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Monetary policy spillover to small open economies: Is the transmission different under low interest rates?☆

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ABSTRACT

We explore the impact of low and negative monetary policy rates in core world economies on bank lending in four small open economies – Canada, Chile, the Czech Republic and Norway – using confidential bank-level data. We show that the impact on lending in these small open economies depends on the interest rate level in the core. During normal times, monetary policy cuts in the core can reduce credit supply in small open economies. In contrast, when interest rates in the core are low, further expansionary monetary policy increases lending in small open economies, consistent with an international bank lending channel. These results have important policy implications, suggesting that central banks in small open economies should watch for the impact of potential regime switches in core economies' monetary policy when rates shift to and from the very low end of the distribution.

1. Introduction

Since the Global Financial Crisis (GFC) of 2007–2009, policy rates in core world economies have remained low relative to historical levels for a prolonged period of time. An extensive body of literature has focused mostly on the impact of this environment on *domestic* outcomes such as monetary policy pass-through, bank profits, risk-taking, and credit allocation (Altavilla et al., 2022; Basten and Mariathasan, 2018; Bittner et al., 2020; Bottero et al., 2019; Brunnermeier and Koby, 2018; Eggertsson et al., 2019). However, considerably less attention has been given to the cross-border spillovers of such a policy, which is of particular relevance since monetary policy spillovers from the core economies can substantially limit the effectiveness of domestic monetary policy in small open economies (SOEs. See, for example, Cao and Dinger (2022)). In theory, expansionary monetary policy in a core economy has an ambiguous effect on the lending of banks – not only

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Table 1
All countries share similar characteristics.

	Canada	Chile	Czech Republic	Norway
Credit to non-financial sector from all sectors to GDP[a]	305%	188%	120%	284%
Credit to non-financial sector from banks to GDP[a]	112%	88%	51%	80%
5-bank asset concentration[b]	92%	77%	66%	64%
Share of foreign-owned banks in total assets[b]	2%	44%	86%	29%
Share of cross-border liabilities in total assets[b]	9%	12%	24%	35%
Share of cross-border assets in total assets[b]	35%	6%	10%	21%
Share of loans to private sector in foreign currency[b]	0%[d]	11%	20%	8%
Year of inflation-targeting adoption	1991	1999	1998	2001
Currency regime	Freely floating	Managed floating	Managed floating	Freely floating
Capital mobility	"Open"	"Gate"[c]	"Open"	"Open"

[a]As of 2019, according to the BIS total credit statistics database.
[b]As of 2019Q4, according to internal information from each central bank.
[c]"Gate" means that a moderate share of types of cross-border financial transactions is subject to significant capital controls (see Fernández et al., 2016).
[d]Since we define domestic loans in Canada as loans given in Canadian dollars, the share of loans in foreign currency by default is zero.

multinational banks, but also domestic banks – in a SOE.[1] On the one hand, the *international bank lending channel* suggests that monetary expansion in the core makes money market funding there cheaper, inducing banks in SOEs to increase their funding from the core and lend more in SOEs (Kashyap and Stein, 2000; Cetorelli and Goldberg, 2012). In contrast, the *portfolio channel* argues that lowering interest rates in the core improves core's borrowers' creditworthiness, inducing banks to shift credit supply away from SOEs (Adrian et al., 2014; Hills et al., 2019). Such ambiguous effects of cross-border monetary policy spillover are further complicated by the historically low interest rates in the core countries after GFC: Although the recent literature shows that a low and negative interest rate environment (LNIRE) can distort monetary policy pass-through and bank lending within the core economies, there is almost no evidence on whether cross-border monetary policy spillovers are modified by LNIRE in the core.

In this paper, we attempt to fill in this gap and investigate the role of monetary policy spillovers from core world economies to lending in SOEs, with particular attention to the degree of spillovers at low or negative interest rates. We trace the impact of monetary policy shocks in three core economies – the US, euro area (EA), and UK – on lending in four SOEs – Canada, Chile, the Czech Republic, and Norway (CCCN hereafter). In the case of Norway, we also account for spillovers from Sweden, as the same Scandinavian banks have a presence in both the Swedish and Norwegian banking sectors. We use proprietary data on bank lending in these four SOEs for the period 2002–2019. Employing such a long time horizon enables us to trace the monetary policy spillovers in times of substantial variations in core economies' interest rates and contrast low-interest-rate periods with "normal" periods. Moreover, there are also substantial variations in the spreads between short- and long-term interest rates in core economies during our sample period, reflecting the variations in monetary policy expectations — in particular the fact that during the quantitative easing (QE) period the US monetary policy was targeting the long-end of the yield curve.[2] Our main contribution to the existing literature is to examine how LNIRE in the core shapes monetary policy spillovers to SOEs.

The availability of confidential bank-level data in the four economies gives us an opportunity to abstract from bilateral confounding effects while we can still explore a sample of sufficiently similar countries. The countries in our sample are all small, financially open economies, with a substantial presence of global banks, and operate an inflation-targeting monetary policy regime with flexible exchange rates (Table 1).[3] Moreover, CCCN are all bank-oriented economies. In Canada and Norway, banks hold total assets of more than 100% of GDP; in Chile and the Czech Republic, the size of the banking sector is smaller but still high compared to emerging economies on average. Also, bank credit is the main source of financing to the non-financial private sector in all four economies. CCCN's banking sectors are highly concentrated, particularly in Canada and Chile, where the 5-bank asset concentration is above 90% and 75%, respectively. Furthermore, banks' cross-border exposure in terms of assets and liabilities is relatively high in all CCCN countries, and accounts for 18% and 20% on average of total bank assets and liabilities, respectively. Also, the average share of foreign currency-denominated loans is 13% of total lending (excluding Canada), and 20% in the Czech Republic. These characteristics might be informative about the role that foreign monetary policies play in shaping domestic lending in CCCN. On top of that, banking sectors in all four countries share important features exposing them to international shocks, including changes in foreign monetary policy rates. Although the four countries vary greatly in size – Canada, Chile, the Czech Republic, and Norway represent 1.4%, 0.3%, 0.3%, and 0.5% respectively of global GDP at purchasing power parity rates as of 2019 – they are all small enough that the monetary policy of the core countries can be considered exogenous to developments in the CCCN's domestic sectors. Owing to their role as commodity exporters, the monetary policy of Canada, Chile and Norway is less synchronized with the global business cycles, implying that domestic policy rates can differ relative to the core economies. Emerging market status for Chile and the Czech Republic also contributes to differences in policy rates relative to the core.

We start the empirical analysis with a common framework across countries, allowing lending in all sample countries to be contingent on spillovers from all core countries. We first look at the impact of changes in short-term interest rates in core countries. We define a core policy rate as "low" if it is in the 1st quartile of its distribution; otherwise, we define it as "normal". To fully capture the monetary policy stance and expectations about monetary policy, we include the spread between short- and long-term interest rates. In particular, we explore whether changes in the yield curve matter for monetary policy spillovers conditional on the short-term policy rate. Next, we explore whether the effect on lending is driven by multinational banks, which may employ their internal capital markets to channel funds across borders. In a more general sense, assuming that frictions in the interbank market are not too pronounced, this channeling of funds can also be intermediated through the interbank market. In this case, we will observe spillover effects in the lending dynamics of multinationals and a wider population of banks. Subsequently, we dig deeper into

[1] We discuss this in more detail in Section 2.

[2] During our sample period, core countries' monetary policy rates range from zero or negative to more than 5% — just before the GFC. The spreads between short- and long-term interest rates in core economies range from −1.5% to 3.5%.

[3] The Czech Republic generally operates a managed floating exchange rate regime; however, during 2013–2017 the CNB employed a temporary asymmetric exchange rate commitment against EUR.

exploring whether the lending response to changes in the core policy rate is uniform across all lending categories, or whether it is driven by specific types of lending. We therefore look at the dynamics of different loan categories in response to changes in the core policy rate. Last but not least, we check whether low interest rates in the core also generate direct implications for bank risk and thus for financial stability in SOEs. Finally, we subject our results to a battery of robustness checks.

By employing a common empirical framework across countries, we reach five main conclusions. First, we find evidence of a portfolio channel effect in normal times. Specifically, a decrease in a core interest rate in normal times leads to a decrease in lending in CCCN. In contrast, when the core policy rate is low, we find evidence of an international bank lending channel in at least two of the four countries, Canada and Norway. A decrease in the core policy rate increases bank lending in SOEs during the period of low policy rates.

Second, both the portfolio and international bank lending channel remain at play even if we consider long-term interest rates, proxied by changes in the yield curve. These channels are prominent especially in the Czech Republic and Norway. The results for Canada and Chile also support the existence of both channels as they yield quantitatively and qualitatively similar results (the same size and direction of the effect), although the results are less precise because of the relatively lower number of observations.

Third, we show that multinational banks' lending exhibits stronger spillover effects in Norway, while the opposite is true for Chile and the Czech Republic. The result for Norway provides some support for the existence of an internal capital market used by multinational banks to channel funds across borders in response to changes in the core policy rate. However, the mixed evidence might also be generated by the fact that well-functioning interbank markets are a fairly good substitute for internal capital markets in terms of shifting liquidity. Moreover, while the majority of banks in Chile and the Czech Republic are foreign-owned, both domestic and foreign banks face the same regulation, limiting the use of the internal capital market.

Fourth, we show that, in all countries except the Czech Republic, the international bank lending channel at low rates operates primarily through mortgage lending and consumer loans. Similar results are found for Chile and Norway when it comes to riskier corporate loans. The latter is consistent with increased risk-taking associated with the international bank lending channel (Morais et al., 2019).

Fifth, we show that policy rate changes in core countries are associated with varying bank risk in SOEs when focusing on the distance to default (as captured by z-score), the volatility of return on assets and the fraction of non-performing loans as measures of bank risk. For instance, the fraction of non-performing loans in all countries except Norway is significantly related to policy rate reductions for at least one core country.

Our main contribution to the existing literature is to investigate whether the level of the core's policy rate influences how core economies' monetary policy spills over to small open economies. We document three novel findings. First, we show that the dominating channel of international monetary policy spillovers varies with the level of the core's policy rates. Specifically, we find evidence that the international bank lending channel is primarily active when the core's policy rates are at their historically low or negative levels. The portfolio channel appears to dominate in normal periods. Using granular bank-level data from four SOEs spanning over almost two decades, including both periods under LNIRE and periods under "normal" interest rates, our results can therefore reconcile the seemingly contradictory results of existing studies that find evidence on either the international bank lending channel (for example, Morais et al. (2019)) or the portfolio channel (for example, Hills et al. (2019)), based on relatively shorter sample periods. Our results illustrate an international search-for-yield channel that is consistent with – but also adds an international angle to – the domestic search-for-yield literature on banking, such as Jiménez et al. (2014). Second, focusing on the period of LNIRE, we specifically show that low and negative policy rates in the core increase bank lending in SOEs. Third, we contribute to the literature on risk spillovers by showing that in our sample, risk spillovers from core economies primarily take place in a low rate environment (Morais et al., 2019).

