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## The international bank lending channel of unconventional monetary policy

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The international bank  
lending channel of  
unconventional monetary policy

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## Abstract

We use a confidential euro area bank-level data set of close to 250 banks to assess outward and inward spillovers of unconventional monetary policies on bank lending. We find that euro area banks increase lending to the rest of the world in response to non-standard ECB monetary policy accommodation. We also find strong evidence that euro area banks increase lending to the domestic non-financial private sector in response to accommodative unconventional monetary policy measures in the US. Inward and outward spillovers are substantially stronger for euro area banks which are liquidity constrained and which rely more on internal capital markets. This suggests that bank-specific supply effects, stemming from banks' increased ability to lend following a central bank balance sheet expansion, are a major driver of monetary policy spillovers, providing strong support to the existence of an international bank lending channel that prevails at the effective lower bound.

*Keywords:* international bank lending channel, monetary policy, quantitative easing, cross-border spillovers

*JEL-Classification:* E44, E52, G01

### *Non-technical summary*

One salient feature of the global economy during the last decades has been the sharp rise in international financial integration. A significant increase in cross-border financial exposures has magnified the geographical interconnection in financial markets and the deepening of cross-market integration. In the context of rising financial globalisation, interlinkages between euro area banks and non-euro area financial markets have considerably increased. This has taken various forms. Euro area banks have been buying securities issued in the US, US banks have provided US dollar funding to euro area banks, and some internationally active banks have been directly involved in foreign lending, usually via foreign branches or subsidiaries. These increased mutual links across financial markets have been reflected in growing foreign claims of euro area banks on non-euro area residents as well as in increasing claims of non-euro area residents on euro area banks.

As a result of the rise in financial globalization, the spillovers of monetary policy shocks on international financial markets may have increased significantly. While monetary policy transmission operates through a number of channels that potentially propagate monetary conditions abroad, including in particular the exchange rate, the increased interconnect-edness of global banks has recently turned the attention to the transmission of shocks via international bank linkages, including the international bank lending channel of monetary policy. Similarly as in the case of the traditional bank lending channel, domestic banks may experience an increase in reservable deposits in response to foreign monetary policy accommodation, operating either through an increase in foreign intra-group funding, or a general rise in international banking flows. As suggested by the (international) bank lending channel, cross-border lending of domestic MFIs should decrease in response to a tightening of domestic monetary policy as a result of higher funding costs. However, if banks are able to tap on alternative sources of funding, for instance via intra-group funding networks, or have enough liquid assets, the drop in lending may be mitigated to some extent.

In this paper, we study the international bank lending channel of unconventional monetary policy when interest rates are trapped at the effective lower bound. Using a confidential euro area bank-level data set comprising almost 250 monetary financial institutions (MFIs), we assess the inward and outward spillovers of central bank balance sheet operations. From an outward perspective we assess whether an expansion of the ECB's balance sheet causes a rise in cross-border lending of euro area MFIs. From an inward perspective we investigate whether foreign central bank balance sheet expansion increases domestic bank loan supply of euro area MFIs.

We show that euro area banks significantly increase cross-border lending in response to ECB unconventional monetary policy measures. We also document that euro area banks extend their lending to the private non-financial sector in response to foreign central bank balance sheet expansions. Finally, we find strong evidence that bank balance sheet characteristics matter. Inward and outward spillovers are substantially stronger for euro area banks which are liquidity constrained. Outward spillovers are also found to be more pronounced for banks with lower ratios of core deposits to liabilities and for banks which rely more on internal (intragroup) capital markets. This suggests that bank-specific supply effects are a major driver of monetary policy spillovers, providing strong support to the existence of an international bank lending channel at the effective lower bound. Moreover, our findings provide suggestive evidence for the effectiveness of the ECB's unconventional monetary policy measures, in particular in the form of long-term refinancing operations (LTRO), which were designed precisely to target banks with liquidity constraints. Our results suggest that banks with liquidity constraints have been most positively affected by quantitative easing measures.

# 1 Introduction

One salient feature of the global economy during the last decades has been the sharp rise in international financial integration. A significant increase in cross-border financial exposures has magnified the geographical interconnection in financial markets and the deepening of cross-market integration. In the context of rising financial globalisation, interlinkages between euro area banks and non-euro area financial markets have considerably increased. This has taken various forms. Euro area banks have been buying securities issued in the US, US banks have provided US dollar funding to euro area banks, and some internationally active banks have been directly involved in foreign lending, usually via foreign branches or subsidiaries. These increased mutual links across financial markets have been reflected in growing foreign claims of euro area banks on non-euro area residents as well as in increasing claims of non-euro area residents on euro area banks.<sup>1</sup>

As a result of the rise in financial globalization, the spillovers of monetary policy shocks on international financial markets may have increased significantly. While monetary policy transmission operates through a number of channels that potentially propagate monetary conditions abroad, including in particular the exchange rate (Georgiadis and Mehl, 2016), the increased interconnectedness of global banks has recently turned the attention to the transmission of shocks via international bank linkages (Cetorelli and Goldberg, 2011; Kalemli-Ozcan et al., 2013), including the international bank lending channel of monetary policy (Temesvary et al., 2015; Morais et al., 2015). Similarly as in the case of the traditional bank lending channel (Bernanke and Blinder, 1988; Kashyap and Stein, 1994), domestic banks may experience an increase in reservable deposits in response to foreign monetary policy accommodation, operating either through an increase in foreign intra-group funding (Temesvary et al., 2015), or a general rise in international banking flows (Baskaya et al., 2016). As suggested by the (international) bank lending channel, cross-border lending of domestic MFIs should decrease in response to a tightening of domestic

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<sup>1</sup>According to the BIS foreign claims statistics, foreign claims of euro area banks have tripled before the outbreak of the euro area sovereign crisis. Since then they receded somewhat but still remain at high levels by historical standards.

monetary policy as a result of higher funding costs. However, if banks are able to tap on alternative sources of funding, for instance via intra-group funding networks, or have enough liquid assets, the drop in lending may be mitigated to some extent.

In this paper, we study the international bank lending channel of unconventional monetary policy, when interest rates are trapped at the effective lower bound. Using a confidential euro area bank-level data set comprising almost 250 monetary financial institutions (MFIs), we assess the inward and outward spillovers of central bank balance sheet operations. From an outward perspective, we assess whether an expansion of the ECB's balance sheet causes a rise in cross-border lending of euro area MFIs. From an inward perspective, we investigate whether foreign central bank balance sheet expansion increases domestic bank loan supply of euro area MFIs.<sup>2</sup> The key challenge arises from disentangling the positive macro effects stemming from accommodative monetary policy measures from bank-specific supply effects. Our identification strategy relies on exploiting the heterogeneity in banks' balance sheet characteristics in our data set, which allows us to use bank and time fixed effects to carefully control for unobserved bank characteristics as well as for time-varying global demand effects. In order to identify bank-specific supply effects reflecting banks' increased ability to grant loans in response to accommodative unconventional monetary policy measures we follow the literature on the domestic bank lending channel and assess whether bank balance sheet characteristics matter for the international monetary-transmission mechanism (Stein and Kashyap, 2000; Jimenez et al., 2012).

We show that euro area banks significantly increase cross-border lending in response to ECB unconventional monetary policy measures. We also document that euro area banks extend their lending to the private non-financial sector in response to foreign central bank balance sheet expansions. Finally, we find strong evidence that bank balance sheet characteristics matter. Inward and outward spillovers are substantially stronger for euro area banks which are liquidity constrained. Outward spillovers are also found to be more pronounced for banks with lower ratios of core deposits to liabilities and for banks which

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<sup>2</sup>For both outward and inward channel, we use a common methodology put forward in the context of the International Bank Research Network.

rely more on internal (intragroup) capital markets. This suggests that bank-specific supply effects are a major driver of monetary policy spillovers, providing strong support to the existence of an international bank lending channel at the effective lower bound.

