 [9.36]
ΣΔ Shadow Interest Rate*International Liquidity Ratio {t-1 to t-4}	0.579 [0.252]**	0.477 [0.258]*	0.369 [0.165]**	0.376 [0.178]**	0.324 [0.197]*	0.377 [0.213]*
Σ International Liquidity Ratio {t-1 to t-4}	–0.391 [0.238]	–0.307 [0.247]	0.0123 [0.234]	–0.0126 [0.244]	1.122 [0.719]	0.603 [0.674]
Target's Currency Dummy*ΣΔ Shadow Interest Rate*International Liquidity Ratio {t-1 to t-4}		0.97 [0.63]		–0.202 [0.574]		1.659 [0.643]***
Constant	8.681 [7.332]	3.264 [6.588]	0.193 [5.97]	–1.414 [6.101]	0.0307 [3.59]	0.71 [3.698]
Source Banking System Macro Controls	Yes	Yes	Yes	Yes	Yes	Yes
Four lags of Dependent Variable	Yes	Yes	Yes	Yes	Yes	Yes
Target Country-Time Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Number of Observations	11048	11048	11097	11097	11048	11048
Differential response of International Liquidity-abundant banking systems (at the 75th ptile) vs. international liquidity-constrained banking systems (at the 25th ptile) to a 100bps decline in the policy interest rate						
	11.41 [4.968]**	10.33 [5.062]**	7.268 [3.254]**	7.215 [3.353]**	6.379 [3.875]*	9.026 [4.059]**

Note: The table reports estimates from Arellano-Bond dynamic panel IV estimations. The dependent variable is the quarterly change in bilateral cross-border bank claims pooled across currencies, across countries [i.e., claims denominated in U.S. dollars, Euro and Japanese Yen]. The Short-to-long international liquidity ratio is the instrument for the short-term international liquidity ratio. Table 1 contains the definition of all variables and the summary statistics for each included variable. Coefficients are listed in the first row, robust standard errors are reported in the row below, and the corresponding significance levels are placed adjacently. Σ indicates that the sum of the four coefficients on the indicated lag terms [and corresponding robust standard errors and significance level] is reported. The Source-Target Same Dummy takes on a value of 1 if the source banking system and the target country is the same, and zero otherwise. The Target Country's Currency Dummy takes on a value of 1 if the target country uses the given denomination as their own currency, and zero otherwise. In addition to the reported variables, four lags of the two-way interactions of the Target-Source Same Dummy with the shadow rate change and International Liquidity Ratio as well as the Target Country's Currency Dummy and International Liquidity Ratio are also included in the specifications. "Yes" indicates that the set of characteristics or fixed effects is included. "No" indicates that the set of characteristics or fixed effects is not included. "--" indicates that the indicated set of characteristics or fixed effects are comprised in the wider included set of fixed effects. "Inst" indicates that the given variable is included in the set of exogenous instruments. *** Significant at 1%, ** significant at 5%, * significant at 10%.

In this pooled specification, we find evidence of the transmission of monetary shocks into lending in all three currencies. The significance levels are generally lower

than in the previous estimates, reflecting smaller sample size. The transmission is statistically significant into the USD-denominated lending of *all* banking systems to the non-banking sector of target countries at either the 5 or 10 percent level (Table 5, Columns 1 and 2). The USD transmission results are also large in magnitude: A 100 bps decrease in the US short-term shadow interest rate increases the USD-denominated lending of international liquidity-constrained banking systems (at the 25th percentile of the international liquidity distribution) to non-banks in target countries by around 11 percentage points *more* than the lending of international liquidity-abundant banking systems (at the 75th percentile of the distribution). In our baseline specification, a monetary easing of this magnitude increases a source banking system's USD lending to non-banks by 4.82 percent points – even if the US itself is neither the source banking system nor the target country. By quantifying these effects, our results add to the findings of the previous literature which has shown that US monetary policy has global effects in part by impacting all USD-denominated bank flows around the world (Ammer et al, 2016 and Alper et al, 2016, among others).

Monetary shocks associated with the euro are significant at the 5 percent level (Columns 3 and 4). Short-term international liquidity-constrained banking systems increase their EUR-denominated lending by 0.37 percentage points *more* in response to a 100 bps decrease in the EUR short-term shadow interest rate than more international liquidity-abundant banking systems. The economic significance is clear: A comparable decrease in the EUR short-term shadow interest rate increases the EUR-

denominated lending of banking systems at the 25th percentile of international liquidity distribution by around 7 percentage points *more* than the lending of banking systems at the 75th percentile.

