Article:

Cao, J and Dinger, V (Accepted: 2021) Financial Globalization and Bank Lending: The Limits of Domestic Monetary Policy. Journal of Financial and Quantitative Analysis. ISSN 0022-1090 (In Press)

Financial Globalization and Bank Lending: The Limits of Domestic Monetary Policy

Jin Cao and Valeriya Dinger*

* Cao, jin.cao@norges-bank.no, Norges Bank Research Department, Norway and CESifo, Germany; Dinger (corresponding author), vdinger@uni-osnabrueck.de, University of Osnabrück, Germany and the Leeds University Business School. We thank Jarrad Harford (the editor), an anonymous referee, 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, Linda Goldberg, 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, ASSA Annual Meeting in San Diego, Annual Meeting of the Western Finance Association (WFA), Deutsche Bundesbank Conference "Financial Intermediation in a Globalized World", 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.

Abstract

Exploring bank-level data from a small open economy, we present evidence that global funding conditions limit the effectiveness of domestic monetary policy in terms of shaping both the volume and the riskiness of bank lending. We show that more favorable global funding conditions associated with a local currency appreciation encourage banks to increase lending, leverage up, take more risks, and thus insulate themselves from lean-against-the-wind domestic monetary policy. These results support the existence of a risk-taking channel of currency appreciation (Bruno and Shin (2015a, b)) at the bank level.

I. Introduction

How does bank lending react to monetary policy in the presence of global financial flows? As the so-called "bank lending channel" in conventional wisdom states, 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, as is shown in the seminal research of Cetorelli and Goldberg (2012). Further, a vast and growing literature has shown that, in the presence of cross-border capital flows, foreign interest rates affect funding costs for domestic banks, so that domestic lending *volumes* are subject to spillovers from core economies' monetary policy (see Morais, Peydró, and Ruiz (2019), Baskaya, di Giovanni, Kalemli-Ozcan, and Ulu (2017) for recent examples and Buch, Bussiere, Goldberg, and Hills (2019) for a review of the literature).

Bank-level empirical studies documenting these spillover effects, however, ignore the impact of exchange rate dynamics in shaping the externalities of foreign monetary policy. Bruno and Shin (2015a) illustrate that this is not an innocuous omission, since exchange rate dynamics interact with foreign monetary policy in shaping the dynamics of local credit. In their model, borrowers face a currency mismatch by borrowing in dollars whilst most of their revenues are denominated in local currency, so any appreciation of the domestic currency is associated with a drop in borrowers' risk at least in the short term. Since banks have to put less capital aside for loans with lower perceived risk, they can increase their leverage and expand their lending volumes. This leads to further inflow of cross-border capital and an appreciation of the currency. A tightening of a core economy's monetary policy can reverse this positive loop: The depreciation of the local currency leads to an upward shift in borrowers' risk and requires deleveraging associated with a drop in lending volumes. Since risks build during the positive stage of the loop and the increase in lending volumes is also associated with a risk shift, Bruno and Shin (2015a) therefore term such dynamics "the risk-taking channel of currency appreciation". While these authors present a thorough test of their predictions at the country-level, the bank-level validity of the presumed channels has not been empirically established so far.

In this paper, we fill this gap by illustrating how global funding conditions that are related to exchange rate dynamics and arise from global risk factors as well as core economies' monetary policy affect the transmission of domestic monetary policy both in terms of loan *volumes* and portfolio *risk*. For this purpose, we employ detailed bank financial reports for all banks in a small open economy, Norway, over more than 20 years. Although we take Norway as a laboratory for identification, we believe that our findings are applicable for other small open economies, too, as is documented by Bruno and Shin (2015b) and Avdjiev, Du, Koch, and Shin (2019) based on macro-level data.

We start by demonstrating that while domestic monetary policy was reasonably effective before 2001—which was the year when the Norges Bank abandoned formal exchange rate interventions and de facto enabled deviations from interest rate parity—after this date the classic lending channel loses its effectiveness in Norway. For this purpose, we estimate a classic lending channel model (Kashyap and Stein (2000) as modified by Cetorelli and Goldberg (2012)) that identifies the impact of policy rates on the supply of bank loans by focusing on how policy rates shape the sensitivity of bank lending volumes to the ex ante liquidity endowment of the banks. We also show that the reduced effectiveness of domestic monetary policy is particularly pronounced in times of domestic policy rate tightening, when the "leaning-against-the-wind" policy fails to achieve the intended reduction in lending volumes. Next, we conjecture that the failure to document a classic bank lending channel for Norway after 2001 is due to the omission of potential changes in funding costs for Norwegian banks in international money markets. To overcome this omission, we integrate global funding conditions as shaped by the interaction between foreign monetary policy and exchange rate dynamics into the empirical model. For this purpose, we include the deviation from uncovered interest rate parity (UIP) as an additional covariate in the classic lending channel model. Since this deviation approximates the component of international funding costs that is not driven by domestic monetary policy, it provides us with a measure of the cost advantage of foreign currency funding determined by exchange rate dynamics. While Bruno and Shin (2015a) explicitly allow for the exchange rate to be endogenous with regard to capital flows and bank lending, we focus on a microeconometric identification strategy based on extracting the exogenous component of UIP deviations, using an instrumental variable technique.

In constructing the instruments, we elaborate on the role of the oil price as well as global risk factors such as the VIX and the broad dollar index, so that at this step we particularly benefit from the choice of Norway as a "laboratory". We also control for the fact that some foreign currency positions are hedged and show that the results of our estimation are robust to using deviations from covered (instead of uncovered) interest rate parities as a proxy for the impact of the cost advantage of foreign currency funding on bank lending.

We then explore the channels through which international funding affects Norwegian banks' lending. We find that the impact of international funding costs is asymmetric. When these costs are favorable, they significantly shape bank lending and reduce the effectiveness of domestic monetary policy. In turn, when international funding costs rise, domestic monetary policy significantly affects bank lending. That is, banks actively arbitrage between global and domestic funding, depending on which cost is more favorable. Zooming into the result that favorable global funding conditions actively shape bank lending in Norway, we show that the use of foreign currency liabilities by Norwegian banks increases when the costs of foreign currency funding decrease.

After establishing how global banking affects the volume of domestic bank lending, we further explore its influence on banks' risk-taking behavior. We test the model of Bruno and Shin (2015a) by tracing how the portfolio of bank loans depends on global funding conditions. Consistent with the predictions of their model, we find that the lending expansion following the currency appreciation is associated with increased bank leverage. The appreciation leads to a higher share of commercial and industrial loans and a lower share of mortgage loans, as well as to an increase in non-performing loans, suggesting that we observe not only a shift in the volume but also the riskiness of bank lending. Since we also observe that capital levels do not rise at the individual bank level, we can assert, consistent with Bruno and Shin (2015a), that banks justify the expansion of loans that generally require higher capital weights by reducing the perceived riskiness of their balance sheets.

Our analysis contributes to several strands of the literature. Our main contribution is to provide the first microeconometric, bank-level evidence on the risk-taking channel of currency appreciation, as proposed by Bruno and Shin (2015a). This evidence highlights the role of international spillovers of monetary policy and illustrates the need to account for currency exchange dynamics, when exploring the interactions between domestic and foreign monetary policy. In a more general sense, by showing that the dynamics of exchange rates and global risk aversion affect domestic lending, our findings 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, McCauley, and Shin (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. Using aggregate data, Rey (2015) finds that US monetary policy affects the leverage of global banks, which leads to co-movements of global asset prices, cross-border capital flows, and credit growth in the international financial system. This result is termed an “irreconcilable duo” —independent monetary policy is only possible if and only if the capital account is managed.

By showing the close link between foreign currency funding costs for Norwegian banks and global risk factors, such as the VIX and the broad dollar currency exchange index, we contribute to the literature relating capital flows to global risk factors. Our bank-level evidence on how these risk factors affect bank leverage supports the insights that both the VIX (Rey (2015)) and later the broad dollar index (Avdjiev et al. (2019), Bruno and Shin (2020), and Erik, Lombardi, Mihaljek, and Shin (2020)) interfere with real economic dynamics by shaping bank leverage. We also show that these relationships persist even when foreign currency positions are hedged. This is consistent with Bräuning and Ivashina's (2020) findings that even with hedged positions, bank lending is still subject to spillover effects that are caused by the shift in credit supply in hedging transactions. Avdjiev et al. (2019) similarly show that cross-border spillovers are related to deviations from covered interest rate parity.

By showing that the existence of a global funding channel makes domestic monetary policy less effective, especially when the central bank wants to tighten monetary policy and restrain a domestic credit boom, our analysis also illustrates a major channel that hampers lean against the wind monetary policies (Gourio, Kashyap, and Sim (2018), Schularick, ter Steege, and Ward (2020)), in particular in small open economies. This needs to be addressed when macroprudential policies are designed in order to contain excessive volatilities over credit cycles.

The rest of the paper is structured as follows: In Section II, we describe the institutional framework and the data. In Section III, we replicate the approach of classic lending channel studies for the case of Norway and illustrate the failure of the traditional lending channel. We go on to explore the effect of global factors measured by the cost advantage of foreign currency funding and show that this is a driving force in bank lending. In Section IV, we illustrate the shifts in bank assets and liabilities associated with the changes in foreign currency funding costs. Robustness checks are carried out in Section V. In Section VI, we discuss the policy implications of our findings and conclude.

II. Institutional Framework and Data

A. Norwegian Banking Sector: A Brief Introduction

As of 2017Q4, there are 100 savings banks and 36 commercial banks in Norway. Of the commercial banks, 12 are foreign-owned, including six subsidiaries and six branches.[1] The commercial banks are limited liability companies. The foreign-owned commercial banks are mostly either subsidiaries or branches of Swedish, Finnish, and Danish banks. The savings banks ("sparebank") were established by Norwegian municipalities as independent entities without external owners, taking deposits and providing credit to local households and regional businesses.