Moreover, our findings provide suggestive evidence for the effectiveness of the ECB's unconventional monetary policy measures, in particular in the form of credit easing programmes. This includes, for instance, the long-term refinancing operations (LTRO) which were designed precisely to target banks with liquidity constraints. Our results suggest that banks with liquidity constraints have been most positively affected by quantitative easing measures. The case of the euro area is unique to the extent that it has been the only major central bank that embarked on balance sheet policies, while still having substantial leeway on its main policy rates. For this reason, we can directly test which of the monetary policies, conventional or unconventional, has been more effective in spurring cross-border lending growth. We find that quantitative easing facilitated the cross-border lending more than interest rate cuts.

Our results complement the findings in literature in various dimensions. First, our results add to the literature on the existence of an international bank lending channel. In particular, our findings confirm the assessment that banks increase cross-border flows in response to monetary policy accommodation which has been documented for the case of the US (Temesvary et al., 2015; Correa and Murry, 2009), and that looser monetary policy in the US leads to increases in lending by US foreign banks operating abroad (Morais et al., 2015). Second, our results are in line with the implications of Cetorelli and Goldberg (2012) who find support for the role of internal capital markets in the transmission of monetary policy shocks across borders.

The remainder of the paper is organised as follows. Section 2 puts forth the empirical framework and discusses the identification of the international bank lending channel. Section 3 describes the data, and Section 4 presents the results of the baseline specifications. Section 5 discusses a number of robustness checks. Finally, Section 6 concludes.



## 2 Empirical framework

The main objective of the paper is to empirically test whether monetary policy shocks in the form of central bank balance sheet operations are transmitted internationally via the international bank lending channel. In this section we first describe the channel in detail and put forward some hypotheses about how the channel could operate. We then discuss some identification challenges and our strategy to address them.

### 2.1 Identification of the international bank lending channel

Our research question relates to the literature establishing the existence of a bank lending channel in the transmission of monetary policy (Bernanke and Blinder, 1992; Kashyap and Stein, 1994). The authors start with the observation that after a monetary policy tightening, usually both the interest rate increases and reservable bank deposits drop. The bank lending channel explains both: when reserve requirements are binding, banks shrink the size of reservable deposits after a tightening of monetary policy, since they increase the interest rate on non-deposit assets. As a result, the aggregate demand and thus lending demand falls leading also to a drop in deposit supply. Hence, banks might have to additionally cut lending if they cannot access alternative sources of funding (commercial papers, intragroup funding). Later, Disyatat (2011) demonstrated that this mechanism can also operate when banks are bound by capital requirements. These studies focused on the bank lending channel operating domestically.

The international bank lending channel of unconventional monetary policy may operate in a somewhat different way compared to the traditional bank lending channel. While the traditional bank lending channel operates via changes in reservable deposits, the bank lending channel of unconventional monetary policy may mainly function via a flattening of the yield curve and an increase in money supply (M3). It consists of three steps. First, following an expansion of the central bank balance sheet, interest rates in that country decline across the maturity spectrum and the supply of money (measured as M3) increases.

Second, the lower interest rate environment coupled with the greater availability of broad money enables banks to increase lending, including cross-border lending, with the latter being particularly pronounced at times of increased international banking flows. Third, the latter, in turn, reflects a positive funding shock for the banks abroad, which may result in an increase in the loan supply, following the same logic as in the traditional bank lending channel (Baskaya et al., 2016).

If the international bank lending channel is meaningful, unconventional monetary policy can spillover across borders. We differentiate between outward and inward spillovers. In an outward spillover, domestic resident banks would increase their foreign lending after an expansionary unconventional monetary policy shock in the home country. An inward spillover occurs when domestic banks increase lending in response to an expansion of a foreign central bank's balance sheet.

While a myriad of papers on the traditional bank lending channel exist, there is little literature on the international bank lending channel. From the outward perspective, Correa and Murry (2009) analyse the transmission of US monetary policy using data on foreign claims to identify the changes in the supply of cross-border funds. They find that following a US monetary policy tightening, US banks, in particular those with foreign offices, significantly reduce their holdings of foreign claims on foreign residents. This is confirmed by Temesvary et al. (2015) who find evidence that US monetary policy affects foreign lending of US-resident banks both via their cross-border claims and via lending activity of their foreign affiliates. Hence, these two studies confirm the existence of the international bank lending channel for US banks. In a similar vein, Cetorelli and Goldberg (2012) find that globally active banks react weaker to changes in the domestic monetary policy, as they can resort to internal capital markets, i.e. they can tap on interbank market to compensate for a drop in deposits.

Concerning the inward spillover, Morais et al. (2015), using a loan-level data set, find evidence that looser monetary policy in the US or the UK leads to an increase in lending by US and UK foreign banks, respectively, operating in Mexico. However, they do not discuss any specific channels for the transmission of shocks across borders.

In establishing bank lending channel operating internationally, two important identification challenges arise. The first one concerns the exogeneity of the monetary policy changes to both domestic and foreign economic and monetary conditions. The second one is related to the identification of bank-specific shocks that allow to infer that the spillovers reflect bank-specific supply rather than macroeconomic demand effects.

For the assessment of inward spillovers, the foreign monetary policy adjustments need to be exogenous to euro area economic conditions and ECB monetary policy. If the foreign policy responds to ECB monetary policy, the recovered coefficients could capture the effect of domestic policy instead of that of foreign monetary policy. We assume that monetary policy in two of the three core financial partners of the euro area, the United States and Japan, is independent from ECB monetary policy, to the extent that the goals of policies are domestic. For the UK, the assumption of independent monetary policy, from the vantage point of the euro area, may be violated in view of the close trade, financial and political linkages across both sides of the channel. For this reason, we do a number of robustness checks to test for the ‘true’ impact of UK monetary policy spillovers on euro area bank lending.

Furthermore, in the context of assessing the outward spillovers, it is essential that domestic monetary policy is exogenous to foreign monetary policy changes as well as to domestic and foreign economic conditions. In robustness checks, we will hence use the residuals from a regression of domestic monetary policy on foreign monetary policy, domestic and foreign inflation as well as GDP growth, in order to obtain a measure of domestic monetary policy not driven by foreign factors.

As mentioned, the second identification challenge is to isolate a bank-specific shock from other macro effects of monetary policy in order to identify bank-specific supply effects in lending changes following the monetary policy shock. In the cross-border context, monetary policy can be transmitted via various channels: the exchange rate channel via changes in financial and trade flows, via changes in interest rates which affect external demand, or via portfolio rebalancing. In addition to that, monetary policy can also influence banks’ foreign activities, which is the focus of this paper.

Therefore, we put forward an identification strategy aiming at disentangling the demand effects, stemming from general macro effects of monetary policy, and supply effects, stemming from a change in banks' willingness or ability to lend following a monetary policy shock. It aims at determining to which extent a bank can insulate its portfolio from monetary policy shocks, in particular, to the outflow of deposits after monetary policy tightening, for instance by accessing external sources of funding. This would allow for the identification of bank-specific supply effects.

While we describe the methodology in detail in the next two subsections, below we put forward some hypotheses about what the results should bring, should the international bank lending channel provide a meaningful transmission of monetary policy across borders.

First, in line with the findings for the traditional bank lending channel (Bernanke and Blinder, 1988; Kashyap and Stein, 1994; Disyatat, 2011), home banks should increase lending in response to an expansion of the foreign central bank's balance sheet. This still could be the outcome of general demand effects, though. If the international bank lending channel works, and this is our second hypothesis, these effects should be different according to banks' balance sheet characteristics. We hence follow Stein and Kashyap (2000) and test to what extent bank balance sheet characteristics matter for transmission. First, effects should be stronger for those banks which have a larger share of internal capital market funding. This is because, in line with the logic of the bank lending channel, these banks have more flexibility in using their excess funds to fund their foreign operations (outward spillover perspective) or operations of their parent companies abroad (inward spillover perspective). In a similar vein, banks that have a larger share of liquid assets on their balance sheet, and, therefore, are more flexible in responding to a liquidity shock, should be less responsive to quantitative easing measures designed to reduce liquidity constraints, such as the ECB's long-term refinancing operations.

We discuss the empirical models and the identification strategy in the next two subsections, for outward and inward spillovers, respectively.