Finally, we see a similar direction for monetary transmission via JPY-denominated lending to non-banks, though the estimates are only significant at the 10 percent level (Columns 5 and 6).[23] In our most complete specification, international liquidity-constrained banking system's JPY-denominated lending to non-banks increases 9.03 percentage points more in response to a 100 bps decline in the JPY short-term shadow interest rate than the lending of international liquidity-abundant banking systems. Comparing magnitudes across currencies, the monetary transmission effects appear greatest in USD-denominated lending to non-banks, followed by EUR lending and smallest in JPY lending.

Overall, our results in Table 5 show that monetary policy-induced shocks associated with a given reserve currency tend to affect all lending to non-banks in that currency across countries. To confirm these findings, in Table 6 we examine the currencies one by one.[24]

[23] We have much fewer observations on JPY-denominated bilateral cross-border lending as compared to data on USD or EUR-denominated lending.

[24] The individual monetary shock terms $\sum_{k=1}^{4}\gamma_k MP_{t-k}^{c}$ are excluded from the Table 6 specifications, since these terms only vary in the time dimension within each currency and therefore cannot be included together with our time fixed effects.

Bilateral bank flows by currency - Instrumental Variable Estimations Table 6

Quarterly change in total bilateral cross-border bank claims on non-banks across countries by currency, for banking systems with different short-term international liquidity ratios during the 2012:Q1-2015:Q4 period

Currency Denomination of Bilateral Flows	[1] *USD*	[2] *USD*	[3] *EUR*	[4] *EUR*	[5] *JPY*	[6] *JPY*
Independent Variables						
ΣΔ Shadow Interest Rate*International Liquidity Ratio {t-1 to t-4}	0.497	0.408	0.266	0.151	0.389	0.395
	[0.245]**	[0.234]*	[0.156]*	[0.145]	[0.234]*	[0.231]*
Σ International Liquidity Ratio {t-1 to t-4}	–0.162	–0.0607	–0.0856	–0.0326	0.6	0.672
	[0.233]	[0.232]	[0.212]	[0.187]	[0.727]	[0.736]
Target Country's Currency Dummy*ΣΔ Shadow Interest Rate*International Liquidity Ratio {t-1 to t-4}	0.853	0.687	–0.949	–0.87	1.475	1.198
	[1.135]	[1.115]	[0.512]*	[0.479]*	[0.613]**	[0.663]*
Target Country's Currency Dummy*ΣΔ Shadow Interest Rate {t-1 to t-4}	–37.61	–37.17	20.23	–3.199	–85.35	–91.08
	[50.45]	[28.89]	[20.43]	[20.21]	[33.11]***	[42.47]**
Constant	–1.382	–3.678	6.824	3.095	–55	–53.77
	[10.87]	[9.683]	[8.383]	[7.949]	[32.86]*	[30.98]*
Four lags of Dependent Variable	Yes	Yes	Yes	Yes	Yes	Yes
Target-Source Same Pairs Included	No	No	No	No	No	No
Source Banking System Macro Controls	Yes	Yes	Yes	Yes	Yes	Yes
Target Country - Time Fixed Effects	No	Yes	No	Yes	No	Yes
Time Fixed Effects	Yes	--	Yes	--	Yes	--
Target Country Fixed Effects	No	--	No	--	No	--
Number of Observations	4775	4775	5146	5146	1127	1127
Differential response of international liquidity-abundant banking systems (at the 75th ptile) vs. international liquidity-constrained banking systems (at the 25th ptile) to a 100bps decline in the policy interest rate						
	9.78	8.031	5.233	2.966	7.67	7.769
	[4.834]**	[4.605]*	[3.062]*	[2.861]	[4.609]*	[4.556]*