Our paper fits into three strands of the literature. The first strand of studies focuses on the bank dimension of the cross-border transmission of monetary policy, in particular, on the transmission of the core world economies' monetary policy to other countries through banks' exposure to international money and capital markets. For instance, Morais et al. (2019) identify how monetary policy in the core economies influences corporate lending in Mexico. They find that a foreign policy rate shock affects the supply of credit to Mexican firms mainly via their respective foreign banks in Mexico. In contrast, investigating the transmission of global financial cycles to domestic credit market conditions in Turkey, di Giovanni et al. (2022) find that an easing in global financial conditions is transmitted mostly by domestic banks that are more exposed to international capital markets. Tracking components of banks' balance sheets, Cao and Dinger (2022) document how foreign monetary policy, jointly with global risk factors, affects international banks' domestic lending by changing their funding conditions, and how such an effect propagates through the domestic money market where non-international banks borrow from international banks. Furthermore, Bush et al. (2021) emphasize that international monetary policy spillovers to domestic lending can also be affected by the domestic macroprudential policy stance.

The second strand of related literature explores the impact of a negative interest rate on bank lending. However, existing studies focus mainly on domestic transmission, especially on how bank lending is affected by policy rate pass-through, i.e., how deposit rates and loan rates react to a low monetary policy rate. For instance, Bittner et al. (2020) find that a negative interest rate is less expansionary in the core economy because the policy rate pass-through to deposit rates is more impaired; such an impaired bank lending channel under impaired monetary policy pass-through is also documented in Eggertsson et al. (2019) for the case of Sweden. Bottero et al. (2019) and Basten and Mariathasan (2018) find that the bank lending channel is less impaired when banks are able to pass on the negative interest rate to depositors by increasing fees; similarly, Altavilla et al. (2022) find that sound banks are able to pass on negative interest rates to corporate depositors, and this incentivizes corporate borrowers to reduce cash holdings and increase investments, which strengthens the real effects of monetary expansion under negative interest rates.

Third, our results also relate to the literature on how monetary policy affects financial stability (Jiménez et al., 2014). By showing that low and negative policy rates in the core not only increase bank lending volumes but are also associated with higher levels of bank risk in SOEs, we highlight that these economies are prone to the potential financial stability hazards of credit growth (Jordá et al., 2011; Schularick and Taylor, 2012) even when the domestic central banks maintain a clear focus on price pressures and systemic risk, and thus attempt to limit credit growth. This evidence is consistent with the existence of an international risk-taking channel of monetary policy (Cecchetti et al., 2020) and suggests that the monetary and the macroprudential policies of an SOE have limited effectiveness: Contractionary domestic monetary policy might not generate the expected effect on credit but also domestic monetary policy easing can be subject to a larger-than-expected increase in lending, due to amplifying effects of the international bank lending channel. This needs to be taken into account when macroprudential policies are designed to limit excessive credit cycle volatility.

The rest of the paper is organized as follows. In Section 2, we present our main hypotheses to be tested and our empirical methodology. In Section 3, we describe the main features and sources of data that are deployed in this paper. In Section 4, we investigate the spillover of monetary policy from the core to SOEs; in Section 5, we show how our results are robust to a wide variety of measurements of monetary policy shocks in the core, as well as different specifications of regression equations. Section 6 concludes.

2. Empirical methodology

How does monetary policy in a core economy affect bank lending in SOEs? Is such spillover modified by the low and negative interest rate environment in the core? For the first question, the literature so far has proposed two main channels working in opposite directions. First, the international bank lending channel (Bernanke, 1983, 1993; Kashyap and Stein, 2000; Cetorelli and Goldberg, 2012) presumes that following an expansionary monetary policy shock in the core, lending in the SOEs is expanded. This effect is driven by three underlying assumptions about international monetary policy spillovers. First, global banks from the core economies may be incentivized to move funds abroad to seek higher returns. Thus, they may increase credit supply to the host countries through their internal capital markets (Morais et al., 2019). Second, when the low interest rate environment in core economies squeezes global banks' net interest margin at home, they may have the incentive to explore other sources of profit, which may induce their foreign subsidiaries to take higher risks. Third, low funding costs in core economies may encourage banks (both domestic- and foreign-owned) in SOEs to increase their funding from core economies, and hence affect bank lending within SOEs. The other channel, the portfolio channel, predicts the opposite effect: A tightening of core monetary policy may reduce the creditworthiness of core economies' borrowers and reduce their collateral values, which may induce multinational banks to increase lending in SOEs (see Barbosa et al. (2018) and Hills et al. (2019)). A loosening of core monetary policy can reverse these effects, thus reduce lending to SOEs. The contrasting predictions of these channels motivate us to empirically test the following hypothesis:

H1: An expansionary monetary policy shock in the core leads to an expansion of bank lending in the SOEs.

Finding support for this hypothesis will be consistent with the international bank lending channel, while rejecting it will deliver evidence for the portfolio channel.

Note that the effects described in the above two channels can be present even if the interest rates in the core are not particularly low. Exploring the spillovers of low interest rates in particular, therefore, requires an examination of how these channels are reinforced or inhibited when monetary policy rates in the core are low or even negative. That is, for example, the international lending channel can be reinforced by particularly strong search-for-yield concerns at the very low end of the interest rate distribution. This effect can be accelerated even further if banks in core economies perceive negative interest rates as a cost they can circumvent by cross-border portfolio rebalancing. On the other hand, the portfolio channel can be less effective when interest rates are generally low, since the net worth of firms in the core is possibly less sensitive to a mild monetary policy tightening in the lower range of the interest rate distribution. To examine how the importance of the above channels changes in low and negative interest rate environments, we therefore test the following hypothesis:

H2: An expansionary monetary policy shock in the core has stronger effects on bank lending in the SOEs when core interest rates are low.

In addition, we expect that the impact of a monetary expansion in a low interest rate environment also depends on banks' expectations with regard to how long such an environment will persist. As is argued by Rajan (2006), when monetary policy rates remain "low for long", the search-for-yield incentive is stronger. We therefore expect the monetary policy spillovers in a low-rate environment to also be influenced by banks' expectations with regard to how long low or negative interest rates in the core will last.

Furthermore, we expect that the spillover of monetary policy shocks in the core to the SOEs is stronger for multinational banks that have operations in both the core and the SOEs. As is shown by Bräuning and Ivashina (2020), multinational banks with affiliates in both core and SOEs allocate credit and raise funding on a "global" basis, taking into account spatial variation in funding costs and returns. Expansionary monetary policy in the core incentivizes these banks to rebalance their global balance sheets, which may lead to changes in lending to the SOEs. We also expect that monetary policy spillover from the core to the SOEs affects banks' risk portfolios in the SOEs. An expansionary spillover induces banks in the SOEs to take more risks, which adds to extra volatility in banks' profitability and results in more non-performing loans, and vice versa. The well-established risk-taking channel that monetary policy influences banks' incentive to take risks (Jiménez et al., 2014) should hold in the international context, too.

To test our main Hypotheses 1 and 2, we start by investigating the degree of monetary policy spillovers and whether these spillovers change when the core policy rate is low. For this purpose, we estimate the following baseline model:

$$\Delta Y_{b,t} = \alpha_0 + \beta_1^c \Delta r_t^c + \beta_2^c \Delta Spread_t^c + \beta_3^c Low_t^c + \delta_1^c (\Delta r_t^c \times Low_t^c) + \delta_2^c (\Delta Spread_t^c \times Low_t^c) + \gamma_1 X_{b,t-1} + \gamma_2 Z_{t-1} + f_b + \epsilon_{b,t} \quad (1)$$

where $\Delta Y_{b,t}$ is the relevant credit variable in each SOE expressed as a quarter-on-quarter log-difference in loans granted by bank b at time t. Indexing core countries with c, the monetary policy indicators are the change in the three-month interbank rate (Δr_t^c) and the change in the slope of the yield curve ($\Delta Spread_t^c$), calculated as the spread between ten-year government bond yield and three-month interbank rate. The yield curve slope allows us to control for the effects of unconventional monetary policy as discussed in Section 3. Low_t^c is a dummy variable for a "low interest rate period" which equals one if the three-month interbank rate of the core country is below its first quartile or negative.

Z_t represents the vector of macroeconomic controls (quarterly GDP growth, quarterly CPI inflation) and $X_{b,t-1}$ the vector of lagging bank-level controls (deposits over liabilities, equity over assets, securities over assets, liquid assets over total assets). Given that our bank-level data do not allow us to fully isolate credit demand from credit supply factors that drive bank lending, including macroeconomic controls in Z_t helps control for demand factors. We also include bank fixed effects f_b. We estimate Eq. (1) for each core country × SOE pair separately, due to the highly collinear nature of the monetary policy changes in the core countries.

The formulation of our empirical model closely follows the approach by Claessens et al. (2018), who, in a study aiming to estimate the impact of low interest rate environment on bank profitability, regress the bank's net interest income (or return on assets) on the three-month interbank rate, the spread between the 3-month and 10-year bond yields and a dummy variable for low interest rate periods, controlling for time-varying bank characteristics and macroeconomic controls, and including bank fixed effects. The proposed methodology allows estimating the direct monetary policy spillovers from the core economies to lending in SOEs in the low and normal interest rate environment, while controlling for other factors. By including SOEs' GDP growth and CPI inflation (and later on also the core's GDP growth and CPI inflation), we control for general economic conditions, acknowledging the difficulty of fully addressing the endogeneity in monetary policy. Nevertheless, following one clear and well-established model specification allows for comparability across countries, which is one of the key benefits of this paper.

3. Data and measurements

This section describes the primary sources and features of our data, as well as the measurements of our key variables. We combine several quarterly datasets between 2002Q1 and 2019Q4 for Canada, Chile, the Czech Republic, and Norway. Table 2 provides a summary of the characteristics of our sample, including its coverage, the sources of our data, our sample selection criteria, etc. As can be seen in Table 2, bank-level balance sheet items come from each country's financial

Table 2
Samples' characteristics.

