Financial Globalization and Bank Lending: The Limits of Domestic Monetary Policy?[1]

Jin Cao and Valeriya Dinger

Abstract

We empirically analyze how bank lending reacts to monetary policy in the presence of global financial flows. Employing a unique and novel dataset in structurally identified regressions, we show that the effectiveness of the bank lending channel is affected when banks can shift to international funding and thus insulate their costs of funding from domestic monetary policy. We isolate the effects of international funding conditions by computing the cost advantage of foreign currency funding in terms of the funding rate differential between domestic and foreign money markets adjusted by the exchange rate dynamics. We find that international funding conditions affect not only banks with access to international markets but also non-international banks via domestic interbank lending.

Keywords: monetary policy, foreign funding channel, bank lending channel, exchange rate dynamics

JEL classification: E52, F36, G21

---

[1] Jin Cao is from the Research Department, Norges Bank, Norway and CESifo, Germany, email: jin.cao@norges-bank.no, address: Bankplassen 2 PB1179 Sentrum, NO-0107 Oslo, Norway. Valeriya Dinger is from University of Osnabrück, Germany, email: vdinger@uni-osnabrueck.de, address: Rolandstraße 8, DE-49069 Osnabrück, Germany and from the Leeds University Business School. The authors thank Joshua Aizenman, Farooq Q. Akram, André K. Anundsen, Söhnke M. Bartram, Henrik Borchgrevink, Markus Brunnermaier, Georgia Bush, Miguel Boucinha, Anusha Chari, Gianni De Nicolò, Julian di Giovanni, Mark Egan, Falko Fecht, Hans Gersbach, Galina Hale, Boris Hofmann, Gerhard Illing, Dirk Krueger, Ulrike Neyer, Steven Ongena, Jean-Charles Rochet, Kasper Roszbach, Anjan Thakor, Francesco Vallascas, Bent Vale, Andrea Vedolin, Jürgen von Hagen, and Frank Westermann as well as participants at seminars in Norges Bank, Bank of Lithuania, University of Munich, University of Zurich, Waseda University, Annual Meeting of the Western Finance Association (WFA), Annual Meeting of Central Bank Research Association at Bank of Canada, CESifo Area Conference on Macro, Money and International Finance, Royal Economic Society Annual Conference, NBRE Spring Institute, ECB and Banco de Portugal workshop "Transmission and Effectiveness of Macroprudential Policies", IFABS Barcelona Conference, German Finance Association Annual Meeting, for useful comments and discussions. This paper should not be reported as representing the views of Norges Bank. The views expressed are those of the author and do not necessarily reflect those of Norges Bank. Declarations of interest: none.

1 Introduction

How does bank lending react to monetary policy in the presence of global financial flows? Conventional wisdom, the so-called "bank lending channel", states that tightening domestic monetary policy raises banks' funding costs in the domestic money market, which leads to a contraction in banks' credit supply, and vice versa (see, for example, Kashyap and Stein, 2000). However, if banks actively fund themselves in international money markets, the traditional bank lending channel may be less effective, or even break down. Research on this issue has been initiated by Cetorelli and Goldberg (2012), who show that global banks active in the US have more diversified sources of liquidity and can thus better insulate themselves from US monetary policy tightening. In recent years, the debate has been extended in the direction of analyzing the spill-over of core economies' monetary policy to emerging economies, where the banking sector is dominated by mostly foreign banks whose assets and liabilities are to a significant extent denominated in a foreign currency (for example, Morais et al., 2019 for the case of Mexico and Baskaya et al. 2017 for Turkey). However, how the monetary policy of core economies interacts with the domestic monetary policy of advanced small open economies is still an open question. Since the banking systems in advanced small open economies are often dominated by domestic banks, and lending is mostly in the domestic currency, the interaction between domestic and global funding costs which is derived from the ability of domestic banks to access global funding sources has been overlooked.

In this paper, we present a first step that empirically analyzes how international funding allows banks to cushion domestic monetary policy shocks in an advanced small open economy, using a novel and unique dataset that includes the currency composition of all balance sheets of the full population of Norwegian banks in the past more than 20 years. First, using standard approaches for identifying the bank lending channel, we show that domestic monetary policy generates very limited explanatory power in explaining bank lending in Norway. This is particularly the case after the central bank, Norges Bank, shifted its monetary policy regime from exchange rate stabilization to flexible inflation targeting in 2001. Our conjecture is that the failure to document a classical bank lending channel for Norway post-2001 is due to the omission of potential changes in the costs of funding of Norwegian banks in international money markets. To approximate the component of international funding costs that is not driven by domestic monetary policy, we compute the cost advantage in foreign currency funding in terms of the funding rate differential between domestic and foreign money markets adjusted by the exchange rate dynamics[2] and include this cost advantage as an additional control variable in our bank lending channel model. Here we particularly benefit from the choice of Norway as a "laboratory", which allows us to focus on fairly exogenous components of the exchange rate dynamics, which are driven by the safe-haven status of NOK investments as well as by oil price dynamics.

Once the cost advantage is included as an additional control in our model, we are able to restore the validity of the lending channel. That is, access to global funding may become favorable for banks if the differentials between the domestic and international money market interest rates are not completely neutralized by the changes in the exchange rate to the degree predicted by interest rate parities, and this, in turn, affects bank lending. This echoes a similar mechanism suggested by Bruno and Shin (2015a), and Baskaya et al (2017). Furthermore, to account for the fact that some of the foreign currency positions of Norwegian banks are hedged, we also rerun the regression using the costs advantage of hedged FX funding positions[3] as an alternative measure for the cost advantage in foreign currency funding. The results remain qualitatively unchanged.

We then explore the channels through which international funding affects the lending of Norwegian banks. We find that the impact of domestic monetary policy is asymmetric: whenever domestic interest rates are rising, lending is not contingent on these, while loosening monetary policy in the form of falling interest rates does increase the capability of banks to lend. Also when the costs of international funding are favorable, bank lending only follows the international funding cost advantage and not domestic monetary policy, while domestic monetary policy affects bank lending when the costs of international funding are not favorable. That is, banks actively arbitrage between global and domestic funding, depending on which costs are the more favorable. Furthermore, international funding does not only affect the lending of large banks, which actively fund themselves in international money market, but also small and regional banks, which have little, if any, access to international funding. Digging deeper into the anatomy of these empirical relations, we find that they are driven by the fact that the international banks exploit favorable funding conditions and increase their foreign currency funding from abroad. This increases their

[2] This corresponds to the deviation of the Norwegian krone exchange rate from the exchange rate predicted by the uncovered interest rate parity (UIP).

[3] This corresponds to the deviation of the Norwegian krone exchange rate from the exchange rate predicted by the covered interest rate parity (CIP), adjusted by the transaction cost.

liquidity supply in the domestic currency to the smaller banks in the domestic money market: the lax international funding conditions are partially passed through in the form of interbank loans to non-international banks, which mainly fund in the domestic market, so that we observe a positive link between the cost advantage in international funding and lending for the *full* sample of Norwegian banks.

Our findings contribute to several strands of the literature. First, we enrich the insights on the bank lending channel by adding further evidence on the cross-border spillovers of monetary policy. Existing literature often focuses on the impact of foreign monetary policy, especially for emerging countries where banks obtain foreign currency funding and issue loans in foreign currencies as well. Temesvary et al. (2018) find that global US banks respond to both domestic and host countries' (Hungarian) monetary policy through cross-border flows via external capital markets from the US to non-affiliates in the host countries, and such a "global bank lending channel" generates a spillover effect of US monetary policy to foreign economies. Morais et al. (2019) show that foreign banks transmit foreign monetary policy to Mexico by increasing the loan supply to local borrowers when foreign monetary policy is soft. Krogstrup and Tille (2015) study the role of the Swiss franc in both bank lending and funding across European countries. They find that in emerging countries CHF funding depends on the exchange rate and the amount of CHF lending, while risk aversion and funding costs matter more in the euro area. Studying the case of Turkey, Baskaya et al. (2017) show that global funding conditions are transmitted to emerging economies. And last but not least, Bräuning and Ivashina (2017) show that even when cross-border positions are hedged in terms of domestic currency, bank lending is still subject to spillover effects which are enforced by the shift of supply in hedging transactions. By contrast, our paper focuses on the effectiveness of domestic monetary policy in a typical advanced open economy, where banks have access to both domestic and foreign currency funding while issuing loans mostly in domestic currency. As we find, banks actively arbitrage between domestic and international money markets, and while domestic monetary policy has limited impact on the latter, the effectiveness of domestic monetary policy transmission through the bank lending channel may be eroded. This is a new complement to the spillover literature.

Second, we contribute to the strand of research on the role of bank heterogeneity in the identification of the lending channel. In their seminal work based on US micro-level data, Kashyap and Stein (2000) find that the impact of monetary policy on lending behavior is quite heterogeneous among banks, and it depends on their liquid asset positions: lending by liquidity-constrained banks is more sensitive to funding shocks. Later, research interest has focused on the role of the internal capital market of big banks: Campello (2002) shows that the internal capital market within a financial conglomerate relaxes credit constraints for its small bank affiliates so that they react less to monetary policy compared with their independent peers. Ashcraft (2006) extends this line of argument by showing that banks affiliated with multi-bank holding companies enjoy better access to external funding, and can, therefore, better shield themselves from negative monetary shocks than stand-alone banks. In recent years, as banks have been increasing their access to the global financial market, the impact of the international funding channel on banks' lending behavior has started to attract attention in research. Using a US bank-level dataset, Cetorelli and Goldberg (2012a) show that US global banks raise funding by reallocating claims between headquarters and foreign subsidiaries, and such an internal capital market makes them better insulated from a contraction in domestic monetary policy. Baskaya et al. (2017) underline that the spillover of foreign monetary policy is mainly driven by large banks with access to international markets, while smaller banks are mostly unaffected by global funding conditions. In this paper, we go one step further and show that the impact of the international funding channel is not restricted to banks and their affiliates that have direct access to foreign currency funding. Through interbank lending in the domestic money market, the effect of foreign currency funding passes through from global banks to regional banks that have almost no access to the international money market.

By showing that the dynamics of exchange rates and global risk aversion affect domestic lending, our findings also echo recent concerns about the rising contribution of international financial factors to domestic credit cycles. Gourinchas and Obstfeld (2012) find that a sharp appreciation of the local currency is a reliable indicator of lending booms and subsequent financial crises. Brunnermeier et al. (2012) argue that the procyclical nature of cross-border bank-intermediated credit flows has given rise to serious economic and financial instabilities. Avdjiev et al. (2015) criticize the "triple coincidence" assumption in the conventional paradigm for monetary economics, i.e., that the GDP boundary coincides with the monetary policy decision-making unit and currency area, for neglecting the effects of international currencies on domestic financial stability. Based on country-level data, Bruno and Shin (2015b) show how US monetary policy spills over to cross-border bank capital flows through fluctuations in banks' risk-taking behavior, amplifying the leverage cycle in the foreign banking sector. On the aggregate level, Rey (2015) finds that the monetary policy of the US affects the leverage of global banks, which leads to co-movements of global asset prices and cross-border capital flows, and credit growth in the international financial system; this results in an "irreconcilable duo" – independent monetary policy is only possible if and only if the capital account is managed. Although our focus in this paper is not on banks' risk-taking behavior or financial stability, our findings imply that the existence of a global funding channel makes domestic monetary policy less effective, especially, for instance, when the central bank wants to tighten its monetary policy and put a brake on a domestic credit boom. This needs to be addressed when macroprudential policies are designed to contain excessive volatilities over credit cycles.