Note: The table reports estimates from Arellano-Bond dynamic panel IV estimations. The dependent variable is the quarterly change in the currency-specific bilateral cross-border bank claims on non-banks, across countries [i.e., claims denominated in U.S. dollars, Euro and Japanese Yen]. The Short-to-long international liquidity ratio is the instrument for the short-term international liquidity ratio. Table 1 contains the definition of all variables and the summary statistics for each included variable. Coefficients are listed in the first row, robust standard errors are reported in the row below, and the corresponding significance levels are placed adjacently. Σ indicates that the sum of the four coefficients on the indicated lag terms [and corresponding robust standard errors and significance level] is reported. The Source-Target Same Dummy takes on a value of 1 if the source and target countries are the same, and zero otherwise. The Target Country's Currency Dummy takes on a value of 1 if the target country uses the given denomination as their own currency, and zero otherwise. In addition to the reported variables, four lags of the two-way interactions of the Target-Source Same Dummy with the shadow rate change and International Liquidity Ratio as well as the Target Country's Currency Dummy and International Liquidity Ratio are also included in the specifications. "Yes" indicates that the set of characteristics or fixed effects is included. "No" indicates that the set of characteristics or fixed effects is not included. "--" indicates that the indicated set of characteristics or fixed effects are comprised in the wider included set of fixed effects. *** Significant at 1%, ** significant at 5%, * significant at 10%.

When we divide up the sample by currency denomination in Table 6, the monetary transmission results point in a similar direction as in Table 5.[25] The sample sizes drop

[25] The subsample of JPY-denominated observations is markedly smaller than the subsamples of the other two denominations.

substantially. For the USD and the JPY, the coefficients on the interactions of the monetary shock and the *International Liquidity Ratio* (first row) retain the same significance levels as in Table 5. However, the significance of our transmission results into EUR lending declines.

We examine our individual estimates more closely by applying two tests. First, we test whether the three coefficient estimates, on USD, EUR and JPY, are statistically indistinguishable from each other, i.e. if $\sum_{k=1}^{4}\gamma_k^{usd} = \sum_{k=1}^{4}\gamma_k^{eur} = \sum_{k=1}^{4}\gamma_k^{jpy}$ in the Equation 1 specifications and $\sum_{k=1}^{4}ï¡_k^{usd} = \sum_{k=1}^{4}ï¡_k^{eur} = \sum_{k=1}^{4}ï¡_k^{jpy}$ in the Equation 2 specification. We find that we cannot reject the equality of transmission coefficients across currencies at the 90 percent confidence level. This implies that monetary transmission through USD-denominated lending around the world is not statistically distinguishable from transmission through EUR and JPY-denominated lending. Second, we test the joint significance of these variables. We cannot reject the null hypothesis of joint significance at the 95 percent confidence level. The results imply that the currency dimension of the bank lending channel is not unique to the USD: We find evidence of transmission in bilateral cross-border lending in the other reserve currencies as well.

5.4 Robustness Checks

We conducted several robustness checks to confirm our results.

Bilateral bank flows pooled across sectors: Instrumental Variable estimation Table 7

Quarterly change in bilateral cross-border bank claims pooled across banks and non-banks, across countries and currencies for banking systems with different short-term international liquidity ratios during the 2012:Q1-2015:Q4 period

Type of Bilateral Flows	[1] All Bilateral Flows	[2] All Bilateral Flows	[3] All Bilateral Flows	[4] All Bilateral Flows	[5] All Bilateral Flows	[6] Excluding Return Flows	[7] Excluding Return Flows
Independent Variables							
ΣΔ Shadow Interest Rate {t-1 to t-4}	–13.2 [4.467]***	–12.08 [4.456]***	–11.62 [4.406]***	–13.13 [4.540]***	–9.281 [4.651]**	–12.96 [4.574]***	–10.36 [4.8]**
ΣΔ Shadow Interest Rate*International Liquidity Ratio {t-1 to t-4}	0.255 [0.0976]***	0.227 [0.0977]**	0.216 [0.0959]**	0.25 [0.0994]**	0.18 [0.101]*	0.246 [0.0999]**	0.201 [0.105]*
Σ International Liquidity Ratio {t-1 to t-4}	–0.0459 [0.127]	–0.0471 [0.13]	–0.0483 [0.13]	–0.0129 [0.132]	–0.0475 [0.145]	–0.0369 [0.133]	–0.0352 [0.147]
Source-Target Same Dummy*ΣΔ Shadow Interest Rate*International Liquidity Ratio {t-1 to t-4}				–0.711 [0.354]**			
Source-Target Same Dummy*ΣΔ Shadow Interest Rate {t-1 to t-4}				17.270 [0.053]***			
Target's Currency Dummy*ΣΔ Shadow Interest Rate*International Liquidity Ratio {t-1 to t-4}					0.0581 [0.293]		0.112 [0.313]
Target's Currency Dummy*ΣΔ Shadow Interest Rate {t-1 to t-4}					–7.282 [14.13]		–9.218 [15.04]
Constant	1.465 [7.614]	4.933 [7.77]	2.95 [7.82]	2.271 [7.598]	2.786 [7.971]	2.725 [8.003]	0.489 [8.097]
Four lags of Dependent Variable	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Target-Source Same Pairs Included	Yes	Yes	Yes	Yes	Yes	No	No
Source Banking System Macro Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Target Country - Time Fixed Effects	No	No	Yes	Yes	Yes	Yes	Yes
Time Fixed Effects	No	Yes	--	--	--	--	--
Target Country Fixed Effects	Yes	No	--	--	--	--	--
Number of Observations	20451	20451	20451	20451	20451	19487	19487
Differential response of International Liquidity-abundant banking systems (at the 75th ptile) vs. international liquidity-constrained banking systems (at the 25th ptile) to a 100bps decline in the policy interest rate							
	5.029 [1.921]***	4.473 [1.924]**	4.258 [1.888]**	4.648 [1.922]**	3.605 [1.913]*	4.848 [1.967]**	4.072 [1.99]**