	Canada		Chile		Czech Republic		Norway	
	Total	Median	Total	Median	Total	Median	Total	Median
Number of banks	9	9	15	12	21	21	226	165[c]
Foreign subsidiaries	1	1	6	5	9	9	5	4
Foreign branches	0	0	0	0	0	0	16	10
– Among foreign banks*								
US banks	0	0	1	0	1	1	1	2
EA banks	0	0	3	3	7	7	4	4
UK banks	1	1	0	0	0	0	0	0
SE banks	0	0	0	0	0	0	9	8
Mortgage banks	0	0	0	0	0	0	41	28
	2019Q4	Median	2019Q4	Median	2019Q4	Median	2019Q4	Median
Sample's Shares (% of Total Assets in Banking System)								
Bank assets	95.8%	95.2%	95.0%	94.9%	98.3%	93.8%	100%	100%
Foreign-owned bank assets	1.7%	2.2%	44.5%	41.1%	85.1%	83.4%	21.0%	21.1%
Assets in foreign currencies	45.1%	41.5%	14.4%	14.3%	14.5%	16.0%	21.4%	20.4%
Data source	The Office of the Superintendent of Financial Institutions (OSFI)[a]		Financial Market Commission (Comisión para el Mercado Financiero or CMF, in Spanish)		Czech National Bank supervisory data statistics		Official Financial Reports by Banks and Financial Undertakings (Offentlig Regnskapsrapportering fra Banker og Finansieringsforetak, ORBOF)	
Sample selection criteria	Six largest internationally active banks that are either a GSIB or a DSIB, the two largest non-SIB domestic banks, and the largest foreign subsidiary. Data on these banks construct a balanced panel		The Chilean sample included focuses on internationally active banks relevant to domestic markets, i.e. big and medium-sized banks as classified by Jara and Oda (2015)[b]		The Czech sample contains all active banks and foreign subsidiaries in the Czech Republic as of 2019 (we excluded two banks with dominant state ownership due to their specific business model)		No sample selection. Banks as outcome of M&As are treated as new banks after M&As	
Data	Consolidated		Unconsolidated		Unconsolidated		Unconsolidated	

* According to the locations of headquarters of foreign subsidiaries/branches.

[a]The OSFI supervises federally chartered commercial banks, trust and loan companies, and foreign bank branches.

[b]Retail banks are not internationally active, while tesoreria banks do not participate in domestic credit markets (Jara and Oda, 2015).

[c]Domestic banks include 99 savings banks ("sparebank", 2019Q4) that were originally established by Norwegian municipalities as independent entities without external owners, taking deposits and providing credit to local households and regional businesses. In 1987 savings banks were entitled to raise external equity in capital market and compete in the same credit market as commercial banks; the difference between savings banks and commercial banks is negligible since then.

supervisory agencies.[4] Except Canada, the collected series correspond to unconsolidated bank data. Banking institutions included in our analysis are representative, as they hold more than 95% of the total assets of the entire banking system in each jurisdiction. Mergers and acquisitions (M&As) are treated differently depending on each country's idiosyncrasies, aiming for simplicity and a proper illustration of the banking system. Thus, in Canada and the Czech Republic, banks that disappeared after M&As are only tiny banks so that only those active banks at the end of 2019 are included in the sample, resulting in a balanced panel of banking institutions. In Chile and Norway, the panel is unbalanced, as they allow banks to merge.[5]

This sample comprises internationally active banks under the scope of local regulation: Domestic-owned banks and foreign subsidiaries are included for all four economies, while for Norway, foreign branches and mortgage banks are also included. As a result, our sample of banks is exposed to changes in foreign monetary policy from core countries, even though foreign-owned banks and foreign currency assets shares are heterogeneous across countries.

Table 3 summarizes the main set of variables used in our empirical analyses described in the following section. For left-hand side variables, we consider the rates of growth in banks' credit to the private sector, as well as credit to different sectors (mortgage, consumer, and corporate loans).[6] In order to deal with extreme values, the dependent variables were winsorized at a 1% level. Also, we include a conventional set of banks' controls (deposits over liabilities, equity over assets, securities over assets, liquid assets over total assets), as well as macro-financial control variables (GDP growth, inflation, domestic interest rates, and time dummies).

Our monetary policy indicators are the three-month interbank rate and the slope of the yield curve, calculated as the difference between ten-year government bond yield and the three-month interbank rate. The combination of these two variables is commonly used in the literature to approximate the impacts of monetary policy for good reasons. The central bank controls the short-term interest rate closely through the policy rate. Its effect on the yield curve is rather indirect, through forward guidance – the communication about future policy rate path – and through large-scale asset purchases. Indeed, the empirical evidence shows that these monetary policy measures have had a considerable impact on the yield curve at all maturities, affecting not only the expectations component of the yield curve but also the term premium (Filardo and Hofmann, 2014; Hördahl and Tristani, 2014). Following Borio and Gambacorta (2017) and Claessens et al. (2018), we define a period as a "low interest rate period" if the three-month

[4] In the Czech Republic, the Czech National Bank (CNB) also supervises domestic banks and subsidiaries as well as, to a limited extent, branches of foreign banks.

[5] In Chile, a dummy variable accounts for the mergers to reflect frequent M&As in the sample horizon. In Norway, by the definition of the data provider, M&As result in new banks.

[6] In Canada, one of the implementations of the International Financial Reporting Standards imposed banks to bring off-balance sheet mortgage-backed securities back on the balance sheet in 2011Q4. A dummy variable taking the value of 1 in 2011Q4 and 0 otherwise is added to the right-hand side of all Canadian estimations described below.

Table 3
Summary statistics.

	Canada (9 banks)[b]							Chile (15 banks)						
	Obs	Min	p25	p50	Mean	p75	Max	Obs	Min	p25	p50	Mean	p75	Max
LHS: QoQ credit growth (%)														
Total	639	−28.0	2.4	6.2	6.5	10.6	46.7	885	−8.7	0.3	1.9	2.5	3.9	83.6
Mortgages	639	−50.0	1.0	6.1	5.9	11.2	40.6	828	−14.8	1.2	2.5	3.1	4.3	74.6
Consumer	639	−59.0	−0.6	5.2	6.4	12.6	100.3	828	−16.3	0.2	2.0	3.1	4.1	84.2
Corporate	639	−57.8	−2.8	6.1	6.5	17.1	78.1	885	−8.8	−0.2	1.8	2.5	4.1	114.0
Bank control variables (ratios in %)[a]														
Deposits to liabilities	639	36.0	44.6	50.6	53.8	59.1	84.6	885	0.0	65.0	71.0	69.0	76.0	96.0
Capital to assets	639	3.6	4.7	5.4	5.6	6.0	9.8	885	0.0	6.0	7.0	8.0	9.0	27.0
Liquid assets	639	0.5	8.3	11.8	11.6	15.0	27.6	885	2.0	11.0	15.0	16.0	20.0	49.0
Securities assets	639	4.6	16.6	21.9	21.5	26.9	42.5	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Macro-financial control variables (%)														
GDP growth	72	−9.1	1.0	2.3	2.0	3.5	5.9	72	−4.2	0.3	0.9	0.9	1.4	3.4
Inflation rates	72	−3.9	1.1	1.7	1.9	2.9	5.3	72	−0.8	0.2	0.8	0.8	1.3	3.1
Domestic interbank rate	72	0.4	1.2	1.5	2.0	2.8	4.9	72	0.4	2.7	3.4	3.7	5.0	8.2
Domestic Spread	72	−0.3	0.8	1.1	1.4	2.1	3.4	62	−2.6	0.2	0.9	1.2	1.8	5.7
Change in domestic rate	72	−1.5	0.0	0.0	0.0	0.1	0.5	72	−4.1	−0.2	0.0	−0.1	0.3	1.3
Change in domestic Spread	72	−0.7	−0.2	−0.1	0.0	0.1	0.7	61	−2.3	−0.3	−0.1	−0.1	0.2	3.7
Domestic Low IR period	72	0.0	0.0	0.0	0.3	0.5	1.0	72	0.0	0.0	0.0	0.3	1.0	1.0

	Czech Republic (21 banks)							Norway (226 banks)						
	Obs	Min	p25	p50	Mean	p75	Max	Obs	Min	p25	p50	Mean	p75	Max
LHS: QoQ credit growth (%)														
Total	1,353	−4.9	0.0	2.5	3.4	6.1	15.8	8,904	−35.3	0.4	2.1	3.1	3.9	88.9
Mortgages	1,308	−9.2	0.2	3.0	4.3	7.1	22.8	8,134	−26.9	0.3	2.3	2.8	4.2	66.4
Consumer	984	−27.0	−1.0	2.1	4.9	7.7	52.6	8,131	−100.0	−5.8	0.6	0.7	7.3	100.0
Corporate	1,334	−12.8	−3.1	0.8	2.4	5.9	26.5	8,417	−57.2	−1.0	1.7	2.4	4.7	93.0
Bank control variables (ratios in %)[a]														
Deposits to liabilities	1378	0.0	60.8	77.7	73.3	96.9	100.0	8904	0.0	56.0	72.0	63.0	82.0	99.0
Capital to assets	1378	1.4	5.9	7.9	10.4	11.1	99.6	8904	−16.0	7.0	9.0	10.0	12.0	100.0
Liquid assets	1378	0.0	1.7	8.6	13.5	20.9	82.0	8904	0.0	3.0	5.0	8.0	8.0	100.0
Securities assets	1295	0.0	5.8	16.5	20.9	32.4	76.8	8904	−7.0	6.0	9.0	10.0	13.0	85.0
Macro-financial control variables (%)														
GDP growth	72	−3.4	0.4	0.7	0.7	1.2	2.7	72	−6.3	−3.2	−0.8	0.5	3.3	9.8
Inflation rates	72	−0.8	0.1	0.4	0.5	0.7	3.9	72	−1.6	0.1	0.4	0.5	0.8	2.7
Domestic interbank rate	72	0.3	0.5	1.7	1.7	2.4	4.3	72	0.8	1.5	2.1	2.7	3.1	7.2
Domestic Spread	72	−0.8	0.7	1.3	1.3	2.0	3.4	72	−1.9	−0.1	0.5	0.5	1.2	2.8
Change in domestic rate	71	−1.2	−0.2	0.0	0.0	0.1	0.6	71	−2.5	−0.1	0.0	−0.1	0.2	0.6
Change in domestic Spread	71	−0.8	−0.4	0.0	0.0	0.2	2.1	71	−1.1	−0.3	−0.1	0.0	0.2	2.2
Domestic Low IR period	72	0.0	0.0	0.0	0.3	1.0	1.0	72	0.0	0.0	0.0	0.3	0.5	1.0

[a]In this table, we present bank control variables in percentages (ratios multiplied by 100) for more detail and better comparison between countries; in the actual regression, however, bank controls are included as simple ratios not multiplied by 100. Remaining variables enter the regression in the same units as presented in this table.
[b]In Canada, domestic lending is defined by loans in Canadian dollars. In addition, there was a large change in the reporting of federally regulated banks' balance sheets in 2011Q4 due to the application of the International Financial Reporting Standards. We apply a dummy variable to control for its impact.

interbank rate of the core country is below its first quartile or negative. Specific threshold values that define low-interest rate periods in the US, euro area, UK, and Sweden are 0.28, 0.00, 0.57, and 0.00, respectively.

