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Capital and liquidity buffers and the resilience of the banking system in the euro area

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Abstract

How do capital and liquidity buffers affect the evolution of bank loans in periods of financial and economic distress? To answer this question we study the responses of 219 individual banks to aggregate demand, standard and unconventional monetary policy shocks in the euro area between 2007 and 2015. Banks' responses are derived from a factor-augmented VAR, which relates macroeconomic aggregates to individual bank balance sheet items and interest rates. We find that banks with high capital and liquidity buffers show a more muted response in their lending to adverse real economy shocks. Capital and liquidity buffers also affect bank responses to monetary policy shocks. High bank capitalisation reduces the degree to which banks increase the average duration of loans to the non-financial corporate sector, while high bank liquidity strengthens the positive response to policy easing of both long- and short-term loans to the non-financial corporate sector. The latter findings substantiate the relevance of interactions between prudential controls and monetary policy.

JEL Classification: E51, E52, G21

Keywords: macroprudential policy, monetary policy, capital requirements, liquidity requirements

Non-technical summary

The paper investigates how banks' capital and liquidity buffers affect their lending in response to macroeconomic shocks and monetary policy interventions. To this end, it contributes to the discussion of the impact of capital- and liquidity-based macroprudential instruments on bank resilience over the business cycle and the interactions between macroprudential and monetary policies.

In our analysis, we consider a large sample of euro area banks focusing on their lending to the non-financial private sector in 2007 – 2015. In order to link a rich set of bank-level data to macroeconomic aggregates, we employ a factor-augmented vector-autoregressive (FAVAR) model. The model includes the euro area output, price level, and monetary policy variables as well as a small number of latent factors, which summarize the dynamics of a large set of bank-level variables: loan volumes and interest rates on new loans. FAVAR models circumvent the high-dimensionality problem, while at the same preserving the simultaneous modelling and endogeneity of large numbers of variables.

We concentrate on the propagation of three types of economic shocks which are likely to have played an important role during the Great Recession: aggregate demand, standard monetary policy and unconventional monetary policy shocks. We document that for most of the banks adverse aggregate demand shocks lead to cuts in bank loans and interest rates to the non-financial private sector. Else, the impacts of standard and unconventional monetary policy actions do not qualitatively differ from each other. For the lion's share of banks a monetary policy easing translates into an increase in long-term loans to the non-financial private sector (NFC) and a reduction in (generally lower risk-weighted) short-term NFC and household loans. The policy easing also triggers cuts in bank interest rates to the overall non-financial private sector.

Next, we check whether bank responses to macroeconomic developments depend on their capital and liquidity ratios. Specifically, we run a set of cross-sectional regressions of impulse response functions of bank-level variables, on the left-hand side, and the capital or liquidity ratios, on the right-hand side.

Our major findings are as follows. First, high bank capitalisation mutes the response of long-term NFC loans and bank interest rates to aggregate demand shocks. Though, very high bank capital levels cease to have a tempering impact on the response of long-term NFC loans. Second, low maturity mismatch on bank balance sheet has a similar cushioning impact on the

response of long-term (as well as short-term) NFC loans to aggregate demands shocks. Third, high bank capitalisation reduces the impact of any monetary policy interventions on NFC loans and of standard monetary policy actions on bank-level interest rates. And, fourth, high bank liquidity moderately amplifies the effects of standard and unconventional monetary policy shocks on NFC loans.

1 Introduction

During the recent financial crisis, the euro area banking system was put under substantial strain. Disruptions in money markets and weak real economic conditions infringed financial intermediation and led to a prolonged period of low credit supply. In order to prevent further deterioration of credit conditions in the euro area, the ECB stepped in with a series of standard and unconventional monetary policy measures. In addition, a far-reaching reform of the regulatory framework of banking supervision has been launched. The latter initiative resulted in a tightening of capital and liquidity requirements and equipped supervisors with a new macroprudential toolkit for dampening fluctuations in bank lending over the business cycle.

Empirical evidence about the effectiveness of macroprudential policies in the euro area is so far limited. Little is known about whether the tighter capital and liquidity requirements entailed in the new regulatory framework will make bank lending more resilient to adverse economic shocks and will be successful in smoothing the supply of credit to the real economy. Another interesting issue is the extent to which the tighter capital and liquidity requirements will affect the effectiveness of monetary policy interventions.

In this paper, we study the impact of banks' solvency and liquidity ratios on their responses to macroeconomic shocks for a sample of 219 banks in the euro area between August 2007 and December 2015. Our methodology is based on Buch, Eickmeier, and Prieto (2014) and evolves in two steps. First, we apply a factor-augmented vector autoregression (FAVAR) model to link bank-level to macroeconomic data. From the model, we derive responses of bank-level loan volumes and interest rates to aggregate demand and monetary policy shocks. Second, we inspect how the responses of individual banks are affected by their capital and liquidity ratios. This allows us to conclude on the role of capital and liquidity buffers in the propagation of macroeconomic shocks and the transmission of standard versus unconventional monetary policy actions.

Our FAVAR includes five macroeconomic variables, i.e. euro area GDP, the GDP deflator, the ECB main refinancing operations (MRO) rate, the spread between the EONIA and MRO, and total ECB assets, all at a monthly frequency. Among bank-level data, the model includes the volumes of outstanding bank loans (notional stocks) and interest rates on new bank loans. We use data for three market segments, i.e. long- and short-term loans to the non-financial corporate sector (NFC loans) and loans to households (household loans). Further, we include banks' equity value, and debt financing costs (approximated by banks CDS spreads). The bank-level data are derived from the euro area Monetary and Financial Institutions (MFI) statistics database.

The FAVAR methodology allows us to bridge macroeconomic and bank-level data in a flexible way, as already explored in similar applications by Jimborean and Mesonnier (2010), Igan, Kabundi, Simone, and Tamirisa (2013), Dave, Dressler, and Zhang (2013) and Buch, Eickmeier, and Prieto (2014). The (high-dimensional) bank data are mapped into a small number of latent factors, which are then included in a standard VAR framework. This approach allows for modelling the simultaneous dynamics of many variables while preserving low dimensionality (Stock and Watson (2002)). At the same time, the large information set included in the VAR may also result in a better empirical identification of structural shocks than in a standard VAR (Bernanke, Boivin, and Eliasz (2005)).

We focus on three types of structural shocks, which are likely to have played an important role over the period 2007 – 2015: aggregate demand, standard and unconventional monetary policy shocks. We identify the structural shocks from their short-run impacts on the observable macro-financial variables using a combination of zero and sign restrictions as proposed by Arias, Rubio-Ramirez, and Waggoner (2014). The impulse responses of individual banks are then derived from the impulse responses of the observable variables and latent factors.

In the second step of our analysis, we relate the impulse responses of individual banks to their capital and liquidity buffers. Following Buch, Eickmeier, and Prieto (2014), we run a series of regressions of cumulated impulse responses of bank variables on measures of bank capitalisation and liquidity at the onset of the crisis.[1] We apply a weighted least squares estimator to account for the different degree to which the FAVAR model explains the dynamics of bank-level variables. The observation weights depend on the variance of bank-level time series explained by observable variables and latent factors in the FAVAR. A significant coefficient of capital and liquidity ratios in a regression signals their tempering or amplifying effect on banks' loan supply after a structural shock.

The advantage of our two-step approach is that it directly identifies the impact of bank capitalisation and maturity mismatch on the propagation of structural shocks. In a similar setup, Buch, Eickmeier, and Prieto (2014) show that US banks with higher capital and liquidity ratios

[1] Bianchi and Civelli (2015) follow a similar two-stage approach to explain changes in the relationship between inflation and output.

are less exposed to macroeconomic shocks. We extend on Buch, Eickmeier, and Prieto (2014) by analysing in greater detail the role of bank capitalisation and liquidity, separating different market segments when looking at bank lending, and isolating unconventional and standard monetary policy shocks. Other empirical literature which employs bank-level regressions to study the impact of bank capitalisation and liquidity uses output or monetary policy rates in place of structural shocks (Berger and Udell (1994), Kashyap and Stein (1994), Ehrmann, Gambacorta, Martinz Pags, Sevestre, and Worms (2001), Kishan and Opiela (2000), Loupias, Savignac, and Sevestre (2002), Gambacorta and Mistrulli (2004), Engler, Jokipii, Merkl, Kaltwasser, and de Souza (2007)).