Note: The table reports estimates from Arellano-Bond dynamic panel IV estimations. The dependent variable is the quarterly change in bilateral cross-border bank claims across countries and currencies [i.e., claims denominated in U.S. dollars, Euro and Japanese Yen], with the claims to non-banks and claims to banks pooled together. The Short-to-long international liquidity ratio is the instrument for the short-term international liquidity ratio. Table 1 contains the definition of all variables and the summary statistics for each included variable. Coefficients are listed in the first row, robust standard errors are reported in the row below, and the corresponding significance levels are placed adjacently. Σ indicates that the sum of the four coefficients on the indicated lag terms [and corresponding robust standard errors and significance level] is reported. The Source-Target Same Dummy takes on a value of 1 if the source banking system and target country is the same, and zero otherwise. The Target Country's Currency Dummy takes on a value of 1 if the target country uses the given denomination as their own currency, and zero otherwise. In addition to the reported variables, four lags of the two-way interactions of the Target-Source Same Dummy with the shadow rate change and International Liquidity Ratio as well as the Target Country's Currency Dummy and International Liquidity Ratio are also included in the specifications. "Yes" indicates that the set of characteristics or fixed effects is included. "No" indicates that the set of characteristics or fixed effects is not included. "--" indicates that the indicated set of characteristics or fixed effects are comprised in the wider included set of fixed effects. *** Significant at 1%, ** significant at 5%, * significant at 10%.

Weighted Estimations: Total Bilateral Bank Flows - Instrumental Variable est. Table 8

Quarterly change in weighted total bilateral cross-border bank claims across countries and currencies for banking systems with different short-term international liquidity ratios during the 2012:Q1-2015:Q4 period