Our baseline monetary policy indicators should capture well changes in both conventional and unconventional monetary policy.[7] Besides these indicators, we also employ three alternative monetary policy indicators in our robustness tests to address various concerns on monetary policy measures: (i) shadow interest rates that characterize the term structure of interest rates, in order to better reflect monetary policy stances especially at the ZLB (Wu and Xia, 2016, 2020); (ii) residuals from SVAR, which are based on a VAR identified using daily data and changes in fed funds futures occurring on FOMC days, that considers output, inflation, and a variety of interest rates to better reflect monetary shocks (Gertler and Karadi, 2015), and (iii) residuals from the Taylor Rule which are estimated as the deviation of actual monetary policy rate from the monetary policy rate implied by the Taylor Rule: Residuals above zero indicate monetary policy tightening, while residuals below zero proxy for monetary policy easing. Fig. 1 shows the dynamic of baseline monetary policy indicators alongside the lending growth for each SOE while Figure A.2 compares the dynamics of our baseline and alternative monetary policy indicators in core countries.

4. Results

4.1. Baseline results

Table 4 presents a cross-country comparison of the baseline model estimates. The model specification in Eq. (1) is estimated for each core country separately. Hence, the table contains three columns for each country, exploring spillovers from the US, EA and UK, and an additional column for Norway that includes results focusing on Sweden as a core country. Estimates for a full list of control variables can be found in the Online Appendix.

[7] It is important to note that the baseline measure of monetary policy retains sufficient variation also at the ZLB for us to identify the effects of core country spillovers on lending and financial stability.

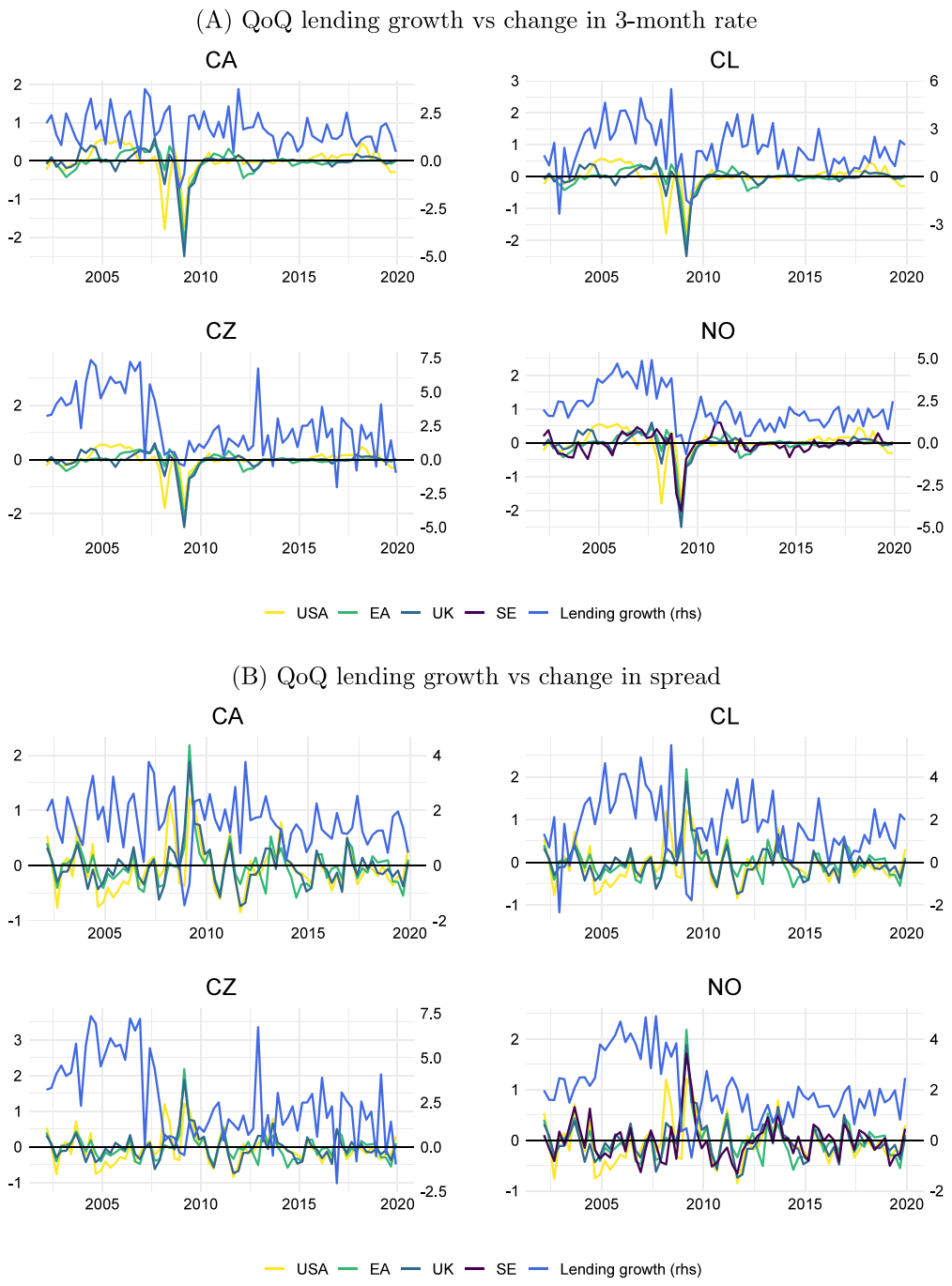

Fig. 1. Baseline monetary policy indicators vs lending growth.

When core countries' policy rates are normal, our results suggest that there are substantial spillovers (depending on the countries, the transmission works either through short-term interest rates or spreads), and that expansionary monetary policy in the core decreases lending in CCCN. This finding is consistent with a portfolio channel, where lower core countries' policy rates improve borrower quality in the core and induce banks to reallocate credit from the SOE to the core. In economic terms, the estimated effects are sizeable. As the row of Δr_t^c in Table 4 shows, among the core countries whose monetary policies generate significant spillovers to SOEs, a 1 unit reduction in a core countries' policy rate is associated with a 1.36–4.46 pp average decrease in quarter-on-quarter lending in the SOEs.

However, this relationship changes substantially when core policy rates are low, as highlighted by the negative coefficient on $\Delta r^c \times Low^c$. This suggests that lending in the SOEs reacts to changes in the core countries' policy rates significantly differently in the low interest rate periods. When policy rates are low, a decrease in the core countries' policy rates is associated with faster growth in domestic bank lending, suggesting that the portfolio channel is outweighed by the international bank lending channel. This effect is found significant in the case of Canada, the Czech Republic and Norway. For the Czech Republic, the relationship passes through changes in the spread of the EA rates, while for Canada and Norway the effect transmits through US short-term interest rates and those of the SE and UK, respectively.

To visualize our results, we calculate marginal effects at mean values of other covariates and plot the adjusted effects for different values of short-term interest rate and spread changes (see Figures B.3–B.5 in Appendix). The difference in effect between the two periods suggests

Table 4
Baseline results.

	Canada			Chile		
	US	EA	UK	US	EA	UK
	(1)	(2)	(3)	(4)	(5)	(6)
Δr_t^c	**2.98****	**3.73***	**4.46****	0.47	**2.18*****	**1.36****
	(1.45)	**(1.97)**	**(1.94)**	(0.68)	**(0.56)**	**(0.62)**
$\Delta Spread_t^c$	2.00	0.54	2.07	-0.16	0.54	**-0.83*****
	(1.32)	(1.56)	(1.57)	(0.28)	(0.44)	**(0.26)**
Low_t^c	0.57	-1.14	**-1.44***	-0.57	-0.01	-0.30
	(0.83)	(1.02)	**(0.73)**	(0.68)	(0.59)	(0.77)
$\Delta r_t^c * Low_t^c$	**-38.74***	-18.86	-10.07	-8.13	10.16	-1.67
	(21.93)	(14.35)	(10.22)	(8.60)	(12.26)	(2.97)
$\Delta Spread_t^c * Low_t^c$	-3.94	-2.73	-2.13	-0.51	-0.75	0.21
	(2.42)	(2.31)	(2.50)	(1.05)	(0.91)	(0.95)
N	648	648	648	885	885	885
No. of banks	9	9	9	15	15	15
Adjusted R^2	0.403	0.403	0.405	0.440	0.450	0.440

	Czech Republic			Norway			
	US	EA	UK	SE	US	EA	UK
	(7)	(8)	(9)	(10)	(11)	(12)	(13)
Δr_t^c	0.06	**1.82*****	0.83	**2.68*****	**1.38*****	**4.11*****	**2.75*****
	(0.47)	**(0.59)**	(0.56)	**(0.38)**	**(0.43)**	**(0.50)**	**(0.46)**
$\Delta Spread_t^c$	0.03	**1.35*****	0.63	**1.32*****	0.32	**1.22*****	**1.71*****
	(0.45)	**(0.50)**	(0.57)	**(0.35)**	(0.30)	**(0.42)**	**(0.40)**
Low_t^c	**-1.70*****	**-1.45*****	**-1.93*****	**-2.90*****	**-0.54****	**-2.70*****	**-1.42*****
	(0.31)	**(0.38)**	**(0.29)**	**(0.30)**	**(0.26)**	**(0.32)**	**(0.25)**
$\Delta r_t^c * Low_t^c$	-5.98	1.55	-3.83	**-7.26*****	-0.97	-7.63	**-5.70****
	(6.58)	(7.50)	(3.02)	**(2.27)**	(5.31)	(6.88)	**(2.62)**
$\Delta Spread_t^c * Low_t^c$	0.13	**-2.46****	0.08	-1.28	0.03	-0.28	**-1.55****
	(1.00)	**(1.11)**	(0.95)	(0.92)	(0.83)	(0.94)	**(0.68)**
N	1,274	1,274	1,274	8,904	8,904	8,904	8,904
No. of banks	21	21	21	226	226	226	226
Adjusted R^2	0.165	0.166	0.173	0.266	0.254	0.268	0.258