What is new and noteworthy in the Norwegian banking sector are the mortgage companies ("kredittforetak"), currently 33 in total as of 2017Q4. These companies 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. As of 2017Q4, total covered bonds outstanding in Norway amounted to EUR 115.183 billion (roughly 15% of total assets in the Norwegian banking sector, or 33% of Norwegian GDP). About 60% of the volume of covered bonds was denominated in foreign currencies.[2] Since a mortgage company's main function is issuing covered bonds to fund the mortgage business of its parent

---

[1] See Norges Bank Historical Monetary Statistics, available on http://www.norges-bank.no/en/Statistics/Historical-monetary-statistics/Money-credit-and-banking/, and the Norwegian Savings Banks Association ("Sparebankforeningen"), available on http://www.sparebankforeningen.no, with our own update.

[2] Our own calculation, based on Finance Norway statistics, available on https://www.fno.no/en/.

bank, we do not consider mortgage companies as separate entities in our estimations but rather match their foreign currency-denominated liabilities to those of their parent banks.[3]

B. Monetary Policy Regimes and Bank Funding Costs

Stabilizing the Norwegian krone exchange rate was one of the monetary authorities' major concerns throughout the 1980s and 1990s. 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.[4] In a move towards a flexible inflation targeting regime, Norges Bank stopped intervening in the foreign exchange market in January 1999.[5] The introduction of inflation targeting[6] was officially formalized in 2001.

Like banks in other open economies, Norwegian banks raise funding from both the domestic money market in domestic currency (NOK) and the international money market in foreign currencies. Most of the loans issued by Norwegian banks (88% in 2017) are, however, issued in domestic currency. Domestic monetary policy creates a wedge between the domestic

---

[3] All empirical results presented in this paper are robust to the use of bank balance sheets without including banks' mortgage companies.

[4] "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.

[5] 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*."

[6] See more background information in Andreassen et al., "Norges Bank Watch 2001", available on http://www.bi.edu/cmeFiles/NBW2001.pdf.

money market rate and the international money market rate. Whether or not this wedge results in different funding costs when using domestic currency funding from those when using foreign currency funding depends on whether the exchange rate between NOK and foreign currencies changes so that the wedge is neutralized. If the exchange rate dynamics are consistent with UIP, the costs of foreign currency funding will be approximately the same as those of funding denominated in domestic currency. When exchange rate stabilization was the monetary policy regime, the domestic key policy rate and exchange market interventions were designed to eliminate arbitrage opportunities in the foreign exchange (FX) market.[7] As a result, even if a bank exploits the interest rate differential when the domestic money market rate is higher than the international rate and borrows in foreign currency, once it converts FX funding to NOK for domestic lending, the dynamics in the NOK exchange rate will fully neutralize the interest rate differential. In other words, under the exchange rate stabilization regime, domestic monetary policy is, in theory, fully effective in changing banks' funding costs, independent of their funding currencies, and there is no cost advantage of FX funding.

However, such effectiveness may have been eroded when exchange rate stabilization was abandoned after the regime change. Without the central bank's active intervention in the FX market, the NOK exchange rate was free to float and subject to the influence of global factors, such as global risk aversion, that are beyond the reach of the central bank in a small open economy, so that interest rate parities may not hold anymore. This may lead to a cost advantage of certain

---

[7] For example, given the spot NOK exchange rate S_t and foreign interest rate r_t^*, to stabilize the future spot NOK exchange rate S_{t+1}, the domestic interest rate r_t shall be set as $1 + r_t = \frac{S_{t+1}}{S_t}(1 + r_t^*)$, which is exactly uncovered interest rate parity (UIP).

funding currencies: suppose funding costs are lower for FX funding, then a tighter domestic monetary policy that only increases the domestic money market interest rate will encourage banks to take cheaper FX funding so that they do not necessarily have to cut domestic lending—as is suggested by the conventional bank lending channel. The effectiveness of domestic monetary policy in driving bank lending is thus reduced.

C. Data Description

Our data employs the monthly ORBOF[8] reports (Report 10 and Report 11) submitted in the period between January 1994 and December 2017, which register the components of balance sheets and income statements for all Norwegian banks —including commercial banks, savings banks, subsidiaries of foreign banks, branches of foreign banks and bank-affiliated mortgage companies. 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.

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),

[8] *Offentlig Regnskapsrapportering fra Banker og Finansieringsforetak*, i.e., official financial reports by banks and financial undertakings.

as well as a battery of domestic and international monetary policy and money market interest rates. The domestic interest rates are drawn from Norges Bank's monetary statistics, while the international interest rates are from the St. Louis Fed's FRED databank. We combine these data with dataset information for the broad dollar index and for the levels and dynamics of the Norwegian krone exchange rates relative to major foreign currencies.

D. The Norwegian Banking Sector as a Suitable Laboratory

The Norwegian bank-level data is unique in that it provides information about the currency denomination, distinguishing between the domestic currency and foreign currencies, for all the categories reported in the balance sheet as well as for most of the profit and loss account items over a considerably long time horizon. This information allows us to track with a very high level of 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 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 opportunity 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.[9] The speed of foreign currency funding growth has been particularly high in the post-2001 period. 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

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

advantage of the Norwegian data is that it allows us to employ global risk attitudes as instrumental variables for exchange rate fluctuations and thus achieve convincing identification. 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 debates on the effect of global factors on local lending have so far focused on emerging periphery economies, where weak banking regulation and fragile institutions prevail. In addition, the Norwegian banking sector was not substantially affected by the 2007-2009 global financial crisis and 2012 European debt crisis: Monetary policy did not 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.

III. Global Financial Flows and Monetary Policy Transmission

A. Lending as a Function of Domestic and Global Funding Conditions

In this section, we examine how domestic monetary policy and global funding conditions jointly determine the dynamics of bank lending supply. Our point of departure is a standard empirical estimation of the effectiveness of the domestic bank lending channel, as proposed by Kashyap and Stein (2000), later modified by Cetorelli and Goldberg (2012). In the framework of these studies, a tightening of monetary policy represents a funding shock for banks, which they cannot fully offset by issuing alternative liabilities. The shock is therefore 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 by assuming that a bank's lending supply will react less to funding shocks if the bank has a high ex ante endowment of liquid assets, since banks can liquidate these assets to cushion the funding shock instead of cutting lending. The supply side of lending dynamics is, therefore, more sensitive to banks' ex ante liquidity endowment when monetary policy is tight. More specifically, the empirical estimation is based on a two-stage procedure (Kashyap and Stein (2000), Cetorelli and Goldberg (2012)).

The first stage is described in equation (1):

(1) $\text{LOAN\_GROWTH}_{i,t} = \sum_{j=1}^{4} \alpha_{t,j}\text{LOAN\_GROWTH}_{i,t-j} + \beta_t X_{i,t-1} + \sigma_t \text{CONTROLS}_{i,t-1} + \varepsilon_{i,t}$

in which $\text{LOAN\_GROWTH}_{i,t}$ is the growth rate of total loans and leases 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, $\ln(\text{LIQUID\_ASSETS\_TO\_ASSETS}_{i,t-1})$. Following Cetorelli and Goldberg (2012), we address a potential identification issue related to the fact that bank liquid asset holdings may react to macroeconomic conditions. We do this by instrumenting observable liquid assets using the residual of a regression of liquid-assets-to-total asset ratio on the ratio of commercial and industrial (C&I) lending to total lending and the ratio of non-performing loans to total loans.[10] The vector $\text{CONTROLS}_{i,t-1}$ includes bank-specific control variables such as the bank's capitalization

[10] In unreported tests, we also show that results are robust to using the observable values of liquid assets to total assets without employing instrumental variable techniques.

ratio, its total assets, deposit growth rate, the type of bank (savings bank or foreign bank subsidiary), the share of liabilities denominated in foreign currency, as well as the amount of write-offs relative to total assets. $\text{CONTROLS}_{i,t-1}$ also includes a vector of macro-level control variables, such as the GDP growth rate and the growth rate of house prices, to capture the impacts of business cycles. A full list of all variables used throughout the empirical analyses and their definition is presented in Table 1.[11] To avoid any simultaneity issues related to the fact that banks jointly determine asset and liability positions on their balance sheet, all control variables enter the regressions with one-quarter lags. $\varepsilon_{i,t}$ denotes the error term.

We run the cross-sectional equation (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 relationship between the time series of β_t and monetary policy interest rates is examined based on the following equation (2):

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

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. We proxy monetary policy rate r by the Norwegian Interbank Offered Rate (NIBOR), and we also provide robustness checks by measuring r by the key policy rate in Section V. Using the Akaike Information Criterion (AIC), we define the number of quarters n to be included in the

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

series of lagged monetary policy rates as six.[12] As in Cetorelli and Goldberg (2012), we consider possible autocorrelation and correct standard errors using the Newey-West variance estimator.

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

[INSERT TABLE 1 HERE]

As mentioned above, the conventional bank lending channel suggests that bank lending should become more sensitive to bank liquidity when monetary policy is tightened, and less so when monetary policy is loosened. In the framework of our estimation, this implies that 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, in which we show the sum of the coefficients of the interest rate lags in terms of point estimate and statistical significance[13], while the time series of the intermediate estimates of β_t are illustrated in Figure A1 in Appendix A. In column 1 of this table, we show the estimate when the model is run for the full sample period (1994-2017). In this case, the sum of the coefficients of the interest rates, $\sum \gamma_j$, is statistically insignificant, suggesting that the conventional transmission mechanism of monetary policy is not supported by our sample.