Furthermore, our paper complements the strand of literature on the international co-movements of interest rates and the international monetary policy spillovers to domestic monetary policy (for example, Obstfeld et al. 2005, Forbes and Warnock 2012, and Buch et al. 2018). We do not address the international monetary policy spillovers to domestic monetary policy per se, but instead, we focus on whether the transmission of domestic monetary policy is changed by global funding. In other words, instead of focusing on the mechanical spillover of foreign monetary policy, we rather concentrate on how domestic and foreign monetary policy interact. In our analysis, we attach particular attention to the fact that international interest rate differentials and thus spillovers from foreign monetary policy matter most when exchange rates do not completely adjust to monetary policy, so that funding costs for banks can differ across different currencies.

The structure of our paper is as follows: section 2 describes the institutional framework and the data. Section 3 replicates the approach of classical lending channel studies for the case of Norway and illustrates the failure of the traditional lending channel. Section 4 introduces the effect of global factors measured by the cost advantage in foreign currency funding and shows that this is a driving force of bank lending. Section 5 illustrates the working mechanism of the foreign funding channel, and robustness checks are carried out in section 6. Section 7 discusses the policy implications of our findings and concludes.

2 Institutional Framework and Data

2.1 Norwegian Banking Sector: A Brief Introduction

As of 2017Q4, there are 100 savings banks and 36 commercial banks in Norway; among the commercial banks, 12 are foreign-owned banks, including 6 subsidiaries and 6 branches.[4] The entire Norwegian banking sector is characterized by a high level of concentration – slightly above the EU average: the shares of the deposit market and lending market for the 10 largest banks are both around two-thirds as of 2017Q4 – the number has been fairly stable since 2000 (Ulltveit-Moe et al., 2013, together with our own update).

Commercial banks are limited liability companies. Foreign commercial banks are either subsidiaries or branches of mostly Swedish, Finnish, and Danish banks. The main difference between subsidiaries and branches of foreign banks is that the subsidiaries are subject to Norwegian regulatory requirements, while the branches are subject to the regulatory requirements of their home countries. Notwithstanding this difference, both types of foreign bank institutions are obliged to submit the same set of reports concerning their balance sheet and income statements to the Norwegian statistical authorities.

Savings banks ("sparebank") were originally established by Norwegian municipalities as independent entities without external owners, taking deposits and providing credit to local households and regional businesses. Nowadays, the difference between savings banks and commercial banks is becoming smaller: since 1987, savings banks have been permitted to raise external equity by issuing primary capital certificates (PCCs), although PCCs do not give their holders ownership over the bank's entire equity capital. In 2002 savings banks were given the option of converting to limited liability savings banks.[5] There is full equality under the law between savings banks and commercial banks in terms of what business they may engage in.

What is new and noteworthy in the Norwegian banking sector are the mortgage companies ("kredittforetak"), currently 33 in total as of 2017Q4. They are subsidiaries of some of the commercial and savings banks, were established after a legal change in 2007 and specialize in issuing covered bonds backed by domestic (over 95% are residential) mortgage loans. A small

[4] See Norges Bank Historical Monetary Statistics, available on http://www.norges-bank.no/en/Statistics/Historical-monetary-statistics/Money-credit-and-banking/, as well as Norwegian Savings Banks Association ("Sparebankforeningen"), available on http://www.sparebankforeningen.no, with our own update.
[5] So far only one savings bank, Gjensidige NOR, has done the conversion. Later it merged with the largest commercial bank in Norway, DNB NOR Bank ASA.

share of these covered bonds is eligible as collateral for Norges Bank's liquidity facilities, but the majority are sold in domestic and international markets. As of 2017Q4, total covered bonds outstanding in Norway amounted to EUR 115.183 billion (roughly 15% of total assets of the Norwegian banking sector, or 33% of Norwegian GDP), and about 60% was denominated in foreign currencies.[6] Since a mortgage company's main function is the issuance of covered bonds to fund the mortgage business of its parent bank, we do not consider mortgage companies as separate entities in our estimations but rather match their foreign currency-denominated liabilities to those of the parent banks.[7]

2.2 Monetary Policy Regimes

Before 2001, stabilizing the exchange rate of the Norwegian krone was one of the major concerns. Monetary policy was then characterized by the central bank's frequent active intervention in the foreign exchange market to maintain a managed floating exchange rate vis-à-vis the currencies of major trading-partner countries.[8] However, as Norwegian economy became more and more exposed to the oil sector in the 1980s, and in the absence of capital controls, fluctuations in oil prices could quickly influence wage and price expectations, the exchange rate and long-term interest rates, leading to excess volatilities in the macro-economy. To better anchor the real economy, starting from 2001, Norges Bank officially migrated to a flexible inflation targeting regime.[9] The Regulation on Monetary Policy of March 29, 2001, stipulates that "… Norges Bank's implementation of monetary policy shall, …, be oriented towards low and stable inflation. The operational target of monetary policy shall be annual consumer price inflation of approximately 2.5 per cent over time." It is also stated that "… the international value of the Norwegian krone is determined by the exchange rates in the foreign exchange market."[10] To emphasize the role of inflation targeting as a better anchor for the economy, in a letter to the Ministry of Finance on March 27, 2001, Norges Bank stated that "… the krone is floating, …, as are the exchange rates

---

[6] Our own calculation, based on Finance Norway statistics, available on https://www.fno.no/en/.
[7] All empirical results presented in this paper are robust to the use of the bank balance sheets without consolidation with the corresponding mortgage companies.
[8] "Two years with inflation targeting in Norway and Iceland", Danmarks Nationalbank, 2003, available on http://www.nationalbanken.dk/en/publications/Documents/2003/06/2003_MON2_two73.pdf.
[9] See more background information in Andreassen et al., "Norges Bank Watch 2001", available on http://www.bi.edu/cmeFiles/NBW2001.pdf.
[10] See "Guidelines for Monetary Policy", Norges Bank, available on http://www.norges-bank.no/en/Published/Submissions/2001/submission-2001-03-27html/.

of other small and open economies. The best contribution monetary policy can make to stabilizing exchange rate expectations is to aim at the objective of low and stable inflation…" In fact, the central bank has stopped intervening in the foreign exchange market since January 1999,[11] even after the Norwegian krone appreciated considerably in the early 2000s due to a substantial government budget surplus. As we will argue in section 3, the change in the monetary policy regime is related to the transmission of global factors to the Norwegian economy and modifies the interaction between these factors and the local monetary policy stance.

2.3 Data Description

Our data employs the monthly ORBOF reports (Report 10 and Report 11) submitted in the period between January 1994 and December 2017, which register the components of all Norwegian banks' – including commercial banks, savings banks, subsidiaries of foreign banks, branches of foreign banks, bank-affiliated mortgage companies – balance sheets and income statements. Since we aim at a consistent comparison with other lending channel empirical studies, which are frequently based on quarterly data, we use the respective end-of-quarter monthly report. The quarterly frequency also allows us a better match with the macroeconomic variables; further, it reduces the noise associated with very frequent loan volume observations.

Even though the data is available for earlier periods, we choose 1994Q1 as a starting point to avoid dealing with the substantial structural transformation of the Norwegian banking landscape during the 1988-1993 Nordic banking crisis, when numerous banks went bankrupt or were nationalized. The sample is an unbalanced panel of 185 banks.

The Norwegian bank-level data is unique in that it provides – for all categories reported in the balance sheet as well as for most of the profit and loss account items – information about the currency denomination, distinguishing between the domestic currency and foreign currencies, over a considerably long time horizon. This information allows us to track with very high precision the dynamics of foreign currency assets and liabilities for the periods with different monetary policy regimes and global funding conditions. This is of crucial importance for the micro-level

[11] See "Monetary Policy in Norway", Norges Bank, available on http://www.norges-bank.no/en/about/Mandate-and-core-responsibilities/Monetary-policy-in-Norway/. It has been emphasized that "… *exchange market intervention, irrespective of whether currency is bought or sold, is not an appropriate instrument for influencing the krone over a longer period*."

examination of how the effectiveness of monetary policy is modified by the currency composition of bank assets and liabilities. The Norwegian banking sector is an ideal laboratory for studying the interactions between domestic monetary policy and global financial factors. First, Norwegian banks have the potential to explore global factor dynamics since many of them have sufficient access to international funding sources. The share of foreign currency-denominated liabilities soared from about 10% of total bank liabilities in the mid-1990s to more than a quarter of total bank funding in 2017.[12] The speed of foreign currency funding growth has been particularly high since 2000, when the Norges Bank abandoned formal currency exchange interventions, thus leaving the Norwegian krone to freely react to international financial factors. The fact that the Norwegian krone market is highly liquid ensures that banks are able to access the FX market with rather low transaction costs. A second major advantage of the Norwegian data is that it allows us to employ global risk attitudes as instruments for exchange rate fluctuations and thus achieve convincing identification. The motivation for these instruments is that Norway is seen by investors as a safe-heaven so that the attractiveness of Norwegian assets increases when global risk is high. To add further strength to the identification, we also take advantage of the fact that the oil price is a strong exogenous determinant of NOK exchange rates so that we can derive some exogenous components of the costs of funding in foreign currency using oil price as an additional instrument. Third, the Norwegian example allows us to explore the role of global factors for bank lending in a high-income economy with free capital movement and very strong institutions, including strict bank regulation that requires banks to hedge a substantial share of their foreign currency positions. This advantage is particularly important given that most of the debate on the effect of global factors on local lending has so far focused on emerging periphery economies, where weak banking regulation and fragile institutions prevail. In addition, the Norwegian banking sector was not much affected by the 2007-2009 global financial crisis and 2012 European debt crisis: monetary policy didn’t reach the zero lower bound and no quantitative easing was carried out so that there is less concern about the impact of unconventional domestic monetary policy in our sample.

We match the bank-level data to macroeconomic aggregate level variables such as GDP, real estate prices (which, as already mentioned, are mostly available with a quarterly frequency), as well as a battery of various domestic and international monetary policy and money market interest rates.

[12] Including foreign currency funding via bank-affiliated mortgage companies.

The domestic interest rates are drawn from Norges Bank's monetary statistics, while the international interest rates stem from the St. Louis Fed's FRED databank. We also merge to the dataset information concerning the levels and dynamics of the Norwegian krone exchange rate relative to major foreign currencies.