The table presents the coefficient estimates of regression specification (1) whereby the dependent variable is a QoQ growth (in %) in domestic lending (excl. interbank loans) by bank b in quarter t in a small open economy outlined on top (Canada, Chile, the Czech Republic or Norway), and the dependent variables are (1) a quarterly change (first difference) in average 3-month interbank rate in a core country/currency c (US, EA, UK or SE) in quarter t, (2) a quarterly change (first difference) in the spread between the average 10-year government bond yield and the average 3-month interbank rate in currency c in quarter t, (3) a dummy variable Low equal to 1 if the average 3-month interbank rate in currency c in quarter t was lower than the 25th percentile within years 2002–2019, and (4 and 5) interaction terms between dummy Low and the other two variables. The specification includes bank-fixed effects and time-varying bank and macro controls, but for brevity they are not reported. Full tables can be found in the Appendix. Every column presents results for a different core country/currency c, and columns are grouped by a small open economy. Note: ***, ** and * denote the 1%, 5% and 10% significance levels. Robust standard errors reported in parentheses, clustered on bank level. Bank fixed effects and control variables included.

that different transmission channels are at play. During the low interest rate period, marginal effects are mostly negative, as indicated by mostly downward sloping red lines. This suggests that positive (negative) changes in the core countries' policy rates, i.e. monetary tightening (easing) in core countries, are associated with slower (faster) lending growth in SOEs. This result supports the existence of an international bank lending channel. In contrast, mostly upward sloping blue lines suggest the dominance of the portfolio channel when policy rates are normal.

Based on our results, we are able to identify which core policy rates matter for the different countries in our sample. In this respect, we find that changes to the policy rates in the euro area are associated with changes in lending in all four countries. The UK policy rates matter for Chile, Norway and Canada while the US policy rates matter for Canada and Norway. On top of that, we find that Norway is highly exposed to changes in the policy rates of its neighbor, Sweden, suggesting that the neighboring countries can have similar types of spillovers as major economies.

Having investigated the general role of a low interest rate environment in international monetary policy spillovers, we next provide evidence on the transmission mechanisms, e.g. in terms of the duration of the low interest rate period, the role of international banks, and variation across different types of lending.

4.2. Persistently low interest rates

Banks are unlikely to substantially change their behavior if the low level of core countries' policy rates is only transitory. Next, we therefore investigate whether the monetary policy spillovers in the low interest rate environment depend on whether or not the policy rate is expected to stay low for a long period of time. We explicitly focus on the role of the duration of the low interest rate period. For this purpose, we include a "low-for-long" variable, $Lowforlong^c$, which is defined as the number of consecutive quarters in which the Low^c dummy is equal to one (i.e. the short-term interest rate has been below its first quartile). The inclusion of this variable on the one hand controls for the fact that core countries' policy rates might need to stay low for some time before SOEs' banks start reshuffling the funding sources towards using more funding from the core; on the other hand, the length of the low interest rate period might be informative about the expectations that policy rates will stay low in the future.

Results of the estimation of Eq. (1) including the $Lowforlong^c$ variable are reported in Table C.23 in the Appendix. Similarly to the previous exercises, we reach quantitatively and qualitatively similar estimates of the coefficients on policy rates which support our main results. On top of that, we find a statistically significant role of the length of the period during which policy rates remain low or negative. With each subsequent quarter of the core countries' policy rates being below their first quartile, the lending dynamics in SOEs are generally more subdued. The effect linked to the prolonged period of low rates more or less replaces the effect previously identified on the Low^c dummy, suggesting that not only the level of policy rates matters but also the length of the period when they are at low levels.

Not surprisingly, we find a stronger and statistically significant reaction of SOEs' bank lending to the core's spreads in the specification

Table 5
The role of international banks.

	Canada			Chile		
	US (1)	EA (2)	UK (3)	US (4)	EA (5)	UK (6)
Δr_t^c	**2.98****	**3.73***	8.57	0.08	**2.95*****	**1.62****
	(1.45)	**(1.97)**	(6.44)	(0.59)	**(0.76)**	**(0.59)**
$\Delta Spread_t^c$	2.00	0.54	6.09	0.40	**1.11****	0.07
	(1.32)	(1.56)	(9.02)	(0.49)	**(0.47)**	(0.72)
$\Delta r_t^c * Low_t^c$	**-38.74***	-18.86	-18.09	-13.29	15.39	-0.94
	(21.93)	(14.35)	(15.60)	(16.52)	(10.54)	(3.64)
$\Delta Spread_t^c * Low_t^c$	-3.94	-2.73	-7.87	**-3.54*****	**-2.98*****	-0.98
	(2.42)	(2.31)	(9.87)	**(0.74)**	**(0.91)**	(1.00)
Low_t^c	0.57	-1.14	**-1.45****	**-1.30****	0.51	**-1.17*****
	(0.83)	(1.02)	**(0.73)**	**(0.52)**	(0.45)	**(0.32)**
$Low_t^c * Family_b^c$	-	-	-	-	-	-
$\Delta r_t^c * Family_b^c$	-	-	-4.63	0.76	-1.86	-0.80
			(7.09)	(1.30)	(1.23)	(0.92)
$\Delta Spread_t^c * Family_b^c$	-	-	-4.50	-1.71	**-2.75*****	-1.21
			(9.97)	(1.05)	**(0.90)**	(1.12)
$\Delta r_t^c * Low_t^c * Family_b^c$	-	-	-31.75	9.64	-13.19	-1.91
			(19.69)	(17.40)	(30.93)	(4.97)
$\Delta Spread_t^c * Low_t^c * Family_b^c$	-	-	6.45	**5.26*****	**5.46*****	**3.57*****
			(10.91)	**(1.56)**	**(1.25)**	**(1.15)**
N	648	648	648	885	885	885
No. of banks	9	9	9	15	15	15
Adjusted R^2	0.403	0.403	0.403	0.450	0.450	0.440

	Czech Republic			Norway			
	US (7)	EA (8)	UK (9)	SE (10)	US (11)	EA (12)	UK (13)
Δr_t^c	0.02	2.98	0.84	**2.02*****	**1.47*****	**3.39*****	**2.42*****
	(0.53)	(1.88)	(0.65)	**(0.34)**	**(0.38)**	**(0.40)**	**(0.43)**
$\Delta Spread_t^c$	0.04	**3.02***	0.68	**0.96*****	0.45	**1.28*****	**1.57*****
	(0.51)	**(1.63)**	(0.68)	**(0.31)**	(0.28)	**(0.33)**	**(0.37)**
$\Delta r_t^c * Low_t^c$	-4.54	**-37.56***	-3.43	**-4.11****	-2.72	-8.25*	-1.40
	(7.43)	**(21.50)**	(3.61)	**(1.68)**	(3.83)	(4.98)	(1.87)
$\Delta Spread_t^c * Low_t^c$	0.41	**-6.39****	-1.02	-0.73	-0.36	-0.50	**-1.74*****
	(1.13)	**(3.20)**	(1.13)	(0.71)	(0.61)	(0.69)	**(0.53)**
Low_t^c	**-1.57*****	0.18	**-2.10*****	**-2.39*****	**-0.75*****	**-2.40*****	**-1.19*****
	(0.35)	(1.09)	**(0.35)**	**(0.23)**	**(0.21)**	**(0.25)**	**(0.20)**
$Low_t^c * Family_b^c$	-0.63	-1.67	0.53	**-4.59*****	2.44	-2.50	-2.61
	(0.72)	(1.09)	(0.62)	**(1.60)**	(2.21)	(1.82)	(1.85)
$\Delta r_t^c * Family_b^c$	0.20	-1.24	-0.02	**7.01*****	-1.25	**7.16****	3.76
	(1.07)	(1.94)	(1.14)	**(2.27)**	(3.58)	**(3.01)**	(2.80)
$\Delta Spread_t^c * Family_b^c$	-0.03	-1.87	-0.15	**3.65***	-1.68	-0.74	1.65
	(1.03)	(1.71)	(1.23)	**(2.19)**	(2.07)	(2.86)	(2.59)
$\Delta r_t^c * Low_t^c * Family_b^c$	-6.76	**44.72****	-1.18	**-26.72***	22.09	4.65	**-49.70****
	(15.63)	**(22.62)**	(6.48)	**(14.25)**	(47.71)	(44.48)	**(21.79)**
$\Delta Spread_t^c * Low_t^c * Family_b^c$	-1.31	4.49	**3.50***	-5.24	4.85	2.07	1.91
	(2.39)	(3.38)	**(2.03)**	(5.54)	(7.19)	(6.16)	(5.56)
N	1,274	1,274	1,274	8,904	8,904	8,904	8,904
No. of banks	21	21	21	226	226	226	226
Adjusted R^2	0.162	0.174	0.174	0.271	0.254	0.272	0.262

The table presents the coefficient estimates of a regression that is similar to specification (1) but includes a dummy variable $Family$, which equals to 1 if bank b had a family member (a branch, a subsidiary or a headquarter) belonging to the same banking group in both the small open economy outlined on top and the core country c. The dummy $Family$ is interacted with the dummy Low, the change in 3-month rate and the change in spread. The triple interactions test whether the results revealed by interaction terms in the baseline regression are stronger/weaker for banks with family members in the core countries. Note: ***, ** and * denote the 1%, 5% and 10% significance levels. Robust standard errors reported in parentheses, clustered on bank level. Bank fixed effects and control variables included.

with the $Lowforlong^c$ variable. By controlling for the effect of each subsequent quarter of low policy rates, we reveal the impact of changing expectations about the core's monetary policy (captured by a rotating yield curve) on SOEs' lending. Specifically, a decrease in the slope of the yield curve at low policy rates translates to higher lending dynamics in Canada and Norway, expanding on our baseline results.

4.3. The role of international banks

Having established the existence of cross-border monetary policy spillovers, we next test whether these spillovers are mostly driven by multinational banks. For this purpose, we define a dummy variable $family_b^c$ capturing whether the bank b has a family member (i.e. a branch, subsidiary or headquarter) belonging to the same banking group in a core country c. We form double and triple interaction terms to explore the differences.