Our analysis relates as well to a gradually emerging literature exploring time-series variation in aggregate (Meeks (2017)) or bank-level (Berrospide and Edge (2010), Aiyar, Calomiris, and Wieladek (2014), Francis and Osborne (2012), Carlson, Shan, and Warusawitharana (2013), and Labonne and Lam (2014)) capital and liquidity buffers. The key difference between these studies and ours is that they focus on the effects of changes in bank capital or liquidity buffers on credit, whereas our analysis looks at the role of the existing buffers in the propagation of various shocks hitting the banking system.

Our major findings are as follows. First, high bank capitalisation mutes the response of long-term NFC loans and bank interest rates to aggregate demand shocks. We also find some evidence for non-linearity in this relationship, as very high capital levels cease to have a tempering effect on the response of long-term NFC loans. Second, high bank liquidity has a similar cushioning impact on the response of long-term (and short-term) NFC loans to aggregate demands shocks. Third, standard and unconventional monetary policy actions trigger a shift in the composition of bank loans from (higher risk-weighted) long-term NFC to (lower risk-weighted) short-term and household loans. Policy easing induces banks to increase higher risk-weighted long-term loans to NFCs and shorten the supply of lower risk-weighted short-term NFC and household loans. However, fourth, high bank capitalisation reduces the impact of any monetary policy shocks on NFC loans and of standard monetary policy shocks on bank-level interest rates. Fifth, high bank liquidity moderately amplifies the effects of standard and unconventional monetary policy shocks on NFC loans.

These findings provide some lessons on the potential effects of macroprudential policies on bank resilience over the business cycle. We show that bank capitalisation and low maturity mismatch on bank balance sheets are likely to smoothen the supply of long-term NFC loans.

This is in line with the hypothesis of Dewatrpont and Tirole (1994) that capital and liquidity buffers act as a buffer against banks losses and reduce the probability of financial distress.[2]

Our results on the interaction between capital and liquidity buffers and monetary policy link in turn to the literature on the bank-lending (Bernanke and Blinder (1988)) and risk-taking (Borio and Zhu (2012), Adrian and Shin (2010)) channels of monetary policy that argue that higher capitalised and liquid banks may be less responsive to central bank's actions.

The structure of the paper is as follows. Section 2 describes the structural FAVAR model, while section 3 describes macroeconomic variables and the bank-level dataset. Section 4 discusses the aggregate and bank-level impulse response functions derived from the FAVAR. Section 5 introduces the weighted regression methodology and reports the results from bank-level regressions. Section 6 presents variations of our methodology to assess the robustness of our findings. Section 7 concludes the paper.

2 Empirical methodology

2.1 A FAVAR model

As in Bernanke, Boivin, and Eliasz (2005) our model is a structural VAR augmented with a set of K latent factors F_t^x,

$$\begin{bmatrix} F_t^y \\ \\ F_t^x \end{bmatrix} = A(L) \begin{bmatrix} F_{t-1}^y \\ \\ F_{t-1}^x \end{bmatrix} + A_0 \epsilon_t, \tag{2.1}$$

where F_t^y is a $Mx1$ vector of observed variables, and F_t^x is a $Kx1$ vector of latent factors. $A(L)$ is a matrix lag polynominal, where both $A(L)$ and A_0 are of dimension $(M+K) \times (M+K)$. Structural innovations ϵ_t are independently normally distributed with identity covariance matrix, $\epsilon_t \sim \mathcal{N}(0, I_{(M+K)})$ and $E[\epsilon_{l,t}\epsilon_{m,s}] = 0$ for all $l, m = 1, \ldots, (M+K) \wedge t$, s=1,..,T and i≠j ∧ t≠s. Vector $F_t^{'} = [F_t^{x'}, F_t^{y'}]$ summarizes the information on all $(M+K)$ factors driving the dynamics of the system.

The vector of latent factors F_t^x is inferred from an $Nx1$ vector of observed time series X_t,

[2] Our results are also consistent with the alternative strand of theoretical literature initiated by Kane (1989), Cole, McKenzie, and White (1995), Furlong and Keeley (1989), which emphasises the role of capital and liquidity buffers in correcting asymmetric information problems and argues that capital and liquidity buffers reduce incentives to take on excessive risk.

where $N >> K + M$ is sufficiently large. An observation equation links X_t to F_t,

$$X_t = \Delta^y F_t^y + \Delta^x F_t^x + u_t, \tag{2.2}$$

where Δ^x is an NxK loading matrix, Δ^y is an MxK loading matrix and $u_t \sim \mathcal{N}(0, H)$ with diagonal covariance matrix H. Further it is assumed that:

$$E[u_{l,t}F_t] = 0 \tag{2.3}$$

$$E[u_{l,t}u_{m,s}] = 0 \tag{2.4}$$

for all $l, m = 1, \ldots, N \wedge t$, $s = 1, \ldots, T$ and i≠j ∧ t≠s.

Together, equations (2.1) and (2.2) demonstrate how a FAVAR model circumvents the problem of high dimensionality of X_t by representing X_t by a small number of factors F_t^x and modelling the joint dynamics of F_t^x and F_t^y in a VAR setting.

In our application, the vector of observable variables F_t^y includes euro area GDP, the GDP deflator, the MRO interest rate, the spread between the EONIA and MRO, and total ECB assets. The term X_t represents a large vector of bank-level variables. It is convenient to think of X_t as being composed of sub-vectors X_j^j i.e. $X_t = [X_t^1, X_t^2, \ldots, X_t^J]$, where each X_t^j with $j = 1, \ldots, J$ represents bank-level variables by type. In more detail, vectors X_t^j include loan volumes and interest rates on new loans by market segment, and selected bank-level market variables.

The FAVAR model is estimated in two steps. In the first step, we use equation (2.2) to estimate the latent factors F_t^x. We apply an algorithm similar to the one proposed by Bernanke, Boivin, and Eliasz (2005), that chooses a set of K latent factors F_t^x, such that they are orthogonal with respect to each other and to the observed variables F_t^y (explaining a higher share of variance of X_t than any other K factors).[3][4] The number of latent factors K is chosen from the Bai and

[3]We propose a two-stage non-iterative algorithm. In the first step, X_t is regressed on observable variables F_t^y. In the second step, the principal component analysis is applied to the residuals from these regressions. F_t^x will be the set of first K principal components from the second stage of the algorithm.

[4]We have evaluated the commonly applied iterative algorithm of Boivin and Giannoni (2007), but concluded that in contrast to the postulate of the authors, the convergence criterion does not guarantee convergence to mutually orthogonal latent factors. Further, if the convergence criterion is replaced with a fixed number of iterative steps, the final outcome is only negligibly different from the result achieved in the first step. The latter implies that the derived factors will not be orthogonal with respect to observed variables. Besides, the share of variance of X_t explained by F^y following Boivin and Giannoni (2007) is lower than in the algorithm of Bernanke, Boivin, and Eliasz (2005) and ours.

Ng (2002) criteria accounting for the presence of observed variables in the model.

In the second step, we insert the estimates of the latent factors into the structural VAR in equation (2.1). The Gibbs sampler is used to derive the posterior distributions of parameters of the reduced-form version of the VAR assuming a zero-mean non-diffuse Normal prior for the reduced form parameters of the lag polynomial, and a Wishart prior for the reduced form covariance matrix with non-zero elements on the diagonal only.