## 2.2 Outward transmission of monetary policy

From an outward perspective, we assess whether ECB balance sheet operations impact the lending behaviour of euro area MFIs to non-euro area residents. In the absence of any bilateral country-specific information on the destination of loans to non-euro area countries, we consider in our baseline empirical specification for outward spillovers euro area MFIs' loans to the rest of the world, i.e. to non-euro area countries.

In contrast to the experience of the Federal Reserve, the Bank of England and the Bank of Japan, where policy rates have been trapped at the zero lower bound since late-2008, the ECB moved its main policy rates (the MRO and, later on, the deposit facility rate (DFR)) throughout our entire sample period, with possible effects on the lending behaviour of euro area MFIs (see Figure 2). In order to disentangle the impact of conventional and unconventional ECB monetary policy measures on MFI loans, for the outward spillovers, we consider both the main policy rate and the ECB's balance sheet as regressors in our specification.<sup>3</sup>

$$\begin{aligned} \Delta Y_{b,t} = & \alpha_0 + \sum_{k=0}^K (\alpha_{1,k} \Delta MP_{t-k}^{EA} + \alpha_{2,k} \Delta QE_{t-k}^{EA}) + \alpha_3 X_{b,t-1} \\ & + \alpha_4 Z_{t-1}^{domestic} + \alpha_5 Z_{t-1}^{foreign} + \alpha_6 \Delta MP_{t-1}^{US} + \alpha_7 VIX_{t-1} + f_b + \epsilon_{b,t}, \end{aligned} \quad (1)$$

where  $Y_{b,t}$  is the log change of lending to the rest of the world by MFI  $b$  at quarter  $t$ .  $\Delta MP_{t-k}^{EA}$  and  $\Delta QE_{t-k}^{EA}$  are changes in the ECB's main policy rate and balance sheet, respectively. Both only vary by time.  $X_{b,t-1}$  is a vector of time-varying bank control variables (see Section 3 for a list of variables).  $Z_{t-1}^{domestic}$  and  $Z_{t-1}^{foreign}$  capture domestic and global demand and credit effects, respectively, whereas  $VIX_{t-1}$  controls for the degree of investors' risk aversion.<sup>4</sup>  $MP_{t-1}^{US}$  captures US, as a proxy for global, monetary policy.

Equation (1) only serves to establish the aggregate main effect of domestic monetary

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<sup>3</sup>We use the MRO (main refining operation) as the main policy rate. However, results do not change qualitatively when using the DFR which has been the ECB's effective policy rate since the adaption of the full allotment regime coupled with significant excess reserves held by euro area MFIs.

<sup>4</sup>The global credit gap (output gap) corresponds to the GDP-weighted global (non-euro area) average of the credit gap (output gap) estimate.

policy changes on euro area MFIs' loans to the rest of the world. The main part of the analysis consists in establishing an international bank lending channel. We focus on the following bank-specific transmission channels: (i) the liquid asset ratio, (ii) the dependence on short-term funding of the domestic bank, and (iii) the dependence on intragroup funding forms. Additionally, we consider (iv) the MFI's total assets.

$$\Delta Y_{b,t} = \alpha_0 + \sum_{k=0}^K (\alpha_{1,k} \Delta MP_{t-k}^{EA} * Channel_{b,t-K-1} + \alpha_{2,k} \Delta QE_{t-k}^{EA} * Channel_{b,t-K-1}) + \alpha_3 * Channel_{b,t-K-1} + \alpha_4 X_{b,t-1} + f_b + \epsilon_{b,t}, \quad (2)$$

where  $Channel_{b,t-K-1}$  is bank-time specific. Thus, for our dependent variable, lending to the rest of the world by euro area MFI  $b$  at time  $t$ , the channel variable measures the cross-border flows of bank  $b$  to the rest of the world at  $t-K-1$ .<sup>5</sup> For all outward spillovers equations  $K$  is equal to three, which is motivated by the idea that we want to capture one year of monetary policy transmission (three lags plus the contemporaneous effect for quarterly data). Time fixed effects  $f_t$  control for all other confounding factors that are constant across entities but vary over time, such as global demand effects. Standard errors  $\epsilon_{b,t}$  are clustered at the bank level.

## 2.3 Inward transmission of monetary policy

From an inward perspective, we assess whether foreign monetary policy shocks affect the lending behaviour of euro area MFIs. In our baseline empirical specification for inward spillovers we consider euro area MFIs loans to the domestic non-financial private sector. Our data set spans the time period Q1 2008 to Q4 2015 matching almost exactly the period when the main policy rates of the Federal Reserve, the Bank of England and the Bank of Japan were stuck at zero lower bound, and hence ineffective as a tool for monetary policy accommodation (see Figure 2).<sup>6</sup> With these central banks entirely resorting to

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<sup>5</sup>In robustness checks we also control for monetary policy in the euro area's core financial partners by including the term  $\Delta MP_{t-k}^{global}$  in Equation (1).

<sup>6</sup>The zero lower bound period spans Q4 2008 to Q4 2015 for the U.S., the UK and Japan.

unconventional monetary policy measures over this period, mostly in the form of central bank balance sheet operations, we choose changes in central bank balance sheets as the monetary policy measure for our baseline specification. In robustness checks we use short-term shadow rates as an alternative measure of the monetary policy stance, capturing both conventional and unconventional monetary policy operations.

$$\Delta Y_{b,t} = \alpha_0 + \sum_{ctry} \left( \sum_{k=0}^K \alpha_{1,k}^{ctry} \Delta Q E_{t-k}^{ctry} \right) + \alpha_2 X_{b,t-1} + \alpha_3 Z_{t-1} + \alpha_4 \Delta MP_{t-1}^{EA} + \alpha_4 VIX_{t-1} + f_b + \epsilon_{b,t}, \quad (3)$$

where  $Y_{b,t}$  is the log change of lending to the private non-financial sector by MFI  $b$  at quarter  $t$ .  $\Delta Q E_{t-k}^{ctry}$  is the measure of changes of the central bank balance sheet (as a ratio over GDP) of the euro area's core financial partners, the US, the UK and Japan.  $Z_{i,t}$  controls for demand effects in euro area country  $i$ , captured by the domestic credit (credit gap estimate) and business cycle (output gap estimate).  $MP^{EA}$  captures ECB monetary policy and  $f_b$  are bank fixed effects. Standard errors  $\epsilon_{b,t}$  are clustered at the bank level.<sup>7</sup>

While Equation (3) summarizes the spillovers of foreign monetary policy shocks to the lending behaviour of euro area MFIs, the specification remains silent on the underlying transmission channels. In particular, it does not disentangle demand and supply effects. The euro area BSI MFI statistics do not contain any bilateral country-specific information on the source (destination) country of cross-border liabilities (assets). Against this lack of information we again focus on three main bank-specific transmission channels to establish an international bank lending channel: the liquid asset ratio, the dependence on short-term funding of the domestic bank, and the dependence on intragroup funding forms. Our main regression of interest for the inward spillovers therefore takes the following form:

$$\begin{aligned} \Delta Y_{b,t} = & \alpha_0 + \sum_{ctry} \left( \sum_{k=0}^K (\alpha_{1,k}^{ctry} * \Delta Q E_{t-k}^{ctry} * Channel_{b,t-k-1}) \right) \\ & + \sum_{ctry} \alpha_2^{ctry} Channel_{b,t-k-1} + \alpha_3 X_{b,t-1} + f_b + f_t + Z_{i,t} + \epsilon_{b,t}, \end{aligned} \quad (4)$$

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<sup>7</sup>We tested for clustering the country level; but inter-cluster correlations suggested that clustering the bank level is more appropriate.

$Channel_{b,t-k-1}$  explores channels of transmission of monetary policy abroad. The channel variables enter the regression at the lag  $t - K - 1$  to make sure that they are not affected by contemporaneous changes in monetary policy.<sup>8</sup> For all equations  $K$  is equal to three.

## 3 Data

### 3.1 Bank-level data

We use a confidential bank-level data set of MFI balance sheet items (BSI) from the ECB. The data set reports confidential locational BSI (assets and liabilities) statistics for close to 250 MFIs from all euro area countries, excluding France. The sample spans the time period from July 2007 to September 2016. We reduce the frequency of the series from monthly to quarterly based on the last month's value of each quarter.

