WORKING PAPER

The global financial cycle, bank capital flows and monetary policy. Evidence from Norway

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NORGES BANK

THE GLOBAL FINANCIAL CYCLE, BANK CAPITAL FLOWS AND MONETARY POLICY. EVIDENCE FROM NORWAY[*]

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Abstract

We investigate the importance of a global financial cycle for gross capital inflows based on monthly balance sheet data for Norwegian banks. The VIX index has been interpreted as an "investor fear gauge" and associated with a global financial cycle. This index has also been found to impact real activity. We include both a global activity variable and the VIX index in our structural VAR model of capital inflows. We find that when global activity falls, banks' foreign funding share falls. Our results suggest that global real activity rather than a global financial cycle is a main driver behind the volume of bank capital inflows. We also study domestic monetary policy and implications for capital flows. Domestic monetary policy helps absorb VIX shocks and there is no indication of procyclical ("carry trade") effects on funding. Monetary policy affects activity and inflation in a standard fashion, and the exchange rate acts as a buffer when shocks hit the economy.

Keywords: *Bank Capital flows, Uncertainty-shocks, Structural VAR*
JEL Classification: *E32, E44, F32, F62, G15.*

1 INTRODUCTION AND SUMMARY

The importance of the global financial cycle for capital flows has been contested. Rey (2015) argues that gross capital flows between countries follow a common global financial cycle, and that flows are associated with risk taking behavior in international financial markets. Bruno and Shin (2015a) describe how a global liquidity cycle or leverage cycle seems to be driven by US monetary policy. These papers consider the global cycle to be captured by the VIX index.[1] Several other papers also find that the VIX index helps explain capital flows.[2] Furthermore, Rey (2015) argues that the financial cycle implies that domestic monetary policy in small open economies - even with flexible exchange rates - is incapable of stabilizing the domestic economy. On the other hand, Cerutti, Claessens, and Rose (2017) find that only a small fraction of gross capital flows is explained by the VIX index. Our results based on monthly aggregate data for 268 Norwegian banks and credit companies[3] suggest that banks' gross capital inflows (as a fraction of banks' total market funding) are driven by global activity shocks and not by the global financial cycle. Furthermore, we confirm standard results regarding the effectiveness of domestic monetary policy, and we show that there is no evidence of carry trade effects of monetary policy on capital inflows. Our results should be regarded against a background where gross international capital flows (see e.g. Forbes and Warnock (2012)) are decoupled from net capital flows between countries in the data. Notably, traditional macroeconomic theory does not put any constraint on the size of *gross* flows between countries, and gross flows can shrink or rise everywhere at the same time.

Identifying how strongly a global financial cycle affects (gross) capital flows, relative to the possible impact of foreign real activity, has policy relevance. The global financial cycle is a potential source of foreign credit supply shocks related to distorted risk perception and risk taking behavior in international financial markets. Macroprudential measures will be more important if the global financial cycle is a dominant force, and some policymakers also argue that regulations of international capital flows might be necessary in certain cases.[4] Traditional stabilization policy - including domestic monetary policy - might be less effective, as argued by Rey (2015). On the other hand, if a main driver of gross international capital flows is global real activity, financial market distortions are not necessarily involved. A main driving force behind gross flows may simply be that higher gross credit flows are necessary to support and facilitate higher real activity and e.g. more trade. Standard domestic macroeconomic policy responses to a stronger foreign economy will then more effectively stabilize the economy. Also, the impact of e.g. higher foreign interest rates will then not necessarily be contractionary and trigger gross capital outflows from the small open economy. The effect will instead depend on whether higher foreign interest rates are the result of strong foreign activity or for example a negative foreign

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[1] Chicago Board Options Exchange Market Volatility Index (VIX). It is a measure of the implied volatility of SP 500 index options.

[2] See Avdjiev, Gambacorta, Goldberg, and Schiaffi (2017), Fratzscher (2012), Obstfeld (2015), Cerutti, Claessens, and Ratnovski (2016) and Forbes and Warnock (2012).

[3] We will refer to banks and credit companies as banks in the following.

[4] See discussion of stabilization challenges related to gross international capital flows in IMF (2016a).

supply shock.[5] Both distortions in international financial markets from e.g. risk taking behavior by global banks *and* global real activity are likely to influence capital flows in practice. For policymakers it is of interest to know whether the dominant force behind gross flows is fluctuations in global real activity (the benign case) or movements caused by financial market distortions (a less benign case) in order to assess the information content of capital flows for policy design.

SVAR studies of capital flows, such as Bruno and Shin (2015a), typically do not include global activity as a potential explanatory variable for capital flows.[6] The same is the case in panel studies such as Avdjiev, Hardy, Kalemli-Ozcan, and Servn (2017). But Forbes and Warnock (2012) find that both uncertainty and global real growth matter for the episodes of extraordinary large gross capital inflows and outflows that they study in a panel data framework. There is further evidence of global activity affecting capital inflows in Jeanneau and Micu (2002), Baek (2006) and Avdjiev et al. (2017). Given the close association between US real activity and the VIX index documented in the literature (see Bloom (2009)), and evidence of global real activity also affecting capital flows, leaving out global real activity from structural VAR analyses of VIX shocks to capital flows seems inappropriate. Also, the relationship between the VIX index and capital flows has been found to be somewhat unstable. Bruno and Shin (2015a) note that their results are sensitive to the sample period and report results for the period 1996-2007.

Our contribution is to jointly study the importance of global real activity and the global financial cycle (represented by shocks to the VIX index) for bank capital inflows to a small open economy in a structural VAR framework. To the best of our knowledge, this paper is the first to do this.[7] Also, unlike most studies of the determinants of capital flows, we use monthly data, which enable us to capture potential short-term effects of uncertainty shocks.[8] In order to distinguish the potential impact of the VIX index on banks' general access to funding from its effect on their access to foreign funding in particular, our object of study is the share of foreign funding in banks' market funding.

We conclude that global real activity rather than the VIX index directly affects banks' foreign funding share. A condition for this conclusion is that reduced risk taking associated with a higher VIX index will affect the foreign funding share with a reasonably short lag, and that the lag is shorter than for real activity shocks. We find that the impact of

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[5]In the literature, empirical evidence of the effect of interest rate differentials on capital flows is inconclusive, see Koepke (2015).

[6]Also Miranda-Agrippino and Rey (2013) and Gauvin, McLoughlin, and Reinhardt (2016) study the effect of the VIX index (and other uncertainty measures) on capital flows using SVAR approaches. They find that the VIX index is an important explanatory variable, but these studies do not include global activity as an explanatory variable.

[7]Rey (2015) presents a VAR study where both global (US) GDP and the VIX index may affect the sum of direct cross-border credit to the non-bank sector in 53 countries. No local/country-level variables are included in that study (except for US variables). Unlike Rey (2015), we exploit the small open economy feature where foreign shocks may be assumed to be exogenous, and we focus on bank capital inflows, as in Bruno and Shin (2015b).

[8]Fratzscher (2012) also studies monthly data. Global real activity and the VIX index are both included in one common global factor in that paper, since the focus is on foreign versus domestic determinants. In this paper we distinguish between different global determinants.

VIX-shocks has a two year lag. VIX shocks do not credibly impact the foreign funding share until after it *first* has (credibly) reduced US Industrial Production (or our alternative measure of global activity, OECD Industrial Production). A one standard error fall in US Industrial Production leads to a 0.2 percentage point fall in the share of foreign currency market funding for Norwegian banks after about one year. The effect of a VIX shock (after about two years) is somewhat less credible and less robust than the direct effect of US Industrial Production. Our interpretation of this is that the effect of the VIX shock goes via its effect on US Industrial Production, and not directly via changed risk taking. Such a lagged effect of VIX shocks is exactly what we should see if real activity rather than risk taking and the global financial cycle is the main driver of capital flows. Results are robust to various estimation periods and different orderings of variables in the foreign (exogenous) block.

Our results on monetary policy independence and the lack of carry trade confirm standard results on the effects of monetary policy. We show that domestic monetary policy does not trigger procyclical capital inflows. Instead, monetary policy acts as a buffer both against domestic and foreign shocks. Such standard effects of monetary policy are consistent with a moderate importance of the global financial cycle for bank capital inflows. The variance decomposition of the foreign funding share forecast errors confirm that VIX shocks have a relatively small impact on the funding share, but global shocks combined have a large impact.

As a small advanced economy with a financial sector that is well integrated into global markets (see IMF (2015)), Norway is a useful case to study. The country has an independent monetary policy and it has had a flexible inflation target since 1999.[9] Bank funding dominates capital markets in Norway, and results for Norwegian banks may be of relevance to other small financially advanced economies.

Our paper is mainly related to three branches of the literature. First, there is a literature on gross capital flows.[10] A motivation for including the VIX index as an explanatory variable for capital inflows can be found in Adrian and Shin (2010), who describe how mark-to-market accounting, and Value-at-Risk benchmarks, make the leverage of security brokers and dealers in the US increase when the VIX index is low. Bruno and Shin (2015b) build on Shin and Shin (2011) and Hahm, Shin, and Shin (2013) and describe a model where regional banks increase their leverage (by borrowing more) when their perception of risk is low and global banks provide ample amounts of funding. Our study is inspired by Bruno and Shin (2015a), in that we identify shocks and assess their impact on local (regional) banks' gross foreign funding. The partial equilibrium explanation of factors influencing capital flows described in Bruno and Shin (2015b) suggest a feedback-loop where lower (perceived) uncertainty leads to higher capital inflows to regional banks

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[9]The inflation targeting regime was formally introduced in 2001, se Alstadheim (2016).

[10]Much attention has been given to "push" versus "pull" effects on capital flows. "Push" variables are foreign explanatory variables in panel regressions for capital flows, while "pull" variables are domestic variables. The degree to which capital flows are driven by "push" versus"pull" effects is disputed, see e.g. Fratzscher (2012) and Cerutti et al. (2017). A potential weakness of panel data studies, is the possibility of endogenous explanatory variables. Koepke (2015) provides a survey of the empirical literature on capital flows.

(national banks in our case), and such effects might be self-reinforcing and persistent.

Papers discussing gross capital flows in *general equilibrium* are few.[11] Macroeconomic models instead typically associate capital flows with incentives for savings and investment (differences in return on investment between countries, as well as cyclical variation in domestic demand). These mechanisms are likely to be important for net capital flows but not necessarily the most important drivers of gross flows. As explained by Jakab and Kumhof (2015), gross bank borrowing and lending can be decoupled from the underlying pattern of saving. At the international level, we see a manifestation of this in the decoupling of gross capital flows from net flows, as discussed in e.g. Forbes and Warnock (2012).

The literature on uncertainty indicators and the interpretation of the information content of the VIX index is also of relevance to this paper. Bloom (2009) shows that the VIX index is a good predictor of real activity, and Berger, Dew-Becker, and Giglio (2017) show that the VIX index may be decomposed into information that represents the business cycle itself, and a form of uncertainty (that has no significant effect on activity). Leduc and Liu (2016) interpret uncertainty reflected in the VIX index as demand shocks. Other papers note that it is hard to distinguish between financial shocks and uncertainty shocks (see Caldara, Fuentes-Albero, Gilchrist, and Zakrajsek (2016) and Popp and Zhang (2016)). Yet other papers suggest that output may affect uncertainty. Robustness of results to different identifying assumptions are therefore of interest, and we find that results in this paper apply across alternative identification schemes.

An alternative measure of uncertainty that we consider is the Economic Policy Uncertainty (EPU) indicator established and discussed in Baker, Bloom, and Davis (2015). This is an indicator which quantifies newspaper coverage of economic policy uncertainty. Our paper shows that policy uncertainty - in contrast to uncertainty reflected in the VIX index - *does* directly impact bank capital inflows, but only in the very short term. This effect is robust to also including effects of global activity in the structural VAR and it is robust to excluding the global financial crisis period from the data.[12]

The literature discussing possible carry trade effects of interest rate increases and a lack of monetary policy independence in small open economies are also relevant for this paper. Evidence of procyclical carry trade effects is limited, but some panel data studies find that positive interest rate differentials attract capital inflows (see IMF (2016b)). Also Miranda-Agrippino and Rey (2013) discuss potential carry trade effects.[13] Our paper can

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[11]Wei and Ju (2006) is one exception. They describe a framework where gross capital flows are driven by variations in financial development and legal protection across countries.