[INSERT TABLE 2 HERE]

[12] Cetorelli and Goldberg (2012) set this number at eight. We have rerun all models using the eight-quarter specifications, and the results are qualitatively the same.

[13] The sum of the coefficients is computed using the *lincom* command in STATA.

Next, we explore the effectiveness of domestic monetary policy for the period before and after the Norges Bank's policy regime switch in 2001. The result in column 2 of Table 2 shows a positive and significant $\sum \gamma_j$, implying that prior to the policy shift in 2001 the conventional lending channel was effective. The fact that $\sum \gamma_j$ is significantly negative for the later period (see column 3) suggests that domestic monetary policy transmission via the bank lending channel breaks down for the period of 2002-2017.[14]

Furthermore, we find that the post-2001 breakdown is more pronounced when the central bank "leans against the wind". As is shown in columns 4 and 5 of Table 2, 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, $r_t - r_{t-4} > 0$), bank lending reacts to monetary policy in a way that is inconsistent with the existence of a lending channel, as $\sum \gamma_j$ is negative. However, when there is a negative change in NIBOR, i.e. when monetary policy becomes looser (defined as $r_t - r_{t-4} < 0$), our estimation is consistent with the existence of a lending channel, as $\sum \gamma_j$ is positive—although it is not statistically significant. Such asymmetry is in line with our conjecture in Section II.B that banks may arbitrage and shift funding towards cheaper FX funding in international money markets when tightening monetary policy increases the costs of domestic money market funding. As a result, banks can avoid the contraction in lending sought by the central bank.

B. Cost Advantage, Global Factors, and the Foreign Funding Channel

[14] 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 2001. A Chow-test also indicates a structural break in 2001.

The breakdown of the bank lending channel in the period 2002-2017 is likely related to the Norges Bank's regime switch. As we discussed in Section II.B, after Norges Bank stopped intervention in FX market, the NOK exchange rate was free to float and was subject to the influence of global factors, such as global risk aversion, so that interest rate parities may not hold anymore. This may lead to a cost advantage for certain currencies, incentivizing banks to arbitrage between domestic and international money markets, reducing the effectiveness of the bank lending channel in domestic monetary policy transmission. Of course, given the fact that substantial advances in information technology have 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 consider the abolition of foreign exchange interventions by the Norges Bank as the step that allows for a stronger effect of global factors on banks' funding costs and domestic monetary policy transmission.

In this section we explore how global funding conditions, which determine the costs of funding in foreign currency and therefore drive banks' incentives to arbitrage between FX and domestic currency funding, interact with domestic monetary policy in shaping bank lending volumes. As discussed in Section II.B, we focus on the cost advantage of foreign currency funding that is given by the deviation from UIP. This costs advantage represents the interest rate differential between Norway and the core economy (in our baseline estimations, we focus on the US as a core, we later present robustness evidence using the euro area) that is orthogonal with regard to domestic monetary policy and contingent on exchange rate dynamics. We construct a simple measure of the cost advantage of US dollar funding, $\tilde{c}_t$, corresponding to the deviation from the uncovered interest parity (UIP) defined in the following way:

(3) $\tilde{c}_t = \frac{\text{IMPLIED\_NOK/USD}_{t+1} - \text{NOK/USD}_{t+1}}{\text{NOK/USD}_t}$

in which NOK/USD_{t+1} represents the observed 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

(4) $\text{IMPLIED\_NOK/USD}_{t+1} = \text{NOK/USD}_t \frac{1+r_t}{1+r_t^*}$

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.[15] In this way, positive deviation $\tilde{c}_t > 0$ means that the actual NOK/USD exchange rate is below (i.e. the NOK is stronger) what is suggested by (4), implying a cost advantage of FX funding.

In Figure 1, we present $\tilde{c}_t$ over the entire horizon of our data sample. Indeed, prior to year 2001, UIP deviations were smaller in magnitude and relatively short-lived, while they became increasingly persistent, especially in a positive direction, once 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 and the broad dollar index).

[INSERT FIGURE 1 HERE]

[15] Similarly, we can represent the cost advantage or UIP deviation in euro funding using the three-month EURIBOR rate and NOK/EUR exchange rate.

In econometric terms, the examination of the effect of monetary policy on lending without considering the FX funding advantage—as in our baseline model—might lead to omitted variable bias. So, in a next set of regressions, we address this issue by re-estimating the model, now including deviation from UIP as an additional explanatory variable. We present this extended model version only for the period 2002-2017, since this is the time when substantial, persistent deviations of $\tilde{c}_t$ from zero are observable and the domestic lending channel breaks down.

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

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

in which $\tilde{c}_{t-m}$ denotes UIP deviation 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.

As discussed earlier, Kashyap and Stein's (2000) approach enables us to identify the supply side of bank funding costs in terms of domestic monetary policy. By expanding the second stage of their model to include UIP deviation (equation (5)), we are still identifying supply-side effects. However, when the second stage model includes UIP deviation, 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 bank lending is less sensitive to ex ante liquidity endowment when UIP deviation is high. This relationship will not be driven by UIP deviation itself but rather by unobservable optimistic sentiment about the Norwegian economy, which shifts up both the NOK exchange rate and loan supply. In our microeconometric setting, we achieve identification by focusing on the exogenous part of the UIP deviations, which we derive by using instruments based on exogenous components of exchange rate dynamics. More specifically, we instrument $\tilde{c}_t$ by the dynamics of global risk as measured by the VIX index (Rey (2015) and the broad dollar index (Erik et al. (2020))[16] by the dynamics of global risk aversion as measured by the spread of US bonds with BBB rating versus AAA-rated bonds and by global oil prices, as measured by the change in the Brent oil barrel price.

Global risk indicators as instrumental variables

Conceptually, the use of the global risk indicators as instrumental variables 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, Shim, and Shin (2016)). The VIX index used to drive global financial cycles and lower VIX implied higher leverage and credit expansion, as is shown in Bruno and Shin (2015a, b). However, recent evidence (Forbes and Warnock (2020), Miranda-Agrippino and Rey (2020)) shows that the negative relationship between the VIX and leverage has broken down since 2009, and after that, Erik et al. (2020) find that the explanatory power of the VIX for global financial cycles has been replaced by the broad dollar index. Indeed, we find that the VIX and the broad dollar index explain the UIP deviation in the NOK/USD exchange rate before and after 2009, respectively, through the following regression

(6) $\tilde{c}_t = \alpha_0 + \alpha_1 \text{GLOBAL\_FACTOR}_t + \varepsilon_t$

[16] We are very grateful to the referee who suggested that we should explore the global risk factors.

in which $\tilde{c}_t$ is the UIP deviation in the NOK/USD exchange rate. The vector GLOBAL_FACTOR_t includes the VIX or broad dollar, or both of them, and it also includes the BBB spread as a proxy detecting the shifts in risk aversion in order to strengthen identification and address the concern that the VIX and the broad dollar index alone might not be a perfect control for global risk. ε_t is the error term.

As the results in Table 3 suggest, for the period 2002-2017, a higher VIX leads to higher $\tilde{c}_t$ (columns 1 and 2). While capital inflows to periphery countries are often negatively correlated with global risk factors and risk aversion, Norway represents the flip side of this phenomenon owing to its strong institutions: The higher global risk, the higher the inflow of capital into the country. This effect was particularly reinforced during the 2007-2009 global financial crisis and the sovereign debt crisis in Europe in 2010-2012, as $\tilde{c}_t$ in Figure 1 is particularly high.

[INSERT TABLE 3 HERE]

In the period 2002-2009, it is a higher VIX (see column 5), not a weaker dollar (that is the lower broad dollar index, see columns 4 and 6), that drives the rise in $\tilde{c}_t$, while the situation is reversed after 2009. In the period 2010-2017, the weaker dollar explains the higher $\tilde{c}_t$ (see columns 7 and 9), and the effect of the VIX is reduced (column 8) compared to the period 2002-2009 (column 5). These findings are closely in line with recent evidence that the broad dollar takes over the role of the VIX in driving global financial flows. With regard to the broad dollar index as a risk measure, the relation between exchange rate dynamics in Norway and the broad dollar index is the same as the one identified globally by Erik et al. (2020), i.e., a strong US dollar generally suggests capital outflows and lower cost advantages of funding in foreign currency. The divergence in the direction of VIX's versus the broad dollar index's impact for the post-crisis period is also consistent with the arguments of Erik et al. (2020). In the rest of this paper, based on these findings and evidence from recent literature, we will use the VIX index and broad dollar index as instruments for UIP deviation for the periods 2002-2009 and 2010-2017, respectively.

Oil price as instrumental variable

We also explore the oil price as 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 the oil price 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 price as an instrument. The oil price might affect bank lending not only via its 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, in the rest of this section, we explore both specifications that use the oil price as an additional instrument and specifications that do not include the oil price 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 of roughly 20, while the exogeneity is formally confirmed by a Hansen overidentification test. The results of the first stage regressions reported in Table B.1, Appendix B suggest, consistently with the estimation illustrated in Table 3, that while the VIX has a positive impact on $\tilde{c}_t$ for the whole period 2002-2017 and the period 2002-2009, the broad dollar index has a negative impact on $\tilde{c}_t$, which is strongly significant in the period 2010-2017.

In Table 4, we report the results of estimating the modified two-step model using equation (5) as the second-step regression, which includes the lagged UIP deviation $\tilde{c}_t$ as another independent variable, with $\tilde{c}_t$ being proxied by different sets of instrumental variables for different time horizons. In Panel A and Panel B, we report the results with the VIX and broad dollar as instruments, respectively, over the whole period 2002-2017. We also report results within each panel with and without the oil price as an instrument.