In our baseline specification for outward spillovers, the dependent variable in the baseline specification is the growth rate of loans to the rest of the world i.e. to residents outside of the euro area. For inward spillovers, we use as the response variable the growth rate of loans to the domestic non-financial private sector by euro area bank  $b$  in euro area economy  $i$  at time  $t$ . Domestic loans correspond to loans granted to residents in euro area economy  $i$ .

Figure 4 shows the development of loans by euro area MFIs by counterparty over the sample period. Loans to the private non-financial sector increased gradually between 2007 and late 2011, and have since remained broadly stable. Interbank loans have also gradually expanded until 2011, but have then temporarily declined between 2012 and 2014, reflecting the deleveraging of euro area MFIs over this period. The deleveraging process of euro area financial institutions is also reflected in loans to the rest of the world (to non-euro area residents) which in 2016 stood at markedly lower levels compared to 2008.

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<sup>8</sup>In robustness, the measures are calculated and averaged over the four quarters including and before  $t - K - 1$ .



As control variables, we use those bank characteristics which we assess to be important for monetary policy transmission, as they reflect both bank credit and bank capital channels. In particular, we use banks' total assets (*Log total assets<sub>b,t-1</sub>*), the percentage of banking organization's regulatory Tier 1 risk-based capital to asset ratio (*Tier1 ratio<sub>b,t-1</sub>*), the liquid asset ratio or percentage of a bank's portfolio of assets that is liquid (*Liquid asset ratio<sub>b,t-1</sub>*), the ratio of retail deposits to total liabilities or percentage of a bank's balance sheet financed with core deposits (*Core deposits ratio<sub>b,t-1</sub>*), and the percentage of banking organization's net intragroup funding, defined as the liabilities minus the assets of the euro area MFI with the rest of the banking group, scaled by total assets (*Net intragroup funding ratio<sub>b,t-1</sub>*).<sup>9</sup> In robustness checks we will also use the percentage of excess reserves over total assets (*Excess reserves ratio<sub>b,t-1</sub>*), which is only available for a considerably shorter time period (since 2012).

In robustness checks for the inward spillovers of monetary policy we modify the dependent variable with respect to the counterparty such as financial and non-financial sector, and the geographic location of the counterparty, i.e. loans to domestic residents or to euro area residents.

Regarding the dependent variable, for baseline specifications we concentrate on lending, instead of overall bank assets, as monetary policy is supposed to work via a international bank lending channel. Hence, concentrating on a subset of assets tied directly to macroeconomic performance might therefore capture better the actual mechanics of international transmission. More importantly, the literature on the existence of a bank lending channel has concentrated on lending, as we are ultimately interested in real effects of monetary policy (Cetorelli and Goldberg, 2012).

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<sup>9</sup>Balance sheet characteristics and transmission variables are adjusted for outliers to ensure that large observations are not driving the results. In the case of variables expressed as ratios, ratios are cut below zero and above unity. All other variables, are winsorised at the 1% level.

## 3.2 Country-level data

We use data on macroeconomic business and financial cycles from a BIS dataset in order to control for global economic and credit conditions for outward specifications and for domestic economic and credit conditions in inward specifications. In particular, we use country-specific estimates of output and credit gaps derived.

## 3.3 Monetary policy shocks

To capture the degree of unconventional monetary policy measures, in the baseline specification for outward spillovers we use changes in the ECB's balance sheet over GDP. For inward spillovers, in turn, we use changes in the ratio of the central banks balance sheets over GDP for the euro area's core financial partners, the US, the UK and Japan (see Figure 1).

An alternative measure of the degree of monetary policy accommodation proposed and used in the literature is the shadow short term interest rate which capture both conventional and unconventional monetary policies. In robustness checks for inward spillovers we therefore use changes in the shadow policy rates for the US, the UK and Japan (see Figure 3). For outward spillovers we use ECB shadow policy rates. We take the shadow policy rates from Krippner (2013) which are shown to be a consistent and effective proxy for monetary policy changes.<sup>10</sup>

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<sup>10</sup>Krippner (2013) uses a 2-factor model which is shown to be more stable over time, as opposed to the 3-factor model employed by Wu and Xia (2016).

## 4 Results

### 4.1 Outward spillovers: Domestic policy measures and lending to non-euro area residents

Table 1 reports the results for our baseline specification on outward spillovers (Equations (1) and (2)). The results indicate that conventional monetary policy in the form of changes in the ECB's main refinancing operations rate did not have any significant impact on cross-border loan growth over the sample period (column (1)). We also do not find any evidence for the international bank lending channel of conventional monetary policy, i.e. bank balance sheet characteristics did not matter for the transmission of standard monetary policy (columns (2) to (4)).

By contrast, the results provide suggestive evidence that unconventional monetary policy, measured as changes in the ECB's balance sheet, has positively affected cross-border credit growth of euro area MFIs between 2008 and 2015. An expansion of the ECB's balance sheet over GDP by 1 percentage point has been associated with a 1.3% increase in euro area MFIs' lending to non-euro area residents (column (1)). Importantly, this result holds while carefully controlling for changes in time-varying demand-side conditions, including domestic and foreign credit and business cycles, financial market volatility and US monetary policy.

We also find strong evidence for the existence of an international bank lending channel of unconventional monetary policy, across a number of dimensions. First, the impact of ECB balance sheet operations on euro area MFIs' lending to the rest of the world is markedly stronger for euro area banks which are more liquidity constrained (column (2)). The more liquid the banks, the less sensitive they are to quantitative easing measures designed to reduce liquidity constraints, such as the ECB's long-term refinancing operations. This finding is in line with Stein and Kashyap (2000) who, for the traditional bank lending channel of conventional monetary policy, find that the impact of monetary policy on lending is stronger for banks with less liquid balance sheets. Second, ECB balance

sheet operations have been more effective in spurring cross-border credit growth with respect to banks which relied less on short-term funding. This may reflect that banks which relied more heavily on short-term funding operations have markedly deleveraged throughout the global financial and the European sovereign debt crisis, irrespective of ECB unconventional monetary policy measures. Third, we find some evidence that banks which have been more dependent on intragroup funding forms tended, on impact, to increase cross-border lending more strongly (column (3)). This is in line with what Cetorelli and Goldberg (2012) find for globally operating banks, namely that net due flows from foreign affiliates to the head office in the United States increase significantly (or outflows decline significantly) when the domestic monetary policy tightens. Our findings mirror also the well-established cross-border credit networks of these banks which benefited from the ECB's financing operations. Positive funding shocks are large enough to increase both domestic and foreign lending and banks with intragroup funding linkages can easier channel these shocks across borders. Finally, the results indicate that larger banks on impact expanded their cross-border operations more strongly in response to ECB balance sheet expansions. While this is not in line with the findings for the domestic bank lending channel of conventional monetary policy, as Stein and Kashyap (2000) find that smaller banks tend to react stronger to monetary policy shocks, our finding for international bank lending channel may be a reflection of the fact that larger banks are likely to have more global cross-border operations. Moreover, larger banks tend to adjust their cross-border operations in a more flexible manner than smaller banks. This result also supports the hypothesis of the importance of internal capital markets of global banks as a channel of propagation of shocks across borders.

As regards the estimates for the bank-specific control variables, all balance sheet variables which are statistically significant have the correct sign. Specifically, the estimates suggest that euro area banks which are less liquidity-constrained, which have a higher capital to asset ratio (Tier1 ratio), which rely less heavily on alternative source of funding outside of deposit taking (a lower core deposit ratio), and which are domiciled in euro area economies with a higher (or positive) output gap tended to exhibit higher lending rates to residents

in the rest of the world over the sample period. Moreover, results also suggest that the global credit gap estimate mattered for lending growth. Lending rates have been higher in periods with higher positive credit gaps outside of the euro area.