3 Bank Lending Channel: The Baseline Results

3.1 Revisiting the Lending Channel

We start the empirical analysis by replicating the standard approach of analyzing the lending channel of monetary policy proposed by Kashyap and Stein (2000) and later modified by Cetorelli and Goldberg (2012a). Following the tradition of these studies, the estimation of the lending channel's effectiveness is based on the assumption that a tightening of monetary policy represents a funding shock for banks, which they cannot fully offset by issuing alternative liabilities so that the shock is transmitted to the asset side of the bank balance sheet. As a result, the monetary policy shock affects the supply of bank lending.

In econometric terms, the identification of the supply-driven effects of monetary policy on observable bank lending volumes is achieved based on the assumption that the transmission of the shock from bank liabilities to bank assets is contingent on the bank's ex ante endowment with liquid assets, as banks with a larger share of liquid assets can cushion the funding shock by liquidating these assets instead of cutting lending. More specifically, by showing that lending by banks with a lower liquidity endowment reacts more strongly to a tightening of monetary policy than the lending of more liquid banks, we may conclude that monetary policy affects observable lending volumes by shifting (not only the demand for but also) the supply of loans.

The estimation is based on a two-stage procedure (Kashyap and Stein, 2000; Cetorelli and Goldberg, 2012a).

The first stage is described in Equation (1):

$$\Delta \ln loans_{i,t} = \sum_{j=1}^{4} \alpha_{t,j} \Delta \ln loans_{i,t-j} + \beta_t X_{i,t-1} + \sigma_t Controls_{i,t-1} + \varepsilon_{i,t} \qquad (1)$$

in which $loans_{i,t}$ is the total lending of bank i in quarter t. The liquidity measure of bank i, $X_{i,t-1}$, is defined as the logarithm of the ratio of a bank's liquid assets to total assets. The vector $Controls_{i,t-1}$ includes bank-specific control variables such as the bank's capitalization ratio, its balance sheet size, deposit growth rate, the type of bank, etc. (a full list of all variables and their definition is presented in Table 1),[13] and $\varepsilon_{i,t}$ is the error term. We also include a vector of macro-level control variables, such as the GDP growth rate, house prices, etc., to capture the impacts of business cycles. To avoid the typical simultaneity issues related to the fact that banks jointly determine asset and liability positions on their balance sheet, these control variables enter the regressions with one-quarter lags.

We run the cross-sectional model (1) quarter by quarter to generate a time series of the coefficients β_t, which represents the time-variant sensitivity of bank lending to the liquid assets of the bank. In the second stage, the relation between the time series of β_t and monetary policy interest rates is examined based on the following model (2):

$$\beta_t = \gamma_0 + \sum_{j=1}^{n} \gamma_j r_{t-j} + \mu_t \qquad (2)$$

in which we regress β_t on monetary policy rates r_{t-j} in the preceding j periods, with μ_t being the error term. Using the Akaike Information Criterion, we define the number of quarters n to be included in the series of lagged monetary policy rates as six.[14] Following Cetorelli and Goldberg (2012a) we consider possible autocorrelation and correct standard errors using the Newey-West variance estimator.

The definition, as well as summary statistics of all variables included in both stages of the estimation, are presented in Table 1.

Cetorelli and Goldberg (2012a) point to a further potential identification issue related to the fact that bank liquid asset holdings may react to macroeconomic conditions, and that this reaction to macroeconomic conditions might be different for banks with different funding modes. They propose an additional identification step in which the observable liquid assets ratio is instrumented by the residual of a regression of liquid-assets-to-total asset ratio on the ratio of commercial and industrial lending to total lending and the ratio of non-performing loans to total loans. This residual is strongly correlated with the observable bank liquidity position but avoids the endogeneity of

---

[13] Results are qualitatively unchanged if we include controls for the type of bank (e.g. savings, commercial, or foreign) throughout all regression specifications.

[14] Cetorelli and Golbderg (2012a) fix this number to 8. We have rerun all models using the 8-quarter specifications, and the results are qualitatively the same.

liquidity with respect to macroeconomic conditions, since these are already controlled for by the characteristics of bank lending.

Table 1: variable definition and summary statistics

This table reports the variable definitions as well as the number of observations, the mean and the median values, the standard deviation and the 1st and the 99th percentile for each of the variables employed in the analysis.

		N	**Mean**	**Median**	**Std. Dev.**	**1 Pctile**	**99 Pctile**
Panel A: bank-level variables							
LOAN GROWTH	Log growth rate of total loans and leases between quarter t and quarter $t-1$	14,706	0.028	0.022	0.200	-0.141	0.356
LIQUID ASSETS TO ASSETS	Ratio of liquid assets to total assets	14,706	0.107	0.084	0.105	0.005	0.575
CAPITALIZATION	Ratio of total shareholders' equity to total assets	14,706	0.058	0.052	0.096	-0.001	0.194
DEPOSIT GROWTH	Log growth rate of total deposits between quarter t and quarter $t-1$	14,289	0.027	0.017	0.185	-0.164	0.375
DEPOSITS	Ratio of total deposits to total assets	14,954	0.666	0.704	0.191	0.001	0.909
WRITE-OFFS	Ratio of total write-offs to total assets (write-off enter the ORBOF report with a negative sign)	14,242	-0.007	-0.004	0.010	-0.037	-0.000
FOREIGN CURRENCY LIABILITIES	Ratio of liabilities denominated in foreign currency to total liabilities	14,242	0.028	0.000	0.010	0.000	0.542
C&I LOANS	Ratio of C&I loans to total loans and leases	14,997	0.247	0.246	0.077	0.000	0.549
SIZE	Logarithm of total assets (in thousand NOK) adjusted for CPI	15,041	14.449	14.179	1.633	10.849	19.132

Panel B: interest rates and international finance controls

KEY POLICY RATE	Interest rate paid by the Norges Bank on commercial bank reserves	15,041	3.543	3.316	2.182	0.500	8.450
NIBOR	Norwegian Interbank Offered Rate with 3-months maturity	15,041	3.997	3.517	2.213	0.808	9.569
COST ADVANTAGE	Log growth rate of the cost advantage in FX funding, defined in section 4.1	15,041	0.002	0.002	0.004	-0.006	0.013
OIL PRICE	Change in barrel price of Brent oil in USD	15,041	0.633	1.066	9.245	-59.716	25.803
VIX	VIX index as published at FRED (St. Louis Fed)	15,041	19.659	18.204	7.547	10.308	58.595
BBB BOND SPREAD	Spread between the yield of BBB- and AAA- rated bonds as published at FRED (St. Louis Fed)	15,041	2.041	1.907	1.079	0.743	7.030

Panel C: macroeconomic controls

GDP GROWTH	Annualized growth rate of GDP (quarterly data) in %	15,041	2.625	2.505	2.255	-1.623	9.126
HOUSE PRICE GROWTH	Annual growth rate of house prices (per sqm)	15,041	0.019	0.018	0.027	-0.038	0.080

If the conventional transmission mechanism of monetary policy were to work, bank lending should become more sensitive to bank liquidity when monetary policy is tightened, and less so when monetary policy is loosened; therefore, the sum of the coefficients of monetary policy rates γ_j should be positive and significant.

The outcome of the two-step regression is reported in Table 2 (the time series of the intermediate estimates of β_t are illustrated in Figure A1 in Appendix A). This table contains two rows of results. The upper row presents the results in the case when the monetary policy rate is measured by the key policy rate of the Norges Bank, which is defined as the rate paid by the central bank on commercial bank reserves. The second row reports the results of the estimation in the case where the money market interest rate NIBOR (Norwegian Interbank Offered Rate) is used as a proxy for the monetary policy stance. The table also reports two columns for each of the rows – one using the standard Kashyap and Stein (2000) specification and one using the approach of instrumenting the liquidity ratio proposed by Cetorelli and Goldberg (2012a). The table reports only the sums of all the coefficients of all lagged values $\sum \gamma_j$ with the respective statistical properties. The coefficients for each of the lagged values of the key policy rate and the NIBOR, that is the individual γ_j , are reported in Appendix B.

Table 2: lending channel in Norway 1994-2017

This table reports the results of the estimation of the regression of the sensitivity of bank loan growth to bank liquidity (β) on monetary policy interest rates, which are measured for the results presented in the upper panel by the rate on bank deposits with the central bank (key policy rate) and for the results presented in the lower panel by the NIBOR (Norwegian Interbank Offered Rate). Column (1) uses the βs that are computed from a regression of bank loan growth on the liquid assets-to-assets ratio, while column (2) is based on instrumenting the liquid assets to total assets ratio. The reported figures in the columns are from the sum of the estimated coefficients on the six lags of each respective monetary policy rate. *, ** and *** indicate significance at the 10%, 5% and 1 % level, respectively.

	β_j (estimated using the liquid assets to total asset ratio) (1)	β_j (estimated using the residual of liquid assets to total asset ratio regression) (2)
$\sum \gamma_j$ (Key policy rate)	-0.0009 (0.0007)	-0.0009 (0.0008)
$\sum \gamma_j$ (NIBOR)	-0.0009 (0.0007)	-0.0004 (0.0007)
Number of observations	23,577	23,577
Adjusted R^2	0.03	0.02

In all the regression specifications reported in this table, the sum of the coefficients of the interest rates is negative and statistically not significant, implying that the sensitivity of lending to the liquidity position of a bank is not higher in times of tighter monetary policy. This result, therefore, suggests that the conventional transmission mechanism of monetary policy is not supported by our sample.

3.2 The Transmission Mechanism and the Shift in Monetary Policy Regimes

The fact that we are not able to document a lending channel for the Norwegian credit market might be surprising at a first glance, as almost uniformly most published studies using micro-level data typically do find lending channel effects, at least for some subcategories of banks (Campello, 2002, Ashcraft, 2006, Cetorelli and Goldberg, 2012a). Nevertheless, the missing effectiveness of monetary policy with respect to lending dynamics is not surprising once the recent findings of the international finance literature, which point to the potential interaction between domestic and foreign monetary policy, are taken into consideration. As suggested by Rey (2015), in the absence of capital controls, the monetary policy of the core economies may affect credit dynamics in non-central countries, which in turn indicates that domestic monetary policy has limits. Rey (2015) illustrates this relationship by documenting the existence of global financial cycles which strongly negatively correlate with risk aversion and uncertainty typically approximated by the VIX index. Bruno and Shin (2015a), who document the cross-border effects of loose monetary policy in core economies, further develop this argument. These authors link the cross-border transmission of monetary policy to the failure of uncovered interest rate parity: exchange rate adjustments fail to offset the interest rate differential between core and non-core economies. Hofmann et al. (2016) further show that the appreciation of a local currency is associated with a decline in the risk spread of the respective economies. This argument implies that exchange rate appreciation has an effect on the costs of funding of banks in non-core economies even when the foreign currency positions are hedged. These exchange rate-driven changes in the costs of funding can, therefore, interact with domestic monetary policy, thus potentially explaining the counterintuitive relationship between domestic interest rates and lending volumes illustrated in Table 2.