[12]We have also considered other uncertainty indicators, such as the forecasting uncertainty identified in Jurado, Ludvigson, and Ng (2015) and the financial stress index established in Hakkio and Keeton (2009). Financial stess and uncertainty are empirically related, and financial stress is a potential driver of capital flows. We therefore find that it is useful to consider various types of uncertainty and stress. However, we find that the credible bands for the responses in gross capital flows to those indicators are not robust to excluding the global financial crisis from the sample. In contrast, our results for the VIX index and the EPU index are robust to excluding the financial crisis period, see Appendix C.6 for robustness on the VIX index result.

[13]Some discussion is also provided in Burnside (2015) and Galati, Heath, and McGuire (2007).

Figure 1: *Alternative transmission channels*
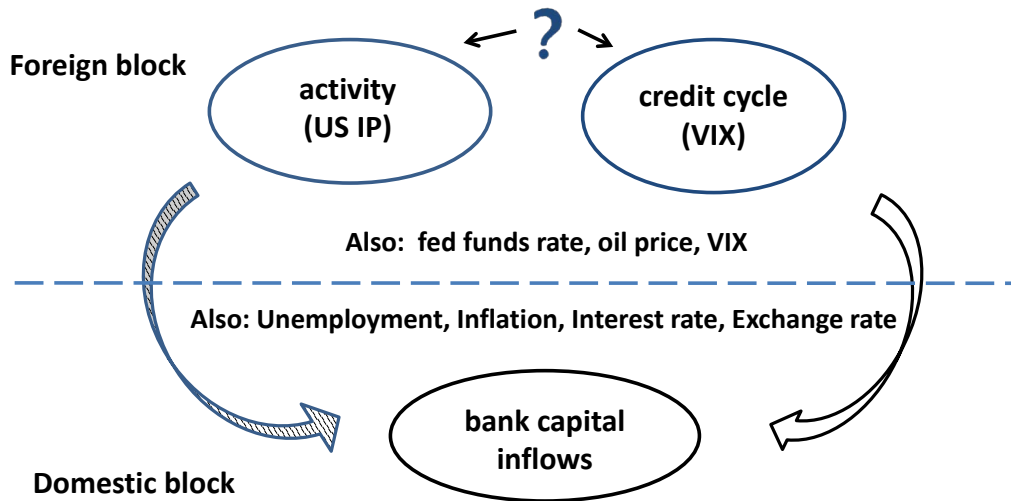
be regarded as a piece of evidence in support of the classical "trilemma" in monetary policy (see e.g. Murray (2013) for a policy discussion and Aizenman, Chinn, and Ito (2016) for an empirical analysis), since domestic monetary policy does not seem to be constrained from responding to domestic or foreign shocks due to a concern for procyclical capital flows.

In Section 2 we discuss some of the institutional background and our econometric approach. Section 3 presents our results on the impact of the global financial cycle and other foreign shocks on capital flows. Section 4 presents our discussion of the impact of domestic monetary policy on capital flows and monetary policy independence. Section 5 concludes, and robustness analyses are presented in the appendixes.

2 FRAMEWORK AND METHODS

2.1 MODELLING APPROACH

Our modelling approach is illustrated in Figure 1. The global financial cycle impact channel (right hand side arrow) captures increased risk-taking by global banks. When risk premia and market volatility are low, international lenders leverage up (as in Adrian and Shin (2010) and Bruno and Shin (2015b)). The reason may be that local banks and their customers may appear less risky when risk premia are low and the value of their assets is high. Also, if the local currency appreciates (and bank customers' balance sheets then strengthen or export income prospects improve), global banks might be more inclined to extend credit to local banks. Foreign funding then enters the small open economy in the

Figure 2: *Definition of foreign funding measure*
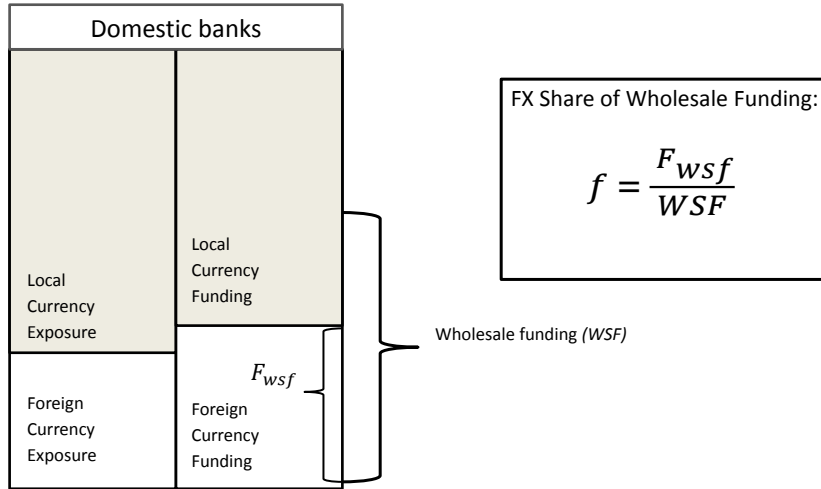
form of wholesale (non-core) foreign currency funding of local banks.[14]

Figure 2 illustrates a situation where (as in the case of Norway) wholesale funding accounts for about 50% of liabilities.[15] In the spirit of the literature, we focus on the share of wholesale funding that is obtained in foreign currency in this paper. This fraction should capture the relative ease with which banks obtain funding abroad.[16] Note that this relative funding measure means that shocks that affect local and foreign funding symmetrically will not be picked up. In order to pick up an effect of the VIX index on capital flows, we will investigate changes in the relative importance of foreign funding. We define the foreign funding ratio f_t as:

$$f_t = \frac{\text{foreign currency denominated wholesale funding (measured in local currency)}}{\text{total local + foreign currency wholesale funding}}.$$

The stylized aggregated balance of domestic banks in Figure 2 illustrates that the foreign currency share of banks' wholesale funding may increase for two reasons: either that banks fund an increased local currency exposure by borrowing abroad, or that banks increase their foreign currency assets and liabilities in a synchronized fashion - they in-

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[14]Wholesale funding includes all liabilities except customer deposits and equity, and it is commonly regarded as the more volatile part of banks' funding. For Norwegian banks, it consists of loans from other banks and financial institutions, unsecured bank bonds and certificates, as well as covered bonds. Almost all foreign funding is wholesale funding (and not customer deposits). For a discussion of financial vulnerability related to wholesale funding, see Hahm et al. (2013).

[15]The aggregated balance sheet of Norwegian banks totals about 120% of GDP, which is moderate compared to banking sectors in some other countries. However, the volumes of foreign exchange assets and liabilities on banks' balance sheets are significant. One reason might be exposures to the petroleum sector, or other export-oriented sectors that demand credit in foreign currency (mainly US dollars). Another reason might be asset management activities and business areas not related to traditional lending activity. A third reason is foreign funding of local currency exposure, when local funding is not enough. Norwegian banks are tightly integrated into a Nordic and global banking network, and the profitability of Norwegian banks is closely related to that of European banks, see IMF (2015).

[16]As discussed in Appendix C.3, our results are robust to measuring foreign funding relative to total funding.

crease the "dollarized" part of their balance sheet.[17]

For risk management reasons, banks typically fully hedge foreign currency assets. This means that some demand for foreign currency funding may be driven by foreign currency exposures. It also means that banks prefer to hedge by using currency swap arrangements when they fund local currency exposure in foreign currency, see Molland (2014).[18] The banks' hedging behavior suggests that their funding costs may be quite similar whether they borrow at home or abroad, thus limiting the potential for large carry trade effects on capital flows from domestic monetary policy.[19]

A trigger for increased "dollarized" bank activity from higher global real activity (left-hand side arrow in Figure 1) could be related to stronger demand for international financial services when global real activity is high. It could also be related to foreign currency borrowing needs in the country's export sector when global demand is high, and hence a corresponding foreign currency funding need in the banking sector (both foreign exchange assets and liabilities on banks' balance sheets may increase in these cases). Finally, domestic real activity is stimulated by higher global real activity, and this may trigger higher domestic demand and higher (net private) foreign funding needs. Notably, the left hand side arrow captures channels that are present also when financial market frictions are not present. To the extent that increased uncertainty has real economic effects (in addition to or instead of effects on risk taking), we would expect to see a lagged impact of uncertainty shocks on the foreign funding share, hitting the economy later than US IP shocks. This is what we find in this paper.

The discussion in this section suggests that we can expect a larger degree of domestic monetary policy independence, in the sense that monetary policy does not strongly affect gross capital flows, if high global activity rather than a strong global financial cycle (driven by search for yield and low risk premia) is an important driver of gross capital flows.

2.2 DATA

We use monthly data from January 1999 to January 2016. The starting point is chosen to avoid the Norwegian banking crisis around 1990 and its aftermath. During the 1990s, Norwegian banks reentered international capital markets, with a steadily increasing foreign funding share. In 1999, Norway adopted a flexible inflation targeting regime (see Alstadheim (2016)), and banks were by then well integrated into international capital markets. 1999 was chosen as a starting point for the estimation of our main model.

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[17]A large part of domestic banks' foreign currency exposure consists of on-lending to other banks and credit institutions, as well as portfolio investments (about 50 percent in the case of the Norwegian banks studied here).

[18]There is limited literature on the degree to which banks hedge their foreign exchange rate risk, but see Froot and Stein (1998) and D'Souza (2002). See Box 1 on page 5 in Molland (2014) for evidence on Norwegian banks.

[19]Deviations from covered interest rate parity may have increased since the global financial crisis, however. See Du, Tepper, and Verdelhan (2017).

Figure 3: *Foreign share of wholesale funding and US Industrial Production.*
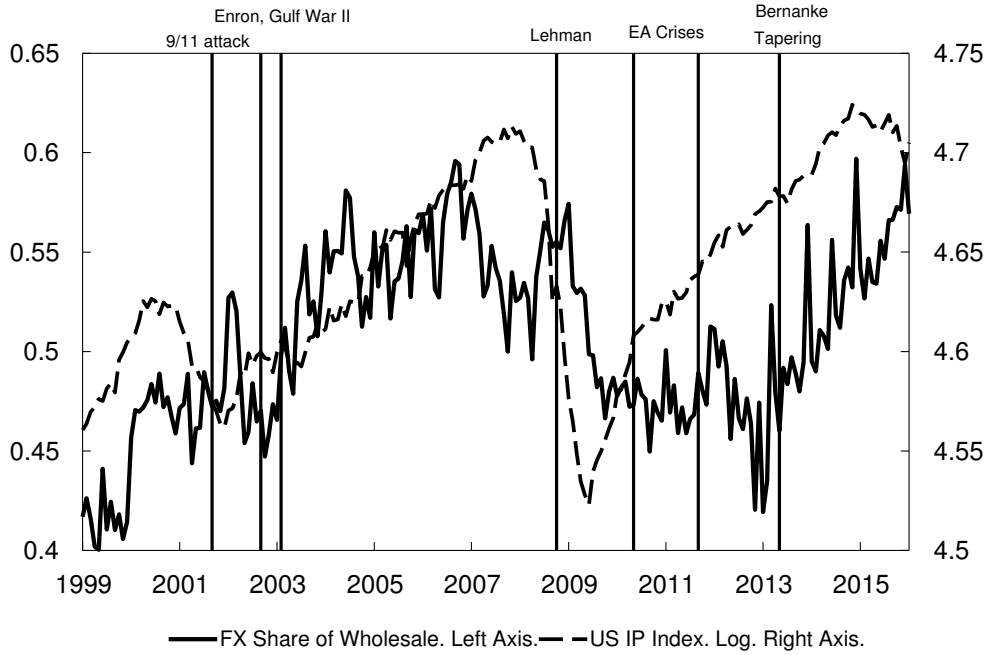
Note: Vertical lines from Bloom (2009) and Yesin (2015). They e.g. indicate the Lehman Brothers bankruptcy in September 2008, the European sovereign debt crisis with the associated bailout of Greece in May 2010 and 2011Q3 respectively, and Bernanke's speech on tapering of quantitative easing in May 2013.

Figure 3 describes the dynamics of gross foreign currency wholesale debt relative to total wholesale debt (f_t), together with the (log) US Industrial Production index. We use balance sheet data for 268 Norwegian banks to construct our measure of foreign funding. Branches and subsidiaries of foreign banks in Norway are excluded from our dataset since their funding is likely to be affected by intra-bank transfers.[20] Banks included in the dataset account for about 75 percent of credit from banks to Norwegian customers.