## **4.2 Inward spillovers: Foreign policy measures and domestic lending to the private sector**

Table 2 reports the estimates of our baseline regression for inward spillovers to euro area MFIs. Column (1) reports results for the specification excluding the transmission channels (Equation (3)). Results in columns (2) to (4) are based on Equation (4). The estimates for the bank-specific control variables have the expected sign and are mostly statistically significant at standard significance levels (columns (1) to (4)). In particular, the estimates suggest that euro area banks which are less liquidity-constrained (a higher liquid asset ratio), which rely less heavily on alternative source of funding outside of deposit taking (a higher core deposit ratio), and which had a lower risk-based capital to asset ratio (Tier 1 ratio) have seen higher growth rates in lending to the domestic real private sector over the past decade, *ceteris paribus*. Column (1) further reports estimates for the domestic and foreign credit and business cycle variables, domestic (ECB) monetary policy and the VIX.<sup>11</sup> The statistically negative coefficient on the VIX suggests that bank lending has been negatively affected by spikes in global financial market volatility. Domestic monetary policy has the expected impact on credit growth of euro area MFIs: a 1 percentage point decline in the euro area short-term shadow rate led to a 3.4% increase in domestic lending. Finally, euro area loan dynamics reflect the domestic credit cycle: a negative domestic credit gap has been associated with lower credit growth. This contrasts with business cycles of major euro area trading partners which have not affected the lending behaviour of euro area financial institutions beyond the impact of the other controls.

Turning to monetary policy spillovers, the estimates reported in column (1) indicate that

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<sup>11</sup>Domestic monetary policy is proxied by the short-term shadow rate to capture both conventional and unconventional ECB monetary policy changes.

U.S. monetary policy accommodation at the zero lower bound is associated with a statistically significant increase in euro area MFIs' credit provision. In response to an increase in the Federal Reserve's balance sheet as a ratio of GDP by 1 percentage point, euro area MFIs increase lending to the domestic non-financial private sector by 3%. Looking at the interaction of the quantitative easing variable with bank-specific characteristics, we also find supportive evidence for the international bank lending channel. The impact of U.S. easing on lending to the real private sector is markedly stronger for euro area banks which are liquidity constrained (column (2)). Similarly as in the case of the outward spillovers, this suggests that bank-specific supply effects are a major driver behind the estimated monetary policy spillovers.

The baseline specification also suggests that UK monetary policy accommodation favourably effects domestic lending to the non-financial private sector. In response to an increase in the Bank of England's balance sheet (measured over GDP) by 1 percentage point, bank lending by euro area MFIs to the non-financial private sector increases by 2.6%, controlling for unconventional US monetary policy measures. While we do not find any evidence that balance sheet measures by the Bank of Japan significantly affect the lending behaviour of euro area banks to the domestic non-financial private sector, we cannot reject the hypothesis of joint significance of balance sheet changes by the US, the UK and Japan, suggesting that foreign monetary policy accommodation at the zero lower bound had an impact on domestic lending in the euro area.

### **4.3 Inward spillovers: Lending to the financial sector**

Table 3 reports the results for the impact of foreign monetary policy changes on the euro area interbank market. While the coefficients of the country-specific central bank balance sheet changes are all positive suggesting that foreign monetary policy accommodation has positively affected euro area domestic credit growth, neither of them is statistically significant. However, at the 20% significance level we cannot reject the hypothesis of joint significance of all foreign monetary policy shocks on domestic bank lending. This

notwithstanding, we cannot find any evidence for that euro area banks increased interbank lending to their peers in response to foreign monetary policy accommodation.

## 5 Robustness

We test the sensitivity of our baseline results to changes in the choice and specification of our monetary policy measure.

In a robustness check we replace changes in central bank balance sheets by estimates of the short-term shadow rate, a metric which captures both conventional and unconventional monetary policy measures. Tables 6 and 7 report results on inward spillovers to loans to the domestic non-financial and financial private sector, respectively. The results are qualitatively unchanged to the baseline specification when using a different metric to capture the degree of an unconventional monetary policy (Column (1) of Table 6). We also find some evidence for the operation of the international bank lending channel (columns (2) and (4))

Tables 4 and 5 report the robustness checks for the outward spillovers. Results are again qualitatively similar, confirming the existence of statistically and economically significant outward spillovers in response to ECB unconventional monetary policy measures.

## 6 Conclusion

This paper examines spillovers of unconventional monetary policy shocks via the international bank lending channel. Using a confidential bank level dataset of almost 250 euro area financial institutions, we find strong support for the existence of an bank lending channel of non-standard monetary policy measures that operates internationally. We find that euro area banks increase lending to the rest of the world in response to ECB quantitative easing measures. We also find evidence that euro area banks significantly increase

their lending to the private sector in response to a central bank balance sheet expansion of the US Federal Reserve. These spillovers are substantially stronger for euro area banks which are liquidity constrained and which rely more on internal capital markets, which supports the international bank lending channel interpretation of the results. Our findings have important implications for the conduct and coordination of monetary policy. In times of increasing financial interconnectedness, the international bank lending channel has become an additional and economically important channel through which monetary conditions are propagated abroad.

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## A Tables

Table 1: Impact of domestic QE on loans to the Rest of the World

	(1) No channel	(2) Liquid assets	(3) Short-term funding	(4) Intragroup funding	(5) Total Assets
Log total assets_t-1	-0.017 <sup>+</sup> (0.14)	-0.016 <sup>+</sup> (0.20)	-0.015 (0.25)	-0.015 (0.25)	-0.015 (0.24)
Tier1 ratio_t-1	0.067 <sup>+</sup> (0.16)	0.112** (0.02)	0.114** (0.02)	0.114** (0.02)	0.118** (0.02)
Liquid assets ratio_t-1	0.236** (0.05)	0.420*** (0.01)	0.386** (0.01)	0.394** (0.01)	0.388** (0.01)
Net IG funding ratio_t-1	-0.048 (0.29)	-0.038 (0.42)	-0.036 (0.42)	-0.090** (0.03)	-0.040 (0.40)
Core deposits ratio_t-1	0.212*** (0.00)	0.191** (0.01)	0.201*** (0.01)	0.199** (0.01)	0.198** (0.01)
L.Credit-to-GDP Gap Estimates	-0.008** (0.01)				
Global Credit Gap_t-1	0.010*** (0.00)				
L.Output Gap Estimates	0.013** (0.02)				
Global Output Gap_t-1	-0.011** (0.05)				
D.US MP_t-1	0.271 (0.58)				
VIX_t-1	-0.004*** (0.00)				
Short-term funding ratio_t-1			0.041 (0.72)		
Sum MP t to t-3(* Channel)	0.812 (0.50)	-0.037 (0.92)	0.329 (0.11)	0.318 (0.36)	0.006 (0.52)
Sum QE t to t-3(* Channel)	0.013*** (0.00)	-0.133*** (0.01)	-0.052** (0.05)	0.022 (0.31)	0.002 (0.20)
MP Impact (* Channel)	0.255 (0.70)	-0.250 (0.17)	0.112 (0.44)	-0.042 (0.49)	0.000 (0.94)
QE Impact * Channel)	0.002 (0.22)	-0.022 (0.41)	-0.015 (0.43)	0.042*** (0.01)	0.002** (0.02)
Time fixed effects	No	Yes	Yes	Yes	Yes
Bank fixed effects	Yes	Yes	Yes	Yes	Yes
Observations	6722	6068	6068	6068	6071
R-squared	0.02	0.03	0.02	0.02	0.02
Adj-R-squared	0.01	0.02	0.02	0.02	0.02
N. of banks	239	235	235	235	235

Robust standard errors; p-values in parentheses

<sup>+</sup>  $p < 0.2$ , \*  $p < 0.1$ , \*\*  $p < 0.05$ , \*\*\*  $p < 0.01$

*Notes: The dependent variable is log changes in loans to the rest of the world. The data are quarterly from 2007Q4 to 2016Q2 for a panel of resident banks. All specifications include fixed effects as specified in the lower part of the table. Standard errors are clustered by banks.*

Table 2: Spillovers of foreign QE on loans to the *domestic non-financial* private sector