The theoretical arguments in the above strand of the literature are based on the assumption that exchange rates reflect the variation in the risk premium; thus, deviations from the uncovered interest rate parity emerge as a proxy for the shifts in the supply of funds to a non-core economy, reflecting the dynamics of the risk premium. A central bank can eliminate the link between the risk premium and exchange rates by active intervention in the foreign exchange market. Moreover, the currency market intervention can provide a central bank with better control of the interaction between international financial factors and domestic monetary policy. The recent history of central bank operations in Norway presents us with a good setup to study the effect of the interaction between international factors and monetary policy. To this end, we examine a regime change that was introduced in 2001: Norges Bank changed its monetary policy regime from exchange rate stabilization to inflation targeting.

Table 3: monetary policy pre- and post-2001

This table reports the results of the estimation of the regression of the sensitivity of bank loan growth to bank liquidity (β) on monetary policy interest rates, which are measured for the results presented in the upper lines by the rate on bank deposits with the central bank (key policy rate) and for the results presented in the lower lines by the NIBOR (Norwegian Interbank Offered Rate). Column (1) uses the βs which are computed from a regression of bank loan growth on the liquid assets to total assets ratio, while column (2) is based on instrumenting the liquid assets to total assets ratio. The reported figures in the columns are from the sum of the estimated coefficients on the six lags of each respective monetary policy rate. Panel A reports the results in the case when the estimation sample is restricted to the period 1994-2000, while Panel B reports the 2001-2017 results. *, ** and *** indicate significance at the 10%, 5% and 1 % level, respectively.

	β_j (estimated using the liquid assets to total asset ratio)	β_j (estimated using the residual of liquid assets to total asset ratio regression)
Panel A: pre-2001		
$\sum \gamma_j$ (Key policy rate)	0.0145***	0.0189***
	(0.0032)	(0.0017)
Number of observations	5,786	7,890
Adjusted R^2	0.10	0.06
$\sum \gamma_j$ (NIBOR)	0.0374***	0.0301***
	(0.0017)	(0.0016)
Number of observations	7,890	7,890
Adjusted R^2	0.12	0.12
Panel B: post-2001		
$\sum \gamma_j$ (Key policy rate)	-0.0052***	-0.0054***
	(0.0011)	(0.0011)
Number of observations	15,687	15,687
Adjusted R^2	0.06	0.05

$\sum \gamma_j$ (NIBOR)	-0.0099***	-0.0086***
	(0.0011)	(0.0012)
Number of observations	15,687	15,687
Adjusted R^2	0.23	0.04

To examine whether the transmission mechanism of monetary policy changes around the introduction of the new monetary policy regime, we split the sample into two sub-samples, pre-2001 and post-2001 (which we define to begin with the first quarter of 2001), and redo the same two-stage regressions. We find that the conventional transmission mechanism is supported by the pre-2001 sub-sample, with the sums of the coefficients γ_js being both positive and significant. However, the mechanism is not supported by the post-2001 sub-sample, where the sums of the coefficients γ_js have the wrong signs, as Table 3 shows.

In addition, in unreported tests, we also split the sample into different sub-periods in order to establish whether 2001 is indeed the year when the regime changed. We consistently find that for any periods prior to 2001 the conventional lending channel is identified, while it is not so for periods starting after 2000. A Chow-test also indicates a structural break in 2000. Given the fact that substantial advances in information technology also improved the international integration of financial markets – thus increasing the international exposures of banks not only in Norway but basically around the globe – we do not argue that the change in the monetary policy regime is the sole driving force of the shift in the lending channel's effectiveness. We rather think of the abolition of the foreign exchange interventions by the Norges Bank as the step that allows for a stronger effect of global factors on banks' funding costs.

Furthermore, within the post-2001 subsample, we find strong asymmetry in banks' reaction to looser and tighter monetary policy. As is shown in Table 4, when there is a positive change in NIBOR, i.e., when monetary policy becomes tighter (defined as a rise in NIBOR during the past 4 quarters, or, $r_{t-1} - r_{t-4} > 0$), bank lending reacts to monetary policy in a "wrong" way as $\sum \gamma_j$ is negative; however, when there is a negative change in NIBOR or when monetary policy becomes looser (defined as $r_{t-1} - r_{t-4} < 0$), bank lending responds to monetary policy "correctly" as $\sum \gamma_j$ is positive and significant, implying that bank lending reacts to loosening domestic monetary policy but not a tightening one. This asymmetry suggests that banks may take advantage of cheap funding from the domestic money market when domestic monetary policy is loosened, while avoiding increasing funding costs under tightening domestic monetary policy by shifting funding towards international money markets, where domestic monetary policy has a much lower impact. We investigate such conjecture in the next section.

Table 4: asymmetric reaction to looser and tighter monetary policy

This table reports the results of the estimation for the post-2001 period of the regression of the sensitivity of bank loan growth to bank liquidity (β) on the NIBOR as a proxy for the monetary policy interest rate. $\sum \gamma_j$ represents the sum of the coefficients of NIBOR's six lags. *, ** and *** indicate significance at the 10%, 5% and 1 % level, respectively.

Post-2001	Positive NIBOR changes	Negative NIBOR changes
$\sum \gamma_j$	-0.0204*** (0.0021)	0.0074*** (0.0018)
Adjusted R^2	0.18	0.03
Number of observations	7,593	8,094

4 What Drives Bank Lending if the Conventional Lending Channel Fails?

The results presented in section 3 show that the effectiveness of the lending channel in the transmission of domestic monetary policy is substantially reduced in the post-2001 period. In this section, we explore whether global factors contributed to the curtailed impact of domestic monetary policy. More specifically, we focus on exploring whether banks employ the interest differentials between Norway and the core economies (especially the US and the euro area) to insulate from tightening of the stance of domestic Norwegian monetary policy. If the interest rate differentials are fully neutralized by exchange rate dynamics, exploring these differentials would not affect banks' funding costs. However, if the interest rate differentials are not fully neutralized, dollar- (or euro-) based investors may generate higher returns by investing in the Norwegian krone, affecting Norwegian banks' funding costs in a way that is not directly related to domestic monetary policy. Moreover, Baskaya et al (2017), Shin (2017) and Rime et al (2017) show that such shifts in the cost of funding, which are ultimately related to the failure of interest rate parities, no matter whether banks hedge their FX positions or not, are persistent so that banks can rely on the foreign currency funding advantage, even accounting for expectations and hedging the foreign currency positions when shaping their lending.

4.1 Cost Advantage and the Foreign Funding Channel

As argued by Rey (2015) and Bruno and Shin (2015a), the cost advantage in banks' FX funding can be driven by the changes in risk aversion and financial market volatility. Indeed, the case of Norway in the post-2001 period describes a setup characterized by the free movement of capital plus no exchange rate interventions, which is consistent with the framework of these models. Positive cost advantages indicate a positive return of investment in the Norwegian krone by dollar- (or euro-) based investors, therefore they de facto represent a positive shift in the supply of funds to Norwegian investors (including banks). While studies using emerging economies data relate these cost advantages to the decline in risk aversion and to periods of low volatility (as in Rey, 2015), the Norwegian example in the post 2000 period allows us to look at the flip side of the phenomenon, where in periods of high volatility and high risk aversion, capital flows to Norway since the strong institutional quality of this country makes it a reasonable safe haven, thus pushing exchange rates in a direction favoring foreign currency funding.[15] This is particularly the case during periods when the perception of the strength of the Norwegian economy was also reinforced by high and rising oil prices.

In order to examine the effect of the shift in the cost of foreign currency funding for Norwegian banks, we construct a simple measure of the cost advantage in US dollar funding in the following way:

$$\tilde{c}_t = \frac{implied\ NOK/USD_{t+1} - NOK/USD_{t+1}}{NOK/USD_t} \qquad (3)$$

in which NOK/USD_{t+1} represents the observable NOK/USD exchange rate in period $t+1$, while the implied NOK/USD exchange rate is the exchange rate that can fully neutralize the interest rate differential (or, the exchange rate under which UIP holds). This implied NOK/USD exchange rate is calculated through

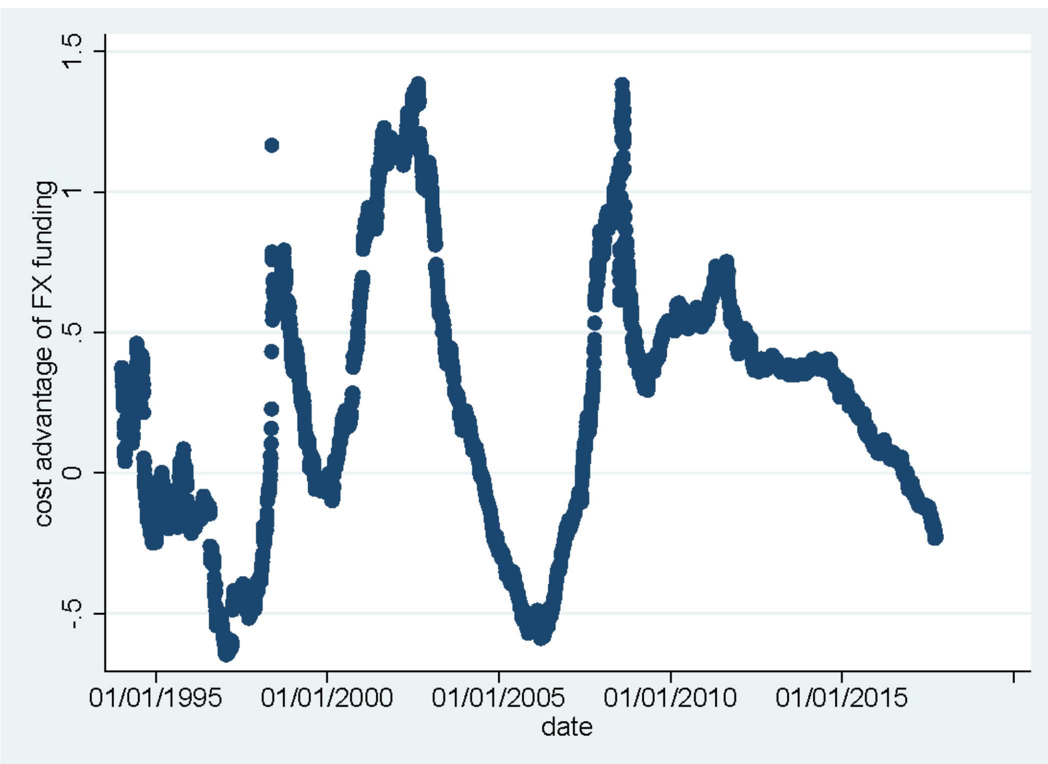
[15] The goal of our analysis is the interaction between global factors (correlated to the cost advantage) and monetary policy rather than the exploration of the sources of the cost advantage. That is why in this paper we do not focus on the sources of these funding cost deviations and their variation over time, for example, those related to the peso problem.

$$implied\ NOK/USD_{t+1} = NOK/USD_t \frac{1+r_t}{1+r_t^*} \qquad (4)$$

where r_t and r_t^* are interest rates in Norway and the US, respectively, measured by three-month NIBOR and the USD LIBOR rates.[16] In this way, $\tilde{c}_t > 0$ means that the actual NOK/USD exchange rate is below what is suggested by (4), implying a cost advantage in FX funding.