The results of these estimations are presented in Table 5. During a low interest rate period, the $family_b^c$ dummy plays a role especially in Norway. In particular, as indicated by the negative and statistically significant coefficient on the triple interaction term between the short-term interest rate, the Low^c dummy, and the $family_b^c$ dummy, the negative effect of the Swedish policy rate on Norwegian domestic bank lending when policy rates are low is much stronger for banks that have a family member in Sweden. Similarly, the same effect of the UK policy rate is stronger for banks that have a family member in the UK. This lends support to the internal capital market channel, whereby banks with access to money markets or central bank liquidity in low interest rate countries channel that cheap liquidity to higher-yield countries. Potential limits to arbitrage, possibly caused by post 2007–2009 crisis regulations and evidenced by deviations in covered interest rate parity (CIP), might have contributed to making this possible.

The interpretation is less conclusive for the other countries, with effects often going in the opposite direction. For example, the change in the core countries' spread during the low interest rate periods has a significantly positive effect on the domestic lending of Chilean banks with a family member in the core but a negative effect on the domestic lending of Chilean banks without such a member. Similar effects can be observed for the Czech Republic.

Furthermore, when the core countries' policy rate is normal, the interaction terms with the $family_b^c$ dummy are mostly not statistically significant, with the exception of Norway. Here we can see again a much stronger positive reaction in the domestic lending of banks with a family member in the core country.

Nevertheless, the significant results for Norway and the lack of significance for other SOEs may be explained by the fact that Norway has enough variation to test the triple interaction, as it has a relatively large

group of banks. The lack of variation (low number of banks) in other countries can explain why results are less precise. The mixed evidence might also be generated by the fact that well-functioning interbank markets are a fairly good substitute for internal capital markets in terms of shifting liquidity.

4.4. Bank lending across loan categories

In Tables C.14–C.16 in the Appendix we investigate whether the core monetary policy spillovers vary across loan categories. Our presumption is that the spillovers from core economies' monetary policy might have a differential impact on different types of loans if risk varies across these loans. We differentiate here between corporate, mortgage and consumer loans. Our results indicate that when core countries' policy rates are normal, the transmission works to a varying degree through all loan categories, with corporate loans being affected in all countries by the rate of at least one core country. In addition, as the countries in our sample are SOEs, the export-import orientation of firms and the usage of foreign currency loans may play a role. For example, exporters use foreign currency loans as a natural hedge against exchange rate risk in the Czech Republic.[8,9]

The results with regard to the period of low interest rates indicate substantial differences across countries and loan categories. More specifically, the negative effect of the core country's policy rate changes seems to be passed on the SOEs mostly through mortgage and consumer loans when interest rates are low. For example, the interactions between the Low^c dummy and changes in core countries' policy rates are significant and negative for Norway and Chile in the cases of both mortgage and consumer loans and for Canada in the case of mortgage loans, consistent with a search-for-yield channel in the low interest rate environment. This channel appears strong with SE, UK and EA rates for Norway, and all three core policy rates for Canada and Chile. The effect on corporate loans is significant and negative, however, only for Chile (US policy rate) and Norway (SE policy rate).

4.5. Implications for financial stability

Our results so far indicate that spillovers from monetary policy changes in the core during periods when their interest rates are low are associated with increasing loan volumes as well as with a shift in the composition across loan categories. In this subsection, we further explore whether low interest rates in the core also generate direct implications for bank risk and thus for financial stability. For this purpose, we run our baseline regression specification (1) using various bank risk measures as the dependent variables. Tables 6–8 present the results for the following dependent variables: z-score, standard deviation of return on assets (ROA) and a ratio of non-performing loans (NPL) to total assets, respectively. Table 6 shows that the coefficient of interest on the interaction term between the short-term interest rate and the Low dummy is statistically significant at least at 10% level only when this coefficient is positive. The results are significant for the following SOE-core pairs: Canada–EA, Chile–EA, Chile–UK, Czech Republic–US, Norway–SE, Norway–EA, and Norway–UK. This suggests that a decrease in a core countries' policy rate is associated with a lower z-score, i.e., higher bank risk, in SOEs, particularly when the core countries' policy rates are already low or negative.

Table 7 suggests that the results on the z-score are at least partially driven by the denominator, i.e., ROA volatility. The coefficient of interest on the interaction term between the short-term interest rate and the Low dummy is negative and statistically significant at the 1% level for the following SOE-core pairs: Canada–EA, Chile–EA, and Norway–UK. For all other pairs the coefficient is insignificant. When using the ratio of NPL over total assets as the dependent variable, the same coefficient is negative and statistically significant for Canada–US, Canada–EA, Canada–UK, and Czech Republic-EA (see Table 8). For other SOE-core pairs it is mostly negative but not statistically significant. Hence, a decrease in core countries' policy rates, especially when policy rates are low, is associated with higher ROA volatility and NPL ratio in SOEs.

Overall, our results suggest that expansionary monetary policy in core economies is associated with higher bank risk in SOEs, especially when interest rates in the core economies are low or negative.

5. Robustness checks

In this section, we explore the sensitivity of our main results to alternative monetary policy indicators, different sets of control variables as well as the estimation approaches.

5.1. Alternative monetary policy indicators

The first alternative we explore is shadow interest rates. In the baseline regression equation, we replace both three-month interbank rate and the spread with the estimated shadow interest rates. Following Wu and Xia (2016, 2020) we compute the shadow rates using information from longer-term interest rates to infer a hypothetical short-term interest rate in the absence of a ZLB. Empirically, the shadow rate is extracted from the term structure of interest rates, especially medium- and long-term interest rates. As shadow rates are estimated using the whole yield curve, they enter the model specification alone, that is, without the yield curve spreads. We keep the definition of the low interest rate period as before for comparability of estimates (i.e. the period is the same as in the baseline regression).

The full regression results are presented in Table C.20 in the Appendix, demonstrating that our main results are robust to using shadow rates. The estimates on the coefficients of shadow rates remain quantitatively and qualitatively very similar, even though their precision decreases in some instances. In other words, an increase in the core's shadow rate has a positive effect on lending in the SOEs when interest rates are normal and a negative effect if they are low or negative.

The evidence for the international bank lending channel during the low interest rate period remains statistically significant for the Czech Republic and Norway, while revealing some additional channels for Canada. Specifically, Canadian lending responds significantly to monetary policy changes in the euro area and UK. Our results with shadow rates also reveal an additional channel from euro area monetary policy to Norwegian domestic lending at low rates which is not present in our baseline specification, consistent with unconventional monetary policy in the euro area having a significant impact on bank lending in Norway. The effect for Chile remains statistically insignificant while the sign of estimated coefficients points to the same direction as for the other three SOEs. The picture is very similar during the period with normal interest rates, supporting our previous evidence for the portfolio channel.

Finding robust estimation results when using shadow rates instead of short-term interbank rates emphasizes the importance of controlling for unconventional monetary policy in the identified transmission channels. As evident from our baseline results, both portfolio and international bank lending channels remain at play if we consider a proxy for changes in the yield curve, calculated as a spread between long and short rates. Not surprisingly then, the alternative specification with shadow rates provides consistent results as they are estimated using the whole yield curve.

Second, we replace our baseline monetary policy indicators with either the residuals of SVAR or the Taylor Rule. A potential identification

[8] The share of foreign currency loans in banks' total corporate loans grew from around 10% to 30% during the period analyzed in the Czech Republic. The share of the foreign currency loans of the 1000 largest exporters was higher, accounting for more than half of banks' loan portfolio as of 2018.

[9] For Chile, we also find differences depending on the currency in which the loan is denominated (not reported).

Table 6
Financial stability analysis. Outcome: z-score.

	Canada			Chile		
	US	EA	UK	US	EA	UK
	(1)	(2)	(3)	(4)	(5)	(6)
Δr_t^c	**3.531*****	**2.926****	**2.999****	8.045	-3.244	0.362
	(1.177)	**(1.459)**	**(1.263)**	(5.600)	(4.919)	(4.652)
Δ Spread$_t^c$	0.170	-0.993	-0.980	0.974	-4.645	-6.040
	(1.259)	(1.488)	(1.537)	(4.990)	(4.647)	(5.253)
Low$_t^c$	-0.503	**6.963*****	0.197	-5.154	**24.277*****	6.690
	(0.946)	**(1.315)**	(1.060)	(3.178)	**(7.339)**	(4.819)
Δ r$_t^c$ × Low$_t^c$	-14.42	**143.1*****	14.10	-71.822	**336.018*****	**122.662***
	(16.90)	**(25.24)**	(10.84)	(54.547)	**(125.452)**	**(64.639)**
Δ Spread$_t^c$ × Low$_t^c$	0.537	**-8.535****	3.529	-8.243	-12.399	-2.926
	(2.724)	**(3.544)**	(2.560)	(9.094)	(13.283)	(10.298)
N	648	648	648	885	885	885
Adjusted R^2	0.215	0.278	0.221	0.08	0.11	0.09

	Czech Republic			Norway			
	US	EA	UK	SE	US	EA	UK
	(7)	(8)	(9)	(10)	(12)	(11)	(13)
Δr_t^c	**-9.220****	-1.874	-0.259	**1.914****	**2.159*****	**6.066*****	**1.973****
	(3.839)	(4.858)	(4.608)	**(0.863)**	**(0.822)**	**(1.010)**	**(0.925)**
Δ Spread$_t^c$	-3.854	**-9.471****	-3.675	**-5.321*****	**-4.103*****	**-3.899*****	**-7.054*****
	(3.808)	**(4.135)**	(4.751)	**(0.943)**	**(0.778)**	**(0.994)**	**(1.042)**
Low$_t^c$	**15.137*****	**6.221****	**8.193*****	**1.818*****	-0.198	**2.439*****	**2.087*****
	(2.513)	**(3.097)**	**(2.416)**	**(0.552)**	(0.556)	**(0.597)**	**(0.557)**
Δ r$_t^c$ × Low$_t^c$	**102.576***	30.969	7.908	**12.473*****	-0.818	**33.477*****	**10.754*****
	(52.946)	(61.235)	(24.696)	**(3.817)**	(2.081)	**(8.275)**	**(4.038)**
Δ Spread$_t^c$ × Low$_t^c$	-11.175	12.558	-7.622	3.121	**5.236*****	**-7.470*****	**11.363*****
	(8.079)	(9.034)	(7.762)	(2.128)	**(1.986)**	**(2.192)**	**(1.785)**
N	1,240	1,240	1,240	13,385	13,385	13,385	13,385
Adjusted R^2	0.086	0.060	0.064	0.357	0.356	0.362	0.360

The table presents the coefficient estimates of regression specification (1) whereby the dependent variable is the z-score of a bank b in quarter t in a small open economy outlined on top (Canada, Chile, the Czech Republic or Norway), and the explanatory variables are (1) a quarterly change (first difference) in average 3-month interbank rate in a core country/currency c (US, EA, UK or SE) in quarter t, (2) a quarterly change (first difference) in the spread between the average 10-year government bond yield and the average 3-month interbank rate in currency c in quarter t, (3) a dummy variable *Low* equal to 1 if the average 3-month interbank rate in currency c in quarter t was lower than the 25th percentile within years 2002–2019, and (4) and (5) interaction terms between dummy *Low* and the other two variables. The specification includes bank-fixed effects and time-varying bank and macro controls but for brevity they are not reported. Every column presents results for a different core country/currency c, and columns are grouped by a small open economy. Note: ***, ** and * denote the 1%, 5% and 10% significance levels. Robust standard errors reported in parentheses, clustered on bank level. Bank fixed effects and control variables included.

challenge faced by our baseline specification is that bank lending in SOEs may be driven by banks' expectations about monetary policy in the core that in turn is likely to reflect global real economic dynamics. In this sense, both bank lending in SOEs and monetary policy in the core may be driven by confounding expectations about global economic developments. The two alternative monetary policy indicators can help us sharpen the identification and focus on unexpected changes in monetary policy.