	[1]	[2]	[3]	[4]	[5]	[6]
Type of Bilateral Flows	All Bilateral Flows	All Bilateral Flows	All Bilateral Flows	All Bilateral Flows	All Bilateral Flows	All Bilateral Flows
Type of Weights	By Source Country	By Source Country	By Target Country	By Target Country	By Source-Target Country	By Source-Target Country
Independent Variables						
ΣΔ Shadow Interest Rate {t-1 to t-4}	–4.039 [3.278]	–11.28 [3.15]***	–15.28 [2.023]***	–15.16 [2.015]***	–10.3 [0.517]***	–13.64 [0.359]***
ΣΔ Shadow Interest Rate*International Liquidity Ratio {t-1 to t-4}	0.279 [0.058]***	0.387 [0.057]***	0.315 [0.05]***	0.312 [0.050]***	0.224 [0.012]***	0.0408 [0.010]***
Σ International Liquidity Ratio {t-1 to t-4}	–0.827 [0.051]***	–0.58 [0.044]***	–0.537 [0.044]***	–0.546 [0.044]***	–0.651 [0.02]***	–1.047 [0.017]***
Target Country's Currency Dummy*ΣΔ Shadow Interest Rate*International Liquidity Ratio {t-1 to t-4}		0.034 [0.015]**		–0.005 [0.016]		0.001 [0.001]**
Target Country's Currency Dummy*ΣΔ Shadow Interest Rate {t-1 to t-4}		–1.516 [0.637]**		0.223 [0.687]		–0.042 [0.0104]***
Constant	–1.033 [0.117]***	–1.737 [0.163]***	–1.767 [0.146]***	–1.895 [0.157]***	–0.061 [0.003]***	–0.057 [0.002]***
Four lags of Dependent Variable	Yes	Yes	Yes	Yes	Yes	Yes
Target-Source Same Pairs Included	No	No	No	No	No	No
Source Banking System Macro Controls	Yes	Yes	Yes	Yes	Yes	Yes
Target Country - Time Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Time Fixed Effects	--	--	--	--	--	--
Target Country Fixed Effects	--	--	--	--	--	--
Number of Observations	10257	10257	12072	12072	12598	12243
Differential response of International Liquidity-abundant banking systems (at the 75th ptile) vs. international liquidity-constrained banking systems (at the 25th ptile) to a 100bps decline in the policy interest rate						
	0.038 [0.008]***	0.053 [0.008]***	0.242 [0.038]***	0.239 [0.038]***	0.172 [0.010]***	0.031 [0.008]***

Note: The table reports estimates from Arellano-Bond dynamic panel IV estimations. The dependent variable is the quarterly change in weighted total bilateral cross-border bank claims across countries and currencies [i.e., claims denominated in U.S. dollars, Euro and Japanese Yen]. The Short-to-long international liquidity ratio is the instrument for the short-term international liquidity ratio. For Columns 1 and 2, the weights are constructed to reflect the given target country's share in the source banking system's total cross-border claims. In Columns 3 and 4, the weights are constructed to reflect the given source banking system's share in the total cross-border claims in the target country. In the last two columns, the weights are constructed to reflect the share of the given source-target pair in the total cross-border claims across all sources and targets. Table 1 contains the definition of all variables and the summary statistics for each included variable. Coefficients are listed in the first row, robust standard errors are reported in the row below, and the corresponding significance levels are placed adjacently. Σ indicates that the sum of the four coefficients on the indicated lag terms [and corresponding robust standard errors and significance level] is reported. The Source-Target Same Dummy takes on a value of 1 if the source banking system and the target country is the same, and zero otherwise. The Target Country's Currency Dummy takes on a value of 1 if the target country uses the given denomination as their own currency, and zero otherwise. In addition to the reported variables, four lags of the two-way interactions of the Source-Target Same Dummy with the shadow rate change and International Liquidity Ratio as well as the Target Country's Currency Dummy and International Liquidity Ratio are also included in the specifications. "Yes" indicates that the set of characteristics or fixed effects is included. "No" indicates that the set of characteristics or fixed effects is not included. "--" indicates that the indicated set of characteristics or fixed effects are comprised in the wider included set of fixed effects. *** Significant at 1%, ** significant at 5%, * significant at 10%.

First, in Table 7 we examine an alternative IV formulation of our Table 3 specifications. In this table, we pool the lending flows to banks and non-banks together, and estimate one set of coefficients, assumed common across the two sectors. The Table 7 results imply that our monetary transmission findings continue to hold. Both the "level" of the monetary shock, and its interaction with the *International Liquidity Ratio*, are highly significant throughout. The economic magnitudes are also significant: The differential impact on lending flows of a 100 bps decline in the shadow interest rate of the currency of lending is around 5 percentage points, comparing liquidity-constrained vs. liquidity-abundant banking systems.

Second, we address potential concerns that the *unweighted* estimations in Tables 2 through 7 implicitly consider all bilateral claim changes to be of equal weight. Indeed, larger claims could contain more information about the drivers of lending as they are less likely to be influenced by idiosyncratic shocks – which would call for weighting the observations (Avdjiev and Takáts, 2016). To address this concern, we conduct a series of *weighted* estimations in Table 8. First, we construct weights that represent the share of bilateral claims in a given target country in the total cross-border claims that the *source* banking system originates to all target countries (Columns 1 and 2). Second, we construct weights that represent the share of bilateral claims from a given source banking system in the total cross-border claims that the *target country* receives from all source banking systems (Columns 3 and 4). Third, we weight each source-target bilateral flows observation by the share that the bilateral

claims between the given source-target pair represent compared to *all* bilateral claims across all source banking systems and target countries at a given time (Columns 5 and 6). Our results from these weighted specifications match the significance of our earlier (unweighted) estimation results, but are smaller in magnitude.[26]