Figure 1 presents $\tilde{c}_t$ over the entire horizon of our data sample. Indeed, $\tilde{c}_t$ (especially in a positive direction) became far wider and more volatile after 2001, when Norges Bank switched its monetary policy regime to inflation targeting and ceased intervening in the FX market. As we will show later, the peaks of the $\tilde{c}_t$ are mainly associated with oil price dynamics as well as with other global factors, such as global risk (as proxied by the VIX index).

Figure 1: advantage in FX funding cost $\tilde{c}_t$, 1994-2017



This graph illustrates the dynamics of $\tilde{c}_t$ for the period 1994-2017, computed from equations (3) and (4).

[16] $\tilde{c}_t$ thus reflects the deviation of actual NOK/USD exchange rate from the rate that is predicted by UIP condition. Similarly, we can represent the cost advantage in euro funding using the three-month EURIBOR rate and NOK/EUR exchange rate.

If banks gain advantage in FX funding, then in econometric terms the examination of the effect of monetary policy on lending without considering the FX funding advantage might lead to omitted variable bias. In a next set of regressions, we address this issue by re-estimating the model, now including the funding cost advantage as an additional explanatory variable.

With $\tilde{c}_t$, stage two regression (previously model (2)) becomes:

$$\beta_t = \gamma_0 + \sum_{m=1}^{2} \theta_m \tilde{c}_{t-m} + \sum_{j=1}^{6} \gamma_j r_{t-j} + \mu_t \qquad (5)$$

in which $\tilde{c}_{t-m}$ denotes the cost advantage in FX funding with m quarter lags. This number of lags is again determined by the Akaike Information Criteria, which points to two quarters as the optimal number of lags to be considered in the estimation. Figure 1 illustrates the stationarity of $\tilde{c}_t$ which has also been established for the other variables in equation (5) by earlier research, so we are not concerned about spurious effects in this time series model. Since, as shown in Figure 1, substantial deviations of $\tilde{c}_t$ from zero are only observable in the post-2001 period and only after the shift of monetary policy regime can such deviations be viewed as exogenous with respect to Norges Bank policy, we present this extended model version only for this later period.

As discussed earlier, Kashyap and Stein's (2000) approach enables us to identify the supply side of the costs of bank funding in terms of domestic monetary policy. By expanding the second stage of their model to include the costs of FX funding (equation (5)), we are still identifying supply-side effects. However, when the second stage model includes the costs of FX funding, identification could be potentially threatened if a positive $\tilde{c}_t$ is generated by positive expectations about investment returns in Norway that simultaneously also affect the sensitivity of loan supply with respect to liquidity. In this case, the estimation of equation (5) may suggest that banks' lending is less sensitive to ex ante liquidity endowment when the cost advantage of FX funding is high, but this relationship will not be driven by the cost advantage itself but rather by unobservable optimistic sentiment about the Norwegian economy, which shifts up both the NOK exchange rate and loan supply. Fortunately, the Norwegian setting allows us to address this identification challenge by using exogenous instruments for the costs of FX funding based on exogenous components of exchange rate dynamics. More specifically we instrument $\tilde{c}_t$ by the dynamics of global risk (measured by the VIX index) and global risk aversion (measured by the spread of US bonds with BBB rating vs AAA-rated bonds), as well as by global oil prices (measured by the change in the Brent oil barrel price).

Conceptually, the use of the VIX index as an instrumental variable is motivated by the argument that capital inflows into periphery countries are strongly correlated with the volatility of global financial markets and the prevailing level of risk aversion (Rey, 2015, Hofmann et al., 2016). Given its strong institutions, Norway, however, represents the flip side of this argument: the higher global risk, the higher the inflow of capital into the country (see discussion of the first stage regression result). This effect was particularly reinforced during the sovereign debt crisis in Europe in 2010-2012. To strengthen identification and address the concern that VIX itself might not be a perfect control for global risk, we also include the BBB spread as an instrument detecting the shifts in risk aversion. And last but not least, the oil price can be a valid instrument for $\tilde{c}_t$, since on the one hand, observable spot NOK exchange rates strongly co-move with the oil price (given that the oil sector accounts for more than one-fourth of Norwegian GDP). On the other hand, because of the relatively small size of local oil reserves and the economy as a whole, Norway-specific factors are not sufficient to affect world oil prices, so the exogeneity of oil prices with respect to exchange rate dynamics and thus with respect to $\tilde{c}_t$ is guaranteed. However, given the importance of oil for aggregate macroeconomic dynamics in Norway, there is a threat to the validity of the exclusion condition of oil prices as an instrument: oil prices might affect bank lending not only via their impact on $\tilde{c}_t$, but can also directly affect the volume of bank lending through credit supply to the oil industry and to industries with strong links to the oil sector. That is why we present both specifications that use oil price as an additional instrument and specifications that do not include oil prices in the vector of instrumental variables.

The choice of instruments passes standard tests: their strength is confirmed by an F-test statistic of the first-stage regression being roughly 19; while the exogeneity is formally confirmed by a Hansen overidentification test.

Table 5: monetary policy and global factors post-2001

This table reports the results of the estimation of the regression of the sensitivity of bank loan growth to bank liquidity (β) on the NIBOR as a proxy for the key policy rate and the cost advantage in FX funding, $\tilde{c}_t$. Panel A reports the main results of the second stage regression, where $\sum \gamma_j$ represents the sum of coefficients of the six lags of the NIBOR, while $\sum \theta_m$ represents the sum of coefficients of the two lags of the cost advantage in FX funding, when $\tilde{c}_t$ is instrumented via the oil price, VIX and BBB spread.

Panel B reports the results of the same model when $\tilde{c}_t$ is instrumented via VIX and BBB spread, only. R^2 is not reported for the instrumental variable regression because no decomposition of the variance of the dependent variable can be assigned to the endogenous dependent variables. *, ** and *** indicate significance at the 10%, 5% and 1 % level, respectively.

Panel A (IV: oil price, VIX and BBB spread):

$\sum \theta_m$	$\sum \gamma_j$
-0.1533***	0.0169***
(0.0147)	(0.0028)
Number of observations	15,687

Panel B (IV: VIX and BBB spread):

$\sum \theta_m$	$\sum \gamma_j$
-0.3387***	0.0502***
(0.0178)	(0.0033)
Number of observations	15,687

For the sake of economy, in this and the following exercises, we focus solely on models using the NIBOR as a proxy for domestic interest rates. This is without loss of generality since we have already shown that results are not sensitive to the choice of domestic interest rates to be used in the model (key policy rate versus NIBOR). The results of the estimation are presented in Table 5.

Both panels of this table illustrate the sum of the coefficients θ_m (of $\tilde{c}_t$) and γ_j (of the interest rates) in the estimation of the model given by equation (5).[17] Panel A reflects the specification when the oil price is included in the vector of instrumental variables, while the results reported in Panel B are derived from an estimation where the oil price is excluded. The coefficients presented in both panels signal two essential results. First, the lagged interest rates enter the regression with a positive statistically significant sum of coefficients. This result is illustrative of the fact that once

[17] The second-stage estimates for all lagged variables θ_m and γ_j are reported in Appendix C.

we control for the effect of global factors, we find significant evidence of the validity of the bank lending channel. In other words, the failure to document bank lending channel effects in the models presented in Table 3 could be attributed to an omitted variable bias stemming from ignoring the interactions between domestic monetary policy and global factors.

Second, the negative and statistically strongly significant sum of the coefficients of $\tilde{c}_t$ lags point to the effect of a global funding channel: when the exchange rate appreciates (an appreciation is given by a lower NOK/USD value which explains the negative sign of the θ_m coefficients) – for reasons such as global financial movements – Norwegian banks obtain favorable funding conditions, which allows them to increase lending because of reduced sensitivity to their liquidity position.

Even though the results in Panel A and Panel B are qualitatively very similar, the estimated coefficients are somewhat higher when oil price is not included as an instrument, suggesting a very strong impact of the instruments for which we also have fewer concerns regarding the validity of the exclusion condition: the VIX and BBB spread. Again, for the sake of economy in the rest of the paper, we will report only specifications using these two instruments. In unreported tests we have re-run the same models including the oil price as an additional instrument, and results are again qualitatively very similar to those using only the VIX and BBB spread.

It is important to notice that the effect of $\tilde{c}_t$ is not only statistically but also economically strongly significant. According to the estimation results presented in Panel B, a one standard deviation change in $\tilde{c}_t$ – in our sample roughly 0.6 – is associated with approximately 20% (0.16=0.3387*0.6) change in the sensitivity β of bank lending to bank liquidity endowment. For the results presented in Panel A, the magnitude is still substantial at about 10%.

The intuition and the strength of the instruments can be verified by the results of the first stage regressions for the two instrumented variables, which are the first and second lag of $\tilde{c}_t$. These results, depicted in Appendix D, show that, consistent with our arguments motivating the choice of instruments, $\tilde{c}_t$ is positively related to an increase in global financial risk and risk aversion as measured by the VIX index and the BBB spread. Taken together, these results suggest that an increase in global financial risk generates an appreciation of the Norwegian krone, or a cost advantage in FX funding. That is, this appreciation is linked to the safe-haven status of Norway in times of increasing global risks. This safe-haven status results in an implicit negative risk premium on investments in Norwegian institutions. This drop in the local risk premium eases banks' funding constraints and thus modifies the effectiveness of monetary policy. The results also, not surprisingly, indicate the strong positive link between the cost advantage in FX funding and oil price dynamics.

Table 6: asymmetric reaction to favorable and unfavorable exchange rate dynamics

This table reports the results of the estimation of the regression of the sensitivity of bank loan growth to bank liquidity (β) on the NIBOR as a proxy for the monetary policy interest rate and the cost advantage in FX funding, $\tilde{c}_t$, which is instrumented by the VIX and the BBB spread for periods with positive and with negative changes of $\tilde{c}_t$. $\sum \gamma_j$ represents the sum of the six lags of the NIBOR, while $\sum \theta_m$ represents the sum of the coefficients of two lags of the $\tilde{c}_t$. R^2 is not reported for the instrumental variable regression because no decomposition of the variance of the dependent variable can be assigned to the endogenous dependent variables. *, ** and *** indicate significance at the 10%, 5% and 1 % level, respectively.