In Table C.21 in the Appendix we present the results based on the residual of SVAR, and in Table C.22 in the Appendix we present the results based on the residual of the Taylor Rule. In the case of the Taylor Rule residual we find that the results are qualitatively comparable to those of our baseline model. With regard to the SVAR residual the results are also comparable but the statistical significance of the estimates is lower.

5.2. Alternative sets of control variables

First, we include CCCN's domestic interest rates (3-month interbank rate and spread) in the same structure as the foreign ones in order to control for domestic monetary conditions. Table C.24 presents the results. During the low interest rate period, the significant negative effect of a core country's interest rates on domestic bank lending is preserved for most countries, compared to baseline specification. For some countries, the effect is stronger (Canada and Chile) while for others there is a switch of the significance from one core country's rates to another (the Czech Republic). More specifically in Canada, the impact of the US rate during the low rate period becomes larger and more significant (at 5% compared to that at 10% for the baseline) after controlling for domestic monetary conditions. This provides additional support for the international bank lending channel for Canadian banks during the low rate period through the US rate. For Norway, the results appear to be mostly robust. We presume that the different outcomes from including domestic interest rates are driven by the varying correlation between domestic rates and those in the respective core economy (see Table A.11). Moreover, consistently with the existence of a domestic bank lending channel, both short-term domestic rates and spreads receive negative coefficients for most countries with the exception of Chile. During a period of normal rates, the estimates remain fairly similar to the baseline specification.

As a next step, we consider including additional macroeconomic control variables. We start by including the inflation rates and the GDP growth rates of core countries to account for potential omitted variable bias and potential confounding effects related to the fact that bank lending might be affected by expected global trends in real economic dynamics and real interest rates rather than by loan supply shifts. The results presented in Table C.25 indicate that when rates are normal, including these additional controls does not qualitatively change the estimated coefficients. However, during low-interest rates periods, the results are robust to this new specification for the Czech Republic and Norway, while the estimates become imprecise for Canada and Chile. This divergence across countries might be driven by a varying intensity

Table 7
Financial stability analysis. Outcome: sd(RoA).

	Canada			Chile		
	US	EA	UK	US	EA	UK
	(1)	(2)	(3)	(4)	(5)	(6)
Δ r_t^c	-0.0155	-9.79e-07	-0.0281	-0.027	-0.019	-0.004
	(0.0370)	(0.0350)	(0.0350)	(0.033)	(0.035)	(0.039)
Δ $Spread_t^c$	0.0200	0.0407	0.0388	0.038	0.055*	0.047
	(0.0291)	(0.0287)	(0.0393)	(0.031)	(0.031)	(0.039)
Low_t^c	**-0.0415****	**-0.0551*****	**-0.0503*****	-0.021	**-0.091*****	**-0.041*****
	(0.0162)	**(0.0134)**	**(0.0134)**	(0.014)	**(0.015)**	**(0.014)**
Δ $r_t^c \times Low_t^c$	0.318	**-1.506*****	-0.117	0.497	**-1.349*****	-0.170
	(0.402)	**(0.493)**	(0.0962)	(0.309)	**(0.384)**	(0.127)
Δ $Spread_t^c \times Low_t^c$	-0.0294	0.0552	-0.0493	-0.023	0.045	-0.042
	(0.0428)	(0.0488)	(0.0457)	(0.054)	(0.050)	(0.053)
N	648	648	648	885	885	885
Adjusted R^2	0.174	0.181	0.181	0.54	0.55	0.54

	Czech Republic			Norway			
	US	EA	UK	SE	US	EA	UK
	(7)	(8)	(9)	(10)	(12)	(11)	(13)
Δ r_t^c	0.0002	-0.002	0.0004	**-0.001*****	**-0.002*****	**-0.001*****	-0.000
	(0.001)	(0.001)	(0.001)	**(0.000)**	**(0.000)**	**(0.000)**	(0.000)
Δ $Spread_t^c$	0.0002	-0.0001	0.0004	**0.001*****	0.000	0.001***	**0.001*****
	(0.001)	(0.001)	(0.001)	**(0.000)**	(0.000)	(0.000)	**(0.000)**
Low_t^c	**-0.002*****	-0.001	**-0.002*****	**-0.000****	-0.000*	**-0.001*****	**-0.001*****
	(0.001)	(0.001)	**(0.001)**	**(0.000)**	(0.000)	**(0.000)**	**(0.000)**
Δ $r_t^c \times Low_t^c$	-0.014	0.010	-0.003	0.001	-0.000	-0.001	**-0.003*****
	(0.016)	(0.019)	(0.008)	(0.001)	(0.002)	(0.001)	**(0.001)**
Δ $Spread_t^c \times Low_t^c$	0.001	0.001	0.0004	-0.000	0.001	-0.001	**-0.002*****
	(0.002)	(0.003)	(0.002)	(0.001)	(0.001)	(0.001)	**(0.000)**
N	1,240	1,240	1,240	13,488	13,488	13,488	13,488
Adjusted R^2	0.020	0.019	0.020	0.445	0.447	0.447	0.447

The table presents the coefficient estimates of regression specification (1) whereby the dependent variable is the standard deviation of return on assets (annualized) of a bank b in quarter t in a small open economy outlined on top (Canada, Chile, the Czech Republic or Norway), and the explanatory variables are (1) a quarterly change (first difference) in average 3-month interbank rate in a core country/currency c (US, EA, UK or SE) in quarter t, (2) a quarterly change (first difference) in the spread between the average 10-year government bond yield and the average 3-month interbank rate in currency c in quarter t, (3) a dummy variable *Low* equal to 1 if the average 3-month interbank rate in currency c in quarter t was lower than the 25th percentile within years 2002–2019, and (4) and (5) interaction terms between dummy *Low* and the other two variables. The specification includes bank-fixed effects and time-varying bank and macro controls, but for brevity they are not reported. Every column presents results for a different core country/currency c, and columns are grouped by a small open economy. Note: ***, ** and * denote the 1%, 5% and 10% significance levels. Robust standard errors reported in parentheses, clustered on bank level. Bank fixed effects and control variables included.

of real economic links between the core and the SOEs. Following Section 4.2, we also include the low-for-long dummy here to account for the quarter duration of these periods (Table C.25). For most cases, this dummy variable proves to be negative and statistically significant, absorbing partially the effects previously attributed to interest rates. Further, we add currency pairs between the core and CCCN, and the foreign currency structure of bank funding in the CCCN.

Last but not least, we explore whether our results are robust to expanding the set of bank-level control variables that can pick loan supply effects not necessarily related to monetary policy shocks in core economies. We expand the set of controls by including additional bank-level controls, such as bank size, non-performing loans to total loans ratio, and changes in the house price index. We do not include these controls in the main specification to retain a tractable number of parameters to estimate and assure cross-country comparability that we cannot guarantee in the most saturated specifications since not all additional controls are available for all countries. The results of this robustness exercise indicate that in general, adding more controls does not affect our main estimates.

5.3. Alternative estimations

Last but not least, we turn our attention to employing alternative estimation approaches. For this purpose, in an unreported test, we first consider a dynamic model specification instead of a static one to check for the potential missing variable issue. Reassuringly, estimates related to the coefficients of interest remain quantitatively and qualitatively unchanged.

In unreported tests, we also estimate additional specifications, considering: (i) annual instead of quarter-to-quarter changes of the dependent variable, (ii) different winsorization schemes, (iii) richer lag structure, (iv) contemporaneous macro controls instead of lagged ones, (v) excluding the interest rate spread or using it in level. In all these cases, we observe little to no change in our main estimates.

Finally, in unreported tests we use a dummy variable "easing" interacted with our variables of interest from the baseline specification in order to test if our main results are symmetric in the cases of monetary policy tightening and easing. Our estimates do not indicate any asymmetry.

6. Concluding remarks

Exploring proprietary bank-level data for four countries – Canada, Chile, the Czech Republic, and Norway – we provide evidence on the monetary policy spillovers from core world economies to lending in SOEs. The main takeaway of our analysis is that low interest rates in the core – the US, euro area and UK – reinforce the existence of an international bank lending channel. In other words, during low interest rate periods of the core economies, further expansionary monetary policy in these countries is associated with increased lending in SOEs. In

Table 8
Financial stability analysis. Outcome: Non-performing loans.