The structural shocks are identified from zero and sign restrictions on the observed macro-financial variables applying the approach of Arias, Rubio-Ramirez, and Waggoner (2014) to obtain draws of the corresponding impulse responses (IRFs) of F_t to structural innovations ϵ_t. These individual draws are then converted into IRFs of bank-level variables in X_t resting on equation (2.2) and the estimate of $\Delta' = [\Delta^{y'}, \Delta^{x'}]$ from the first step of the procedure.

2.2 Identification of structural shocks

The zero and sign restrictions used to identify structural innovations ϵ_t are summarised in Table 1. Aggregate demand shocks are identified from the restriction that an adverse shock leads to an immediate decline in both GDP and inflation. We also define aggregate supply shocks from the restriction that an adverse shock causes a decrease in GDP but an increase in inflation.[5] The sign restrictions identifying aggregate demand and supply shocks are imposed for a horizon of 3 months.

An (accommodative) standard monetary policy shock is identified as a reduction in the MRO rate which affects GDP and inflation only with a lag (e.g. Peersman and Smets (2001)). No additional restrictions are imposed on the response of the ECB assets or the EONIA spread.

An unconventional monetary policy shock is identified from an increase in total ECB assets and a widening of a negative EONIA spread. This specification follows Lenza, Pill, and Reichlin (2010) and Boeckx, Dossche, and Peersman (2014) and rests on the observation that a share of unconventional monetary policy actions after 2008 were targeted at increasing market liquidity (see also Gambacorta, Hofmann, and Peersman (2014)).[6] Unconventional monetary policy shocks, like standard monetary policy shocks, are assumed to have zero contemporaneous

[5] Though the propagation of aggregate supply shocks is not discussed in our analysis, adding them to the set of structural shocks helped the identification of the remaining structural innovations (especially monetary policy shocks).

[6] The liquidity supplied by the ECB after the onset of the crisis exceeded the needs of the banking sector, which resulted in a voluntary recourse to the deposit facility. Consequently, the EONIA decoupled from the MRO and fell towards the deposit facility rate implying a negative spread between the EONIA and MRO.

impact on GDP and inflation.

Finally, in order to better distinguish between standard and unconventional monetary policy shocks, the latter are also assumed to involve no change in ECB interest rates.[7]

Table 1: Identification of structural shocks

	MRO	EONIA	ECB total assets	GDP deflator	GDP
Accommodative standard monetary policy	-	-		0	0
Accommodative unconventional monetary policy	0	-	+	0	0
Adverse aggregate demand				-	-
Adverse aggregate supply				+	-

3 Data

This section describes the data used for the FAVAR and the subsequent regression analysis. The section concludes with a short discussion of latent factors derived in the first step of the FAVAR estimation.

Our FAVAR sample ranges from August 2007 to March 2015 and is left-censored by the availability of bank-level data. The monthly growth rate of the euro area GDP and GDP deflator are interpolated to monthly frequency using the Chow and Lin (1971) algorithm. To interpolate GDP we use the indices of industrial production and retail sales, while for GDP deflator we use the HICP and the monthly industrial producer price index (all data are seasonally adjusted). The MRO rate and the spread between MRO rate and the EONIA are used as monthly averages and the total ECB assets as at the end of a month.

Data on bank loans and interest rates on new loans to the non-financial private sector used on the FAVAR estimation are taken from the Monetary Financial Institutions (MFI) statistics and semi-consolidated. Cross-sectional information on bank capitalisation and maturity mismatch used in bank-level regressions is taken from Bankscope.

[7] A variation of this identification strategy has been used by Peersman (2011), where unconventional monetary policy shocks are assumed to be orthogonal to both standard monetary policy and credit multiplier shocks.

3.1 MFI bank-level data

Bank loans and interest rates on new loans to the non-financial private sector are taken from the Monetary Financial Institutions (MFI) statistics.[8] The statistics have been originally set up to monitor monetary developments in the euro area and consists of individual balance-sheet statistics (iBSI) and individual interest rate statistics (iMIR). It is compiled by national central banks and the ECB for all euro area countries on a monthly basis.

The individual MFI statistics is particularly suitable for the purpose of our study. First, it rests on common reporting standards for all euro area member states and the dataset has been continuously maintained from August 2007. Second, it is available for the largest credit institutions resident in euro area countries. In particular, it includes all parent companies of euro area G-SII groups. Third, loans are recorded at their principal value (rather than the imputed values) i.e. the amount that is actually at disposal of a deposit holder or borrower. This makes individual MFI statistics particularly suitable for assessing the interactions between the financial sector and the real economy. The downside of the individual MFI statistic is that, in contrast to supervisory data, it does not account for asset risk and does not report bank capitalisation.[9]

Credit institutions included in the sample operate in Austria, Belgium, Germany, Finland, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Slovenia and Spain.[10] We work with semi-consolidated data in order to focus on group level decisions rather than internal banking group policies. We distinguish three types of loans by market segment and duration. These are the notional stock series of NFC loans with an original maturity of above one year, $LoansNFClong$, and with an original maturity less than one year, $LoansNFCshort$, and household loans, $LoansHH$. The corresponding effective interest rate are interest rates on new long-term NFC loans, $InterestNFClong$, and new short-term NFC loans, $InterestNFCshort$, and new household loans, $InterestHH$. The dynamics of loans in the three segments is likely to differ because of differences in the evolution of sectoral demand factors and due to regulatory differences in their risk weighting. Segment-based or original maturity-based distinction has proven to be important in earlier empirical studies e.g. den Haan, Sumner, and Yamashiro (2007), Jimborean and Mesonnier (2010). Finally, to represent market conditions, we include

[8] We focus on credit institutions in the MFI statistics which are therein defined as undertakings whose business is to receive deposits and other repayable funds from the public and grant credits for their own account.

[9] The loan data we use are reported on a gross basis i.e. without regards to any provisions made against them.

[10] Appendix A provides a detailed description of the sample of banks, applied screens and statistical adjustments.

bank-level CDS spreads, CDS, and stock prices, $StockPrice$, in our data set.

The sample covers a period of depressed economic activity (Figure 7) and lending conditions. Table 2 summarises the bank-level data. The sample means of monthly growth rates of NFC loans are modest 0.2% for long-term loans and -0.2% for short-term loans. The mean monthly growth rate of household loans is 0.11%. The mean change in the level of effective interest rates on new loans to the non-financial private sector is -0.03pp, owing to the substantial reduction in the ECB interest rates at the beginning of the period (Figure 2).

Table 2: Descriptive statistics of bank-level time series variables 2007 – 2015

Variables	N. of series	Mean	Std.dev.	5th quantile	95th quantile	Transformation
LoanNFClong	123	0.215	1.440	-1.775	2.443	m-o-m growth rate in %
LoanNFCshort	114	-0.234	8.125	-9.678	8.691	m-o-m growth rate in %
LoanHH	120	0.106	1.207	-1.090	1.445	m-o-m growth rate in %
InterestNFClong	98	-0.031	0.776	-1.188	1.064	m-o-m change in pp
InterestNFCshort	114	-0.031	0.558	-0.837	0.697	m-o-m change in pp
InterestHH	118	-0.027	0.370	-0.510	0.419	m-o-m change in pp
CDS	22	1.720	24.319	-27.606	35.548	m-o-m growth rate in %
StockPrice	43	-2.166	16.763	-25.232	18.435	m-o-m growth rate in %

The FAVAR model requires a certain degree of co-movement among bank-level data in order to achieve a good approximation of their dynamics from a small number of latent factors. A Principal Component Analysis (PCA), which is summarised in Appendix B, shows a strong co-movement among individual banks for long-term NFC loans, household loans, and bank-level interest rates on new short-term NFC loans. For each of the three variables, the first PC explains more than 20% of the variation in the bank-level series. For comparison, Buch, Eickmeier, and Prieto (2014) needs the first six PCs to account for 20% of the variation in the data set of US bank loans.

Moreover, there is a high degree of correlation between bank-level loans across different market segments. For instance, the first PCs of long-term NFC loans and household loans show a high degree of co-movement, reflecting a process of economy-wide deleveraging (Figure 3). The same holds for interest rates on new loans in different market segments (Figure 4).