Post-2001	Positive changes in $\tilde{c}_t$	Negative changes in $\tilde{c}_t$
$\sum \theta_m$	-0.1282***	-0.2553***
	(0.0184)	(0.0214)
$\sum \gamma_j$	0.0014	0.0467***
	(0.0030)	(0.0041)
Number of observations	6,838	8,849

Digging deeper into the mechanics of the effects documented in Table 5, we split the post-2001 sample into periods when exchange rate dynamics were becoming more favorable for global funding ($\tilde{c}_t$ rose) and periods when exchange rate dynamics were becoming less favorable for global funding ($\tilde{c}_t$ fell). To this end, we particularly benefit from the existence of a substantial variation in the dynamics of the cost advantages of foreign currency funding, with the 2001-2014 period being characterized by mostly positive dynamics, while the post-2014 period shows a substantial decline in this cost advantage. While the costs of foreign currency funding always significantly affect bank lending (negative and significant $\sum \theta_m$ in both subsamples), the results shown in Table 6 point to banks' asymmetric reactions to domestic monetary policy under positive versus negative exchange rate dynamics: when global funding conditions become more favorable, bank lending does not react to domestic monetary policy (insignificant $\sum \gamma_j$), suggesting that banks rely more on international money markets; in contrast, when global funding conditions become less favorable, bank lending is sensitive to domestic monetary policy (positive and significant $\sum \gamma_j$), implying that banks turn to the domestic money market when international sources of funding become less favorable.

4.2 Currency Hedging, Deviations from CIP, and Global Funding Supply

In sum, the evidence presented in the past section underlines the cost advantage in FX funding as animportant determinant of Norwegian bank lending. The economic and the statistical significance of the cost advantage might be surprising at a first glance, given the fact that Norwegian regulations require banks to hedge some of their foreign currency exposure by means of swap or forward contracts (as stipulated by Chapter IV of Act No. 40 of 10 June 1988 (Financial Institutions Act) for all financial institutions, as well as Regulation No. 550 of 25 May 2007 for mortgage companies, see Molland, 2014). In practice, banks need to exchange foreign currency for NOK, after they borrow in foreign currencies, and they need to make sure that sufficient foreign currency is available when the loan matures. Typically, banks enter foreign currency swaps if the funding is short-term, or cross-currency basis swaps if the funding is long-term.

However, in reality, spot transactions still account for around 34% of total FX turnover in NOK as of 2016 and spot turnover is greatest in USD (Norges Bank 2018), so that cost advantage in FX funding in terms of UIP deviations does matter for banks. And even if foreign currency liabilities are hedged, such deviations can still be relevant to the banks' funding costs. As already mentioned, this is the case on the one hand, since the UIP deviations reflect a shift in the supply of international funds to Norway, which then shifts the funding costs of Norwegian banks. On the other hand, even if positions are hedged at the maturity of the liabilities' contracts, the maturity mismatch between assets and liabilities generates a liquidity risk in that a bank has to revolve the foreign currency liability to match the maturity of the assets. The conditions under which the corresponding liabilities roll over will depend on exchange rate dynamics, no matter whether the initial foreign currency exposure is hedged or not. Further, as shown by Bräuning and Ivashina (2017), the inflow of a substantial amount of capital into a country and the corresponding need for hedging the exchange rate positions shift the demand-supply equilibrium in the markets for hedging instruments, thus also affecting the costs of the hedge.

Taking the debate further, we also find that global factors matter for bank lending even if we focus on completely hedged positions. More specifically, we follow the approach of Hofmann et al. (2016) in analyzing the risk-shifting effects of currency appreciation and focus on exploring how the cost advantage coming from hedged FX positions, measured by the deviation from covered interest rate parity (CIP), affects the effectiveness of the lending channel. To this end, we construct the local currency risk-spread measure proposed by Du and Schreger (2016) as a proxy for the deviations from CIP. This measure is defined as the spread of the yield of local currency (in our case NOK) government bonds achievable by a dollar-based investor over the yield of a US Treasury security with the same maturity. While CIP deviations cannot be identified using the NIBOR/LIBOR differential since the NIBOR rate is by definition quoted as the LIBOR rate plus the forward premium, the Du-Schreger measure, which is government bond yield-based, does identify some non-negligible deviations from CIP, reflecting the cost advantage in FX funding with hedging.

In order to explore the role of global factors on the hedged banks' foreign currency positions, we rerun the regression specifications using the Du-Schreger measure of the cost advantage $\tilde{c}_{DS,t}$ instead of $\tilde{c}_t$, i.e., the second step is specified as

$$\beta_t = \gamma_0 + \sum_{n=1}^{2} \delta_n \tilde{c}_{DS,t-n} + \sum_{j=1}^{6} \gamma_j r_{t-j} + \mu_t \qquad (6)$$

Again, we improve the identification by controlling for the fact that both the Du-Schreger measure and bank lending might be driven by unobservable characteristics of the state of the Norwegian economy. To this end, we use the VIX index as an instrument for the Du-Schreger measure.

The results of the estimations are presented in Table 7, which contains two columns. The results reported in the first column reflect the estimation results when the Du-Schreger measure is computed as the spread of the yield between government bonds with a maturity of 5 years. The period covered in the estimation is 2001Q1-2017Q4. The second column reports the results of a specification based on the Du-Schreger measure computed for short-term (three-month) government bonds. Since short-term Norwegian bonds were only issued starting from 2003, this specification is run for the 2003Q1-2017Q4 sample.

Table 7: Du-Schreger's local currency risk measure and the lending channel

This table reports the results of the estimation of the regression of the sensitivity of bank loan growth to bank liquidity (β) on the NIBOR as a proxy for the monetary policy interest rate and the cost advantage in FX funding with hedging, $\tilde{c}_{DS,t}$, approximated by the Du-Schreger measure and instrumented by the VIX and BBB spread. $\sum \gamma_j$ represents the sum of the six lags of the NIBOR, while $\sum \delta_n$ represents the sum of the two lags of $\tilde{c}_{DS,t}$. R^2 is not reported for the instrumental variable regression because no decomposition of the variance of the dependent variable can be assigned to the endogenous dependent variables. *, ** and *** indicate significance at the 10%, 5% and 1 % level, respectively.

	Du-Schreger $\tilde{c}_{DS,t}$, 5 years	Du-Schreger $\tilde{c}_{DS,t}$, 3 months
	(1)	(2)
$\sum \delta_n$	-0.0014***	-0.0285***
	(0.0002)	(0.0028)
$\sum \gamma_j$	0.0167***	0.0122***
	(.0034)	(0.0032)
Number of observations	14,109	14,109

For both specifications, the results are again consistent with a strong role for global factors in shaping domestic Norwegian lending. More specifically, we find that even when we control for the hedging of foreign currency positions, the volatility-implied $\tilde{c}_{DS,t}$ are still significantly related to Norwegian banks' ability to insulate themselves from domestic monetary policy shocks. This is particularly the case when we focus on $\tilde{c}_{DS,t}$derived from short-term interest rate differentials (column (2) of Table 7), signaling particularly strong opportunities for banks to insulate themselves from domestic monetary policy at times when covered interest rate differentials exist even in the short run.

5 The Working Mechanism of Foreign Funding Channel

Our results in section 4 suggest that international financial conditions play a key role in determining bank lending in Norway. We find that for the full sample of banks the greater cost advantage in FX funding is associated with less sensitivity of lending to ex ante liquidity We also find that once this effect is controlled for, bank lending is also contingent on domestic monetary policy.

In a next set of regressions, we present further tests that aim at identifying the mechanism behind the channels that generate this effect. We start by exploring whether the effect of the cost advantage in FX funding is mainly driven by those banks that have access to foreign currency funding. For this purpose, we split the sample of banks quarter-by-quarter into two subsamples: one for those from banks that actively use foreign currency funding (call them "international" banks), and the other one for banks that do not (call them "non-international" banks). Note that the difference between the two groups of banks is not their differential reaction to potential benefits of using foreign currency funding, but rather ex ante institutional characteristics of the banks. So, the first subsample mainly consists of large, international banks that have access to international money markets through their foreign branches as well as large domestic savings banks that actively participate in international money markets, while the second subsample encompasses small, regional and stand-alone banks that mainly fund themselves domestically.[18] Table 8 illustrates the results of the re-estimation of the model reported in Table 4 for the two subsamples. Comparing the results for these two subgroups of banks, we find two major differences.

Table 8: monetary policy and global factors for banks with and banks without access to foreign currency funding

This table reports the results of estimating the regression of the sensitivity of bank loan growth to bank liquidity (β) on the NIBOR as a proxy for the monetary policy interest rate and the cost advantage in FX funding, $\tilde{c}_t$, which is instrumented by VIX and the BBB spread for banks with foreign currency funding and for banks with no foreign currency funding. R^2 is not reported for the instrumental variable regression because no decomposition of the variance of the dependent variable can be assigned to the endogenous dependent variables. *, ** and *** indicate significance at the 10%, 5% and 1 % level, respectively.

	"international" banks (1)	"non-international" banks (2)
$\sum \theta_m$	-0.2403*** (0.0664)	-0.1593*** (0.0136)
$\sum \gamma_j$	0.0001 (0.009)	0.0425*** (0.0039)

[18] In unreported tests, we illustrate the robustness of the finding by similarly showing that banks that use substantial amounts of foreign currency funding (e.g. at least 10% of total liabilities are denominated in foreign currency) have a stronger adjustment of lending to changes in the cost advantage than banks with little or no use of foreign currency funding. Similarly, lending by banks that use substantial amounts of foreign currency funding are not sensitive to domestic monetary policy rate dynamics.

Number of observations	8,472	6,963

First, for the group of banks using foreign currency funding, the effect of monetary policy on the sensitivity of lending to liquidity is negative, implying that the conventional bank lending channel of monetary transmission mechanism is not a proper description of these banks' lending behavior. The opposite is true for the banks with no foreign currency liabilities whose lending is subject to the conventional lending channel relationship.

The second difference consists of the different economic effects of the cost advantage on the sensitivity of lending to liquid assets across the two subsamples. While for *both* groups of banks the effect of the cost advantage is statistically significant and negative, the magnitude of the sum of the θ_m coefficients is substantially higher for banks relying on foreign currency funding.[19] This result implies that the cost advantage shifts the lending behavior of both types of banks, but the effect is much stronger for banks that actively use foreign currency funding. The finding that global factors affect not only the behavior of banks with substantial global exposures but also of banks with purely domestic positions mostly denominated in domestic currency substantially contributes to the literature on the spill-over effects of monetary policy. We basically show that the relevance of the interaction between domestic and foreign monetary policy is not restricted to global banks only, which have been almost the sole focus of existing microeconometric research (Cetorelli and Goldberg, 2012a, b, Bräuning and Ivashina, 2017, Timesvary et al., 2015, Baskaya et al., 2017).

The finding that even bank lending by the second group, i.e., banks not relying on foreign currency funding, reacts to the cost advantage implies that the foreign funding channel passes through the international banks to the domestic interbank market, where banks borrow from each other in NOK. Again, this result is in sharp contrast to the results of studies on the spill-over effect of monetary policy to emerging economies and suggests that the Norwegian interbank market achieves a more efficient allocation of capital relative to emerging markets' interbank markets. To examine how the foreign funding channel affects the population of all Norwegian banks, we first document the positive correlation between growth in the volume of banks' total foreign currency funding (fcf_t) and the (lagged) cost advantage by estimating the following simple model:

[19] A t-test confirms that difference between the sum of the estimated coefficients is statistically significant at 1%.

$$\Delta \ln fcf_t = \alpha_0 + \sum_{n=0}^{k} \eta_n \tilde{c}_{t-n} + \varphi_t \qquad (7)$$

Table 9: the response of total foreign currency funding to the cost advantage

This table reports the results of estimating the regression of the growth rate of total foreign currency funding at the bank level on (1) simultaneous $\tilde{c}_t$, or (2) simultaneous and lagged $\tilde{c}_t$.