[INSERT TABLE 4 HERE]

The coefficients presented in both panels signal two essential results. First, under all settings, the negative and statistically strongly significant sums of the coefficients of $\tilde{c}_t$ lags, $\sum \theta_m$, point to the existence of a global funding channel: Norwegian banks are less sensitive to their liquidity position when expanding lending volumes if the cost advantage of foreign currency funding is high, that is, when they face favorable global funding conditions.

Second, the lagged interest rates enter the regression with a positive statistically significant sum of coefficients, $\sum \gamma_j$, when the VIX is used as instrument, while the significance is slightly weaker when the broad dollar is used instead. This result is illustrative of the fact that once we control for the effect of global factors, we find evidence of the validity of the bank lending channel. In other words, as presumed, the failure to document bank lending channel effects in the models presented in Table 2 could be attributed to an omitted variable bias stemming from ignoring global factors. This result also implies that the VIX drives financial inflows to Norway both before 2009 (especially during the 2007-2009 global financial crisis) and after 2009 (especially during the sovereign debt crisis in Europe in 2010-2012), while consistent with Erik et al. (2020), the role of the broad dollar in driving global financial flows mostly emerges after 2009.

To test the emerging role of the broad dollar after 2009, in Panel C, we report the results based on the VIX and broad dollar as instruments for the periods 2002-2009 and 2010-2017, respectively. In both sub-panels, negative and significant $\sum \theta_m$ confirms that cheaper FX funding eases banks' funding conditions and makes them less sensitive to domestic monetary policy, and the bank lending channel is restored with positive and significant $\sum \gamma_j$. Results in both sub-panels are quantitatively similar, and significance indeed emerges in the period of 2010-2017 with the broad dollar used as instrument. These results, together with the results of the estimation of the first stage regression presented in Table B.1, Appendix B, suggest that the VIX and the broad dollar index are valid instruments for the periods 2002-2009 and 2010-2017, respectively. Therefore, for the sake of economy in the rest of the paper, we will mostly report only specifications using the VIX for the period 2002-2009 and the broad dollar index for the period 2010-2017.

Taken together, the results in Table 4 suggest that global financial risk factors generate UIP deviations with respect to the Norwegian krone, and these UIP deviations are associated with a comparative cost advantage of FX funding. That is, in times of increasing global risks with a higher VIX, the safe-haven status of Norway results in an implicit negative risk premium on investments in Norwegian institutions. The drop in FX funding costs eases banks' funding constraints and thus modifies the effectiveness of monetary policy. For the later time period, the attractiveness of dollar funding is related to the broad dollar index and still significantly affects domestic lending: in times of declining global risk with a weakening dollar, the appreciation in the Norwegian krone with positive UIP deviation also makes dollar funding attractive and relaxes banks' lending constraints.

Next, we address the potential asymmetry of the impact of global funding conditions. For this purpose, we explore whether our results change when banks face more favorable ($\Delta\tilde{c}_t > 0$) or less favorable ($\Delta\tilde{c}_t < 0$) FX funding conditions. In Table 5, we report the results with the VIX as instrument for the period 2002-2009, and the results with the broad dollar as instrument for the period 2010-2017.

[INSERT TABLE 5 HERE]

As shown, global funding channel and domestic monetary policy jointly drive bank lending, as we have documented, even when FX funding becomes less favorable ($\Delta\tilde{c}_t < 0$). This is because when banks are locked in FX funding, they cannot perfectly replace it with domestic funding when the cost advantage of FX funding declines. However, the table also shows that after 2009, bank lending is more sensitive (higher $\sum \gamma_j$) to monetary policy when $\Delta\tilde{c}_t < 0$, implying that banks do shift from FX funding to domestic funding, which is sensitive to monetary policy.[17]

C. Currency Hedging, Deviations from CIP, and Global Funding Supply

In sum, the evidence presented in the previous section underlines the cost advantage of FX funding as an important determinant of Norwegian bank lending. The economic and the statistical

[17] In unreported tests, we also explore whether our results are driven by the sign or level of $\tilde{c}_t$, by replacing $\tilde{c}_t$ with a dummy variable that equals 1 for $\tilde{c}_t > 0$ and 0 otherwise. The results of this test are qualitatively the same as those in Table 5, suggesting that controlling for the sign of the cost advantage, $\tilde{c}_t$, alone is sufficient to both document a significant impact of the cost advantage and restore the effectiveness of domestic monetary policy. In unreported tests we provide some further evidence of how the tightening (or loosening) of domestic and global funding conditions interact. These tests are based on dividing our dataset into four subsamples, representing the four possible scenarios of loosening and tightening domestic monetary policy, each combined with rising and declining cost advantages of foreign currency funding. They show that a loosening of domestic monetary policy boosts lending in times of tightening global conditions. Consistent with the results of Table 5, these tests also indicate that banks can insulate themselves from the tightening of domestic monetary policy when global funding conditions become more favorable.

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 currencies for NOK after they borrow in foreign currencies, and they need to make sure that sufficient foreign currencies are available when loans mature. 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 highest in USD (Norges Bank (2018)), so that the cost advantage of 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 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 Norwegian banks' funding costs. 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 must roll over 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 (2020), 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 cost of the hedge.

Taking this 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 generated by 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 local currency (in our case NOK) 3-month government bond yields achievable by a dollar-based investor over yields on US Treasury securities 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 non-negligible deviations from CIP, reflecting the cost advantage of 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, or CIP deviation $\tilde{c}_{DS,t}$ instead of $\tilde{c}_t$, i.e., the second step is specified as

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

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, as before, we use the VIX index and the broad dollar index as instruments for the Du-Schreger measure.

The results of the estimations are presented in Table 6, which contains four columns. The results reported in the first two columns reflect the estimation results with the VIX and the broad dollar as instruments, respectively, and the period covered in the estimation is 2002-2017. In the third and fourth columns, we report the results of specifications with the VIX and the broad dollar as instruments, over the periods 2002-2009 and 2010-2017, respectively.

[INSERT TABLE 6 HERE]

For the entire time horizon, when $\tilde{c}_{DS,t}$ is instrumented by the VIX as column 1 shows, the result is again consistent with a strong role for global factors in shaping domestic Norwegian lending: Even when we control for the hedging of foreign currency positions, the $\tilde{c}_{DS,t}$ is still significantly related to Norwegian banks' ability to insulate themselves from domestic monetary policy shocks. This provides the micro-level evidence for Avdjiev et al. (2019), who find on a macro level that global risk factors are associated with CIP deviations that drive cross-border financial flows. Furthermore, although the power of the broad dollar index as instrument is weak over the entire time horizon 2002-2017 (as column 2 shows), it does result in joint significance for global funding and monetary policy for the period 2010-2017 as column 4 shows; this is again in line with recent evidence (Erik et al. (2020)) that the broad dollar index emerges as a driver of global financial flows after 2009. Overall, our results imply that even when banks hedge their FX positions, short-term CIP deviations, $\tilde{c}_{DS,t}$, that are derived from short-term interest rate differentials still signal particularly strong opportunities for banks to insulate themselves from domestic monetary policy at times when favorable CIP differentials exist—even in the short run.

IV. Global Funding, Portfolio Composition, and the Risk-Taking Channel of Currency Appreciation

After establishing how the global funding channel affects the *volume* of bank lending when interest rate differentials are not neutralized by exchange rate dynamics, in this section, we dig deeper and explore how global funding conditions affect the currency decomposition of bank assets and liabilities as well as banks' *risk-taking*, which we proxy by the shifts in loan portfolios.

Our analysis starts in Section IV.A, where we explore whether banks utilize the cost advantage for foreign currency funding and increase the share of funding denominated in foreign currency with rising UIP deviations. Next, in Section IV.B, we examine how the cost advantage for foreign currency funding affects bank leverage and the composition of bank asset portfolios in terms of different types of loans. To this end we lean on the argument, pioneered by Bruno and Shin (2015a), that cross-border financial flows via global banks can affect bank risk-taking. In Bruno and Shin's setup, global banks borrow from international money markets and issue foreign currency-denominated loans to domestic firms. When the domestic currency appreciates, firms' net worth increases, due to the currency mismatch on their balance sheet. This results in a general reduction of credit risk that brings down banks' value-at-risk and allows banks to increase their leverage by expanding lending, also to borrowers that would have otherwise been considered as being too risky. Currency appreciation, therefore, increases banks' risk-taking. Using aggregate level data, Bruno and Shin (2015a, b) present empirical support for this argument.

We provide the first micro-level test for Bruno and Shin (2015a), using our bank-level data. As already discussed, our empirical set up is slightly different, since in Norway the currency mismatch is mostly observed within banks (rather than firms) that have access to foreign currency funding from international money markets but issue loans mostly in NOK. Also, while in Bruno and Shin (2015a) firms completely rely on foreign currency loans, banks in Norway can choose between international foreign currency funding and domestic NOK funding. If a bank raises FX funding, say, from the spot market, its funding cost is

$$\frac{S_{t+1}}{S_t}(1 + r_t^*),$$

given the spot NOK/USD exchange rate S_t and foreign interest rate r_t^*; if the bank raises NOK funding from the domestic money market instead, its funding cost is $1 + r_t$, with r_t being the domestic interest rate. An appreciation of the local currency (in our case the NOK) that is not related to monetary policy rate differentials will, therefore, be reflected in an increase in the cost advantage $\tilde{c}_t$ of FX over domestic funding, which is given by

$$\text{(8)}\quad \tilde{c}_t = \frac{S_t}{S_{t+1}}\frac{1+r_t}{1+r_t^*} - 1$$

and corresponds exactly to the UIP deviation defined in equation (3). [18]

To pin down the international risk-taking channel for banks à la Bruno and Shin (2015a), we therefore use our measure for global funding conditions, $\tilde{c}_t$, as a "currency appreciation" measure for banks.