3.2 Structural information on bank balance sheets

Information on bank capitalisation and maturity mismatch on bank balance sheets are taken from Bankscope. We focus on the Tier1 capital to risk-weighted assets ratio, $Tier1/RWA$, as a measure of bank capitalisation and the ratio of liquid assets to customer deposits, $Liq.assets/Dep.$, as a measure of bank liquidity. The Tier1 capital ratio plays a relevant role in post-Basel III regulations[11], whereas the liquid assets to deposit ratio comes the closest to the definition of the Liquidity Coverage Ratio out of all measures of maturity mismatch available in Bankscope for years 2006 – 2007.

In our robustness checks, we employ two alternative measures of bank capitalisation and maturity mismatch. Regarding alternative bank capitalisation measures, we include the ratio of total regulatory capital to risk-weighted assets, CAR, and the ratio of Tier1 capital to total assets, i.e. the leverage ratio, $Tier1/TA$. Regarding alternative measures of maturity mismatch on bank balance sheets we use the ratio of liquid to total assets (same as Gambacorta and Marques-Ibanez (2011)), $Liq.assets/TA$, and the ratio of loans to customer deposits, LTD.

Table 3: Descriptive statistics of banks' balance sheet indicators (mean values 2006 – 2007)

Variables	N	Mean	Std.dev.	Min	Max
$Tier1/RWA$	82	7.773	1.262	5.400	10.700
CAR	84	10.728	1.365	7.560	14.200
$Tier1/TA$	77	4.233	1.589	1.442	8.273
$Liq.assets/Dep.$	106	32.123	19.985	1.880	86.540
$Liq.assets/TA$	116	20.225	11.298	1.159	46.447
LTD	102	72.053	27.407	12.715	139.295

Table 4 summarises the correlation coefficients between structural indicators of bank capitalisation and liquidity. The table shows a high correlation between the risk-sensitive measures of bank capitalisation, i.e. the CAR and $Tier1/RWA$ ratios, while the leverage ratio $Tier1/TA$ is uncorrelated with either of these measures. There is also a high correlation between two measures of shorter-term maturity mismatch, $Liq.assets/Dep.$ and $Liq.assets/TA$, whereas both correlate substantially weaker with our measure of structural maturity mismatch LTD. Inter-

[11] Another relevant capitalisation measure in the post-Basel III regulatory environment, the CET1 ratio, has a very limited sample coverage.

estingly, the correlation between risk-sensitive capitalisation measures and short-term liquidity indicators is negative.

Table 4: Correlations between structural bank-level variables

	$Tier1/RWA$	CAR	$Tier1/TA$	$Liq.assets/Dep.$	$Liq.assets/TA$
CAR	0.7526^{***}				
$Tier1/TA$	0.1302	0.0373			
$Liq.assets/Dep.$	0.229^{**}	0.120	-0.4195^{***}		
$Liq.assets/TA$	0.084	0.068	-0.498^{***}	0.691^{***}	
$Inv.LTD$	0.325^{***}	0.286^{***}	-0.294^{***}	-0.083	-0.059

Legend: *** - statistically significant at below 1% level, ** - statistically significant at 5% level, * - statistically significant at 10% level.

3.3 Latent factors

We proceed with the first step of the FAVAR estimation routine, i.e. the estimation of equation (2.2) based on the entire set of bank level data X_t summarised in Table 2. We set the number of latent factors to $K = 3$, though we also check, along the route of Boivin, Giannoni, and Mihov (2009), whether adding further latent factors substantially changes the results.

The first latent factor absorbs a high share of the variation in bank-level long-term NFC loans and household loans. Figure 7 reports the fraction of the variance of bank-level variables explained by observed variables and latent factors. Furthermore, the evolution of the first latent factor (Figure 6) mimics the dynamics of the deleveraging process in the euro area. We name it accordingly a *deleveraging factor*. The second, *credit price factor* , relates to interest rates on new loans, and especially interest rates on short-term NFC loans. The third factor explains a substantial share of the variation in bank-level CDS and stock prices. For this reason, we label it a *market factor*.

Overall, the observed variables and latent factors replicate relatively well the contemporaneous variation in bank-level long-term NFC and household loans and in interest rates on short-term NFC loans, and to a lesser extent the variation in the remaining bank-level interest variables.

4 The propagation of EA-wide structural shocks

In this section, we discuss the propagation of structural shocks into macroeconomic aggregates, bank-level loan volumes and interest rates. This way we verify the identification of structural shocks ahead of relating the individual bank responses to their initial level of capitalisation and liquidity in the next section. At all instances, we discuss structural shocks of one-standard deviation magnitude.

To this end, Figure 7 displays the posterior density of impulse response functions (IRFs) of macroeconomic variables to adverse aggregate demand, accommodative standard and unconventional monetary policy shocks. The grey areas mark the central 70% of the IRFs distribution, while the solid lines represent the median of the IRFs distribution. Dashed lines represent IRFs from the model delivering results closest to the median outcomes.[12] Further, we compare the IRFs from the FAVAR model with the IRFs based on a standard VAR model including only observable variables F_t^y. Dashed red lines mark the central 70% of the distributions of VAR-based IRFs. Finally, Figures 9-11 along with Table 8 show the impact of the structural shocks on bank-level variables. They report the distribution (and moments) of median IRFs of bank-level variables for the cross-section of banks. The Columns of Figures 9-11 show the time pattern of bank-level responses.

4.1 Aggregate demand shocks

An adverse aggregate demand shock leads to a 0.23% decline in output within two quarters following the shock and a 0.06% decline in price level within three quarters. Output slowly returns to the baseline starting from the end of the first year, whereas the effect on price level is highly persistent and holds until the end of the three year horizon. The negative aggregate demand shock triggers an immediate response of monetary policy along both the standard and unconventional angles. The MRO rate declines gradually to stabilise three quarters after the shock at around 11bp below its initial level. The balance sheet of the ECB expands by 0.37% immediately though transitorily, contributing to the reduction of the EONIA spread by up to 1.5pp two quarters after the shock.

Including bank-level information provides a detailed picture of the behaviour of banks while affecting the estimates of the impulse responses of macroeconomic aggregates only marginally.

[12] These IRFs were selected following the algorithm of Fry and Pagan (2005). For a discussion and interpretation of IRFs derived from the model closest to the median see therein.

Following an adverse aggregate demand shock most of the banks reduce their loans to the non-financial private sector (Figure 9) with a median drop of -0.23% in bank-level long-term NFC loans, -0.53% in short-term NFC loans and -0.12% in household loans two years after the shock (Table 8). Bank-level interest rates on new loans to non-financial private sectors decline as well, in line with a reduction in loan demand and a monetary policy easing (with a median response of 6pp in bank-level interest rates on new long-term NFC loans, -13.8pp in interest rates on new short-term NFC loans, and 8.7pp in interest rates on new household loans). After an initial increase, banks' CDS ultimately decline. Stock prices follow the reverse pattern with an initial drop and an increase thereafter.

The analysis of macro-level and bank-level IRFs points to an important role of endogenous monetary policy responses in the propagation of aggregate demand shocks in our sample. This observation will also be relevant when interpreting the results from bank-level regressions and is supported by two additional observations. First, aggregate demand disturbances explain a considerable part of the overall forecast error variance of the MRO rate, even in comparison to the share explained by standard monetary policy shocks (Figure 8). Second, there is a positive relationship between the bank-level reaction to accommodative monetary policy shocks and adverse aggregate demand shocks for NFC and household loans in Table 5. Banks that have been most responsive to monetary policy actions are also those that reduced their loans the least following adverse aggregate demand shocks, possibly benefiting most from the endogenous monetary policy easing.