Third, we also confirm the validity of our results by examining whether our findings are due to random variation. We conduct these placebo tests in two ways. First we estimate our Table 2 specifications by replacing the dependent variable with randomly generated data, and examine the impact of monetary shocks on these random numbers.[27] Second, we generate random data to replace the observed monetary shocks, and estimate the impact of the variation in these random numbers on bilateral cross-border lending flows. In both cases, we find that the random data does *not* replicate our results.

6. Discussions

We discuss two additional areas which might matter for the interpretation of our results. First, we look at the implication of using shadow interest rates instead of policy

[26] A direction for future research could also be to constrain the estimated variables in such a way that the estimated bilateral lending flows would add up to the observed total lending flows at the level of the source banking system or target country. Such a method is relatively straightforward when applied on fixed effects (Amiti and Weinstein, 2013), but not in our richer setup.

[27] We generate random data so as to match the first two moments (mean and variance) of the observed data that we replace. These placebo results are available from the authors upon request.

rates. Second, we discuss how other potential measure of funding abundance, such as capital or deposit funding ratios, might affect our results.

6.1 Shadow interest rates vs. policy rates

As discussed above, the period for which we have BIS IBS Stage 1 data available was characterized by exceptionally accommodative monetary policies, such that the main policy interest rates – having reached the effective lower bound – were no longer representative of the stance of monetary policy. Hence, we have used shadow interest rates to capture changes in prevailing monetary conditions. However, a relevant concern is that shadow rates are not representative of banks' actual funding costs – which, unlike shadow rates, do not decline below zero.

While this concern could be valid, it would at most imply that the currency dimension of the bank lending channel is even stronger than what our estimates suggest. The reason is that the response to actual short-term rate changes, if anything, should be stronger than the response to liquidity conditions. In our analysis, we used shadow rates, which banks do not directly observe and cannot directly use in their loan pricing to elicit supply related lending changes, because the short-term funding costs remained close to zero. Hence, in our sample period we can observe only the reaction of banks to the liquidity-enhancing quantitative easing and large scale asset purchase programs – and not their reaction to price changes. Once policy rates rise above the zero lower bound, the combination of reduced liquidity and higher short-term funding costs may cause banks to respond stronger than what we have seen

when they reacted only to liquidity enhancements as captured by the the shadow interest rates.

In addition, as mentioned earlier, declines in the short-term shadow interest rate are designed to correspond to quantitative easing and large-scale asset purchase (LSAP) actions – and as such, reflect a flattening of the yield curve on banks' portfolio. The additional balance sheet liquidity induced by a relative increase in short-term rates (induced by unconventional monetary policies) is a potent way through which declines in shadow rates may correspond to higher lending (investment) by banks, even in the absence of changing bank funding costs. While the use of shadow rates suggest that the currency dimension of the bank lending channel might be even stronger when actual short-term rates are also changing, we would caution against drawing too strong conclusions at this stage. As the period we examine is characterized by extraordinary monetary policies, we should continue exploring the currency dimension of the bank lending channel during policy normalisation. We hope that our work will be useful for this endeavour.

6.2 Bank capitalisation and deposits

Our identification of the bank lending channel relies on the interaction of banks' international liquidity conditions with the policy rate, positing that less liquid banks or banking systems are more likely to react to changing monetary and liquidity conditions. While we include source country macro controls in all our specifications (which indirectly characterize time-varying source banking system conditions), there

are other potential banking system-related drivers, which (though unrelated to monetary policy) may affect lending activity. Recall that our Arellano-Bond estimations implicitly control for time-invariant lending banking system specific fixed effects, and thereby for most variables in level form. Yet, additional interactions with monetary policy could matter.