A. Global Funding Condition and FX Liabilities

[18] We rearrange equation (8) as $1 + \tilde{c}_t = \frac{S_t}{S_{t+1}}\frac{1+r_t}{1+r_t^*}$ and take logarithm on both sides to get $-\tilde{c}_t = \frac{S_{t+1}-S_t}{S_t} + (r_t^* - r_t)$. We then apply the UIP condition $r_t^* - r_t = -\frac{\bar{S}_{t+1}-S_t}{S_t}$ with $\bar{S}_{t+1}$ being the implied spot NOK exchange rate and express $\tilde{c}_t$ as $\tilde{c}_t = \frac{\bar{S}_{t+1}-S_t}{S_t}$, which is exactly the term defined by equation (3).

First, we examine how the dynamics of the cost advantage of foreign currency funding affect banks' use of foreign currency liabilities. For this purpose, we estimate the following model:

(9) $\text{FX\_LIABILITIES}_{it} = \alpha_0 + \sum_{n=0}^{1} \eta_n \tilde{c}_{t-n} + \sum_{j=0}^{1} \zeta_j r_{t-j} + \sigma_t \text{CONTROLS}_{i,t-1} + \vartheta_i + \varphi_{i,t}$,

in which the share of foreign currency funding in banks' total assets ($\text{FX\_LIABILITIES}_{it}$) is regressed on (lagged) UIP deviation $\tilde{c}_t$, (lagged) monetary policy rate r_t. As suggested by AIC, the number of lags for both $\tilde{c}_t$ and r_t is set at 2. We also include a set of lagged bank- and macro-level control variables, $\text{CONTROLS}_{i,t-1}$, which consists of bank's total assets, deposit and loan growth rate, the GDP growth rate and the growth rate of house prices. To control for unobservable and persistent factors affecting the use of foreign currency funding, we estimate the model using bank-level fixed effects ϑ_i. As in Section III, we address the potential endogeneity of the cost advantage of foreign currency funding via instrumenting $\tilde{c}_t$ by the VIX index and the BBB spread for the period 2002-2009 and by the broad dollar index and the BBB spread for the period 2010-2017.

Results are reported in Table 7, in which we show how banks react in FX funding, when global funding conditions improve ($\Delta\tilde{c}_t > 0$) or deteriorate ($\Delta\tilde{c}_t < 0$). We report the results with $\tilde{c}_t$ instrumented by the VIX and the broad dollar for the periods 2002-2009 and 2010-2017, respectively. We find that banks increase FX liabilities when global funding conditions improve ($\Delta\tilde{c}_t > 0$, as columns 1 and 3 show), while they do not necessarily reduce FX exposure in funding liabilities when global funding conditions deteriorate ($\Delta\tilde{c}_t < 0$, see columns 2 and 4). This result suggests that foreign exchange positions are not reversed promptly by Norwegian banks when favorable foreign funding conditions are reversed. Banks can, therefore, be vulnerable to the hazards of forced deleveraging implied by the international risk-taking channel à la Bruno and

Shin (2015a) when a previously appreciating currency starts to depreciate, given that bank leverage and risk have been built up during currency appreciation. The strength of a bank's balance sheet is therefore contingent on whether or not favorable exchange rate dynamics persist or not.

[INSERT TABLE 7 HERE]

B. Portfolio Adjustments and Risk-Taking

As mentioned above, in this subsection we focus on a microeconometric (bank-level) test of the international risk-taking channel of currency appreciation. More specifically, we trace the relationship between bank portfolio composition, various measures of portfolio risk, bank leverage and global funding conditions, proxied by $\tilde{c}_t$. For this purpose, we estimate the following modified version of model (9):

(10) $\text{BANK\_PORTFOLIO}_{it} = \alpha_0 + \sum_{n=1}^{2} \eta_n \tilde{c}_{t-n} + \sum_{j=1}^{2} \zeta_j r_{t-j} + \sigma_t \text{CONTROLS}_{i,t-1} + \vartheta_i + \varphi_{i,t}$

where $\text{BANK\_PORTFOLIO}_{it}$ represents a set of dependent variables related to bank asset portfolios, leverage and risk, such as the share of loans denominated in foreign currency (FX_LOANS), of commercial and industrial loans (C&I_LOANS) and of mortgage loans (MORTGAGE_LOANS) in total loan volumes, the ratio of common equity to total assets (LEVERAGE) as well as risk measures such as the share of non-performing loans to total loans (NPL), the ratio of loan loss provisions to total assets (LLP) and the z-score of the bank (ZSCORE).[19] The main explanatory variables $\tilde{c}_t$and r_t, the set of control and instrumental variables, and the estimation method are

[19] This is computed using $\text{ZSCORE}_{it} = \frac{\text{ROA}_{it} + \text{CAR}_{it}}{\sigma(\text{ROA}_i)}$, in which ROA_{it} denotes bank i's return on assets (ROA) in quarter t, CAR_{it} denotes the bank's total equity to total assets ratio, and $\sigma(\text{ROA}_i)$ is the standard deviation of ROA.

identical to the ones in model (9). The only difference is that we take one and two legs of $\tilde{c}_t$ and r_t rather than one lag and the simultaneous value to account for the time needed for funding conditions to be reflected in bank portfolio decisions. In unreported tests, we confirm the robustness of the results when the simultaneous and one lag values are used.

In Panel A of Table 8, we report the results for the period 2002-2009 with the VIX index and BBB spread as instruments, and in Panel B we report the results for the period 2010-2017 with the broad dollar index and BBB spread as instruments. Column 1 of both panels indicates that a drop in the cost of foreign currency funding does not increase the share of loans that banks grant to customers in foreign currencies, suggesting that banks face most of the benefits and risks stemming from a currency mismatch. In Section III, we have already shown that banks' lending volumes increase when global funding conditions become favorable. Columns 2 and 3 of both panels in Table 8 further suggest that, under favorable FX funding conditions, banks over proportionally expand riskier C&I loans relative to less risky mortgage loans, implying that banks are taking more risks in their lending. This indication is further confirmed by the results illustrated in columns 4 and 5 of both panels, which signal that not only the perceived riskiness of the loans as measured by LLP is increasing, but also the realized loan risk as measured by NPL goes up when global funding conditions are more favorable. Consistent with Bruno and Shin (2015a), these results indicate that the confidence associated with favorable funding conditions encourages banks to undertake additional risks when expanding loans. This mirrors similar results for domestic funding conditions (e.g. Jiménez, Ongena, Peydró, and Saurina (2014)). Since banks exploiting favorable global funding conditions tend to increase (risky) lending, they not only increase their leverage (see column 6) but also suffer a deterioration of the general bank's risk level as measured by the z-score (column 7). In other words, a higher cost advantage from foreign currency funding has the potential to increase bank margins and thus strengthen bank balance sheets, but it also pushes bank lending to the edge of capital capacity, so that no improvement in bank capitalization is observed. Our results thus support the international risk-taking channel of currency appreciation in Bruno and Shin (2015a, b): NOK appreciation that is not neutralized by domestic monetary policy allows banks to increase leverage and risk-taking. The results are also consistent with Adrian and Shin (2014), who argue that banks actively manage their balance sheets to maintain value-at-risk at no more than available equity.

[INSERT TABLE 8 HERE]

V. Robustness Checks

In this section, we conduct several robustness checks for the previous results. First, as Christiano, Eichenbaum, and Evans (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 two 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.

Next, in order to quantify the stance of monetary policy in the US when the target federal funds rate was around the zero lower bound between December 2008 and December 2015, we also control for the changes in the Federal Reserve’s monetary policy stance 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 UIP deviation, or the cost advantage of 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 9. In Panel A/Panel B, we report results based on using the VIX/broad dollar as instrument for the entire period 2002-2017, and in Panel C/Panel D, we report results based on using the VIX/broad dollar as instrument for the period 2002-2009/2010-2017. Our results are robust to monetary policy measures (columns 1 and 2 of all panels): Under each of the settings, improved FX funding conditions reduces the sensitivity of bank lending to liquidity ($\sum \theta_m < 0$), and tightening domestic monetary policy increases the sensitivity of bank lending to liquidity ($\sum \gamma_j > 0$). Our results are also robust to using an alternative measure of US monetary policy as well as UIP deviation, or the cost advantage of EUR funding, within the period 2002-2009/2010-2017 when the VIX/broad dollar prevails as global risk factor, as columns 3 and 4 in Panel C/Panel D show. Overall, the results here are consistent with those reported in Table 4.

[INSERT TABLE 9 HERE]

VI. Concluding Remarks

In this paper, we provide the first micro-level evidence on how banks' global funding limits the bank lending channel of domestic monetary policy transmission in a small open economy, as well as how such global financial flows modify banks' balance sheets and affect their risk-taking behavior. Using Norwegian data, we show that global funding conditions dampen the effectiveness of domestic monetary policy: Exchange rate dynamics that do not fully neutralize the interest rate differentials generate favorable global funding conditions for Norwegian banks, raise their incentives to use foreign currency funding and insulate banks from domestic monetary policy tightening. These favorable global funding conditions improve bank liquidity, allowing banks to adjust their balance sheets by increasing leverage and taking on more credit risk.

These results support the existence of a risk-taking channel of currency appreciation (Bruno and Shin (2015a, b)) and raise concerns about the challenges to conducting monetary policy in small open economies. The concerns are especially valid in the case when central banks try to limit risks that are associated with lending booms and that pose a threat to financial stability by adopting the “lean-against-the-wind” type of monetary policy. In principle, raising funding costs in domestic money markets by tightening monetary policy is desirable in order to contain domestic credit booms. However, as we show in our paper, it may also make it comparatively more favorable for banks to raise funding in international money markets to avoid the adverse impact of domestic monetary policy on their lending, and this may even increase their risk-taking. To maintain the effectiveness of domestic monetary policy and contain banks’ risk-taking encouraged by global funding flows, one potential solution is to design complementary macroprudential policies that target domestic banks’ exposure to risks via foreign currency funding. We leave this issue to our future research.