4.2 Monetary policy shocks

An accommodative standard monetary policy shock is reflected in a gradual but persistent reduction in the MRO rate by 10bp within a year after the shock. In line with earlier studies based on a similar data sample, the impact of a standard monetary policy shock on inflation and output proves very small or even moderately negative. These studies provide two explanations for the missing impact of monetary policy on inflation and output. Lenza, Pill, and Reichlin (2010) argue that during the recent recession the lagged response of output and inflation has been overshadowed by the high and positive contemporaneous correlation between ECB interest rates, output, and inflation (and negative correlation for ECB assets), while Bluwstein and Canova (2015) point to large imbalances within the euro area which may have jeopardised area-wide output and inflation gains.

Table 5: The correlation coefficients between bank responses to structural shocks a year after the shock

	Adverse aggregate demand	Accomm. standard monetary policy	Adverse aggregate demand	Accomm. standard monetary policy	Adverse aggregate demand	Accomm. standard monetary policy
	LoanNFClong		*LoanNFCshort*		*LoanHH*	
Accomm. standard monetary policy	0.357***		−0.048		0.543***	
Accomm. unconventional monetary policy	0.586***	−0.203**	0.399***	−0.265***	0.555***	−0.262***
	InterestNFClong		*InterestNFCshort*		*InterestHH*	
Accomm. standard monetary policy	−0.157		0.046		-0.026	
Accomm. unconventional monetary policy	0.219**	−0.323***	0.040	−0.397***	0.166*	−0.297***

Legend: The correlations are derived on cumulated IRFs 12 months after a shock for a FAVAR model closest to the median as in Fry and Pagan (2005). Weights proportional to the percentage of variance captured by FAVAR observed variables and latent factors are applied. *** - statistically significant at below 1% level, ** - statistically significant at 5% level, * - statistically significant at 10% level.

An accommodative unconventional monetary policy shock leads to an increase of the ECB balance sheet by 1.5% and a decline in the spread between the EONIA and MRO by 4bp at the end of the first quarter. The effects of the shock on the ECB assets and the EONIA spread gradually fade after a quarter. A year later, the ECB balance sheet is only 0.4% larger and the EONIA spread 1bp lower than in the baseline. Interestingly the contributions of standard and unconventional monetary policy shocks to the forecast variance of the ECB assets are similar (Figure 8). This finding likely reflects an increase in the endogenous component in the ECB assets following the introduction of the fixed tender full allotment policy in 2008. An unconventional monetary policy shock triggers a lagged but moderately positive response of output.

The effects of standard and unconventional monetary policy shocks on bank level interest rates are strikingly similar. Following a monetary policy easing, the decline in bank-level interest rates is immediate, observed across all market segments and persistent, as shown in Figures 10 and 11.

The response of loan volumes to a monetary policy easing differs by market segment. Either monetary policy intervention results in a shift in banks' portfolios towards long-term NFC loans, implying a change in the average duration of NFC loans and in the riskiness of the overall NFC loan portfolio (as in Lenza, Pill, and Reichlin (2010) and Gambacorta and Marques-Ibanez (2011)). An accommodative standard monetary policy shock induces as well a shift out of lower risk-weighted (mostly mortgage based) household loans to NFC loans. Interestingly, different banks react to standard and unconventional policy shocks: the correlation of bank-level responses to standard and unconventional policy shocks is negative across all market segments, both for interest rates (-0.29 to -0.32) and for loan volumes (-0.20 to -0.26).

Finally, banks' CDS prices decline after both types of monetary policy easing signalling a reduction in risk premium. For most banks stock prices increase after an accommodative unconventional monetary policy shock, but decline after an analogous standard monetary policy shock.

5 Linking the heterogeneity of banks' responses to capital and liquidity buffers

In this section we turn to the second part of our analysis and relate the cross-sectional differences in bank-level responses to measures of bank capitalisation and maturity mismatch. We estimate a set of cross-section regressions of the form:

$$irf_i^{j,s,h} = \alpha z_i + bG_i + \epsilon_i. \tag{5.1}$$

The dependent variable is the cumulated bank-level responses of bank i, for bank-level variable j, structural shock s, and horizon h.
Bank-level variables include loan volumes ($j \in \{LoanNFClong,\ LoanNFCshort, LoanHH\}$) and interest rates on new loans ($j \in \{InterestNFClong,\ InterestNFCshort, InterestHH\}$). We report regression results for horizons $h = 3, 6, 12, 24$.

The right-hand side of a regression includes information on bank capitalisation or liquidity, z, and control variables G. Following Kashyap and Stein (1994), Stein and Kashyap (2000) or Dave, Dressler, and Zhang (2013) we focus on one structural factor (either $Tier1/RWA$ or $Liq.assets/Dep.$) at a time. Control variables include the size (total assets) of a bank (linear and squared) and a set of indicator variables representing the relative shares of bank's exposures by country. These country exposure indicators sum up to one for each bank and allow for netting out country-specific effects in the response of banks to euro area wide shocks. Such effects may arise owing to limited synchronization of national business cycles with the aggregate euro area cycle, or due to differences between national supervisory regimes. To avoid endogeneity issues, all right-hand side variables of the regressions are measured at the beginning of the sample, as the mean value for 2006 and 2007.

The IRFs of individual banks have wide uncertainty bands, which mostly reflect the large set of possibly divergent structural models that satisfy the imposed zero and sign restrictions. While Buch, Eickmeier, and Prieto (2014) use the median response of bank-level IRFs as the dependent variable in their regressions, aggregating the information from such divergent models may give a misleading picture of the association between bank-level IRFs and structural factors. To address this issue, we base our regressions on the full posterior distribution of individual bank-level IRFs. We repeatedly (i.e. 5000 times) draw from the joint posterior distribution of bank-level IRFs for each bank, shock type, variable and horizon. In a next step, we regress the pooled large sample of IRFs on the set of exogenous variables, clustering residuals by bank. This approach can be interpreted as averaging the elasticities of bank-level IRFs over the distribution of structural models consistent with our set of sign and zero restrictions.

To address heteroscedasticity in the residuals, we estimate equation (5.1) from a weighted OLS estimator with weights being proportional to the percentage of the variance of variable j for bank i explained by observable and unobservable factors. An IRF observation of a variable receives the higher weight the higher the share of its variance explained by equation (2.2).

In the remainder of the section, we first discuss the effect of capital buffers on shaping the individual bank responses and then turn to the role of liquidity buffers.

5.1 The role of capital buffers

The regression results for capital buffers are presented in Table 12. Negative estimates indicate a dampening and positive estimates an amplifying effect of bank capitalisation on the cumulative IRFs. Tier1 capital ratios generally temper the magnitude of bank responses to aggregate demand shocks. They mute the response of all bank-level variables except household loans, and their impact is highly persistent, lasting for more than two years following aggregate demand shocks.

Table 6 allows assessing the materiality of the impact of bank capitalisation. It reports by how much, in relative terms, the responses of bank-level variables are affected by an increase in the Tier1 capital ratio by 1pp. Specifically, it summarises median estimates of the relative change in the magnitude of bank-level responses to structural shocks. The figures in the upper left corner of the table show that for most of the banks in the sample a 1pp higher Tier1 capital ratio would temper the response of long-term NFC loans to aggregate demand shocks by at least 1.8%. The amplifying effect of Tier1 capital ratios on household loans is also material, with the magnitude of their response levied by 6%. The corresponding reduction in the magnitude of responses of bank-level interest rates is around 5% for new NFC loans and 0.8% for new household loans.

Table 6: The median* percentage change in the magnitude of bank responses corresponding with an increase in Tier1 capital ratios by 1pp

	Loan volumes			Interest rates		
	Long-term NFC	Short-term NFC	HH	Long-term NFC	Short-term NFC	HH
Aggregate demand	−1.771	−1.560	+5.997	−4.881	−5.622	−0.561
Standard monetary policy	×	−1.288	+2.516	−10.888	−4.578	×
Unconventional monetary policy	−2.304	−7.547	−1.120	×	×	+0.846

Legend: * the median of median individual bank responses. Derived on the basis of regression estimates in Table 12. × - an estimate of the coefficient on Tier1 capital ratio not significant at 10% confidence level.