	(1)	(2)	(3)	(4)
	No channel	Liquid assets	Short-term funding	Intragroup funding
Log total assets_t-1	-0.016 (0.20)	-0.021 <sup>+</sup> (0.13)	-0.021 <sup>+</sup> (0.12)	-0.021 <sup>+</sup> (0.11)
Tier1 ratio_t-1	-0.038** (0.04)	-0.046* (0.06)	-0.046** (0.05)	-0.045* (0.05)
Liquid assets ratio_t-1	0.241* (0.06)	0.210 <sup>+</sup> (0.14)	0.173 <sup>+</sup> (0.11)	0.172 <sup>+</sup> (0.11)
Net IG funding ratio_t-1	0.004 (0.78)	-0.002 (0.84)	-0.003 (0.77)	0.073 (0.23)
Core deposits ratio_t-1	0.071*** (0.00)	0.083*** (0.00)	0.083*** (0.00)	0.082*** (0.00)
US Credit Gap_t-1	0.001 <sup>+</sup> (0.10)			
UK Credit Gap_t-1	0.001 (0.36)			
JP Credit Gap_t-1	-0.000 (0.93)			
EA Credit Gap_t-1	0.002* (0.09)			
US Output Gap_t-1	-0.007 (0.21)			
UK Output Gap_t-1	0.010 <sup>+</sup> (0.18)			
JP Output Gap_t-1	-0.001 (0.49)			
EA Output Gap_t-1	0.005 (0.50)			
D.MP Domestic_t-1	-0.034 <sup>+</sup> (0.12)			
VIX_t-1	-0.003** (0.03)			
Short-term funding ratio_t-1			0.004 (0.89)	
Sum D.QE US t to t-3(* Channel)	0.030 (0.12)	-0.060** (0.02)	0.007 (0.69)	-0.002 (0.94)
Sum D.QE UK t to t-3(* Channel)	0.026** (0.03)	0.021 (0.46)	0.003 (0.86)	-0.048 (0.22)
Sum D.QE JP t to t-3(* Channel)	-0.009* (0.09)	0.015 (0.42)	-0.005 (0.67)	-0.018** (0.04)
Sum Impact D.QE	0.011* (0.10)	-0.031 (0.26)	-0.002 (0.85)	0.042* (0.09)
Sum all D.QE	0.046 (0.08)	-0.024 (0.66)	0.005 (0.86)	-0.067 (0.32)
Bank controls	Yes	Yes	Yes	Yes
Time fixed effects	No	Yes	Yes	Yes
Bank fixed effects	Yes	Yes	Yes	Yes
Observations	5520	5847	5847	5847
R-squared	0.02	0.02	0.02	0.02
Adj-R-squared	0.01	0.02	0.01	0.01
N. of banks	236	233	233	233

Robust standard errors; p-values in parentheses

<sup>+</sup>  $p < 0.2$ , \*  $p < 0.1$ , \*\*  $p < 0.05$ , \*\*\*  $p < 0.01$ 

Notes: The dependent variable is log changes in loans to the domestic non-financial private sector. The data are quarterly from 2007Q4 to 2016Q2 for a panel of resident banks. All specifications include fixed effects as specified in the lower part of the table. Standard errors are clustered by banks.

Table 3: Spillovers of foreign QE on EA MFIs' loans to the *domestic financial* sector

	(1)	(2)	(3)	(4)
	No channel	Liquid assets	Short-term funding	Intragroup funding
Log total assets_t-1	-0.048** (0.03)	-0.041** (0.04)	-0.041* (0.06)	-0.041** (0.04)
Tier1 ratio_t-1	-0.003 (0.96)	-0.015 (0.78)	-0.020 (0.73)	-0.010 (0.85)
Liquid assets ratio_t-1	-0.090 (0.61)	-0.361* (0.08)	-0.105 (0.59)	-0.112 (0.55)
Net IG funding ratio_t-1	-0.093* (0.08)	-0.060 (0.26)	-0.055 (0.29)	0.084 (0.63)
Core deposits ratio_t-1	-0.048 (0.61)	0.007 (0.94)	0.004 (0.96)	-0.000 (1.00)
US Credit Gap_t-1	0.003 (0.59)			
UK Credit Gap_t-1	0.001 (0.78)			
JP Credit Gap_t-1	0.004 (0.78)			
EA Credit Gap_t-1	-0.003 (0.85)			
US Output Gap_t-1	0.004 (0.90)			
UK Output Gap_t-1	-0.002 (0.97)			
JP Output Gap_t-1	-0.024*** (0.00)			
EA Output Gap_t-1	0.023 (0.74)			
D.MP Domestic_t-1	-0.016 (0.80)			
VIX_t-1	-0.003 (0.45)			
Short-term funding ratio_t-1			-0.026 (0.86)	
Sum D.QE US t to t-3(* Channel)	0.051 (0.46)	0.212*** (0.00)	-0.059 (0.25)	0.168*** (0.00)
Sum D.QE UK t to t-3(* Channel)	0.076 (0.29)	0.066 (0.60)	-0.015 (0.75)	-0.061 (0.34)
Sum D.QE JP t to t-3(* Channel)	0.034 (0.34)	0.019 (0.74)	-0.041 (0.30)	-0.076 (0.10)
Sum Impact D.QE	0.045 (0.16)	0.190* (0.07)	-0.065 (0.13)	0.057 (0.52)
Sum all D.QE	0.160 (0.17)	0.297 (0.16)	-0.115* (0.08)	0.031 (0.75)
Bank controls	Yes	Yes	Yes	Yes
Time fixed effects	No	Yes	Yes	Yes
Bank fixed effects	Yes	Yes	Yes	Yes
Observations	5493	5807	5807	5807
R-squared	0.01	0.02	0.02	0.02
Adj-R-squared	0.01	0.02	0.02	0.01
N. of banks	241	238	238	238

Robust standard errors; p-values in parentheses

+  $p < 0.2$ , \*  $p < 0.1$ , \*\*  $p < 0.05$ , \*\*\*  $p < 0.01$ 

Notes: The dependent variable is log changes in loans to the domestic financial sector. The data are quarterly from 2007Q4 to 2016Q2 for a panel of resident banks. All specifications include fixed effects as specified in the lower part of the table. Standard errors are clustered by banks.

Table 4: Loans to the Rest of the World—Taylor-residual-SSR

	(1) No channel	(2) Liquid assets	(3) Short-term funding	(4) Intragroup funding	(5) Total Assets
Log total assets_t-1	-0.015 <sup>+</sup> (0.18)	-0.016 (0.21)	-0.015 (0.22)	-0.015 (0.23)	0.007 (0.84)
Tier1 ratio_t-1	0.079 <sup>+</sup> (0.10)	0.111** (0.02)	0.116** (0.02)	0.117** (0.02)	0.114** (0.02)
Liquid assets ratio_t-1	0.231** (0.05)	0.035 (0.92)	0.381** (0.01)	0.384** (0.02)	0.389** (0.01)
Net IG funding ratio_t-1	-0.045 (0.33)	-0.042 (0.38)	-0.034 (0.45)	0.164 (0.38)	-0.043 (0.37)
Core deposits ratio_t-1	0.212*** (0.00)	0.200** (0.01)	0.207*** (0.01)	0.196** (0.01)	0.196** (0.01)
L.Credit-to-GDP Gap Estimates	-0.004 (0.22)				
Global Credit Gap_t-1	0.005** (0.02)				
L.Output Gap Estimates	0.016*** (0.00)				
Global Output Gap_t-1	-0.009 <sup>+</sup> (0.11)				
VIX_t-1	-0.002*** (0.00)				
Sum D.MP EA t to t-3(* Channel)	-0.105*** (0.00)	1.507* (0.07)	0.328 (0.25)	0.002 (1.00)	-0.014 (0.48)
Sum D.MP EA*ZLB t to t-3	0.032 (0.50)	-1.073 (0.36)	-0.723* (0.07)	0.008 (0.98)	0.014 (0.62)
Sum all MP (*ZLB)	-0.072** (0.01)	0.435 (0.42)	-0.395 (0.20)	0.010 (0.96)	-0.000 (0.99)
Sum Impact MP	-0.019** (0.03)	0.171 (0.48)	0.081 (0.43)	-0.086 (0.43)	-0.007 (0.18)
Sum Impact MP*ZLB	0.002 (0.89)	-0.164 (0.68)	-0.152 (0.34)	0.022 (0.86)	0.005 (0.58)
Sum all Impact	-0.017 (0.12)	0.007 (0.98)	-0.071 (0.58)	-0.064 (0.45)	-0.002 (0.75)
Time fixed effects	No	Yes	Yes	Yes	Yes
Bank fixed effects	Yes	Yes	Yes	Yes	Yes
Observations	6754	6068	6068	6068	6071
R-squared	0.02	0.03	0.03	0.02	0.03
Adj-R-squared	0.01	0.02	0.02	0.02	0.02
N. of banks	239	235	235	235	235

Robust standard errors; p-values in parentheses

<sup>+</sup>  $p < 0.2$ , \*  $p < 0.1$ , \*\*  $p < 0.05$ , \*\*\*  $p < 0.01$ 

Notes: The dependent variable is log changes in loans to the rest of the world. The data are quarterly from 2007Q4 to 2016Q2 for a panel of resident banks. All specifications include fixed effects as specified in the lower part of the table. Standard errors are clustered by banks.