Figure 4 shows the two alternative uncertainty measures that we consider as part of the foreign block of our model. The VIX index captures the implied volatility of the S&P 500. Our second measure is Economic Policy Uncertainty (EPU), which is an indicator based on newspaper coverage of economic policy uncertainty, see Baker et al. (2015). In addition to one of the uncertainty measures, the foreign block of our model includes the fed funds rate (i_t^*), the oil price (oil) and US Industrial Production (y_t^*). The model includes four domestic variables, in addition to the gross foreign funding share of banks: the unemployment rate (u_t), the CPI inflation rate (π_t), the three-month money market (NIBOR) rate (i_t) and the nominal exchange rate in NOK per 1 USD (er_t).

We measure the level of U.S. industrial production, the oil price, the VIX index and the EPU index in logs. The remaining variables are measured in levels. Details of the data

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[20]This means that Nordea's Norway-based subsidiary, converted into a branch in 2017, is not included in the dataset. Also, the New York branch of DnB is excluded from the dataset, in order to avoid including gross transactions by DnB with the New York Fed.

Figure 4: *Two Measures of Uncertainty*

— –VIX (log), left axis. ——EPU (log), right axis.
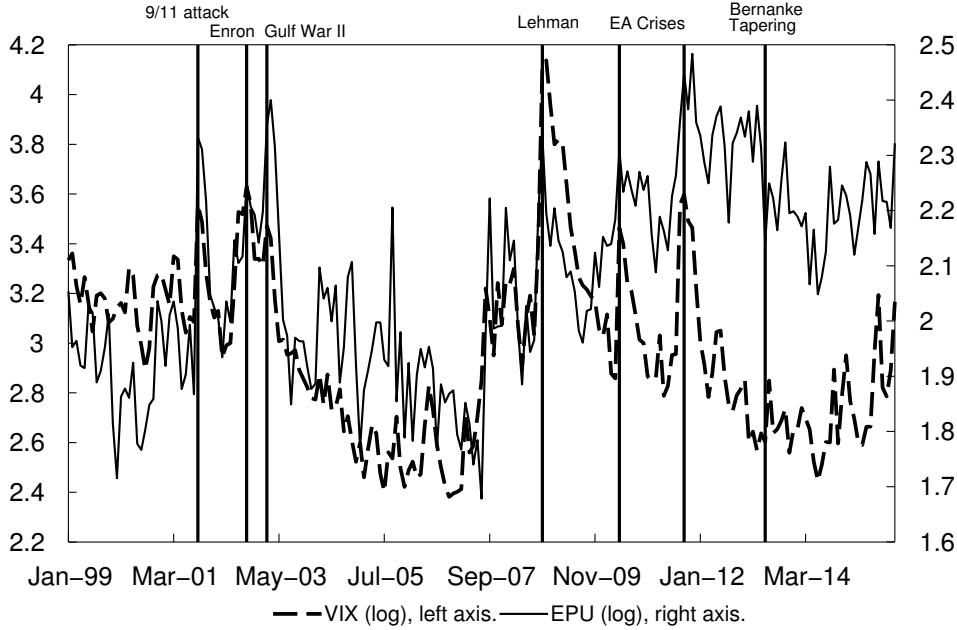
Note: Vertical lines as in Figure 3.

are presented in Appendix B.

2.3 ESTIMATION

Let $x_t^F = [y_t^*, i_t^*, oil, unc]$ be a vector of the foreign variables and let $x_t^D = [u_t, \pi_t, i_t, er_t, f_t]$ denote the domestic variables. The reduced form version of our model is:

$$\begin{bmatrix} x_t^F \\ x_t^D \end{bmatrix} = \alpha_t + \sum_{s=0}^{p} \begin{bmatrix} A_{11}(s) & 0 \\ A_{21}(s) & A_{22}(s) \end{bmatrix} \begin{bmatrix} x_{t-s}^F \\ x_{t-s}^D \end{bmatrix} + Z_t + \begin{bmatrix} \epsilon_t^F \\ \epsilon_t^D \end{bmatrix} \tag{1}$$

where $[\epsilon_t^F, \epsilon_t^D]'$ is a vector of domestic and foreign reduced form shocks. Unit root tests suggest that foreign output, the oil price, nominal exchange rate, and gross foreign funding are all non-stationary. Accordingly, we include a time trend in the model. We also include a constant term and an exogenous dummy variable for a swap arrangement that may have affected banks' foreign funding during the global financial crisis, α_t.[21]

The block exogeneity assumption captures that domestic shocks do not affect foreign variables in any time period, and hence $A_{12} = 0$. The VAR model is estimated using Bayesian techniques with uninformative Jeffrey priors as in e.g. André, Gupta, and Kanda (2012). We follow Ivanov and Kilian (2005) in considering the Akaike Information Criterion (AIC) for lag selection in our model with monthly data. The criterion suggests three

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[21]From November 2008 to December 2009 the Norwegian government implemented a swap arrangement to mitigate the funding concerns of Norwegian banks, in the wake of the financial crisis. This arrangement possibly decreased gross foreign funding needs, as banks could more easily obtain funding from other sources. To control for this effect, we include a dummy variable in the model. Results are robust to not including the dummy (see Appendix C.5)

lags, but our main model is estimated with six lags in order to capture more potential dynamics. Results for the impact of foreign shocks on gross foreign funding are robust to including fewer or more lags.[22]

2.4   STRUCTURAL IDENTIFICATION

We use a Cholesky recursive ordering of variables in the exogenous foreign block, as described in table 1. Foreign output (US Industrial Production) is ordered first and an output shock can hence affect any variable. We assume that a fed funds rate shock does not affect foreign output in the same month, but we allow for monetary policy to affect uncertainty.[23] The oil price and the uncertainty measures (the VIX index or the EPU index) are ordered last in the exogenous foreign block. This recursive ordering is based on the assumption that asset prices and uncertainty measures respond faster to shocks than macroeconomic variables such as output, and the ordering is inspired by that of Bruno and Shin (2015a).[24] In contrast, in the literature studying links between uncertainty shocks and real activity, the ordering is often different, with e.g. the VIX index being allowed to immediately impact other variables.[25] Our results are robust to ordering the VIX index first. The ordering of the uncertainty measure and the oil price is debatable. Several studies have e.g. found a strong association between the VIX index and the oil price. An increase in global risk perception, as discussed in Sari, Soytas, and Hacihasanoglu (2011), is found to have a temporary negative effect on oil prices. On the other hand, Kang, Ratti, and Yoon (2015) show that stock market volatility decreases in response to an oil demand shock and increases with an oil supply distortion.

Our focus of attention is on the share of foreign funding, f_t. We order this variable last. This means that foreign funding can respond contemporaneously to all variables in the model, domestic and foreign. We otherwise allow for a contemporaneous response in domestic monetary policy to the unemployment rate and the inflation rate. The ordering of the interest rate and the exchange rate is debatable. An alternative identification scheme, with sign restrictions and a contemporaneous response in the interest rate and the exchange rate to each other, is discussed in Section 4 and appendix C.11 on page 36.

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[22]The AIC criterion for lag selection implies that the VIX model should be estimated with two lags, while the model with the Economic Policy Uncertainty indicator should be estimated with three lags.

[23]In this study we choose to focus on foreign uncertainty shocks and activity shocks, and not on foreign monetary policy or the oil price. We economize on variables to include and do probably not identify a fully structural US monetary policy shock here (since US inflation is not included among our variables). We do not distinguish between oil supply- or demand shocks either.

[24]A difference is that we are dealing with the impact on local banks in a small open economy, whereas Bruno and Shin (2015a) analyze the core economy where shocks originate. The ordering of variables in their main five variable VAR is (1) Fed funds rate (2) broker dealer leverage (3) BIS banking flows (4) VIX and (5) US dollar Real Effective Exchange Rate. In their appendix, they consider a VAR which includes US Industrial Production (but not capital flows), and the ordering is then (1) US Industrial Production, (2) fed funds target rate (3) broker dealer leverage (4) VIX and (5) Real Effective Exchange Rate.

[25]In e.g Bloom (2009), the ordering is (1) log of the stock market index (2) the stock market volatility indicator (derived from the VIX index) (3) Federal Funds rate, followed by other variables, with the US Industrial Production index last.

Table 1: *Recursive (Cholesky) identification structure*

Shock	y_t^*	i_t^*	oil	$unc.$	u_t	π_t	i_t	er_t	f_t
Foreign output shock									
Fed funds rate shock	0								
Oil price shock	0	0							
Uncertainty shock	0	0	0						
Domestic unemployment shock	0	0	0	0					
Domestic inflation shock	0	0	0	0	0				
Domestic interest rate shock	0	0	0	0	0	0			
Nominal exchange rate shock	0	0	0	0	0	0	0		
Foreign funding shock	0	0	0	0	0	0	0	0	

Note: y_t^* is log U.S. Industrial Production, i_t^* is the U.S. fed funds rate, oil is the log crude oil price in USD, u_t is the domestic unemployment rate, π_t is domestic CPI inflation, i_t is the domestic 3-month money market rate, er_t is the log nominal exchange rate in NOK per USD, and f_t is the share of banks' wholesale funding in foreign currency. The variable name *unc.* denotes one of our uncertainty or financial stress indicators: VIX or EPU.

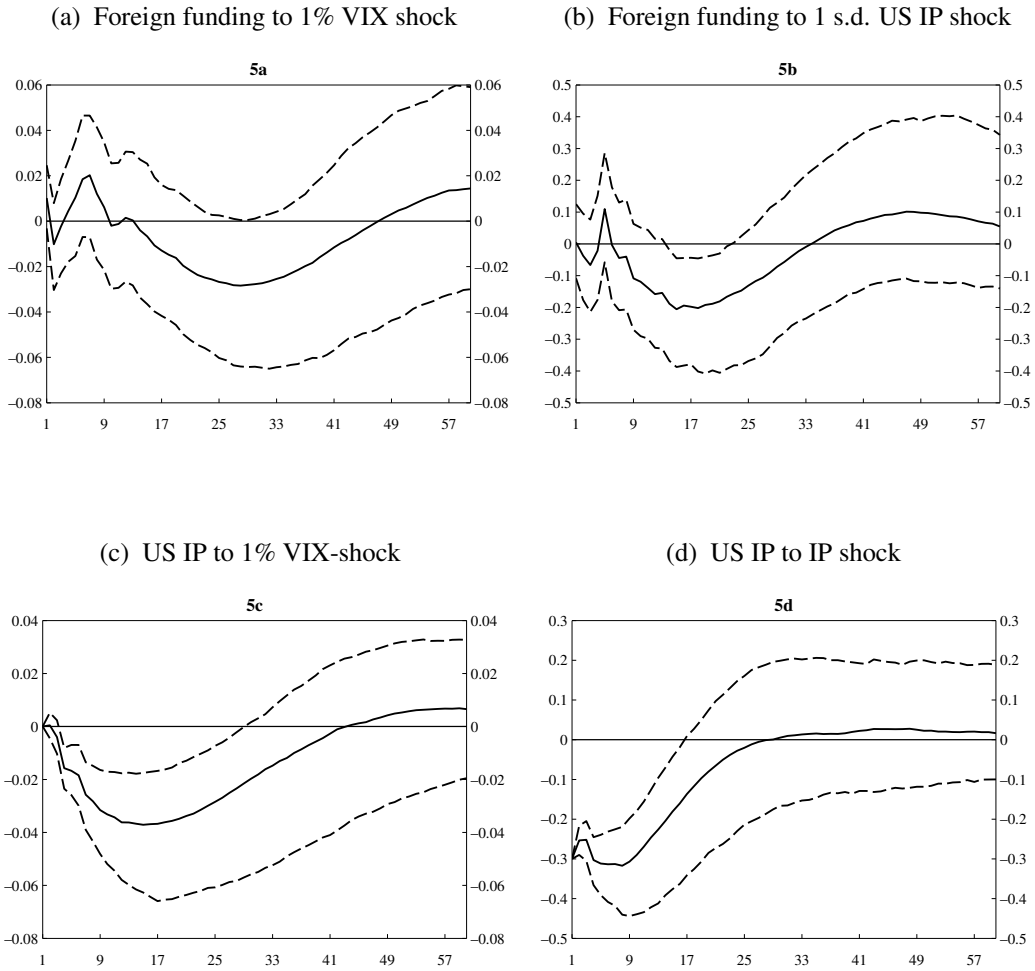## 3   BANK CAPITAL INFLOWS AND FOREIGN SHOCKS

Figure 5 shows our main result.[26] The share of foreign funding responds credibly to a shock to US Industrial Production after about one year (see Figure 5b). About two years after a VIX shock occurs, and one year after it has affected US Industrial Production (see Figure 5c), the VIX shock tentatively affects the funding share as well (as seen in Figure 5a). We interpret this to mean that the effect of the VIX index goes via its effect on US IP to the foreign funding share, rather than the VIX index exhibiting an independent impact through risk taking in global financial markets as discussed in section 2. A premise for this conclusion is an assumption that lower risk taking behavior (distortions in financial markets) associated with a higher VIX index should affect the foreign funding share earlier, and not later, than real shocks.[27] Figure 5a resembles a lagged but non-credible version of 5b. The similar but lagged pattern in the graph is exactly what we should see if the VIX index impacts foreign funding indirectly via its impact on real activity (instead of independently through risk taking behaviour). The similar pattern is additional evidence in support of our conclusion. A version of the model with fewer lags confirms this picture, see Figure 6.