Bank capitalisation also matters for the transmission of monetary policy shocks (bottom rows of Tables 12 and 6). High Tier1 capital ratios reduce the magnitude of responses of NFC loans to monetary policy impulses. As shown earlier, changes in monetary policy affect the composition of NFC loans. For instance, monetary policy easing leads to an increase in long-term, but a decline in short-term NFC loans. Our regressions indicate that highly capitalised banks reduce short-term NFC loans to a lesser degree, and increase long-term NFC loans to the same or a lower degree compared to banks with low capitalisation.

The impact of bank capitalisation on the transmission of standard versus unconventional monetary policy shocks differs in various other aspects. Higher Tier1 capital ratios reduce the reaction of interest rates to changes in the MRO rate. This finding adds to the earlier empirical evidence on the bank lending channel such as Berger and Udell (1994) (for the US), Gambacorta and Mistrulli (2004), Gambacorta and Marques-Ibanez (2011) and Gambacorta and Mistrulli (2014). However, there is no effect of Tier1 capital ratios on the pass-through of unconventional policies in bank-level interest rates. Further, high Tier1 ratios amplify the response of household loans following standard monetary policy shocks but reduce their response to unconventional monetary policy shocks.

The effects of bank capitalisation on the propagation of aggregate demand shocks and monetary policy shocks are closely intertwined. Our results on the transmission of monetary policy shocks indicate that banks with higher Tier1 capital are less responsive to endogenous monetary policy responses than banks with low Tier1 capital, at least as regards interest rates. The same cross-sectional pattern of bank responses emerges following aggregate demand shocks, where banks with higher Tier1 ratios report smaller responses of interest rates. This reminds us about the infeasibility of separating the effect of banks capitalisation on the propagation of aggregate demand shocks, ignoring the endogenous monetary policy response. Our results remain silent on the question whether tighter capital regulation would dampen cyclical changes in interest rates to the non-financial private sector in the absence of countercyclical monetary policy.

5.2 The role of liquidity buffers

The regression results for liquidity buffers are shown in the lower rows of Table 13. Higher liquid assets to deposit ratios reduce the response of NFC loans to aggregate demand shocks (Table 7) by a substantial margin. An increase in the liquid assets to deposit ratio by 10pp results in a 3.4% and 4.7 % reduction in the response of long- and short-term NFC loans, respectively. These results relate to the evidence on the higher lending activity of banks with larger liquidity buffers during the recent crisis in the US (Cornett, McNutt, Strahan, and Tehranian (2011) and Kapan and Minoiu (2013)). The impact of higher liquid assets to deposit ratios on the propagation of aggregate demand shocks into household loans is already ambiguous.

Bank liquidity has a heterogeneous impact on bank-level interest rates in different market segments following aggregate demand shocks. Higher liquid assets to deposit ratios amplify the response of interest rates on new NFC loans, while they dampen the response of interest rates on new household loans.

Besides, bank liquidity affects the transmission of monetary policy shocks. Higher liquid assets to deposit ratios translate into larger responses of long-term NFC loans and smaller opposite signed responses of short-term NFC loans. Overall, these results imply that banks with lower maturity mismatch increase NFC loans more than other banks following a monetary policy easing. Nonetheless, these effects are substantial only for unconventional monetary policy shocks (a 1% median change in the magnitude of responses of long-term NFC loans, and 3.9% of short-term NFC loans), while negligible (a below 0.3% median change in the magnitude of banks' responses) for standard monetary policy shocks. Bank liquidity proves to have little impact on the pass-through of monetary policy impulses into household loans.

Table 7: The median* percentage change in the magnitude of bank responses corresponding with an increase in liquid assets to customer deposits ratios by 10pp

	Loan volumes			Interest rates		
	Long-term NFC	Short-term NFC	HH	Long-term NFC	Short-term NFC	HH
Aggregate demand	−3.376	−4.747	×	+2.004	×	−2.757
Standard monetary policy	+0.170	−0.285	−0.329	−2.200	+1.492	×
Unconventional monetary policy	+1.034	−3.880	+0.260	+2.808	−0.598	+0.443

Legend: * the median of median individual bank responses. Derived on the basis of regression estimates in Table 13. × - an estimate of the coefficient on liquid assets to customer deposit ratio not significant at 10% confidence level.

Finally, bank liquidity has an assorted and often offsetting impact on the transmission of monetary policy into bank-level interest rates. The impact differs by the type of monetary policy shocks and market segment. For instance, higher liquid assets to deposit ratios reduce the magnitude of responses of interest rates on new long-term NFC loans and amplify those of interest rates on new short-term NFC loans to standard monetary policy shocks, while the reverse holds true for unconventional monetary policy shocks.

5.3 Non-linearity of the relationship between capital and liquidity buffers and bank-level responses

Following Carlson, Shan, and Warusawitharana (2013) we test for non-linearity in the relationship between bank capitalisation and liquidity and the reaction of banks to structural shocks. Such non-linearity may arise from banks' pursuit to maintain a certain precautionary level of capital (Valencia (2014)) or avoid crossing regulatory thresholds. From a policy perspective, non-linearity in the relationship between capital (or liquidity) buffers and the reaction of banks to macroeconomic shocks may inform about decreasing gains from setting too restrictive prudential controls.

We re-estimate all bank-level regressions adding the squared Tier1 capital ratios or liquid assets to deposit ratios on the right-hand side of equation (5.1). The estimated relationships between structural variables and bank response are plotted in Figure 12 for Tier1 capital ratios, and Figure 13 for liquid assets to deposit ratios.

We find a non-linear effect of Tier1 capital ratios on the propagation of structural shocks into bank-level NFC loans and interest rates on new on household loans. Detected non-linearities occasionally explain why bank capitalisation proved statistically insignificant in some linear regressions estimated earlier. At average capitalisation levels, the earlier findings regarding the responses of NFC loans from Table 6 generally hold. Banks with higher Tier1 capital ratios adjust their long-term NFC loans (short-term NFC loans) less (more) following aggregate demand shocks and more (less) following monetary policy shocks. However, for banks with Tier1 capital ratios above a certain threshold, these relationships reverse. A further increase in Tier1 capital ratios ceases to temper the responses of long-term NFC loans to aggregate demand shocks or to reinforce the transmission of monetary policy shocks into long-term NFC loans.

In addition, higher Tier1 capital ratios appear to reduce the magnitude of responses of interest rates on new household loans to structural shocks at average bank capitalisation levels; but not anymore at very high capitalisation levels.

The evidence for non-linear effects of bank liquidity on their reaction to structural shocks is generally weak. For most bank-level variables, the quadratic relationship between banks' responses and liquid assets to deposit ratios is either statistically insignificant or close to linear. Only for household loans, higher liquidity buffers prove to amplify the magnitude of bank responses to monetary policy shocks, while exceedingly high liquidity buffers to temper those.

6 Robustness checks

We evaluate the robustness of our results along two dimensions. First, we check whether the results are sensitive to changes in the measurement of bank lending activity and the identification of structural shocks. To this end, we test different specifications of a FAVAR model. Second, we check whether the empirical relationship between bank responses to structural shocks and their capital and liquidity buffers depends on the measurement of bank capitalisation and maturity mismatch on their balance sheets or the choice of control variables in bank-level regressions. For this purpose, we test different specifications of the latter.

Alternative measurement of bank lending activity

The evolution of new bank loans offers an alternative description of bank lending. Notional stocks of bank loans inform about the dynamics of loans that are currently at disposal of the non-financial private sector, i.e. the dynamics of private sector purchasing power. The volumes of new loans inform about the intensity of bank lending activity in the reference period, ignoring the effect of loan repayments on banks' overall exposures.

A FAVAR model has been re-estimated substituting the notional stocks of bank loans with the volumes of new bank loans (normalised via the outstanding stock of loans). Table C.1 in Appendix C provides the summary statistics of bank-level variables, including the volumes of new long-term NFC loans, $NewCreditNFClong$, new short-term NFC loans, $NewCreditNFCshort$, and new household loans, $NewCreditHH$. New long-term NFC and household loans exhibit similar dynamics as the corresponding notional stock series (FigureC.1). There is, however, a difference between the behaviour of new and notional stocks of short-term NFC loans. New short-term NFC loans move in tandem with other non-financial private sector loans, whereas the notional stocks of short-term NFC loans followed an individual trend.