Appendix

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

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

[INSERT FIGURE A1 HERE]

B. The first-stage regression results of the instrumental variable estimation whose second stage results are presented in Table 4

[INSERT TABLE B.1 HERE]

References

Adrian, T., and H. S. Shin. “Procyclical Leverage and Value-at-Risk.” *Review of Financial Studies*, 27 (2014), 373–403.

Avdjiev, S., R. N. McCauley, and H. S. Shin. “Breaking Free of the Triple Coincidence in International Finance.” Working Paper, Bank for International Settlements (2015).

Avdjiev, S., W. Du, C. Koch, and H. S. Shin. “The Dollar, Bank Leverage, and Deviations from Covered Interest Parity.” *American Economic Review: Insights*, 1 (2019), 193–208.

Baskaya, Y. S., J. di Giovanni, S. Kalemli-Ozcan, and M. F. Ulu. “International Spill-overs and Local Credit Cycles.” NBER Working Paper, 23149 (2017).

Brunnermaier, M. K. et al. “Banks and Cross-border Capital Flows: Policy Challenges and Regulatory Responses.” Committee on International Economic Policy and Reform (2012).

Bruno, V., and H. S. Shin. “Cross-border Banking and Global Liquidity.” *Review of Economic Studies*, 82 (2015a), 535–564.

Bruno, V., and H. S. Shin. “Capital Flows and the Risk-taking Channel of Monetary Policy.” *Journal of Monetary Economics*, 71 (2015b), 119–132.

Bruno, V., and H. S. Shin. “Dollar and Exports.” Working Paper, Bank for International Settlements (2020).

Bräuning, F., and V. Ivashina. “Monetary Policy and Global Banking.” *Journal of Finance,* 75 (2020), 3055-3095.

Buch, C. M., M. Bussiere, L. Goldberg, and R. Hills. “The International Transmission of Monetary Policy.” *Journal of International Money and Finance*, 91 (2019), 29–48.

Cetorelli, N., and L. S. Goldberg. “Banking Globalization and Monetary Transmission.” *Journal of Finance*, 67 (2012), 1811–1843.

Christiano, L. J., M. Eichenbaum, and C. L. Evans. "Monetary Policy Shocks: What Have We Learned and to What End?" In *Handbook of Macroeconomics*, Vol. 1A, J. Taylor and M. Woodford, eds. Amsterdam: Elsevier (1999), Chapter 2.

Du, W., and J. Schreger. "Local Currency Sovereign Risk." *Journal of Finance*, 71 (2016), 1027–1070.

Erik, B., M. J. Lombardi, D. Mihaljek, and H. S. Shin. "The Dollar, Bank Leverage, and Real Economic Activity: An Evolving Relationship." *AEA Papers and Proceedings*, 110 (2020), 529–534.

Forbes, K. J., and F. E. Warnock. "Capital Flow Waves—or Ripples? Extreme Capital Flow Movements since the Crisis." NBER Working Paper, 26851 (2020).

Gourinchas, P.-O., and M. Obstfeld. "Stories of the Twentieth Century for the Twenty-first." *American Economic Journal: Macroeconomics*, 4 (2012), 226–265.

Gourio, F., A. K. Kashyap, and J. W. Sim. "The Trade Offs in Leaning against the Wind." *IMF Economic Review*, 66 (2018), 70–115.

Hofmann, B., I. Shim, and H. S. Shin. "Sovereign Yields and the Risk-taking Channel of Currency Appreciation." Working Paper, Bank for International Settlements (2016).

Jiménez, G., S. Ongena, J.-L. Peydró, and J. Saurina. "Hazardous Times for Monetary Policy: What Do Twenty-three Million Bank Loans Say about the Effects of Monetary Policy on Credit Risk-taking?" *Econometrica*, 82 (2014), 463–505.

Kashyap, A. K., and J. C. Stein. "What Do a Million Observations on Banks Say about the Transmission of Monetary Policy?" *American Economic Review*, 90 (2000), 407–428.

Miranda-Agrippino, S., and H. Rey. "The Global Financial Cycle after Lehman." *AEA Papers and Proceedings*, 110 (2020), 523–528.

Molland, J. L. “Norwegian Banks’ Foreign Currency Funding of NOK Assets.” Staff Memo, Norges Bank (2014).

Morais, B., J.-L. Peydró, and C. Ruiz. “The International Bank Lending Channel of Monetary Policy Rates and QE: Credit Supply, Reach-for-yield, and Real Effects.” *Journal of Finance,* 74 (2019), 55–90.

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

Rey, H. “Dilemma not Trilemma: The Global Financial Cycle and Monetary Policy Independence.” NBER Working Paper, 21162 (2015).

Schularick, M., L. ter Steege, and F. Ward. “Leaning against the Wind and Crisis Risk.” Working Paper, CESifo (2020).

Wu, J. C., and F. D. Xia. “Measuring the Macroeconomic Impact of Monetary Policy at the Zero Lower Bound.” *Journal of Money, Credit and Banking*, 48 (2016), 253–291.

Figure 1: Cost Advantage of Dollar Funding Measured by Deviation from UIP, $\tilde{c}_t$, 1994-2017

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

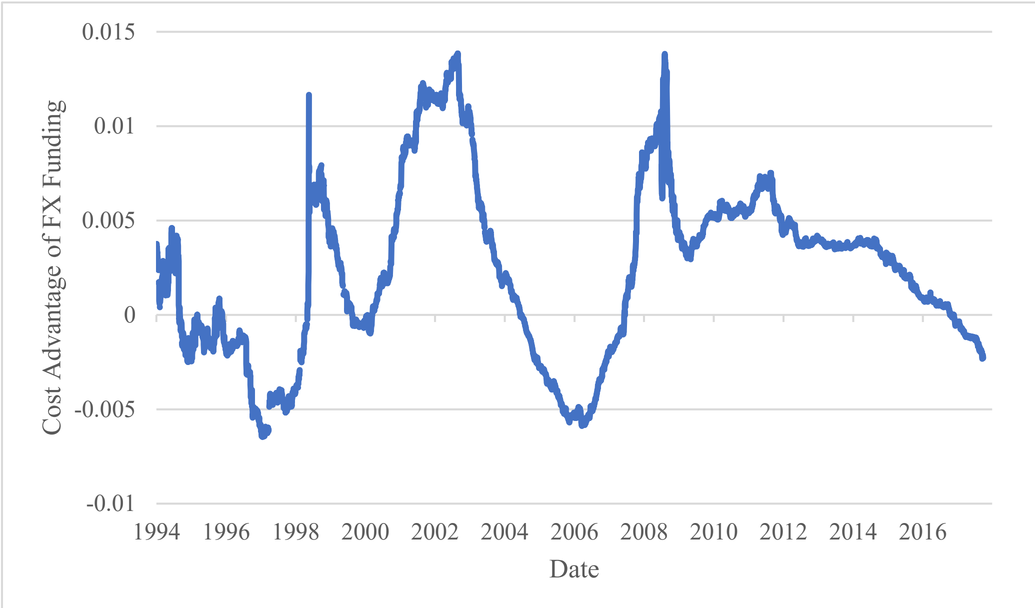

Figure A1: Estimates of β_t

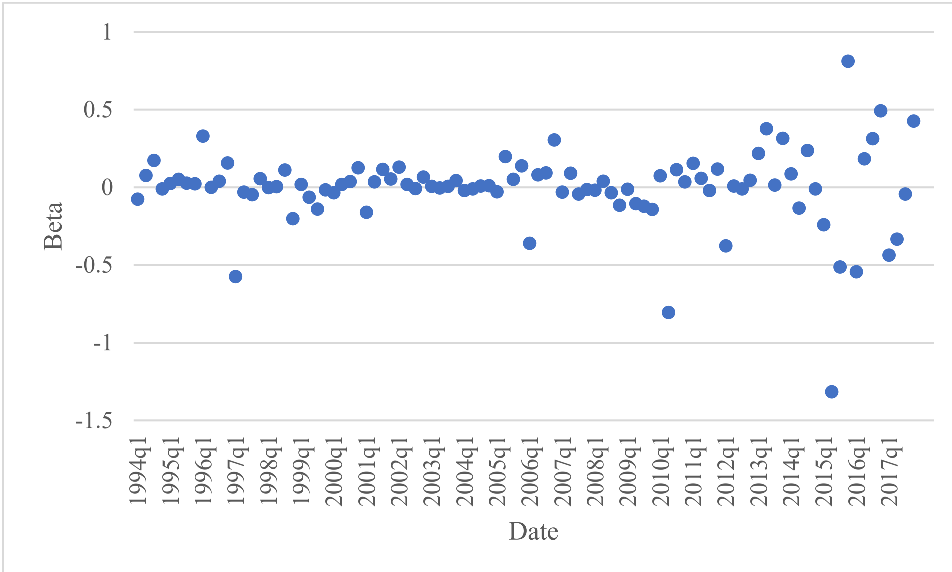

Table 1: Variable Definition and Summary Statistics

In this table, we report 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	14,221	0.060	0.053	0.093	0.002	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-offs 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
FOREIGN_CURRENCY_LOANS	Ratio of loans denominated in foreign currency to total loans	14,390	0.024	0.000	0.095	0.000	0.519
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
MORTGAGE_LOANS	Ratio of mortgage loans to total loans and leases	13,663	0.607	0.638	0.183	0.010	0.986
SIZE	Logarithm of total assets (in thousands of NOK) adjusted for CPI	15,041	14.449	14.179	1.633	10.849	19.132
NON_PERFORMING_LOANS	Ratio of non-performing loans to total loans and leases	13,645	0.020	0.013	0.026	0.000	0.109
LOAN_LOSS_PROVISIONS	Ratio of loan loss provisions to total loans and leases	13,455	0.001	0.000	0.008	-0.002	0.016
ZSCORE	Sum of a bank's return on assets (ROA) and equity ratio, normalized by standard deviation of ROA	14,194	13.191	12.030	10.002	0.374	38.669