If excluding the US Industrial Production index from the model, the effect of the VIX index is stronger and comes in earlier, as discussed in appendix C.10. Our results suggest

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[26]The ordering of variables is as described in Table 1. More details for the main model are provided in Appendix A (model A). The process for the identified VIX index shock and the estimated impact on US Industrial Production are similar to results in e.g. Bloom (2009).

[27]If the direct impact of changing risk taking behavior comes in with a long lag, and twice as long as the impact of real activity, disentangling the risk taking effect from the effect of a higher VIX index on funding via real activity may be hard.

Figure 5: *Impulse responses - main results*

(a) Foreign funding to 1% VIX shock

5a

(b) Foreign funding to 1 s.d. US IP shock

5b

(c) US IP to 1% VIX-shock

5c

(d) US IP to IP shock

5d

Note: Figures include 84% Bayesian error bands and the median impulse response function. 1000 draws. Periods after initial shock in months on the x-axis. Foreign funding share in percentage points on y-axis (fig. a and b). US Industrial Production, change in percent (fig. c and d)

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Figure 6: *Response of foreign funding. Model with three lags*
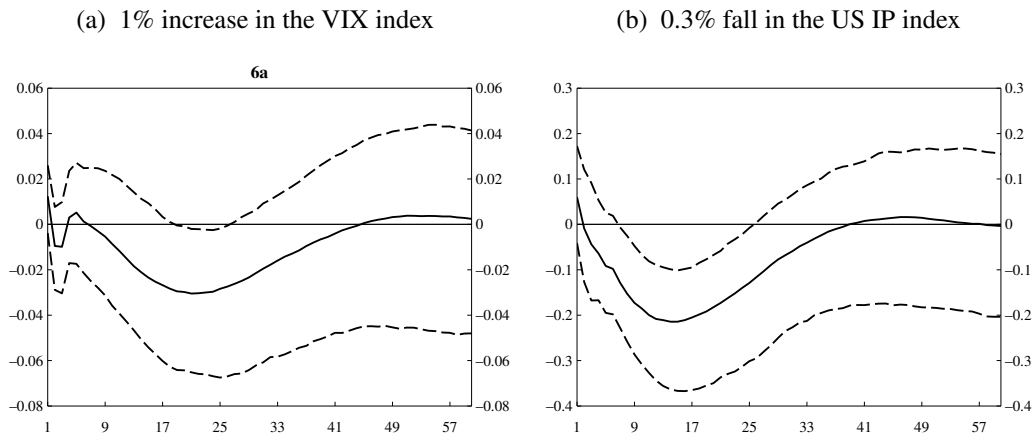
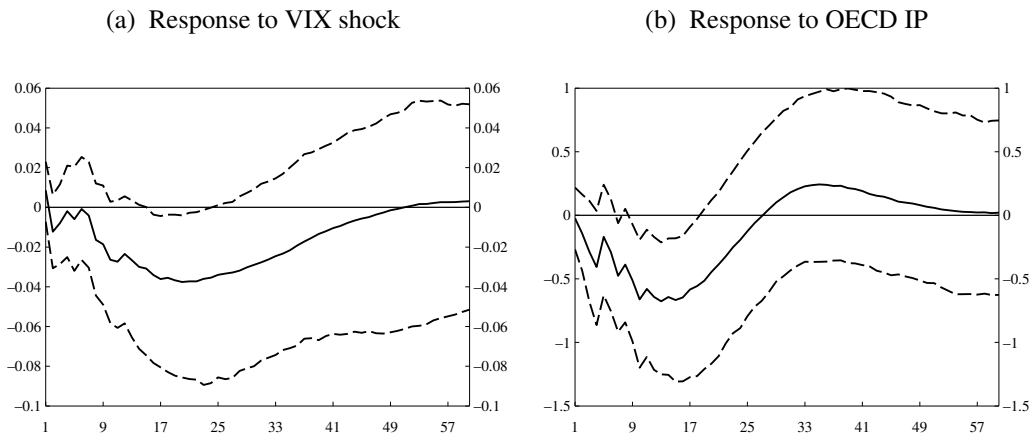(a) 1% increase in the VIX index   (b) 0.3% fall in the US IP index

Note: Figures include 84% Bayesian error bands and the median impulse response function. Periods after initial shock in months on the x axis. Percentage points on the y axis.

that excluding the global activity variable from the model may lead to biased results.

Our conclusion does not mean that banks' ease of access to funding is unaffected by the VIX index or risk taking behavior. It is the relative use, or access to, foreign versus domestic funding that is unaffected.[28] Our main result is also robust to e.g. different orderings of variables in the exogenous block (see Figure C.1 in Appendix C.1 on page 28), or changing the sample period (see Appendix C.7 on page 32) or using a different global activity variable, as shown in Figure 7.

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[28]Risk premia in Norwegian and foreign money markets are closely related, see Bernhardsen, Kloster, and Syrstad (2012). This is consistent with the relative use of foreign funding not changing very much when the VIX index changes. It is also consistent with a common factor in the movement of global asset prices, as discussed in Miranda-Agrippino and Rey (2015).

Figure 7: *Response of foreign funding, USIP replaced by OECD IP*

(a) Response to VIX shock   (b) Response to OECD IP

Note: Figures include 84% Bayesian error bands and the median impulse response function. Periods after initial shock in months on the x axis.

The foreign funding share consistently does not respond quickly to VIX shocks, but does so potentially with a lag when global activity affects foreign funding. When excluding the financial crisis period, there is no credible effect of Industrial Production on foreign funding, and also no effect of the VIX index on the foreign funding share, see Appendix C.6 on page 32.

The variance decomposition in Figure 8 shows that shocks to the VIX index explain much less of the forecast error of the foreign funding share than other foreign shocks (combined) do. But the decomposition also shows that foreign shocks are important, in contrast to the conclusions in Cerutti et al. (2017).

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Figure 8: *Forecast error variance decomposition of foreign funding share f_t*
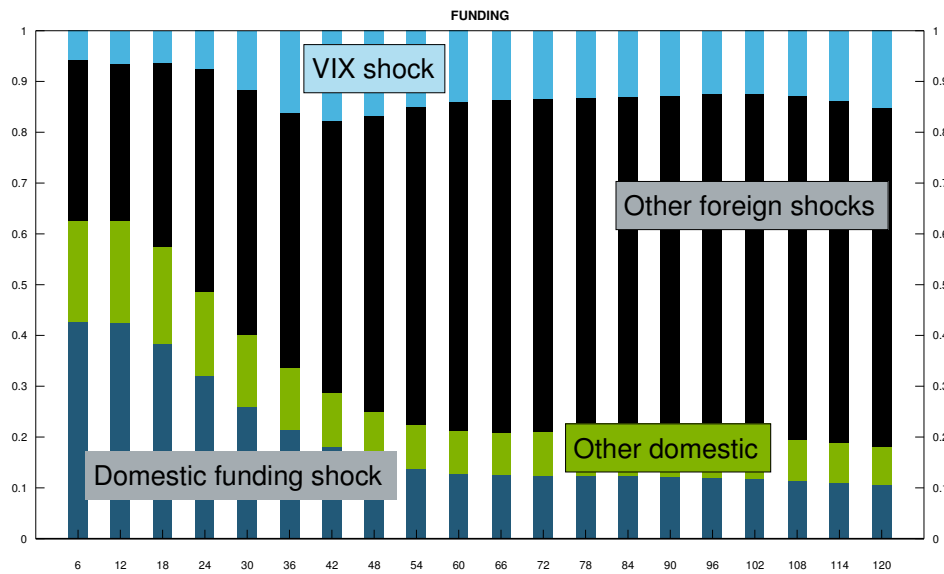
Note: Other foreign shocks include shocks to the US IP index, shocks to the fed funds rate and oil price shocks. Domestic shocks include shocks to the unemployment rate, shocks to the 3-month NIBOR interest rate and shocks to the CPI (inflation) rate. The Figure covers a 10 year time horizon (120 months).

Uncertainty can affect the foreign funding share directly, even though VIX shocks as identified here do not (except via their impact on real activity). Figure 9a shows the response in the share of funding in foreign currencies to a 1% increase in the EPU index with 84% credible bands. The model is like the main model, but the Economic Policy Uncertainty indicator replaces the VIX index. There is an immediate and short-lived response to an EPU shock. The response is robust to estimating the model with data ending in 2007 (see appendix C.2). This uncertainty effect might have been hard to capture with quarterly data. The difference between the impact of the VIX shock and the EPU shock is notable given the similarities in the dataseries (see Figure 4 on page 10).

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Figure 9: *Foreign funding share and Economic Policy Uncertainty*

(a) Response of funding to 1% EPU shock

(b) Response of funding to 1 s.d. US IP shock
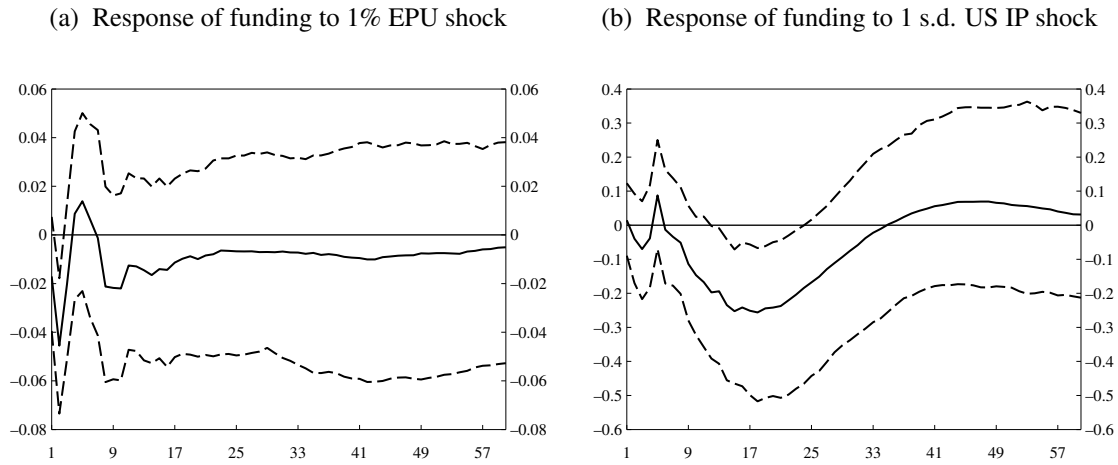
Note: Model with 6 lags. Figures include 84% Bayesian error bands and the median impulse response function. Periods after initial shock in months on the x axis. Funding share measured in percentage points on the y axis in Figure b).

4 MONETARY POLICY INDEPENDENCE

A negative interest rate shock does not have a credible impact on the foreign funding share, see Figure 10. Hence, there is no indication of weaker reliance on foreign funding when the interest rate is lowered e.g. in order to stabilize the domestic economy. The interest rate shock (Figure 10d) is fairly standard, showing overshooting consistent with what Bjørnland (2008) finds for Norway. Figure 11b shows the increase in CPI inflation after an interest rate reduction, with a peak impact after about 1.5-2 years. The profile of the inflation response is also consistent with the finding in Bjørnland (2008).[29] The effect on unemployment is similar to what others find as well.

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[29]We may note that the effect of the interest rate on inflation is relatively strong compared to e.g. Bjørnland (2008). The estimation period from 1999-2016 applied in our main model gives a stronger effect of monetary policy shocks on inflation than e.g. the effect identified when estimating on the period 1993-2007.