We find only minor differences in the reaction of new loans compared to the notional stocks of loans in response to structural shocks. New short-term NFC loan volumes appear to be less sensitive to aggregate demand shocks (Figure C.2) and more sensitive to monetary policy shocks compared to the corresponding notional stocks (Figure C.3 and C.4).

The impact of bank capitalisation on the behaviour of long-term NFC loans is qualitatively similar irrespectively of which measure of bank lending is used. However, the impact differs for new loans and notional stocks in other market segments. Higher bank capitalisation gives rise to a more pronounced shift between new short-term and long-term NFC loans following monetary policy shocks than was the case for the notional stocks of NFC loans. It also increases the pass-through of unconventional monetary policy shocks, and reduces that of aggregate demand shocks, into new household loans; whereas bank capitalisation had a reverse impact on the reactions of notional shocks of household loans.

Finally, the impact of bank maturity mismatch on bank loans following structural shocks proves sensitive to the measurement of lending activity. A possible explanation is that bank liquidity is likely to be among the key factors influencing banks' willingness to postpone loan repayment. To the degree banks tighten or extend repayment conditions in response to structural shocks, the dependency of their reaction on liquidity buffers, will also drive the dynamics of new loans versus notional stocks of loans apart.

Identification of structural shocks

Our results regarding the propagation of structural shocks are not sensitive to changes in the identification of structural shocks. We have tested the following alternative specifications of structural shocks: (i) monetary policy shocks are assumed to have only a delayed impact on bank-level variables (which is achieved by imposing an additional set of zero restrictions on the contemporaneous responses of latent factors following monetary policy shocks); (ii) an additional market risk premium shock is added to the set of structural shocks (it is assumed to increase the spread between the EONIA and MRO rate, and have no effect on the ECB balance sheet); (iii) an additional deleveraging shock is added to the set of structural shocks (leading to an increase in bank-level loans, with no immediate impact on GDP). In particular, scheme (i) follows Bernanke, Boivin, and Eliasz (2005) in assuming that monetary policy can respond contemporaneously to fluctuations in all variables, but none of the latent factors can contemporaneously respond to monetary policy.

Alternative measures of bank capitalisation and liquidity

The empirical literature employs different measures of bank capitalisation and maturity mismatch on bank balance sheets. Moreover, for some measures, such as CAR, the sample coverage is broader than for the benchmark Tier1 ratios. Therefore we re-estimate all bank-level equations using alternative measures of structural variables listed in Table 3. Detailed results are reported in Appendix D.

The effect of bank capitalisation on the propagation of aggregate demand and monetary policy shocks is statistically significant and same-signed when bank capitalisation is measured with CAR instead of Tier1 ratios, with two exceptions only. The relationship between CAR and the reaction of short-term NFC loans are differently signed in the longer horizon. By contrast, the effect of CAR on the reaction of household loans is statistically insignificant. There are no substantial differences between regression outcomes for liquid assets to total assets and liquid assets to deposit ratios.

Many of the above results do no longer hold if bank capitalisation is measured by leverage ratios or bank liquidity by loan to deposit ratios. This is not an unexpected result provided that the correlation coefficients between Tier1 and leverage ratios and between liquid assets to consumer deposit ratios and loan to deposit ratios are very low (Table 4).

Extended specifications of bank-level regressions

Further, we add a range of additional control variables to bank-level regressions. These include the ratio of loans to the non-financial private sector to total assets as a measure of the involvement of banks in traditional lending activity, deposits to total funding ratio (both indicators were used in bank level regressions by Gambacorta and Mistrulli (2014)), banks' reliance on market funding (proxied by the ratio of inter-bank deposits to total assets) and a measure of connectedness (the ratio of bank exposures to interbank market to total assets). The estimates of coefficients on Tier1 and liquid assets to consumer deposit ratios prove robust to including those additional control variables in the regressions.

Finally, we also test for the stability of estimated coefficients when bank capitalisation and liquidity measures are simultaneously included in regressions (see Appendix E). The significance and sign of the estimates of coefficients remain largely unaffected. There is an important policy message emerging from this robustness check. Bank capitalisation and liquidity affect the propagation of structural shocks in a complementary fashion, their effects (and possibly also the effects of capital versus liquidity regulation) add up.

7 Conclusions

We investigate how bank capitalisation and liquidity affect the transmission of macro-financial shocks into bank lending. To this end, we estimate a structural FAVAR for the euro area, where we combine macroeconomic aggregates with a set of latent factors that summarize the lending behaviour of euro area commercial banks (MFIs) in 2007 – 2015. We then run a series of cross-sectional bank-level regressions, which relate banks' responses to structural shocks to their capital and liquidity buffers.

Our results suggest that highly capitalised banks are more willing to take on risk on their balance sheets in adverse circumstances. Following negative aggregate demand shocks most of the banks cut loans and interest rates to all segments of the non-financial private sector. However, banks with high Tier1 capital ratios reduce their long-term NFC loans less than other banks. While they reduce their short-term NFC and household loans more than other banks. These results add to the evidence of Gambacorta and Mistrulli (2004) for the euro area, or Jimenez, Ongena, Peydro, and Saurina (2012) for Spain, that higher capital ratios limit the pro-cyclicality of credit. We also document that these relationships between bank lending and capitalisation may break at very high bank capitalisation levels.

Monetary policy affects the non-financial private sector lending on an intensive margin. In response to a monetary policy easing, most of the banks cut interest rates. The response of loan volumes is more nuanced with the majority of banks increasing long-term NFC loans and reducing short-term NFC and household loans. Thus, a policy easing facilitates the shift from short-term NFC and household loans into long-term NFC loans, meaning that banks become more willing to increase their shares of higher risk-weighted loans.

Bank capitalisation modifies the transmission of monetary policy impulses into NFC loans. Following a monetary policy easing, high bank capitalisation limits a negative response of short-term NFC loans, while it has no or a tempering effect on a positive response of long-term NFC loans. Bank capitalisation has a different impact on the transmission or standard and unconventional monetary policy shocks into household loans. It amplifies the effect of standard monetary policy and tempers that of unconventional monetary policy impulses.

Regarding the role of maturity mismatch on bank balance sheets, we find that high bank liquid assets to deposit ratios increase the supply of NFC loans under adverse macroeconomic conditions. This effect adds to the analogous effect of bank capitalisation. Bank liquidity amplifies as well the transmission of unconventional monetary policy measures into loans to the non-financial sector.

Above all, our results emphasise the relevance of the interactions between macroprudential and monetary policies. We show that macroprudential policies, by influencing bank capitalisation and liquidity buffers, are likely to affect both cyclical fluctuations in credit and monetary policy transmission channels. Further, the differing effect of bank capitalisation on the transmission of standard versus unconventional monetary policy measures suggests that monetary policy-mix may need to vary for systems with high versus with low capitalised banks.

Two other comments apply to all our results. First, our sample covers a long recession period and the results need to be interpreted against this backdrop. For instance, should the impact of monetary policy be asymmetric within the business cycle, our results will capture the transmission of monetary policy during economic slowdowns only. Second, we analyse the impact of bank capitalisation or liquidity on credit supply rather than credit demand. The evolution of credit demand following euro area shocks is likely to be country- rather than bank-specific, and we focus on the differences in banks' responses.

There are further questions opened up by our analysis. Why does bank capitalisation have different effects on the transmission of standard and unconventional monetary policy shocks? Does this result reflect e.g. selection effects in the use of unconventional measures, or do the differences between the transmission mechanisms have a more structural interpretation? While our analysis documents these differences additional work is needed to provide an explanation.