	Simultaneous $\tilde{c}_t$ ($k = 0$)	Simultaneous and lagged $\tilde{c}_t$ ($k = 1$)
$\sum \eta_n$	0.2434*** (0.0666)	0.2464*** (0.0676)
Adjusted R^2	0.28	0.28
Number of observations	9,985	9,955

The estimated correlations are reported in Table 9. They illustrate that for $\tilde{c}_t$ both with and without lag there is a strong positive link between banks' foreign currency funding and global funding conditions. This implies that international banks (those in group (1) from Table 8) increase borrowing from abroad when global borrowing conditions are favorable[20]. Next, we explore how the Norwegian interbank market facilitates the pass-through of these favorable global conditions from international banks to domestic non-international banks. For this purpose, we examine how interbank liabilities of domestic non-international banks (those are the banks in the second group from Table 8) react to policy rates and $\tilde{c}_t$. More specifically, we differentiate between $ib\_dep\_NOK_{i,t}$ and $ib\_dep\_FX_{i,t}$ which denote total NOK- and FX-denominated total interbank deposits of bank i in quarter t, respectively and estimate the following models

$$\Delta \ln ib\_dep\_NOK_{i,t} = \alpha_0^{'} + \sum_{n=1}^{2} \eta_n^{'} \tilde{c}_{t-n} + \sum_{k=1}^{2} \omega_k^{'} r_{t-k} + \nu_{i,t}^{'}, \qquad (8)$$

$$\Delta \ln ib\_dep\_FX_{i,t} = \alpha_0^{''} + \sum_{n=1}^{2} \eta_n^{''} \tilde{c}_{t-n} + \sum_{k=1}^{2} \omega_k^{''} r_{t-k} + \nu_{i,t}^{''}, \qquad (9)$$

in which r_t denotes the three-month NIBOR rate. The results are reported in Table 10.

[20] In unreported tests we find that this relation holds not only at the bank level but also at the aggregate level: the share of liabilities denominated in foreign currency in total bank liabilities in Norway is positively correlated with $\tilde{c}_t$.

These results clearly show how the foreign funding channel passes through to Norwegian banks that do not rely on foreign currency funding. They indicate that the volume of interbank deposits of the non-international banks does not react to monetary policy; instead, it reacts to the cost advantage in FX funding, whose impact is positive and significant. This implies that these banks borrow more from other banks whenever positive $\tilde{c}_t$ alleviates the relative costs of global funding for Norwegian banks. More importantly, the currency denominations of the interbank liabilities shows that the changes happen to the interbank deposits in NOK, not in foreign currencies, meaning that the foreign funding channel works through NOK loans from the international banks to the less international ones. So, the more domestically-oriented banks can also benefit from the cost advantage in FX funding by receiving additional interbank funding denominated in NOK.

Table 10: interbank deposits of banks with no foreign currency liabilities

This table reports the results of the estimation of regressions of the logarithmic change in the volumes of interbank deposits on the lag values of $\tilde{c}_t$ and NIBOR. $\sum \eta_n$ and $\sum \omega_k$ represent the sum of the coefficients of the two lags of $\tilde{c}_t$ and NIBOR, respectively. Column (1) is based on interbank deposits denominated in NOK, while column (2) is based on interbank deposits denominated in foreign currency (FX). *, ** and *** indicate significance at the 10%, 5% and 1 % level, respectively.

For positive values of $\tilde{c}_t$	NOK interbank deposits (1)	FX interbank deposits (2)
$\sum \eta_n$	0.5934***	-0.3429
	(0.1732)	(4.0100)
$\sum \omega_k$	-0.06477	0.0076
	(0. 0354)	(0.0082)
Number of observations	2,126	2,126
Adjusted R^2	0.05	0.02

We further underline the role of the domestic interbank market for the pass-through of the foreign funding channel to non-international banks by comparing the relative importance of domestic monetary policy and $\tilde{c}_t$ for the lending dynamics of non-international banks with high reliance on interbank funds to that of non-international banks, which are mostly funded via retail deposits. For this purpose, we look at the distribution for all non-international banks of the share of interbank liabilities in total liabilities and identify the highest (banks relying heavily on interbank funding) and the lowest (mostly retail-funded banks) quantile of this distribution. We then rerun the two-step regression specified by equations (1) and (5) for the identified subgroups of banks relying heavily on interbank funding and mostly retail-funded banks (highest and lowest quartile, respectively).

Table 11: monetary policy and global factors for banks relying more and banks relying less on funding from domestic interbank market

This table reports the results of estimating the regression of the sensitivity of bank loan growth to bank liquidity (β) on the NIBOR as a proxy for the monetary policy interest rate and the cost advantage in FX funding, $\tilde{c}_t$, which is instrumented by VIX and the BBB spread for banks relying more and for banks relying less on funding from domestic interbank market. R^2 is not reported for the instrumental variable regression because no decomposition of the variance of the dependent variable can be assigned to the endogenous dependent variables. The number of observations for the banks in the lowest quartile of interbank liabilities is substantially lower due to the more imbalanced nature of the data for these very small banks. *, ** and *** indicate significance at the 10%, 5% and 1 % level, respectively.

	Non-international banks in highest 25% quantile of interbank liabilities (1)	Non-international banks in lowest 25% quantile of interbank liabilities (2)
$\sum \theta_m$	-0.3106*** (0.0961)	-0.0695*** (0.0193)
$\sum \gamma_j$	0.1037* (0.0306)	0.0282*** (.0049)
Number of observations	1,199	3,860

The results, which are reported in Table 11, show that banks relying most on interbank funding react to $\tilde{c}_t$, while banks relying least on interbank funding do not ($\sum \theta_m$ gives the wrong sign). Both groups, like domestic banks, also react to domestic monetary policy as Table 8 shows, while banks in the highest 25% quantile react more strongly and lead to a higher value of $\sum \gamma_j$. This reflects the fact that banks that rely least on interbank funding are mostly small regional banks that have a substantial monopolistic position in the local deposit market, which allows them to partially decouple their retail funding from monetary policy shocks, hence their credit supply responds less to domestic monetary policy.

In sum, we find that even though the banks with more international funding are those that are best insulated from domestic monetary policy, the dynamics of the Norwegian interbank market exposures suggests that these bank pass through some of their international funding advantage to banks with more domestic operations by channeling funds to these banks via the interbank market when international funding conditions are beneficial.

6 Robustness Checks

In this section, we conduct several robustness checks for the previous results. First, as Christiano et. al. (1999) argue, there is little consensus on the measurement of monetary policy shocks. Here we do not attempt to propose one perfect measurement, but rather we take four alternative monetary policy indicators that are typically used in the literature to replace the one in regression (2): (i) the key policy rate; (ii) changes in three-month NIBOR; (iii) percentage changes in 3-month NIBOR; (iv) interbank overnight lending rate.

Next, we also control for the changes in the Federal Reserve's monetary policy by using the Wu-Xia shadow rate (Wu and Xia 2016) to proxy the US monetary policy rate. And last but not least, we show that the results are robust to using the estimated cost advantage in EUR funding rather than USD funding. This is to address the concern that a substantial share of foreign currency funding might be denominated in EUR rather than in USD.

The results of all the robustness specifications are reported in Table 12. For each of the alternative specifications, the variables enter the regression with statistically significant coefficients of the expected signs, and the results here are consistent with those reported in Table 5.

Table 12: robustness checks

This table reports the results of the estimation of the regression of the sensitivity of bank loan growth to bank liquidity (β) on the NIBOR as a proxy for the policy rate and the cost advantage in FX funding, $\tilde{c}_t$, which is instrumented by the VIX and the BBB spread. It replicates the results presented in Table 5 for different specifications of the monetary policy rate (columns (1)-(4), as well as controlling for the quantitative easing period (column (5)) and uses the cost advantage in EUR funding instead of USD funding (column (6)). R^2 not reported for the instrumental variable regression because no decomposition of the variance of the dependent variable can be assigned to the endogenous dependent variables. *, ** and *** indicate significance at the 10%, 5% and 1 % level, respectively.

	Key policy rate	Change in NIBOR	Percentage change in NIBOR	Overnight rate	Quantitative easing (Wu-Xia shadow rate)	Cost advantage in EUR funding
	(1)	(2)	(3)	(4)	(5)	(6)
$\sum \theta_m$	-0.2141*** (0.0131)	-0.1219*** (0.0074)	-0.1355*** (0.0083)	-0.1613 *** (0.0092)	-0.2734*** (0.0294)	-0.0015*** (0.0028)
$\sum \gamma_j$	0.0291 *** (.0023)	0.0925 *** (0.0115)	0.5688*** (0.0454)	0.0182 *** (0.0014)	0.0445*** (0.0044)	0.0040** (0.0016)
Obs.	15,687	15,687	15,687	15,687	15,687	8,942

7 Concluding Remarks

In this paper, we provide the first micro-level evidence on the limits of the effectiveness of the conventional bank lending channel in the transmission mechanism of domestic monetary policy when banks have access to global funding sources. Using Norwegian data, we show that global funding conditions modify the effectiveness of domestic monetary policy. More specifically, we show that exchange rate dynamics that do not fully neutralize the interest rate differentials can generate beneficial global funding conditions for Norwegian banks, raise their incentives to use foreign currency funding and insulate banks from domestic monetary policy tightening.

Examining the mechanism of transmission of global factors, we find that, while large Norwegian banks borrow substantially in foreign currency, they issue NOK-dominated interbank loans to smaller domestic banks. Those international banks increase their foreign currency funding when international funding conditions are favorable, and this also increases their liquidity supply to the non-international banks in the domestic money market, making almost the entire banking sector partially shielded from domestic monetary policy shocks.