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-month maturity	15,041	3.997	3.517	2.213	0.808	9.569
COST_ADVANTAGE	The cost advantage of FX funding, defined in equation (3)	15,041	0.003	0.004	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
BROAD_DOLLAR_INDEX	Dollar exchange rate index against a broad currency index as published at FRED (St. Louis Fed)	15,041	110.194	110.941	10.199	90.240	129.025

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

Table 2: Lending Channel in Norway 1994-2017

In this table, we report the estimates of the regression for the sensitivity of bank loan growth to bank liquidity (β) on monetary policy interest rates, which are measured by the NIBOR (Norwegian Interbank Offered Rate). Column 1 presents the result for the whole period of 1994-2017, column 2 presents the result for the period of 1994-2001, and columns 3-5 present the results for the period of 2002-2017. Among the results for the period of 2002-2017, column 3 reports the result for the whole subsample, while columns 4 and 5 report the results for periods with tightening monetary policy ($\Delta r > 0$) and loosening monetary policy ($\Delta r < 0$), respectively. The reported figures in the columns are from the sum of the estimated coefficients on the six lags of each monetary policy rate. *, ** and *** indicate significance at the 10%, 5% and 1% level, respectively.

	1994-2017	1994-2001		2002-2017	
			All	$\Delta r > 0$	$\Delta r < 0$
	1	2	3	4	5
$\sum \gamma_j$	0.0016	0.0301***	-0.0052***	-0.0308***	0.0021
	(0.0011)	(0.0022)	(0.0017)	(0.0033)	(0.0020)
No. of obs.	13,928	4,571	9,357	4,438	4,919
Adjusted R^2	0.02	0.12	0.03	0.16	0.03

Table 3: Global Risk Factors and UIP Deviation post-2001

In this table, we report the results of time series regressions for the determinants of the cost advantage, $\tilde{c}_t$, measured by UIP deviation, following equation (6). Columns 1-3 report the results for the full period 2002-2017, columns 4-6 report the results for the period 2002-2009, and columns 7-9 report the results for the period 2010-2017. In each group of results, $\mathrm{GLOBAL\_FACTOR}_t$ includes BBB spread, plus the VIX or broad dollar, or both of them. *, ** and *** indicate significance at the 10%, 5% and 1% level, respectively.

	2002-2017			2002-2009			2010-2017		
	$\tilde{c}_t$	$\tilde{c}_t$	$\tilde{c}_t$	$\tilde{c}_t$	$\tilde{c}_t$	$\tilde{c}_t$	$\tilde{c}_t$	$\tilde{c}_t$	$\tilde{c}_t$
	1	2	3	4	5	6	7	8	9
VIX	0.035***	0.034***		0.039	0.051**		0.021***	0.032***	
	(0.012)	(0.012)		(0.024)	(0.022)		(0.005)	(0.011)	
Broad dollar	-0.004		-0.003	0.013		0.020*	-0.018***		-0.019***
	(0.005)		(0.005)	(0.011)		(0.010)	(0.001)		(0.002)
BBB spread	-0.049	-0.040	0.175***	-0.054	-0.133	0.190***	-0.084	-0.040	0.104**
	(0.090)	(0.089)	(0.043)	(0.160)	(0.145)	(0.055)	(0.055)	(0.136)	(0.048)
Constant	0.164	-0.271**	0.190	-1.831	-0.509**	-2.363**	2.061***	-0.139	2.176***
	(0.568)	(0.119)	(0.599)	(1.157)	(0.220)	(1.140)	(0.197)	(0.184)	(0.256)
Observations	64	64	64	32	32	32	32	32	32
R^2	0.319	0.312	0.228	0.390	0.361	0.333	0.904	0.387	0.829

Table 4: Monetary Policy and Global Factors post-2001

In this table, we report the estimates of the regression for the sensitivity of bank loan growth to bank liquidity (β) on the NIBOR as a proxy for the key policy rate and UIP deviation, $\tilde{c}_t$. The panels report the main results of the second stage regression, where $\sum \theta_m$ represents the sum of coefficients of the two lags of UIP deviation, while $\sum \gamma_j$ represents the sum of coefficients of the six lags of the NIBOR, when $\tilde{c}_t$is instrumented via the oil price, the VIX/broad dollar and the BBB spread. In Panel A, we report the results with $\tilde{c}_t$ instrumented by the VIX for the whole period 2002-2017: Panel A.1 with $\tilde{c}_t$ instrumented by the oil price, the VIX, and the BBB spread, and Panel A.2 with $\tilde{c}_t$ instrumented by the VIX and the BBB spread. In Panel B, we report the results with $\tilde{c}_t$ instrumented by the broad dollar for the whole period 2002-2017: Panel B.1 with $\tilde{c}_t$ instrumented by the oil price, the broad dollar, and the BBB spread, and Panel B.2 with $\tilde{c}_t$ instrumented by the broad dollar and the BBB spread. In Panel C, we report the results with $\tilde{c}_t$ instrumented by the VIX/broad dollar for the periods 2002-2009 and 2010-2017: Panel C.1 with $\tilde{c}_t$ instrumented by the VIX and the BBB spread for the period 2002-2009, and Panel C.2 with $\tilde{c}_t$ instrumented by the broad dollar and the BBB spread for the period 2010-2017. 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 Using the VIX as instrument, 2002-2017

Panel A.1 IV for $\tilde{c}_t$: Oil price, VIX, and BBB spread, 2002-2017

	$\sum \theta_m$		$\sum \gamma_j$
	-0.532**		0.004***
	(0.229)		(0.002)
Number of observations		9,357	

Panel A.2 IV for $\tilde{c}_t$: VIX and BBB spread, 2002-2017

	$\sum \theta_m$		$\sum \gamma_j$
	-3.114***		0.049***
	(0.261)		(0.005)
Number of observations		9,357	

Panel B Using the broad dollar as instrument, 2002-2017

Panel B.1 IV for $\tilde{c}_t$: Oil price, broad dollar, and BBB spread, 2002-2017

	$\sum \theta_m$		$\sum \gamma_j$
	-0.550***		0.002

	(0.120)	(0.002)
Number of observations	9,357	

Panel B.2 IV for $\tilde{c}_t$: broad dollar and BBB spread, 2002-2017

	$\sum \theta_m$	$\sum \gamma_j$
	-3.743***	0.057***
	(0.2626)	(0.005)
Number of observations	9,357	

Panel C: Using the VIX/broad dollar as instrument for the period 2002-2009/2010-2017

Panel C.1 IV for $\tilde{c}_t$: VIX and BBB spread, 2002-2009

	$\sum \theta_m$	$\sum \gamma_j$
	-5.475***	0.189***
	(0.253)	(0.009)
Number of observations	4,768	

Panel C.2 IV for $\tilde{c}_t$: Broad dollar and BBB spread, 2010-2017

	$\sum \theta_m$	$\sum \gamma_j$
	-6.710***	0.249***
	(1.304)	(0.045)
Number of observations	4,589	

Table 5: Asymmetric Reaction to Favorable and Unfavorable Exchange Rate Dynamics

In this table, we report the estimates of the regression for 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 of FX funding, $\tilde{c}_t$, which is instrumented by the VIX (for the period 2002-2009, columns 1 and 2), the broad dollar (for the period 2010-2017, columns 3 and 4) 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.

	2002-2009 (IV: VIX and BBB spread)		2010-2017 (IV: Broad dollar and BBB spread)	
	$\Delta\tilde{c}_t > 0$	$\Delta\tilde{c}_t < 0$	$\Delta\tilde{c}_t > 0$	$\Delta\tilde{c}_t < 0$
	1	2	3	4
$\sum \theta_m$	-8.547***	-2.868***	-2.868***	-62.139***
	(0.258)	(0.146)	(0.146)	(2.733)
$\sum \gamma_j$	0.342***	0.184***	0.184***	2.157***
	(0.010)	(0.049)	(0.049)	(0.092)
No. of obs.	2,083	1,449	1,449	3,140

Table 6: Du-Schreger's Local Currency Risk Measure and the Lending Channel

In this table, we report the estimates of the regression for 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 of FX funding with hedging, $\tilde{c}_{DS,t}$, approximated by the Du-Schreger measure (the spread of 3-month Norwegian government bond yields achievable by a dollar-based investor over yields on US Treasury securities with the same maturity), instrumented by the VIX/broad dollar 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 $\tilde{c}_{DS,t}$. In columns 1 and 2, we report the results with $\tilde{c}_{DS,t}$ instrumented by the VIX and the broad dollar for the whole period 2002-2017, respectively. In columns 3 and 4, we report the results with $\tilde{c}_{DS,t}$ instrumented by the VIX and the broad dollar for the periods 2002-2009 and 2010-2017, respectively. 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.