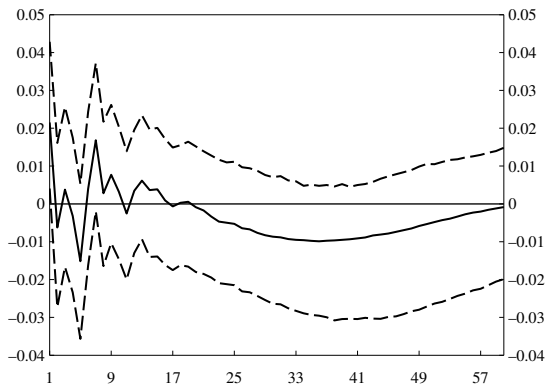Figure 10: *Response to a 1 p.p. reduction in the domestic key policy rate*
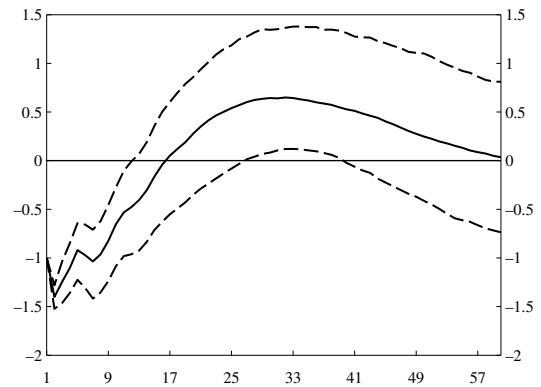
(a) Unemployment rate.
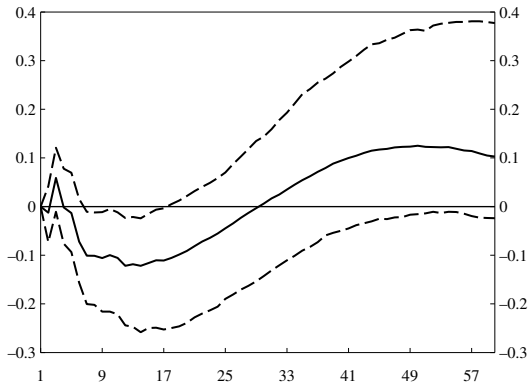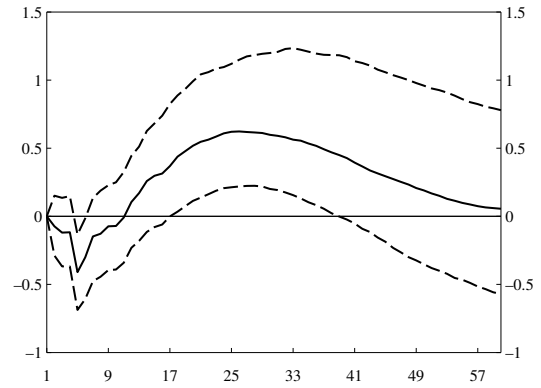
(b) CPI inflation.

(c) Share of foreign funding
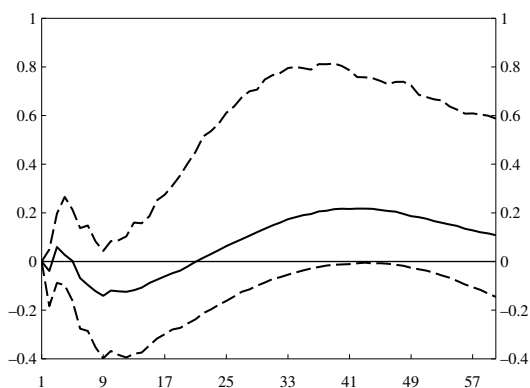
(d) 3-month money market rate

Note: Figures include 84% Bayesian error bands and the median impulse response function. Periods after initial shock in months on the x axis. Percentage points on the y axis.
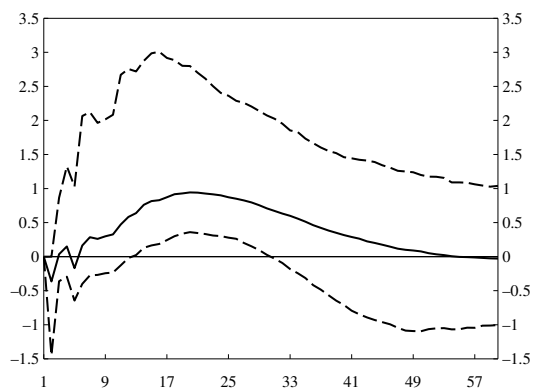
The impact of a monetary policy shock on foreign funding is also robust to alternative identification, as shown in Figure 11. The Figure illustrates a monetary policy shock identified with sign restricions (as described in appendix C.11 on page 36).

Figure 11: *Response to a domestic monetary policy shock (identified w/sign restrictions).*
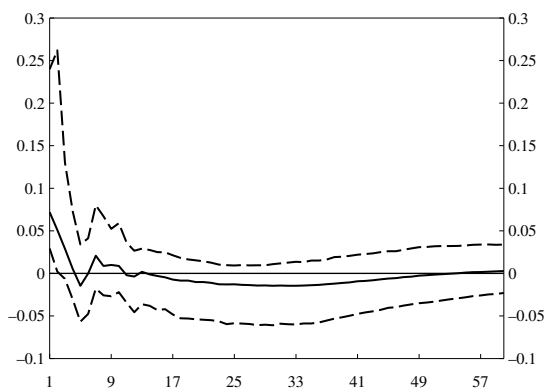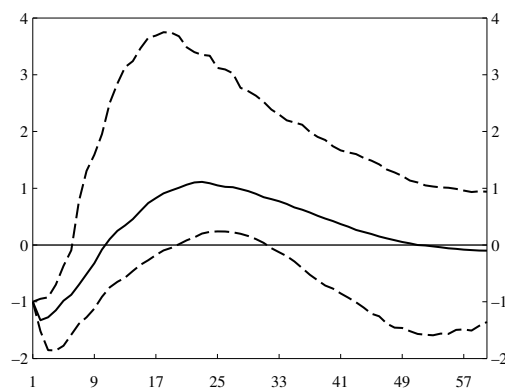
(a) Unemployment rate.

(b) CPI inflation.

(c) Share of foreign funding
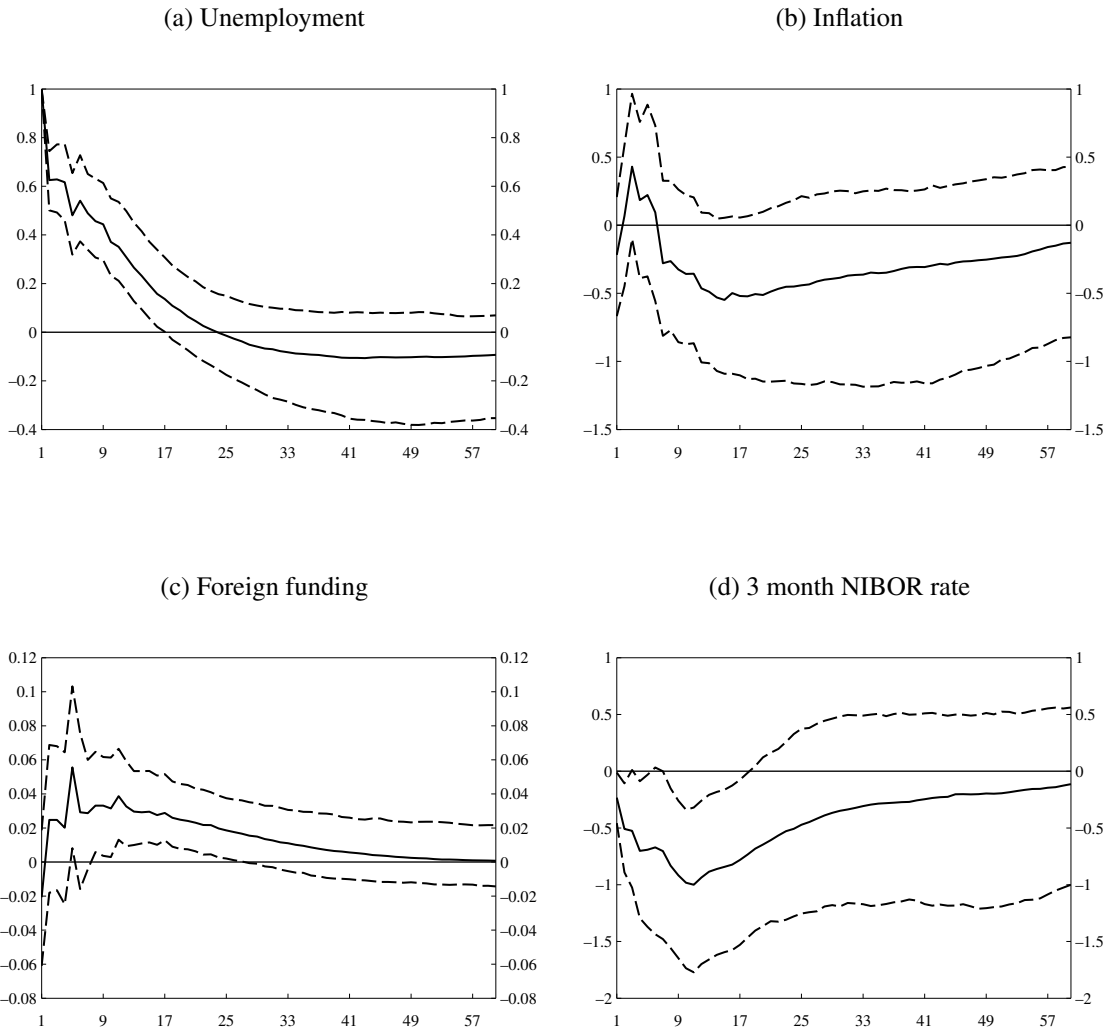
(d) 3-month money market rate

Note: Figures include 84% Bayesian error bands and the median impulse response function. Periods after initial shock in months on the x axis. Percentage points on the y axis.

We also find that monetary policy works as a shock absorber, without procyclical impact on the share of foreign funding. To see this, we may first note that the NIBOR 3-month (unsecured) money market interest rate does not credibly increase in response to a VIX-shock, as shown in Figure C.9a on page 34 (although the response is quite uncertain). The key policy rate therefore seems to absorb the VIX shock and to some degree act as a buffer against the increase in the risk premium that is usually associated with a VIX shock.[30] A version of the model estimated with the key policy rate (the folio rate) instead of the NIBOR rate confirms that the folio rate does not increase, and instead tends to fall (although with a fairly long lag) in response to the VIX shock. This happens although the oil price falls and the exchange depreciates in response to the VIX shock. Monetary policy is not tightened but allows the exchange rate to act as a buffer in response to a VIX shock (see Figure C.9b). Furthermore, Figure 12 shows that the interest rate falls in response to a negative unemployment shock (reduced domestic activity) in this model, without negatively impacting the foreign funding share of banks. Such an interest rate response is instead associated with a tentative *increase* in the foreign funding share (Figure 12c). There does therefore not seem to be any reason for monetary policy to be reluctant to respond to negative domestic shocks out of concern for banks access to foreign funding.

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[30]See also a discussion of the relationship between the key policy rate and interbank rates in Norway in Bache and Bernhardsen (2009).

Figure 12: *Domestic activity (unemployment) shock*

(a) Unemployment

(b) Inflation

(c) Foreign funding

(d) 3 month NIBOR rate

Note: Figures include 84% Bayesian error bands and the median impulse response function. Periods after initial shock in months on the x axis. Percentage points on the y axis.

5 CONCLUSION

Our results suggest that a global financial cycle, as measured by shocks to the VIX index, is not important for Norwegian banks' use of foreign funding *relative* to their use of domestic funding. Global shocks seem to be important, judged by the forecast error variance decomposition of banks' foreign funding share, but foreign *real* activity rather than the financial cycle seems to be robustly important for banks' quantitative reliance on foreign market funding. This conclusion is based on an assessment of impulse response functions. It is also based on the assumption that a direct impact of a higher VIX index on foreign funding via risk taking behavior in international financial markets should affect the foreign funding share without a very long lag. We find that VIX-shocks affect the

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foreign funding share after about two years. This lag is one year longer than the effect of global (US) real activity shocks on foreign funding. Our interpretation of this is that positive VIX shocks may reduce banks' foreign funding share indirectly, via reduced real activity. A shock to global activity (as measured by US Industrial Production or OECD Industrial Production) credibly reduces the foreign funding share after about one year. We note that a lack of impact of VIX shocks on the foreign funding share of banks is fully consistent with the VIX index affecting banks' funding conditions in general. Our results suggest that such an impact will be symmetric on foreign and domestic funding conditions.

We find no indications that domestic monetary policy is constrained by procyclical capital flows when responding to shocks. The interest rate and the exchange rate act as buffers when foreign and domestic shocks occur. A negative domestic interest rate shock does not trigger a lower foreign funding share. This is consistent with global real activity rather than the global financial cycle driving the volume of bank capital inflows.