	Canada			Chile		
	US	EA	UK	US	EA	UK
	(1)	(2)	(3)	(4)	(5)	(6)
Δ r_t^c	**-0.115*****	**-0.126*****	-0.0401	-0.055	**-0.131***	0.078
	(0.0360)	**(0.0405)**	(0.0403)	(0.068)	**(0.079)**	(0.081)
Δ $Spread_t^c$	0.00341	**0.0633****	**0.0978****	-0.065	-0.049	0.057
	(0.0324)	**(0.0316)**	**(0.0405)**	(0.075)	(0.075)	(0.091)
Low_t^c	**-0.0467*****	**-0.164*****	**-0.121*****	**-0.137*****	**-0.330*****	**-0.263*****
	(0.0137)	**(0.0196)**	**(0.0146)**	**(0.039)**	**(0.048)**	**(0.036)**
Δ $r_t^c \times Low_t^c$	**-0.910****	**-1.001*****	**-0.335*****	-0.444	-0.053	-0.147
	(0.358)	**(0.282)**	**(0.124)**	(0.983)	(0.783)	(0.331)
Δ $Spread_t^c \times Low_t^c$	0.0557	-0.0130	-0.0569	0.013	0.013	-0.135
	(0.0520)	(0.0457)	(0.0499)	(0.149)	(0.118)	(0.118)
N	648	648	648	885	885	885
Adjusted R^2	0.321	0.390	0.352	0.42	0.45	0.43

	Czech Republic			Norway			
	US	EA	UK	SE	US	EA	UK
	(7)	(8)	(9)	(10)	(12)	(11)	(13)
Δ r_t^c	-0.002	**0.005****	0.001	**-0.001****	**-0.002*****	**-0.003*****	-0.001
	(0.002)	**(0.002)**	(0.002)	**(0.000)**	**(0.001)**	**(0.001)**	(0.001)
Δ $Spread_t^c$	**-0.008*****	-0.002	**-0.006*****	-0.001	-0.001	**-0.002*****	-0.001
	(0.002)	(0.002)	**(0.002)**	(0.000)	(0.001)	**(0.001)**	(0.001)
Low_t^c	**0.011*****	**-0.009*****	**0.003*****	**-0.002*****	**-0.002****	0.001	-0.000
	(0.001)	**(0.001)**	**(0.001)**	**(0.001)**	**(0.001)**	(0.001)	(0.001)
Δ $r_t^c \times Low_t^c$	-0.026	**-0.054****	-0.004	-0.002	0.002	-0.006	0.008
	(0.023)	**(0.027)**	(0.011)	(0.004)	(0.019)	(0.008)	(0.011)
Δ $Spread_t^c \times Low_t^c$	**0.012*****	**0.011*****	**0.008****	0.003	-0.001	**0.004*****	0.002
	(0.003)	**(0.004)**	**(0.003)**	(0.002)	(0.002)	**(0.001)**	(0.001)
N	1,254	1,254	1,254	11,773	11,773	11,773	11,773
Adjusted R^2	0.173	0.131	0.105	0.395	0.395	0.395	0.394

The table presents the coefficient estimates of regression specification (1) whereby the dependent variable is the non-performing loans over total assets of a bank b in quarter t in a small open economy outlined on top (Canada, Chile, the Czech Republic or Norway), and the explanatory variables are (1) a quarterly change (first difference) in average 3-month interbank rate in a core country/currency c (US, EA, UK or SE) in quarter t, (2) a quarterly change (first difference) in the spread between the average 10-year government bond yield and the average 3-month interbank rate in currency c in quarter t, (3) a dummy variable Low equal to 1 if the average 3-month interbank rate in currency c in quarter t was lower than the 25th percentile within years 2002–2019, and (4) and (5) interaction terms between dummy Low and the other two variables. The specification includes bank-fixed effects and time-varying bank and macro controls but for brevity they are not reported. Every column presents results for a different core country/currency c, and columns are grouped by a small open economy. Note: ***, ** and * denote the 1%, 5% and 10% significance levels. Robust standard errors reported in parentheses, clustered on bank level. Bank fixed effects and control variables included.

contrast, in normal periods, a core economy's monetary policy expansion can result in shrinking lending volumes in SOEs. This suggests that the portfolio channel dominates outside the low interest rate periods. We also document that when policy rates are low, core countries' policy rate reductions are associated with higher bank risk in SOEs.

We subject our main analysis to a battery of additional tests, which support our main results and further expand our understanding of transmission channels. First, long-term yields and expectations about the future path of the core's monetary policy seem to play an important role in the identified transmission. Specifically, lower long-term yields in core countries during the low policy rate periods tend to contribute to higher lending in the SOEs. Second, we find evidence of internal capital markets fueling the transmission in Norway, as lending by multinational banks exhibits stronger spillover effects; however, the results for other countries show quite the opposite. Third, the international bank lending channel at low policy rates operates through different types of loans, reflecting the specifics of each economy and risk-taking associated with this channel.

The presented results provide an improved understanding of the impact of monetary policy cross-border spillovers and help reconcile the existence of both a portfolio channel and an international bank channel. In terms of policy implications, they illustrate that macroprudential regulators should watch for potential regime switches in the impact of core monetary policy when rates shift to and from the very low end of the distribution, given that our results document that there are not only lending but also risk spillovers. That is, for example, while monetary policy expansions in the core might initially tighten local credit supply in SOEs, the credit supply can start increasing once core economies' rates drop to a sufficiently low level, while bringing about elevated risk levels in the banking sector. The reverse is likely to happen once the core starts tightening its monetary policy.

Appendix A. Supplementary data

Supplementary material related to this article can be found online at https://doi.org/10.1016/j.jfs.2023.101116.

References

Adrian, T., Etula, E., Muir, T., 2014. Financial intermediaries and the cross-section of asset returns. J. Finance 69 (6), 2557–2596.
Altavilla, C., Burlon, L., Giannetti, M., Holton, S., 2022. Is there a zero lower bound? The effects of negative policy rates on banks and firms. J. Financ. Econ. 144 (3), 885–907.
Barbosa, L., Bonfim, D., Costa, S., Everett, M., 2018. Cross-border spillovers of monetary policy: What changes during a financial crisis? J. Int. Money Finance 89, 154–174.
Basten, C., Mariathasan, M., 2018. How banks respond to negative interest rates: Evidence from the Swiss exemption threshold. CESifo Working Paper Series 6901, CESifo Group Munich..
Bernanke, B.S., 1983. Irreversibility, uncertainty, and cyclical investment. Q. J. Econ. (MIT Press) 98 (1), 85–106.
Bernanke, B.S., 1993. Credit in the macroeconomy. Quarterly Review, Federal Reserve Bank of New York.

Bittner, C., Bonfim, D., Heider, F., Saidi, F., Schepens, G., Soares, C., 2020. Why so negative? The effect of monetary policy on bank credit supply across the Euro area. Mimeo, European Central Bank.

Borio, C., Gambacorta, L., 2017. Monetary policy and bank lending in a low interest rate environment: Diminishing effectiveness? J. Macroecon. 54, 217–231.

Bottero, M., Minoiu, C., Peydró, J.-L., Polo, A., Presbitero, A.F., Sette, E., 2019. Negative monetary policy rates and portfolio rebalancing: Evidence from credit register data. IMF Working Papers, International Monetary Fund.

Bräuning, F., Ivashina, V., 2020. Monetary policy and global banking. J. Finance 75 (6), 3055–3095.

Brunnermeier, M.K., Koby, Y., 2018. The reversal interest rate. Working Paper 25406, National Bureau of Economic Research.

Bush, G., Gómez, T., Jara, A., Moreno, D., Styrin, K., Ushakova, Y., 2021. Macroprudential policy and the inward transmission of monetary policy: The case of Chile, Mexico, and Russia. Rev. Int. Econ. 29 (1), 37–60.

Cao, J., Dinger, V., 2022. Financial globalization and bank lending: The limits of domestic monetary policy. J. Financ. Quant. Anal. 57 (8), 3223–3251.

Cecchetti, S.G., Mancini-Grifoli, T., Narita, M., Sahay, R., 2020. US or domestic monetary policy: Which matters more for financial stability? IMF Econ. Rev. 68, 35–65.

Cetorelli, N., Goldberg, L.S., 2012. Banking globalization and monetary transmission. J. Finance 67 (5), 1811–1843.

Claessens, S., Coleman, N., Donnelly, M., 2018. "Low-for-long" interest rates and banks' interest margins and profitability: Cross-country evidence. J. Financ. Intermediation 35 (A), 1–16.

di Giovanni, J., Kalemli-Özcan, Ş., Ulu, M.F., Baskaya, Y.S., 2022. International spillovers and local credit cycles. Rev. Econom. Stud. 89 (2), 733–773.

Eggertsson, G.B., Juelsrud, R.E., Summers, L.H., Wold, E.G., 2019. Negative nominal interest rates and the bank lending channel. Working Paper Series 25416, National Bureau of Economic Research.

Fernández, A., Klein, M.W., Rebucci, A., Schindler, M., Uribe, M., 2016. Capital control measures: A new dataset. IMF Econ. Rev. 64 (3), 548–574.

Filardo, A., Hofmann, B., 2014. Forward guidance at the zero lower bound. BIS Quarterly Review March, Bank for International Settlements.

Gertler, M., Karadi, P., 2015. Monetary policy surprises, credit costs, and economic activity. Am. Econ. J.: Macroecon. 7 (1), 44–76.

Hills, R., Ho, K., Reinhardt, D., Sowerbutts, R., Wong, E., Wu, G., 2019. The international transmission of monetary policy through financial centres: Evidence from the United Kingdom and Hong Kong. J. Int. Money Finance 90, 76–98.

Hördahl, P., Tristani, O., 2014. Inflation risk premia in the Euro area and the United States. Int. J. Central Bank. 10 (3), 1–47.

Jara, A., Oda, D., 2015. Agrupación de instituciones bancarias a partir del análisis de cluster: una aplicación al caso de Chile. Documento de Trabajo 744, Banco Central de Chile, Santiago, Chile.

Jiménez, G., Ongena, S., Peydró, J.L., Saurina, J., 2014. Hazardous times for monetary policy: What do twenty-three million bank loans say about the effects of monetary policy on credit risk-taking? Econometrica 82 (2), 463–505.

Jordá, Ó., Schularick, M., Taylor, A.M., 2011. Financial crises, credit booms, and external imbalances: 140 years of lessons. IMF Econ. Rev. 59, 34–78.

Kashyap, A.K., Stein, J.C., 2000. What do a million observations on banks say about the transmission of monetary policy? Amer. Econ. Rev. 90 (3), 407–428.

Morais, B., Peydró, J.-L., Roldán-Pena, J., Ruiz-Ortega, C., 2019. The international bank lending channel of monetary policy rates and QE: Credit supply, reach-for-yield, and real effects. J. Finance 74 (1), 55–90.

Rajan, R.G., 2006. Has finance made the world riskier? Eur. Financial Manag. 12 (4), 499–533.

Schularick, M., Taylor, A., 2012. Credit booms gone bust: Monetary policy, leverage cycles, and financial crises, 1870-2008. Amer. Econ. Rev. 102 (2), 1029–1061.

Wu, J.C., Xia, F.D., 2016. Measuring the macroeconomic impact of monetary policy at the zero lower bound. J. Money Credit Bank. 48 (2–3), 253–291.

Wu, J.C., Xia, F.D., 2020. Negative interest rate policy and the yield curve. J. Appl. Econometrics 35 (6), 653–672.