	2002-2017 (IV: VIX and BBB spread)	2002-2017 (IV: Broad dollar and BBB spread)	2002-2009 (IV: VIX and BBB spread)	2010-2017 (IV: Broad dollar and BBB spread)
	$\tilde{c}_{DS,t}$, 3-month	$\tilde{c}_{DS,t}$, 3-month	$\tilde{c}_{DS,t}$, 3-month	$\tilde{c}_{DS,t}$, 3-month
	1	2	3	4
$\sum \delta_n$	-0.028***	0.003	-0.059***	-0.088*
	(0.004)	(0.003)	(0.006)	(0.009)
$\sum \gamma_j$	0.190***	-0.022***	0.201***	0.155***
	(0.005)	(0.004)	(0.022)	(0.024)
No. of obs.	9,357	9,357	4,768	4,589

Table 7: The Response of Total Foreign Currency Funding to UIP Deviation

In this table, we report the estimates of the regression for the share of total foreign currency funding at the bank level on simultaneous and lagged $\tilde{c}_t$, as in equation (9) using both simultaneous and $\tilde{c}_t$ with one lag, as well as domestic interest rates and bank- and macro-level variables as controls. We report the results for periods with increasing $\tilde{c}_t$ (columns 1 and 3) and decreasing $\tilde{c}_t$ (columns 2 and 4). $\tilde{c}_t$ is instrumented by the BBB spread, together with the VIX and the broad dollar for the period 2002-2009 (columns 1 and 2) and the period 010-2017 (columns 3 and 4), respectively. 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.

	2002-2009 (IV: VIX and BBB spread)		2010-2017 (IV: Broad dollar and BBB spread)	
	$\Delta\tilde{c}_t > 0$	$\Delta\tilde{c}_t < 0$	$\Delta\tilde{c}_t > 0$	$\Delta\tilde{c}_t < 0$
	1	2	3	4
$\sum \eta_n$	0.669*	0.140	10.819**	-2.062**
	(0.227)	(0.250)	(5.392)	(1.038)
No. of obs.	2,083	2,685	1,289	3,300

Table 8: Global Funding and International Risk-Taking

In this table, we report the estimates of the regressions for a set of variables measuring the composition of bank asset portfolio and bank risk on lagged $\tilde{c}_t$, as well as domestic interest rates and bank- and macro-level variables as controls. In Panel A, we report the results for the period 2002-2009 using the BBB spread together with the VIX as instruments for $\tilde{c}_t$. In Panel B, we report the results for the period 2010-2017, using the BBB spread together with the broad dollar index as instruments for $\tilde{c}_t$. 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.

Panel A: 2002-2009 (IV: VIX and BBB spread)

	FX lending 1	C&I loans 2	Mortgage loans 3	NPL 4	LLP 5	Equity ratio 6	z-score 7
$\sum \alpha_n$	0.173	3.806***	-1.214	1.637***	0.659***	-0.264***	-102.173***
	(0.530)	(0.831)	(1.046)	(0.199)	(0.127)	(0.123)	(25.377)
No. of obs.	4,480	4,429	4,428	4,445	4,430	4,480	4,480

Panel B: 2010-2017 (IV: Broad dollar and BBB spread)

	FX lending 1	C&I loans 2	Mortgage loans 3	NPL 4	LLP 5	Equity ratio 6	z-score 7
$\sum \alpha_n$	-2.070*	0.280*	-5.938***	1.266***	0.239*	-17.194***	-3164.097***
	(1.110)	(0.113)	(1.271)	(0.285)	(0.172)	(0.564)	(99.665)
No. of obs.	4,079	3,974	3,925	3,929	4,002	4,020	4,020

Table 9: Robustness Checks

In this table, we report the estimates of the regression for the sensitivity of bank loan growth to bank liquidity (β) on monetary policy rate and UIP deviation, $\tilde{c}_t$. The panels report the main results of the second stage regression, where $\sum \theta_m$ represents the sum of coefficients of the two lags of UIP deviation, while $\sum \gamma_j$ represents the sum of coefficients of the six lags of the NIBOR, with $\tilde{c}_t$ instrumented via the oil price, the VIX/broad dollar and the BBB spread. In Panel A, we report the results with $\tilde{c}_t$ instrumented by the VIX for the entire period 2002-2017. In Panel B, we report the results with $\tilde{c}_t$ instrumented by the broad dollar index for the entire period 2002-2017. In Panel C, we report the results with $\tilde{c}_t$ instrumented by the VIX for the period 2002-2009. In Panel D, we report the results with $\tilde{c}_t$ instrumented by the broad dollar for the period of 2010-2017. In each of the panels, column 1/2 reports the results with Norges Bank's key policy rate/changes in NIBOR used as proxy for the monetary policy rate in equation (2), column 3 reports the results with the Wu-Xia shadow rate used to proxy the US monetary policy rate in computing UIP deviation, and column 4 reports the results with UIP deviation in the NOK/EUR exchange rate used in equation (2). 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 Using VIX and BBB spread as instruments, 2002-2017

	Key policy rate	Change in NIBOR	ZLB (Wu-Xia shadow rate)	Cost advantage $\tilde{c}_t$ of EUR funding
	1	2	3	4
$\sum \theta_m$	-1.842***	-0.958***	-0.2734***	-0.064***
	(0.199)	(0.108)	(0.0294)	(0.404)
$\sum \gamma_j$	0.028 ***	0.096 ***	0.0445***	-0.008**
	(0.004)	(0.018)	(0.0044)	(0.002)
No. of obs.	9,357	9,357	9,357	9,357

Panel B Using broad dollar and BBB spread as instruments, 2002-2017

	Key policy rate	Change in NIBOR	ZLB (Wu-Xia shadow rate)	Cost advantage of EUR funding
	1	2	3	4
$\sum \theta_m$	-2.603***	-1.581***	-0.056***	-1.148***
	(0.204)	(0.150)	(0.008)	(0.153)
$\sum \gamma_j$	0.037 ***	0.051 ***	-0.010***	0.050**
	(0.004)	(0.017)	(0.002)	(0.008)

No. of obs.	9,357	9,357	9,357	9,357

Panel C Using VIX and BBB spread as instruments, 2002-2009

	Key policy rate	Change in NIBOR	ZLB (Wu-Xia shadow rate)	Cost advantage of EUR funding
	1	2	3	4
$\sum \theta_m$	-2.678***	-0.042***	-0.667***	-0.887***
	(0.111)	(0.036)	(0.045)	(0.210)
$\sum \gamma_j$	0.090 ***	0.053 ***	0.139***	0.001
	(0.004)	(0.009)	(0.009)	(0.001)
No. of obs.	4,768	4,768	4,768	4,768

Panel D Using broad dollar and BBB spread as instruments, 2010-2017

	Key policy rate	Change in NIBOR	ZLB (Wu-Xia shadow rate)	Cost advantage of EUR funding
	1	2	3	4
$\sum \theta_m$	-19.991***	-0.200***	0.022***	-1.369***
	(0.2.654)	(0.035)	(0.008)	(0.087)
$\sum \gamma_j$	0.755 ***	0.030**	0.073***	0.165**
	(0.111)	(0.014)	(0.011)	(0.019)
No. of obs.	4,589	4,589	4,589	4,589

Table B.1 First-Stage Regression Results for Table 4

Panel A: In this panel, we present the first stage of the two-stage instrumental variable estimation presented in Panel A.2 of Table 4, i.e., the specification using the VIX and BBB spread as instrumental variables for the whole period 2002-2017.

	$\tilde{c}_t\ (t-1)$		$\tilde{c}_t\ (t-2)$	
	coefficient	p-value	coefficient	p-value
VIX				
L1.	0.010	0.000	0.014	0.000
L2.	0.007	0.000	0.005	0.000
BBB Spread				
L1.	-0.037	0.000	0.006	0.648
L2.	0.092	0.000	0.018	0.118
Constant	-0.553	0.000	-0.494	0.000
Number of obs.		9,357		9,357
Adjusted R^2	0.55		0.56	

Panel B: In this panel, we present the first stage of the two-stage instrumental variable estimation presented in Panel B.2 of Table 4, i.e. the specification using the broad dollar index and BBB spread as instrumental variables the whole period 2002-2017.

	$\tilde{c}_t\ (t-1)$		$\tilde{c}_t\ (t-2)$	
	coefficient	p-value	coefficient	p-value
Broad Dollar				
L1.	0.018	0.000	0.020	0.000
L2.	-0.022	0.000	-0.019	0.000
BBB Spread				
L1.	-0.023	0.000	0.065	0.000
L2.	0.141	0.000	0.046	0.000
Constant	-0.080	0.000	-0.311	0.000
Number of obs.		9.357		9,357
Adjusted R^2	0.556		0.559	

Panel C: In this panel, we present the first stage of the two-stage instrumental variable estimation presented in Panel C.1 of Table 4, i.e. the specification using the VIX and BBB spread as instrumental variables for the period 2002-2009.

	$\tilde{c}_t\ (t-1)$		$\tilde{c}_t\ (t-2)$	
	coefficient	p-value	coefficient	p-value
VIX				
L1.	0.010	0.000	0.010	0.000
L2.	0.010	0.000	-0.007	0.000
BBB Spread				
L1.	0.080	0.000	0.126	0.986
L2.	-0.009	0.159	0.018	0.003
Constant	1.320	0.000	1.199	0.000
Number of obs.		4,768		4,768
Adjusted R^2	0.952		0.949	

Panel D: In this panel, we present the first stage of the two-stage instrumental variable estimation presented in Panel C.2 of Table 4, i.e. the specification using the broad dollar index and BBB spread as instrumental variables for the period of 2010-2017.

	$\tilde{c}_t\ (t-1)$		$\tilde{c}_t\ (t-2)$	
	coefficient	p-value	coefficient	p-value
Broad Dollar				
L1.	0.002	0.000	0.004	0.000
L2.	-0.015	0.000	-0.014	0.000
BBB Spread				
L1.	0.011	0.000	0.091	0.000
L2.	0.040	0.000	0.026	0.000
Constant	1.452	0.000	1.072	0.000
Number of obs.		4,589		4,589
Adjusted R^2	0.951		0.964	