This study does not assess the importance of the global financial cycle for asset prices. Our results are fully consistent with e.g. global comovements of asset prices.

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A THE MODELS

Table A.1: Overview of models

	Main model (A)	Long sample (B)	Pre Crisis (C)	3 Lags (D)
No. of obs:	199	271	105	202
Sample:	1999M1-2016M1	1993M1-2016M1	1999M1-2007M12	1999M1-2016M1
Ordering of var.:	Foreign: y_t^*, i_t^*, oil, unc. Domestic: u_t,i_t,pi_t,er_t,f_t.			
No. of lags:	6	6	3	3
$Dummy^{(1)}$:	Y	Y	Y	Y

Note:[1] Dummy for swap arrangement during financial crisis. D=1 in M1 2008- M12 2009.
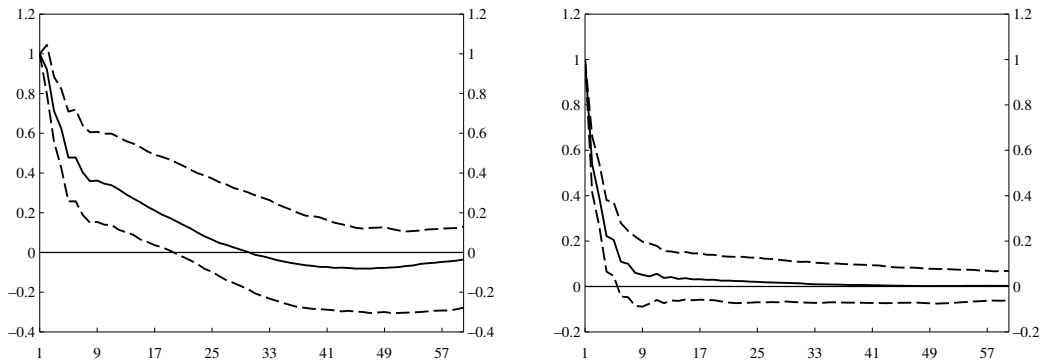
All models are estimated in (log) levels.

A.1 THE UNCERTAINTY SHOCK PROCESSES

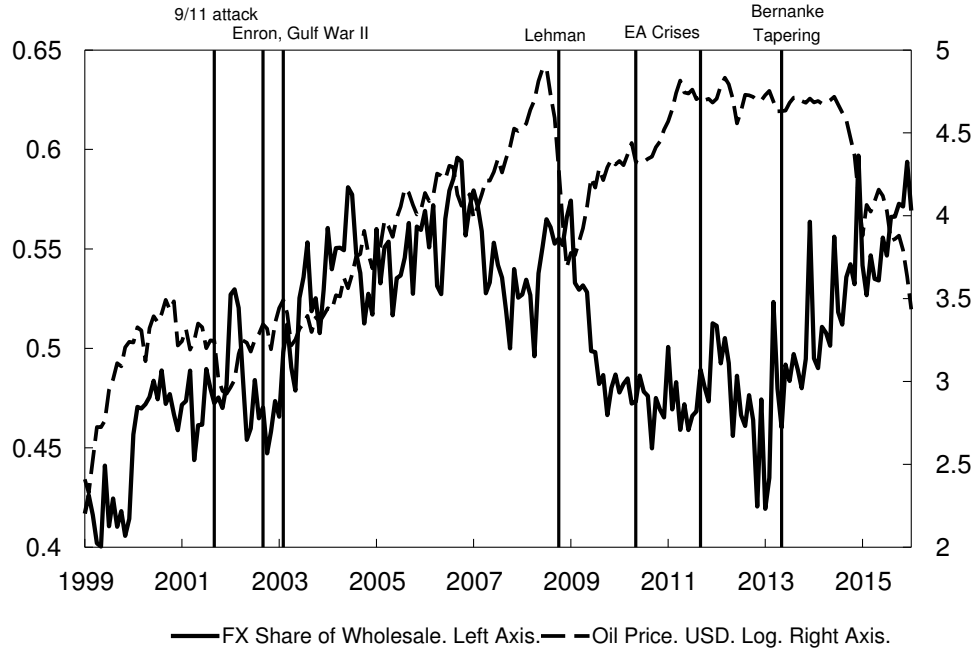Figure A.1: *Property of identified uncertainty indicator shocks, main model (A)*

(a) VIX. Shock to the VIX index.

(b) EPU. Shock to the EPU index.

Note: Figures include 90% Bayesian error bands and the median impulse response function. Periods after initial shock in months on the x-axis.

Figure B.1: *Foreign share of wholesale funding and the oil price.*

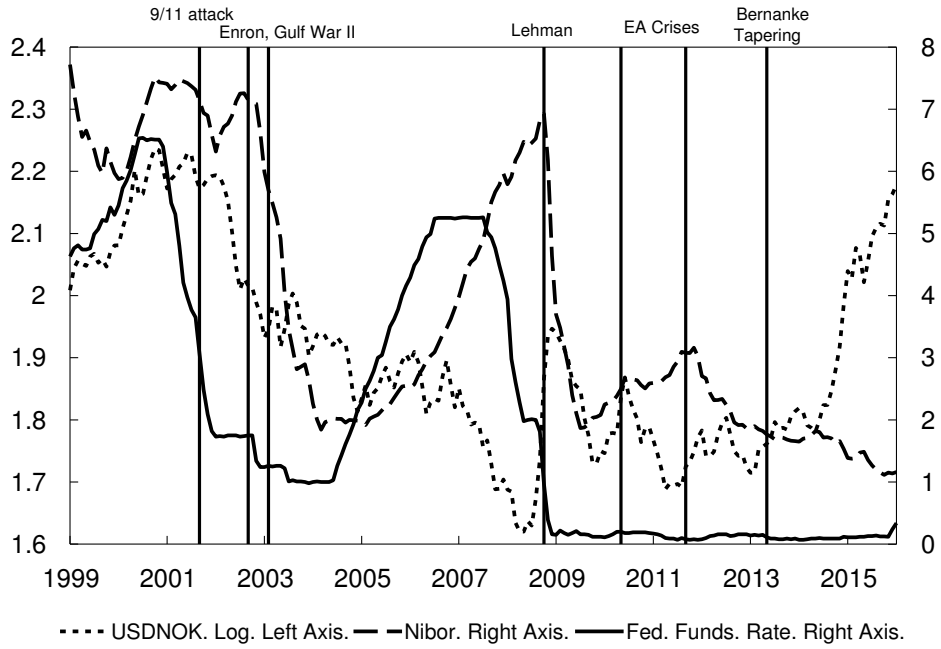*Note:* Vertical lines as in Figure 3.

B THE DATA

Table B.1: Sources

Variable name	Source	Description
y_t^*	IMF	U.S. industrial production. Index number. Log. Seasonally adjusted.
y_t^* (2)	OECD	OECD industrial production. Index number. Log. Seasonally adjusted.
i_t^*	IMF	U.S. federal funds rate. Percent per annum. Unadjusted.
oil	Thomson Reuters	World, Energy, Oil, Brent Dated, FOB Sullom Voe, Close, USD. Log. Unadjusted.
y_t	Statistic Norway	NAV. Unemployment rate. Seasonally adjusted.
π_t	Statistics Norway	Inflation. 12 month percentage change in log Consumer Price Index. Norway. Adjusted for taxes and energy prices. Base year: 1998. Log. Seasonally adjusted.
i_t	Norges Bank	NIBOR 3-month nominal interest rate. Unadjusted.
er_t	Thomson Reuters	Nominal exchange rate. Norway, spot rates, USD/NOK, close. NOK. Log. Unadjusted.
f_t	ORBOF	Banks' wholesale funding in foreign currency as share of total wholesale funding. Unadjusted.
$f_t(2)$	ORBOF	Banks' wholesale funding in foreign currency as share of total bank assets. Unadjusted.
VIX	Thomson Reuters	U.S. CBOE, Volatility Index (VIX). Close, USD. Daily data averaged to be monthly. Log.
EPU	www.policyuncertainty.com	Index of European newspaper coverage of policy-related economic uncertainty. Log.

Figure B.2: *Unemployment, inflation and the NOK interest rate.*
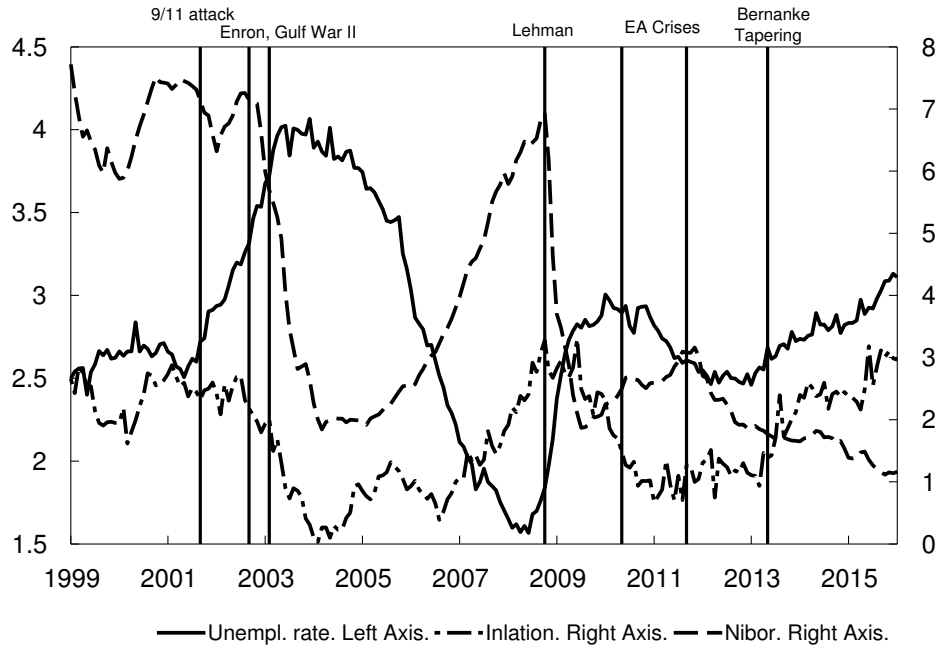
Note: Vertical lines as in Figure 3.

Figure B.3: *NOKUSD exchange rate, the fed funds rate and NIBOR.*

Note: Vertical lines as in Figure 3.

C ROBUSTNESS

C.1 ALTERNATIVE RECURSIVE ORDERING

Here we change our baseline identification and allow all foreign variables to respond to the VIX shock. The model in Figure C.1 is otherwise like the main model (model A in Appendix A). Figure C.1 shows that there is no evidence of a response in the foreign funding share to a VIX shock with this alternative ordering, just as in the main model. Furthermore, there is also here a clear response of foreign funding to US Industrial Production.

Figure C.1: *Response of foreign funding. Ordering the VIX index first*
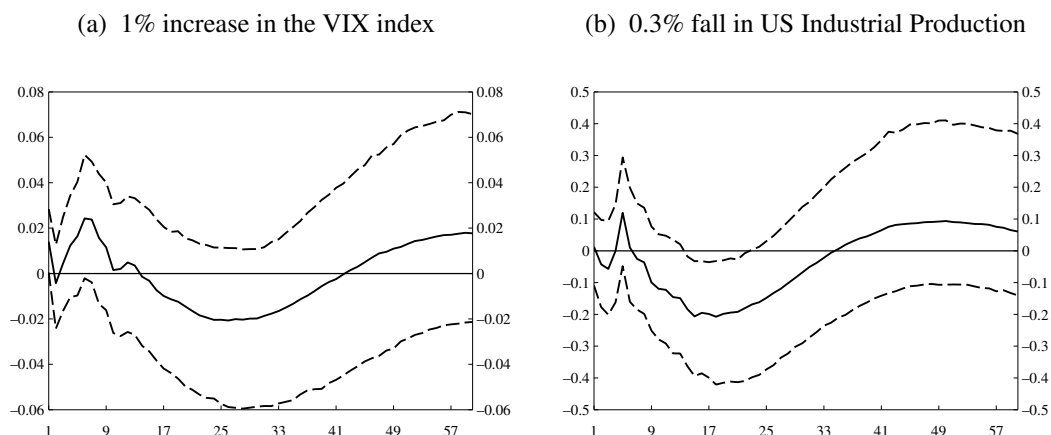
(a) 1% increase in the VIX index   (b) 0.3% fall in US Industrial Production

Note: Figures include 84% Bayesian error bands and the median impulse response function. Periods after initial shock in months on the x-axis. Percentage points on y axis.