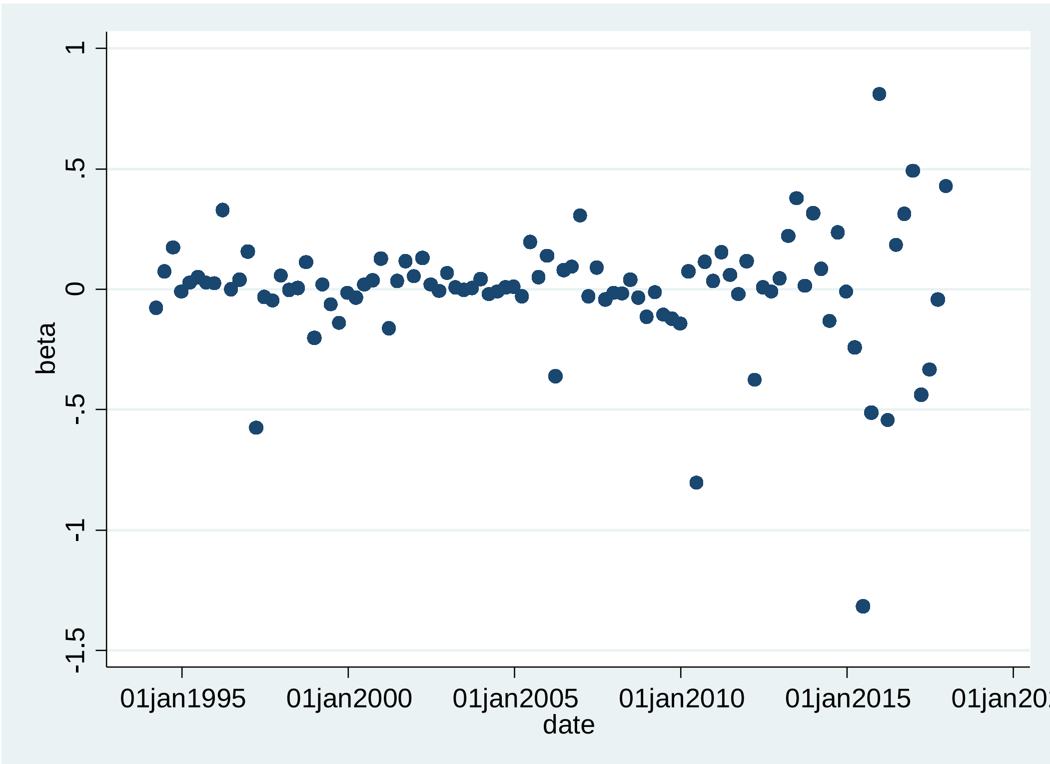
As is seen in our results, when the Norwegian krone is appreciating and global risk aversion is high, the negative risk premium attracts capital inflows that lead to growth in bank lending, and the same results still hold after we take into account the fact that Norwegian banks hedge their foreign currency positions. These results are consistent with the so-called dilemma of global financial cycles (Rey, 2015) and can therefore be seen as the first micro level evidence for the limits of domestic monetary policy in affecting aggregate credit supply, when the capital account is not controlled (Rey, 2015, Hoffmann et al., 2016). In the sense that we focus on Norway, a high income economy with strong institutions, the results are also complementary to Rey (2015), Hoffmann et al. (2016) and Baskaya et al (2017), who mainly explore emerging economies.

Appendix

A. The intermediate estimates of $\boldsymbol{\beta_t}$

Figure A1 presents the time series of β_t that is estimated from the first step regression of our model, as described in equation (1).

Figure A1: estimates of β_t



B. The second-stage estimates of lagged variables for Table 2

Table A1 presents the coefficients of each of the lagged values of the interest rates (key policy rate) or NIBOR, which are derived from the estimation of the second-stage of our model given by equation (2). These are the γ_j used for the computation of $\sum \gamma_j$ reported in Table 2.

Table A1: coefficients of the lagged values of the interest rates (key policy rate) / NIBOR, estimated from equation (2)

Key policy rate

	β_t (using the liquid assets to total asset ratio)		β_t (using the residual of liquid assets to total asset ratio regression)	
	coefficient	p-value	coefficient	p-value
L1.	0.028	0.000	0.022	0.000
L2.	-0.053	0.000	-0.035	0.000
L3.	0.074	0.000	0.059	0.000
L4.	-0.116	0.000	-0.102	0.000
L5.	0.131	0.000	0.116	0.000
L6.	-0.064	0.000	-0.061	0.000
Constant	0.009	0.000	0.021	0.000
Number of obs.		23,577		23,577
Adjusted R^2		0.004		0.022

Three-month NIBOR

	β_t (using the liquid assets to total asset ratio)		β_t (using the residual of liquid assets to total asset ratio regression)	
	coefficient	p-value	coefficient	p-value
L1.	0.017	0.000	0.017	0.000
L2.	-0.035	0.000	-0.029	0.000
L3.	0.056	0.000	0.062	0.000
L4.	-0.096	0.000	-0.113	0.000
L5.	0.111	0.000	0.124	0.000
L6.	-0.053	0.000	-0.063	0.000
Constant	0.006	0.066	0.022	0.000
Number of obs.		23,577		23,577
Adjusted R^2		0.022		0.072

C. The second-stage estimates of lagged variables for Table 5

Table A2 presents the coefficients of each of the lagged values of the NIBOR as well as those of the cost advantage in FX funding, which are derived from the estimation of the second stage of our model given by equation (2). These are the γ_j and θ_j used for the computation of $\sum \gamma_j$ and $\sum \theta_j$ reported in Table 5, Panel B.

Table A2: coefficients of the lagged values of the NIBOR / the cost advantage in FX funding, estimated from equation (2)

	β_t (IV regression using VIX and BBB spread)	
	coefficient	p-value
$\tilde{c}_t$(cost advantage)		
L1.	-21.925	0.000
L2.	-11.943	0.011
three-month		
NIBOR		
L1.	-0.010	0.245
L2.	0. 088	0.000
L3.	-0.021	0.068
L4.	-0.1201	0.000
L5.	-0.226	0.000
L6.	-0.113	0.000
Constant	-0.045	0.000
Number of obs.		15,687
Adjusted R^2		0.149

D. The first-stage regression results of the instrumental variable estimation whose second stage is presented in Table 5.

Table A3: first-stage regression results for Table 5

Panel A: This panel presents the first stage of the two-stage instrumental variable estimation presented in Panel A of Table 5, i.e. the specification using the oil price, the VIX and BBB spread as instrumental variables.

	$\tilde{c}_t\ (t-1)$		$\tilde{c}_t\ (t-2)$	
	coefficient	p-value	coefficient	p-value
Oil price				
L1.	0.001	0.091	-0.001	0.000
L2.	0.001	0.000	0.002	0.000
VIX				
L1.	0.010	0.000	0.005	0.000
L2.	0.005	0.000	0.013	0.000
BBB Spread				
L1.	-0.044	0.000	0.000	0.000
L2.	0.105	0.000	-0.001	0.283
Constant	-0.006	0.000	-0.005	0.000
Number of obs.		15,687		15,687
Adjusted R^2		0.542		0.563

Panel B: This panel presents the first stage of the two-stage instrumental variable estimation presented in Panel B of Table 5, i.e. the specification using the VIX and BBB spread as instrumental variables.

	$\tilde{c}_t\ (t-1)$		$\tilde{c}_t\ (t-2)$	
	coefficient	p-value	coefficient	p-value
VIX				
L1.	0.010	0.000	0.015	0.000
L2.	0.005	0.000	0.004	0.000
BBB Spread				
L1.	-0.044	0.000	-0.000	0.986
L2.	0.105	0.000	0.027	0.003
Constant	-0.551	0.000	-0.739	0.000
Number of obs.		15,687		15,687
Adjusted R^2		0.522		0.539

References

Avdjiev, S., McCauley, R. N. and Shin, H. S. (2015), Breaking free of the triple coincidence in international finance, *BIS Working Papers*, No. 524.

Ashcraft, A. B. (2006), New evidence on the lending channel, *Journal of Money, Credit, and Banking* 38, 751–775.

Baskaya, Y. S., di Giovanni, J., Kalemli-Ozcan, S. and M. F. Ulu (2017), International spill-overs and local credit cycles, *NBER Working Paper* 23149.

Bräuning, F. and Ivashina, V. (2017), Monetary policy and global banking, *NBER Working Paper Series*, No. 23316.

Brunnermaier, M. K. et al. (2012), Banks and cross-border capital flows: Policy challenges and regulatory responses, Committee on International Economic Policy and Reform.

Bruno, V. and Shin, H. S. (2015a), Cross-border banking and global liquidity, *Review of Economic Studies* 82, 535–564.

Bruno, V. and Shin, H. S. (2015b), Capital flows and the risk-taking channel of monetary policy, *Journal of Monetary Economics* 71, 119–132.

Buch, C. M., Bussiere, M., Goldberg, L. and Hills, R. (2018), The international transmission of monetary policy. *NBER Working Paper* 24454.

Campello, M. (2002), Internal capital markets in financial conglomerates: Evidence from small bank responses to monetary policy, *Journal of Finance* 57, 2773–2805.

Cetorelli, N. and Goldberg, L. S. (2012a), Banking globalization and monetary transmission, *Journal of Finance* 67, 1811–1843.

Cetorelli, N. and Goldberg, L. S. (2012b), Liquidity management of U.S. global banks: Internal capital markets in the great recession, *Journal of International Economics* 88, 299–311.

Christiano, L. J., Eichenbaum, M. and Evans, C. L. (1999), Monetary policy shocks: What have we learned and to what end? In: J. Taylor and M. Woodford (eds.), *Handbook of Macroeconomics*, Vol. 1A. Elsevier, Amsterdam, Chapter 2.

Du, W. and Schreger, J. (2016), Local currency sovereign risk. *Journal of Finance* 71, 1027-1070.

Forbes, K. J. and Warnock, F. E. (2012), Capital flow waves: Surges, stops, flight, and retrenchment. *Journal of International Economics* 88, 235–251.

Gourinchas, P.-O. and M. Obstfeld (2012), Stories of the Twentieth Century for the Twenty-First", *American Economic Journal: Macroeconomics* 4, 226–65.

Hofmann, B., Shim, I. and Shin, H. S. (2016), Sovereign yields and the risk-taking channel of currency appreciation, *BIS Working Papers*, No. 538.

Kashyap, A. K. and Stein, J. C. (2000), What do a million observations on banks say about the transmission of monetary policy? *American Economic Review* 90, 407–428.

Krogstrup, S. and Tille, C. (2015), What drives the funding currency mix of banks? Unpublished working paper, Swiss National Bank, Graduate Institute of International and Development Studies.

Molland, J. L. (2014), Norwegian banks' foreign currency funding of NOK assets, *Staff Memo*, 2/2014, Norges Bank.

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

Norges Bank (2018), *Norway's Financial System 2018*. Available at https://www.norges-bank.no/en/Published/Publications/norways-financial-system/2018/.

Obstfeld, M., Shambaugh, J. C. and Taylor, A. M. (2005), The trilemma in history: Tradeoffs among exchange rates, monetary policies, and capital mobility. *Review of Economics and Statistics* 87, 423–38.

Rey, H. (2015), Dilemma not trilemma: The global financial cycle and monetary policy independence, *NBER Working Paper*, No. 21162.

Rime, D., Schrimpf, A. and O. Syrstad (2017), Segmented Money Markets and Covered Interest Parity Arbitrage, *Norges Bank Working Papers*, No. 15/2017

Shin, S. H. (2015), Exchange Rates and the Transmission of Global Liquidity, Bank of Korea-IMF Conference Keynote, BIS.

Temesvary, J., Ongena, S. and Owen, A. L. (2018), A global lending channel unplugged? Does U.S. monetary policy affect cross-border and affiliate lending by global U.S. banks? *Journal of International Economics* 112, 50–69.

Ulltveit-Moe, K. H., Vale, B., Grindaker, M. H. and Skancke, E. (2013), Competitiveness and regulation of Norwegian banks, *Staff Memo*, 18/2013, Norges Bank.

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