The literature mentions two such potential interaction factors: bank capitalisation (Temesvary et al, 2016; Kishan and Opiela, 2000; Berger and Bouwman, 2009; and Gambacorta and Shin, 2016, for instance) and share of consumer deposit funding (Ivashina and Sharfstein,2010); Demirgüc-Kunt and Huizinga, 2010; and Beltratti and Stulz, 2012, for instance). Both factors may act as proxies for balance sheet resilience. Bank funding markets utilize information on bank capitalization or deposit funding as a signal of balance sheet health. Specifically, in a rising interest rate environment (corresponding to tightening monetary policy conditions in a given currency) all banking systems lending in that currency experience higher funding costs. However, banking systems with less capital or less deposit funding see their funding costs increase disproportionately more, because markets perceive banks with lower capitalisation or weaker deposit base as riskier. Therefore, this "balance sheet channel" posits that banking systems with less capital or deposits are subject to more negative balance sheet effects following a tightening in monetary policy, and thereby cut their lending more.

Importantly, these controls, both capitalisation and deposit funding ratios, should be defined at the banking system level (rather than at the level of the country where the banking system is headquartered) as the triple-coincidence literature pointed out (McGuire (2010), Cecchetti et al (2010), and Avdjiev, McCauley and Shin (2015)). Unfortunately, the two variables are not available for banking systems (i.e. based on nationality), they are available at best only for lending countries (i.e. based on residence).[28] Hence, these controls are not available at this point.

Given the importance of controlling for bank capitalisation and deposit funding, building a reliable database for lending banking systems and controlling the robustness of our results when interacting them with shadow policy rates, and after normalization with policy rates, is a promising avenue for future research.

7. Conclusion

In this paper, we add to the existing literature on the cross-border bank lending channel of monetary policy by examining how the use of a currency in cross-border lending transmits monetary policy-induced shocks across countries. We do so by using new and unique data on bilateral cross-border lending flows across a wide array

[28] Deposit funding ratios for lending banking systems are not available in the BIS IBS at all. Capitalisations measures are available, with measures on tier 1 capital, total equity, risk-weighted assets and total assets, but only for around one-half of the lending banking systems and only starting at Q4 2013 or later. Furthermore, one should also be cautious about bank capitalisation measures in this period as the period under investigation entails the Basel III implementation process which affected the definitions of capital adequacy. Hence, the capitalisation figures are not necessarily comparable neither across time nor across jurisdictions.

of source banking systems and target countries of borrowers, broken down by currency denomination (USD, EUR and JPY).

We obtain three main results. First, monetary policy-induced shocks in a currency significantly affect cross-border bank lending flows in that currency, even when neither the lending banking system nor the host country of borrowers uses that currency as their own. This is what we call the currency dimension of the bank lending channel. Second, we find that this currency dimension of the bank lending channel works primarily through lending to non-banks. Third, we find that these currency effects work similarly across the three main currencies, that is, the transmission effects are present in EUR and JPY-lending as well as in USD-lending. All these results are robust across our various IV estimations and additional specifications.[29]

We hope that our results will help policymakers and researchers gain further insight into how the global use of currencies transmits monetary policy shocks through the international banking system. In particular, our results suggest that when policymakers in countries hosting large-scale cross-border borrowers think about external spillovers to their economies they should explicitly consider the currency denomination of the cross-border claims.

[29] An interesting extension of our paper is to examine the relationship between the currency denomination of bilateral bank flows and bilateral foreign bank presence (Claessens and van Horen, 2014). We plan to explore this research question in a different project.

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Annex

Largest lenders and borrowers by nationality

Table A1

Largest lender – reporting country

USD		EUR		JPY	
JP-Japan	1,883,050	FR-France	1,383,875	JP-Japan	322,871
US-United States	1,293,980	DE-Germany	1,322,681	FR-France	124,360
GB-United Kingdom	945,431	NL-Netherlands	735,682	GB-United Kingdom	102,716
CH-Switzerland	714,115	GB-United Kingdom	650,922	US-United States	85,936
DE-Germany	682,607	IT-Italy	508,848	CH-Switzerland	33,212

Largest borrower – counterparty country

USD		EUR		JPY	
US-United States	3,832,446	GB-United Kingdom	1,146,941	JP-Japan	397,289
GB-United Kingdom	1,146,051	FR-France	1,060,967	GB-United Kingdom	121,011
JP-Japan	528,389	DE-Germany	917,798	US-United States	63,255
CA-Canada	269,119	NL-Netherlands	613,745	FR-France	51,858
LU-Luxembourg	245,091	IT-Italy	547,907	LU-Luxembourg	51,281

Note: The amounts are reported in million USD.