C.2 EXCLUDING THE GLOBAL FINANCIAL CRISIS PERIOD, EPU MODEL

Impulse responses for the model where the VIX index is replaced by the Economic Policy Uncertainty index, with and without the global financial crisis period, are shown in Figure C.2. The response of foreign funding is robust to excluding the period after 2007.

Figure C.2: *Response of foreign funding to 1% EPU shock*

(a) 3 lags model, 1999-2016

(b) 3 lags model, 1999-2007
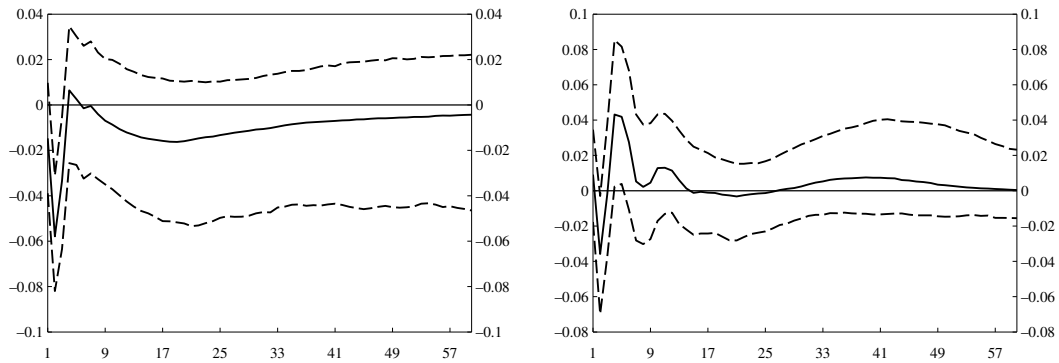
Note: Figures include 84% Bayesian error bands and the median impulse response function. Periods after initial shock in months on the x axis. Percentage points on the y axis.

C.3 FOREIGN FUNDING RELATIVE TO TOTAL ASSETS

We also estimate our model with an alternative foreign funding measure, where the local currency value of foreign currency funding is measured relative to total assets instead of relative to total wholesale funding. Again estimation results are robust to this adjustment of the model.

Figure C.3: *Response of foreign funding measured against total assets*

(a) 1% increase in the VIX index
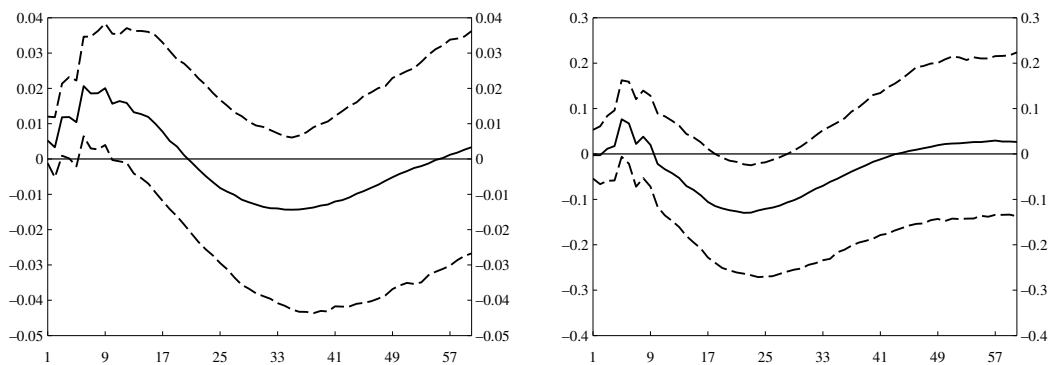
(b) 0.3% fall in the US IP index

Note: Figures include 84% Bayesian error bands and the median impulse response function. Periods after initial shock in months on the x-axis. Percentage points on y axis.

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C.4   Exchange rate bias on the measured effect on foreign funding?

The absolute value of foreign currency funding is measured in local currency. To see how a depreciation can directly impact (and increase) the share of foreign funding, when foreign funding is measured in local currency, consider the ratio:

$$f_t = \frac{x}{x + a} \tag{C.1}$$

where x denotes the level of non-core (wholesale) funding in foreign currencies and a is non-core funding in NOK. If the NOK-USD exchange rate appreciates, then both the numerator and denominator (via x) will decrease. However, the numerator will decrease at a faster rate than the denominator, making the foreign funding ratio approach 0 as the currency appreciates. Shocks associated with an appreciation will tend to reduce the foreign funding share. Shocks associated with a depreciation will tend to increase the share. Hence, there is a possibility that we do not detect negative effects on foreign funding from positive VIX shocks if the depreciation effect is strong.

In order to cross-check our results and see if they are also robust if the direct exchange rate effect is important, we establish a quasi measure of foreign funding by dividing our funding measure by the US dollar exchange rate:

$$f_t = \frac{x}{x + a} \times \frac{1}{USDNOK} \tag{C.2}$$

The movement in the foreign funding ratio following an appreciation of NOK will, with this quasi-measure, be countered by a fall in the USD per NOK ratio, and the quasi measure approaches infinity as the exchange rate appreciates. If a decrease in the share of foreign funding (as measured in this paper) when the VIX index increases is covered up by a NOK exchange rate depreciation, we should find that it appears when using this alternative measure instead.

Figure C.4 shows that our results are robust to this possible bias.

Figure C.4: *Response of adjusted funding measure.*
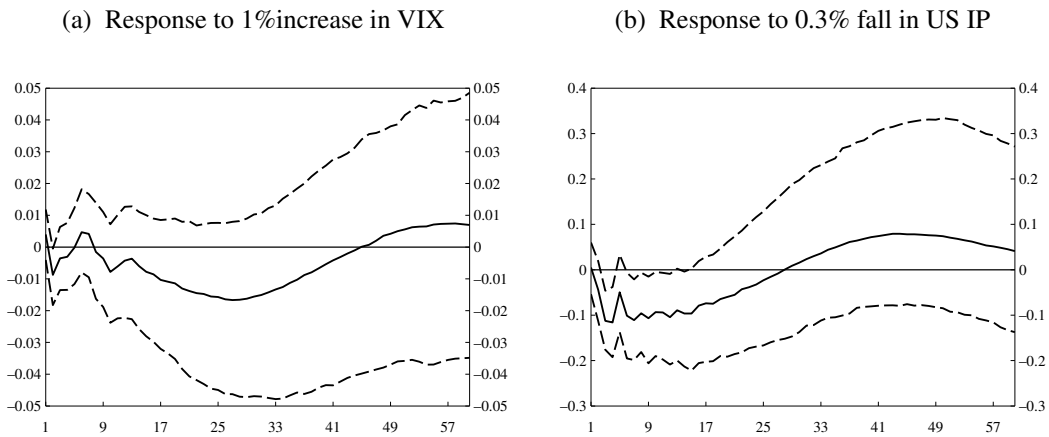
(a) Response to 1%increase in VIX

(b) Response to 0.3% fall in US IP

Note: Figures include 84% Bayesian error bands and the median impulse response function. Periods after initial shock in months on the x-axis.

C.5 ESTIMATION WITHOUT DUMMY FOR CRISIS MEASURE

Results are robust to not including the dummy for the swap arrangement introduced in Norway during the financial crisis.

Figure C.5: *Response of foreign funding. No dummy for crisis measure easing banks' funding*
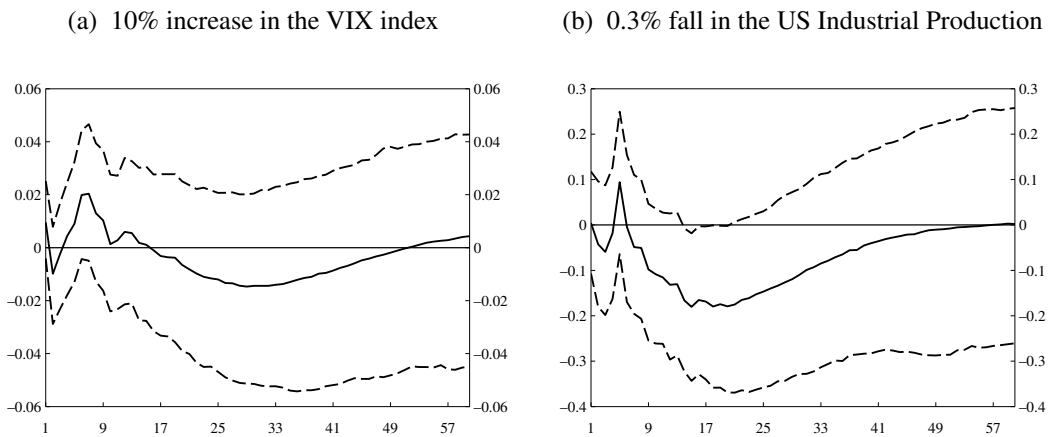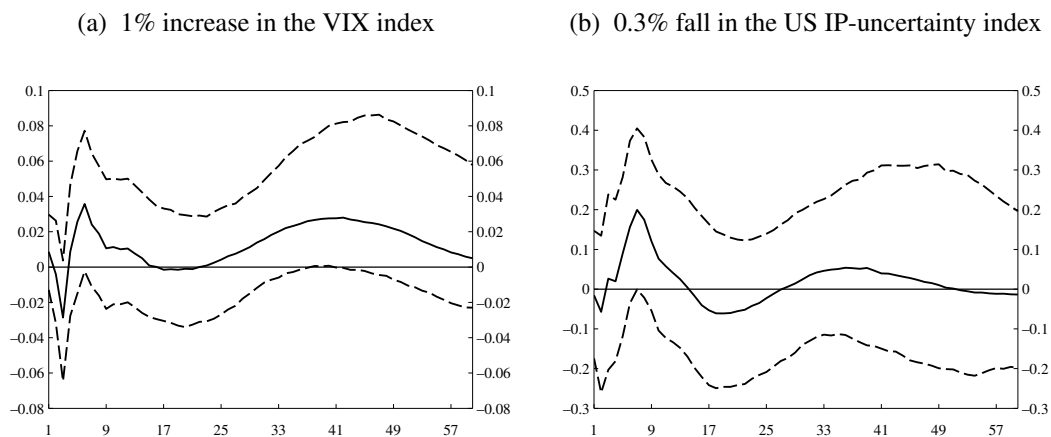
(a) 10% increase in the VIX index

(b) 0.3% fall in the US Industrial Production

Note: Figures include 84% Bayesian error bands and the median impulse response function. Periods after initial shock in months on the x-axis.

C.6 Excluding the financial crisis period, VIX model

We estimate our model excluding the time period after December 2007, in order to check the extent to which the most recent financial crisis drives our results. The financial crisis indeed drives the effect of global activity on the foreign funding share. Our main result, that there is no credible negative effect of the VIX shock on foreign funding is robust.

Figure C.6: *Response of foreign funding, data for 1999-2007*

(a) 1% increase in the VIX index

(b) 0.3% fall in the US IP-uncertainty index

Note: Figures include 84% Bayesian error bands and the median impulse response function. Periods after initial shock in months on the x-axis. Percentage points on y-axis.