Table 5: Loans to the Rest of the World—SSR

	(1) No channel	(2) Liquid assets	(3) Short-term funding	(4) Intragroup funding	(5) Total Assets
Log total assets_t-1	-0.016 <sup>+</sup> (0.15)	-0.016 (0.22)	-0.015 (0.24)	-0.015 (0.24)	0.013 (0.69)
Tier1 ratio_t-1	0.075 <sup>+</sup> (0.13)	0.107** (0.03)	0.115** (0.02)	0.116** (0.02)	0.118** (0.02)
Liquid assets ratio_t-1	0.236** (0.04)	-0.029 (0.93)	0.383** (0.01)	0.386** (0.02)	0.393** (0.01)
Net IG funding ratio_t-1	-0.045 (0.32)	-0.041 (0.40)	-0.032 (0.47)	0.019 (0.93)	-0.037 (0.43)
Core deposits ratio_t-1	0.209*** (0.00)	0.202*** (0.01)	0.207*** (0.01)	0.196** (0.01)	0.206*** (0.01)
L.Credit-to-GDP Gap Estimates	-0.001 (0.82)				
Global Credit Gap_t-1	0.004 <sup>+</sup> (0.12)				
L.Output Gap Estimates	0.013** (0.02)				
Global Output Gap_t-1	-0.008 <sup>+</sup> (0.14)				
VIX_t-1	-0.002*** (0.01)				
Sum D.MP EA t to t-3(* Channel)	-0.542 (0.72)	-6.854 (0.64)	18.513 (0.12)	-9.408 (0.43)	-0.711 (0.32)
Sum D.MP EA*ZLB t to t-3	-20.555 (0.20)	-19.017 (0.89)	13.484 (0.94)	1.651 (0.99)	-37.654*** (0.00)
Sum all MP (*ZLB)	-21.098 (0.19)	-25.871 (0.85)	31.997 (0.86)	-7.757 (0.94)	-38.365*** (0.00)
Sum Impact MP	-0.695 (0.38)	6.614 (0.71)	4.053 (0.68)	-5.933 (0.45)	-0.551 (0.26)
Sum Impact MP*ZLB	-8.042* (0.10)	-15.101 (0.79)	-16.006 (0.81)	-0.590 (0.97)	-9.074*** (0.00)
Sum all Impact	-8.738* (0.07)	-8.487 (0.86)	-11.953 (0.85)	-6.523 (0.73)	-9.625*** (0.00)
Time fixed effects	No	Yes	Yes	Yes	Yes
Bank fixed effects	Yes	Yes	Yes	Yes	Yes
Observations	6754	6068	6068	6068	6071
R-squared	0.02	0.03	0.03	0.02	0.03
Adj-R-squared	0.01	0.02	0.02	0.02	0.02
N. of banks	239	235	235	235	235

Robust standard errors; p-values in parentheses

<sup>+</sup>  $p < 0.2$ , \*  $p < 0.1$ , \*\*  $p < 0.05$ , \*\*\*  $p < 0.01$ 

Notes: The dependent variable is log changes in loans to the rest of the world. The data are quarterly from 2007Q4 to 2016Q2 for a panel of resident banks. All specifications include fixed effects as specified in the lower part of the table. Standard errors are clustered by banks.

Table 6: Loans to the *domestic non-financial* private sector—Short-term shadow rate (SSR)

	(1)	(2)	(3)	(4)
	No channel	Liquid assets	Short-term funding	Intragroup funding
Log total assets_t-1	-0.032** (0.04)	-0.021* (0.09)	-0.021* (0.09)	-0.021* (0.08)
Tier1 ratio_t-1	-0.055*** (0.00)	-0.052** (0.02)	-0.052** (0.01)	-0.050** (0.02)
Liquid assets ratio_t-1	0.206+ (0.11)	0.148* (0.07)	0.168* (0.10)	0.161+ (0.12)
Net IG funding ratio_t-1	-0.001 (0.92)	-0.003 (0.76)	-0.006 (0.61)	0.003 (0.76)
Core deposits ratio_t-1	0.078*** (0.00)	0.087*** (0.00)	0.086*** (0.00)	0.086*** (0.00)
Credit Gap_t-1	-0.000 (0.91)			
Output Gap_t-1	0.000 (0.77)			
D.MP Domestic_t-1	0.001 (0.80)			
VIX_t-1	-0.000 (0.84)			
Short-term funding ratio_t-1			-0.008 (0.73)	
Sum D.SSR US t to t-3(* Channel)	-1.349* (0.09)	11.780 (0.17)	-6.941 (0.40)	-10.080** (0.02)
Sum D.SSR UK t to t-3(* Channel)	0.405 (0.51)	-5.103 (0.36)	6.619 (0.30)	5.755* (0.05)
Sum D.SSR JP t to t-3(* Channel)	0.241 (0.74)	-21.153 (0.50)	-15.612* (0.08)	-9.879 (0.29)
Sum of Impact D.SSR	0.208 (0.39)	-1.860 (0.82)	-5.697* (0.09)	-4.193 (0.20)
Sum of all D.SSR	-0.703 (0.36)	-14.476 (0.67)	-15.933 (0.15)	-14.204 (0.17)
Bank controls	Yes	Yes	Yes	Yes
Time fixed effects	No	Yes	Yes	Yes
Bank fixed effects	Yes	Yes	Yes	Yes
Observations	5605	6059	6059	6059
R-squared	0.02	0.02	0.02	0.02
Adj-R-squared	0.01	0.01	0.02	0.01
N. of banks	231	233	233	233

Robust standard errors; p-values in parentheses

+  $p < 0.2$ , \*  $p < 0.1$ , \*\*  $p < 0.05$ , \*\*\*  $p < 0.01$

Notes: The dependent variable is log changes in loans to the domestic non-financial private sector. The data are quarterly from 2007Q4 to 2016Q2 for a panel of resident banks. All specifications include fixed effects as specified in the lower part of the table. Standard errors are clustered by banks.

Table 7: Dependent variable: Loans to the *domestic financial* sector—Short-term shadow rate (SSR)

	(1)	(2)	(3)	(4)
	No channel b/p	Liquid assets b/p	Short-term funding b/p	Intragroup funding b/p
Log total assets_t-1	-0.064** (0.02)	-0.045** (0.04)	-0.045** (0.05)	-0.045** (0.05)
Tier1 ratio_t-1	0.018 (0.74)	0.028 (0.64)	0.028 (0.65)	0.028 (0.64)
Liquid assets ratio_t-1	-0.035 (0.83)	-0.125 (0.47)	-0.104 (0.56)	-0.111 (0.52)
Net IG funding ratio_t-1	-0.064** (0.03)	-0.014 (0.68)	-0.015 (0.65)	-0.015 (0.67)
Core deposits ratio_t-1	-0.053 (0.63)	0.005 (0.95)	0.012 (0.90)	0.008 (0.93)
Credit Gap_t-1	-0.000 (0.24)			
Output Gap_t-1	0.004 <sup>+</sup> (0.17)			
D.MP Domestic_t-1	0.115*** (0.00)			
VIX_t-1	0.002** (0.05)			
Short-term funding ratio_t-1			-0.184 (0.26)	
Sum D.SSR US t to t-3(* Channel)	11.981 (0.02)	18.826 (0.35)	-9.551 (0.55)	8.269 (0.80)
Sum D.SSR UK t to t-3(* Channel)	-7.359 (0.02)	-15.540 (0.42)	0.432 (0.98)	-4.550 (0.82)
Sum D.SSR JP t to t-3(* Channel)	5.944 (0.07)	-3.146 (0.91)	-41.760 (0.11)	0.180 (1.00)
Sum of Impact D.SSR	2.470 (0.15)	-28.093 (0.04)	4.226 (0.77)	3.759 (0.70)
Sum of all D.SSR	10.565 (0.04)	0.140 (1.00)	-50.879 (0.10)	3.899 (0.93)
Bank controls	Yes	Yes	Yes	Yes
Time fixed effects	No	Yes	Yes	Yes
Bank fixed effects	Yes	Yes	Yes	Yes
Observations	5588	6018	6018	6018
R-squared	0.02	0.03	0.03	0.02
Adj-R-squared	0.01	0.02	0.02	0.02
N. of banks	236	238	238	238