C.7 Longer estimation period

We also estimate our model with data from 1993 to 2016. During the 1990-2000 period, Norwegian banks reentered international capital markets. Again estimation results are robust to this adjustment of the model.
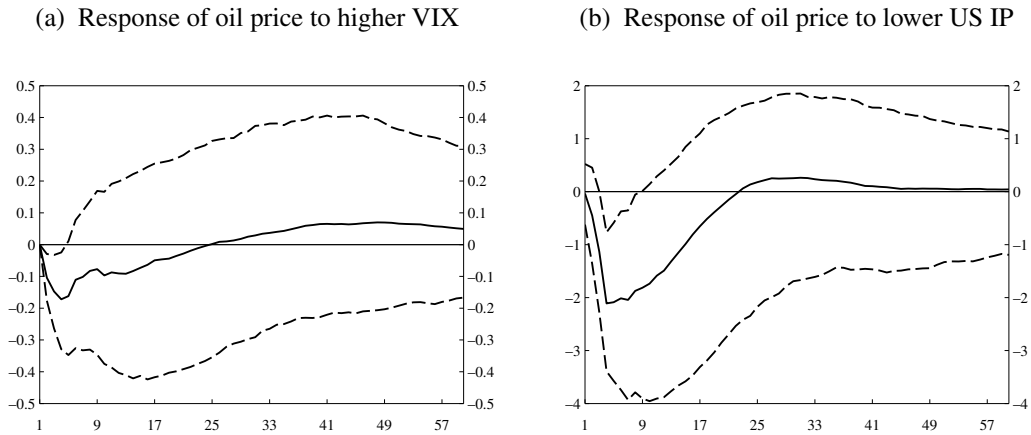
Figure C.7: *Response of foreign funding, longer sample*
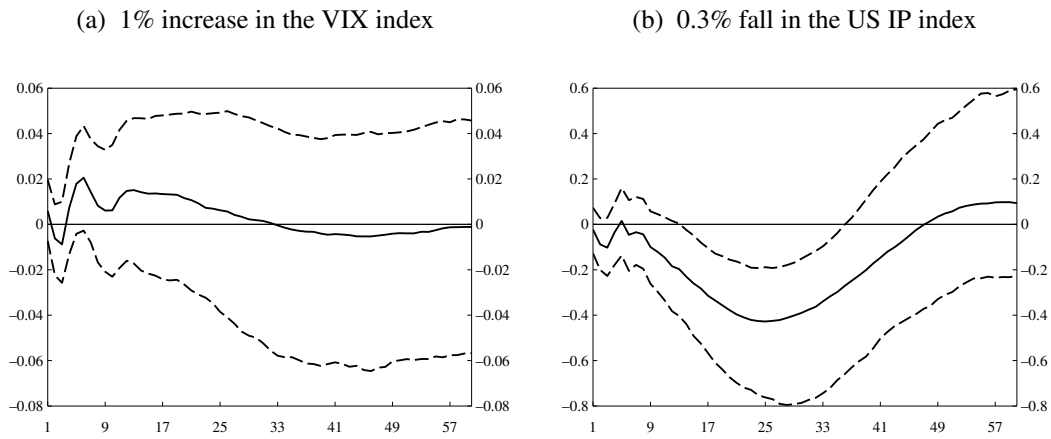
(a) 1% increase in the VIX index

(b) 0.3% fall in the US IP index

Note: Figures include 84% Bayesian error bands and the median impulse response function. Periods after initial shock in months on the x-axis. Percentage points on the y-axis.

C.8   RESPONSE OF THE OIL PRICE

Figure C.8: *Response of oil price to contractionary shocks*

(a) Response of oil price to higher VIX

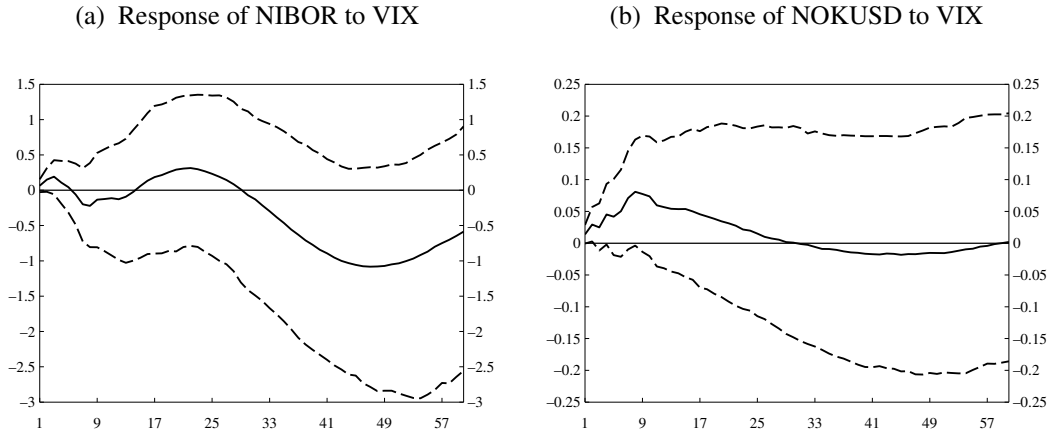(b) Response of oil price to lower US IP

Note: Figures include 90% Bayesian error bands and the median impulse response function. Periods after initial shock in months on the x-axis. Change in oil price in percent on the y axis.

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C.9 RESPONSE OF THE INTEREST RATE AND OF THE EXCHANGE RATE

Figure C.9: *Response of NIBOR and exchange rate to VIX*

(a) Response of NIBOR to VIX

(b) Response of NOKUSD to VIX

Note: Figures include 84% Bayesian error bands and the median impulse response function. Periods after initial shock in months on the x-axis. NIBOR in percentage points, Exchange rate in percent.

C.10 EXCLUDING GLOBAL ACTIVITY FROM THE SVAR MODEL

To further investigate the role of global activity for the foreign funding share, we estimate versions of the model without US Industrial Production. When removing all foreign variables except the VIX index from the exogenous block, the impact of uncertainty on foreign funding is moved forward, indicating that it may capture some of the direct effect of global activity, see Figure C.10a. Also when including both the fed funds rate and the VIX index, the effect of the VIX index on foreign funding is credible at the 84% level (see C.10b). The specification in our Figure C.10b corresponds to that of Bruno and Shin (2015b), in that the VIX index and the fed funds rate are included, but not the oil price or global activity. It seems that in this specification, the VIX shock stands in for global activity and possibly also the oil price. Figure C.11 on page 36 illustrates that the impact of the VIX shock on funding (when excluding US Industrial Production and the oil price) is robust to the ordering of variables.

The oil price is an important driver for the Norwegian economy. Figure C.11a on page 36 illustrates that the more direct (earlier) impact of the VIX index on foreign funding may not be robust, even when excluding US Industrial Production from our model, if the oil price is included. The reason might be that the oil price may work well as a global demand indicator for Norway, and can stand in for US Industrial Production in the time period that we study.[31] Our main conclusion, that the VIX index seems to affect the foreign fund-

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[31] See response in oil price to the VIX index and to US Industrial Production in Figure C.8 on page 33.

Figure C.10: *No global activity variable in model. Response in f. funding to VIX shock*
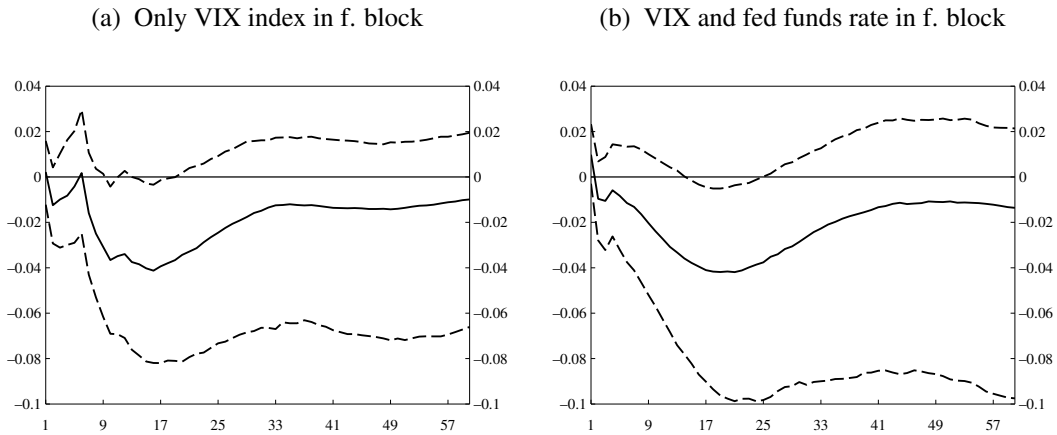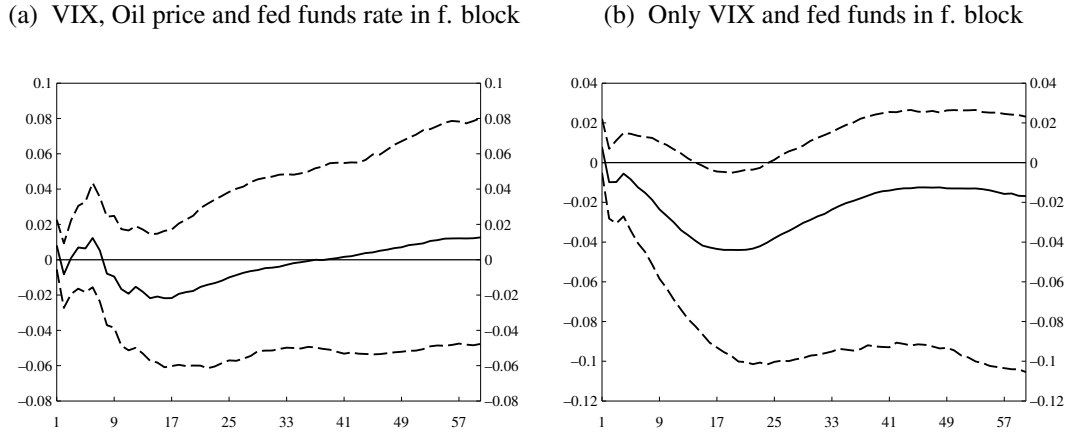
(a) Only VIX index in f. block (b) VIX and fed funds rate in f. block

Note: Figures include 84% Bayesian error bands and the median impulse response function. Periods after initial shock in months on the x axis. Change in foreign funding share in percentage points on the y axis.

ing share only via global activity holds for a wide range of alternative specifications.[32] Excluding US Industrial Production and oil from the foreign block, but changing the ordering to have VIX first, again leads to a credible effect of the VIX shock on the foreign funding share, as shown in Figure C.11b. Including both the oil price, the VIX index and the fed funds rate (but still no US Industrial Production) in the foreign block makes the effect non-credible. The negative effect of the VIX index on foreign funding is again shown to be quite fragile.

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[32]In a model estimated on data from 1993, without US Industrial Production, the response in foreign funding to VIX shocks is credibly *positive* rather than negative. This surprising pattern might have to do with the fact that foreign funding of Norwegian banks increased relatively sharply during the 1990s, while international capital markets were then influenced by e.g. the Asia crisis and the Long Term Capital management crisis. The structural adjustment of banks and their re-entering of international capital markets during the 1990s suggests that it is more appropriate to start estimations from 1999, as we do in our main model.

Figure C.11: *No US IP in model. VIX ordered first. Response in f.funding to VIX shock.*

(a) VIX, Oil price and fed funds rate in f. block

(b) Only VIX and fed funds in f. block

Note: Figures include 84% Bayesian error bands and the median impulse response function. Periods after initial shock in months on the x-axis. Percentage points on y the axis.

C.11 SIGN RESTRICTIONS USED TO IDENTIFY STRUCTURAL SHOCKS

Our results are based on a Cholesky identification. Table C.1 provides an overview of an alternative identification scheme. We use a combination of zero and sign restrictions.[33] Our main interest is in the funding variable, and hence we let all shocks have an unrestricted impact on funding (f_t).

We identify five standard domestic shocks: a demand, supply, monetary policy, funding share, and exchange rate shock. Demand shocks move unemployment and prices in opposite directions, while supply shocks cause the two variables to move in the same direction. An expansionary domestic monetary policy shock reduces the three-month money market rate, has zero impact on unemployment and inflation in the same month, but depreciates the exchange rate on impact. The latter restriction is motivated by results in Bjørnland (2008). We identify an exchange rate shock as an increase (depreciation) in the NOK-USD exchange rate, which has a positive impact on the money market rate in the same month.

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[33]This combination of restrictions poses some estimation issues, and we use the Binning (2013) algorithm to circumvent this issue.

Table C.1: *Identifying sign and zero restrictions*

Shock	y_t^*	i_t^*	oil	$unc.$	u_t	π_t	i_t	er_t	f_t
Foreign output shock	+								
Foreign monetary policy shock	0	+							
Oil price shock	0	0	+						
Uncertainty shock	0	0	0	+					
Domestic demand shock	0	0	0	0	-	+			
Domestic supply shock	0	0	0	0	-	-			
Domestic monetary policy shock	0	0	0	0	0	0	-	+	
Nominal exchange rate shock	0	0	0	0	0	0	+	+	
Foreign funding shock	0	0	0	0	0	0	0	0	+

Note: y_t^* is log U.S. Industrial Production, i_t^* is the U.S. fed funds rate, oil is the log crude oil price in USD, u_t is the domestic unemployment rate, π_t is domestic CPI inflation, i_t is the domestic 3-month money market rate, er_t is the log nominal exchange rate in NOK per USD, and f_t is the share of banks' wholesale funding in foreign currency. The variable name *unc.* denotes one of our uncertainty or financial stress indicators: VIX or EPU.

The results both regarding the impact of US industrial production on funding, as well as monetary policy independence are confirmed with this alternative identification strategy, see e.g. responses in Figure 11 in the main text.