Robust standard errors; p-values in parentheses

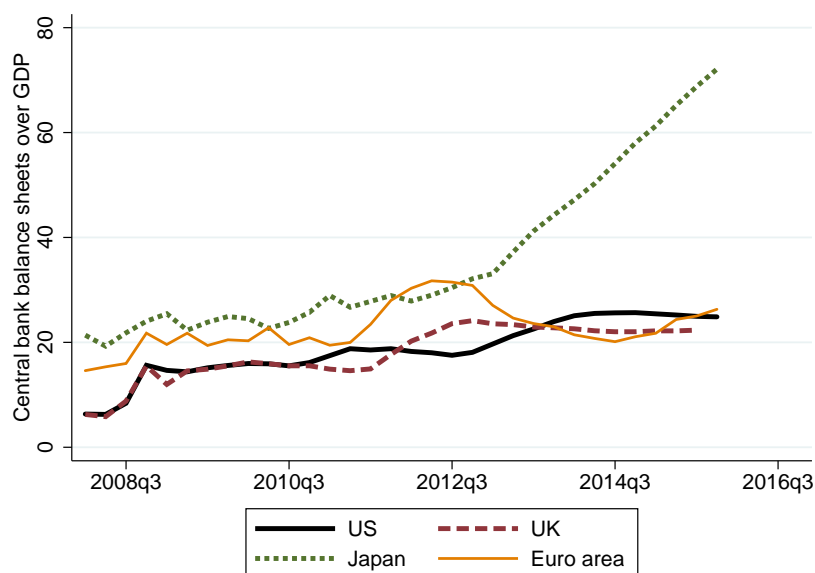
<sup>+</sup>  $p < 0.2$ , \*  $p < 0.1$ , \*\*  $p < 0.05$ , \*\*\*  $p < 0.01$

Notes: The dependent variable is log changes in loans to the domestic financial sector. The data are quarterly from 2007Q4 to 2016Q2 for a panel of resident banks. All specifications include fixed effects as specified in the lower part of the table. Standard errors are clustered by banks.



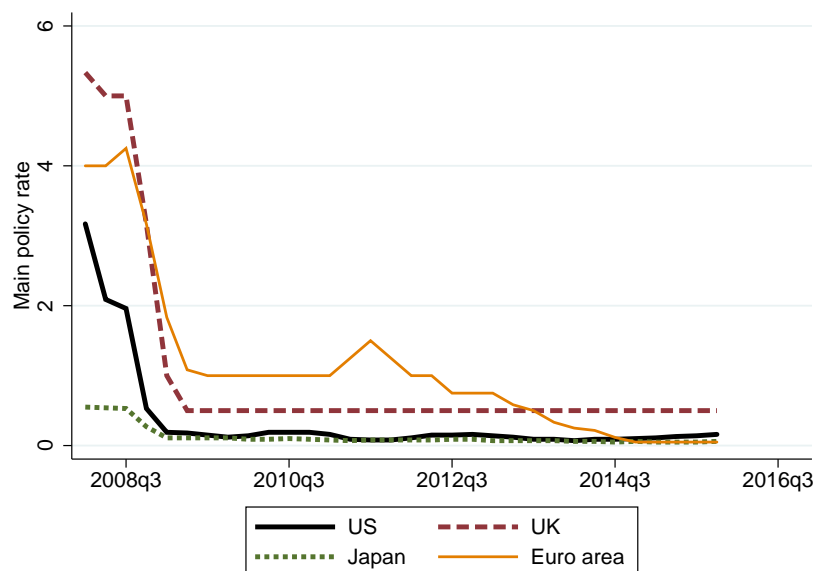
## B Figures

Figure 1: Development of central bank balance sheets



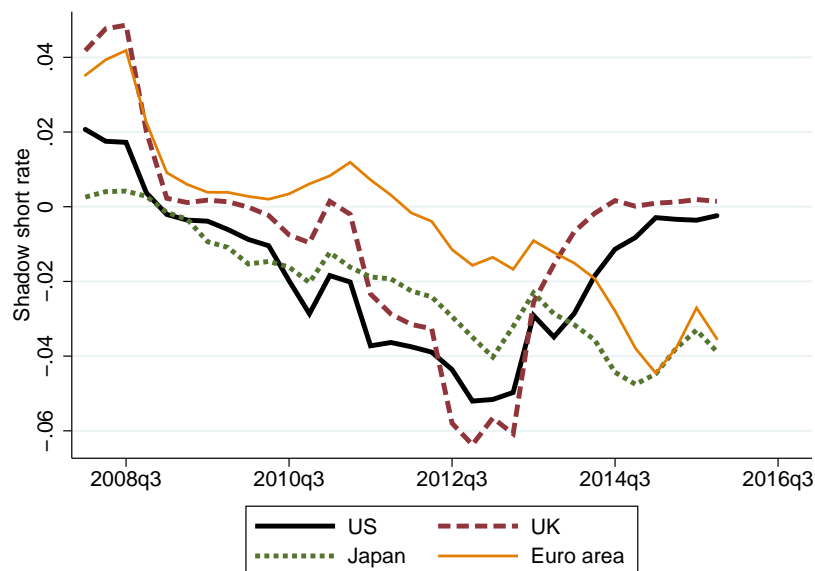
Notes: Central bank balance sheets as a ratio over GDP.

Figure 2: Development of main policy rates across major jurisdictions



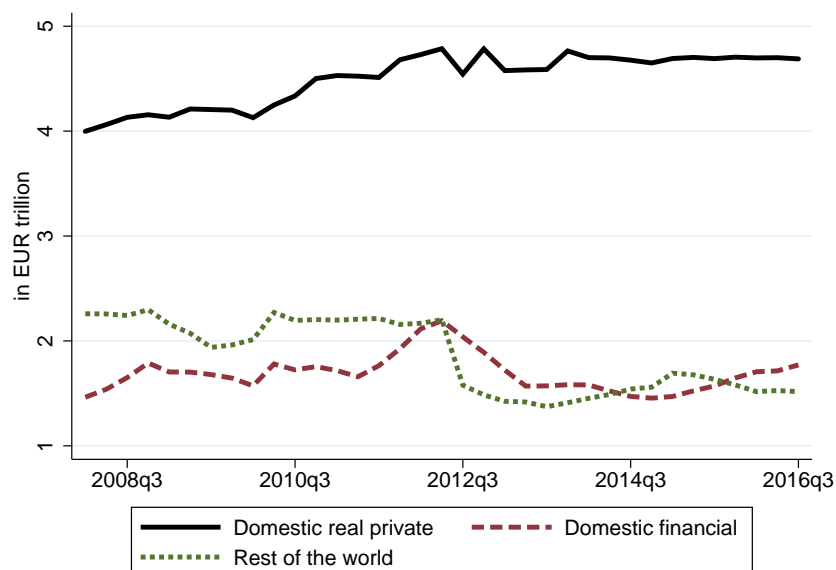
Notes: For the euro area the policy rate is the MRO

Figure 3: Development of short term shadow rates across major jurisdictions



Notes: Shadow short-term rates based on Krippner (2013).

Figure 4: Development of loans by euro area MFIs by counterparty



Source: Euro area MFI BSI statistics.

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