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Figures and tables

Figure 1: GDP and inflation

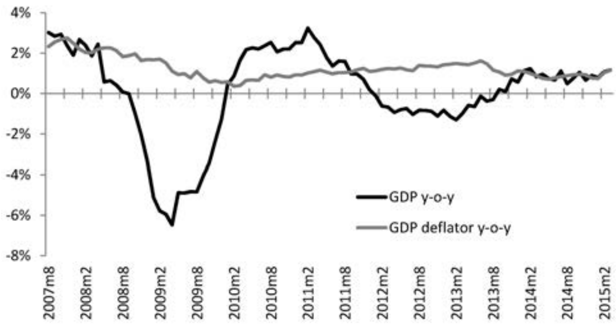


Figure 2: Monetary policy variables

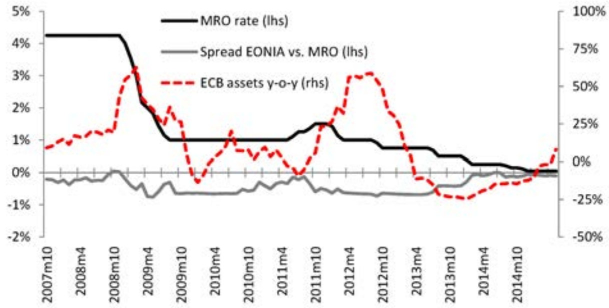


Figure 3: First Principal Component for bank-level loan volumes (3 month moving average)

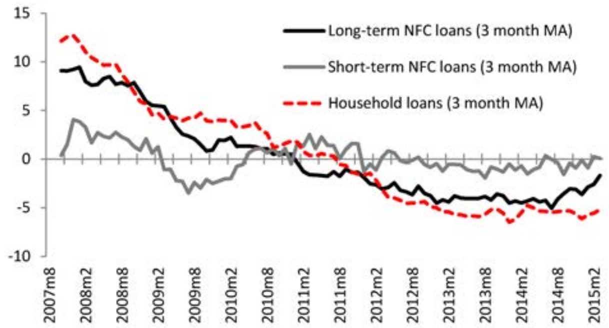


Figure 4: First Principal Component for bank-level interest rates on new loans (3 month moving average)

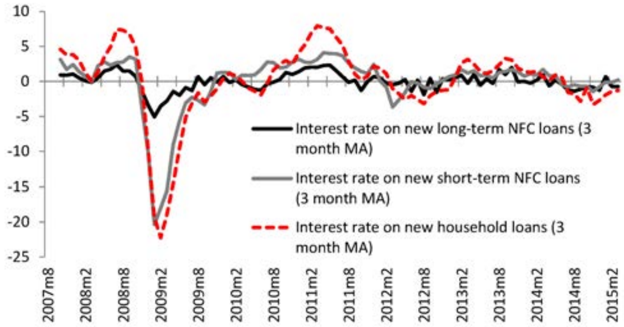


Figure 5: The share of variance of bank-level variables explained by observable variables and latent factors

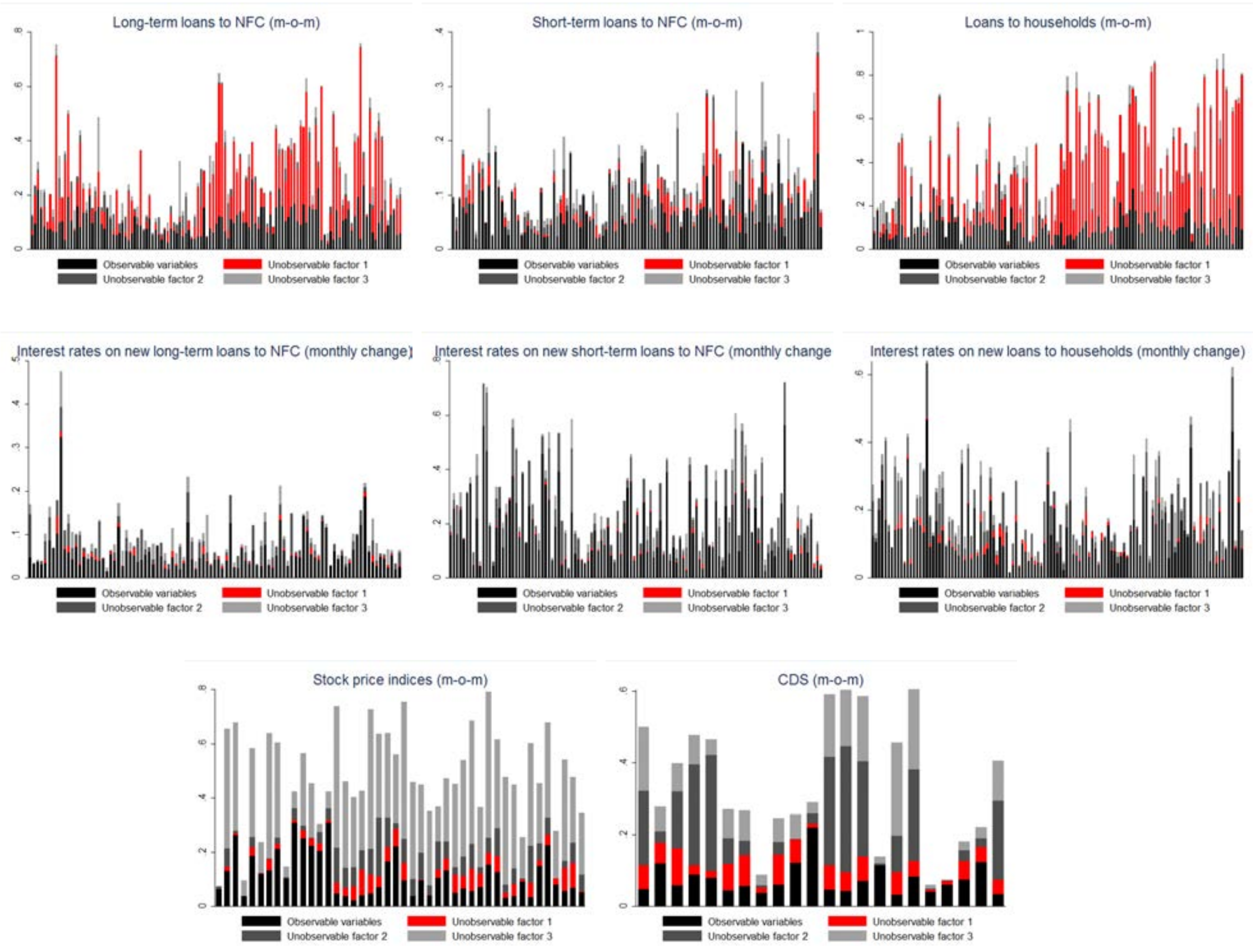


Figure 6: Evolution of latent factors in the benchmark FAVAR model

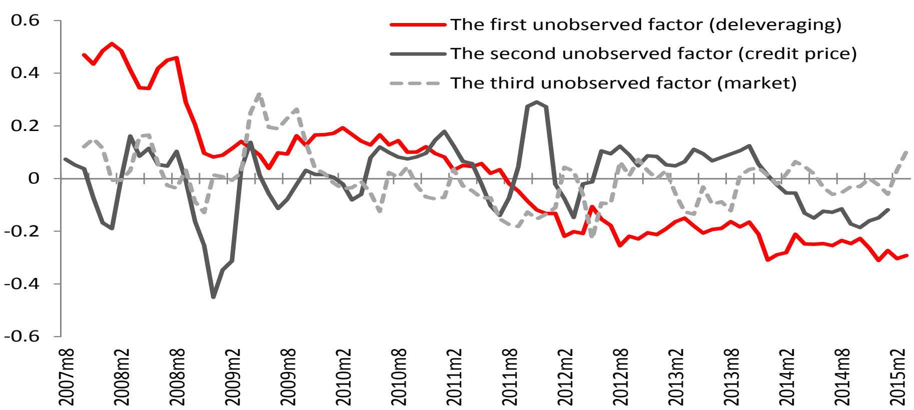
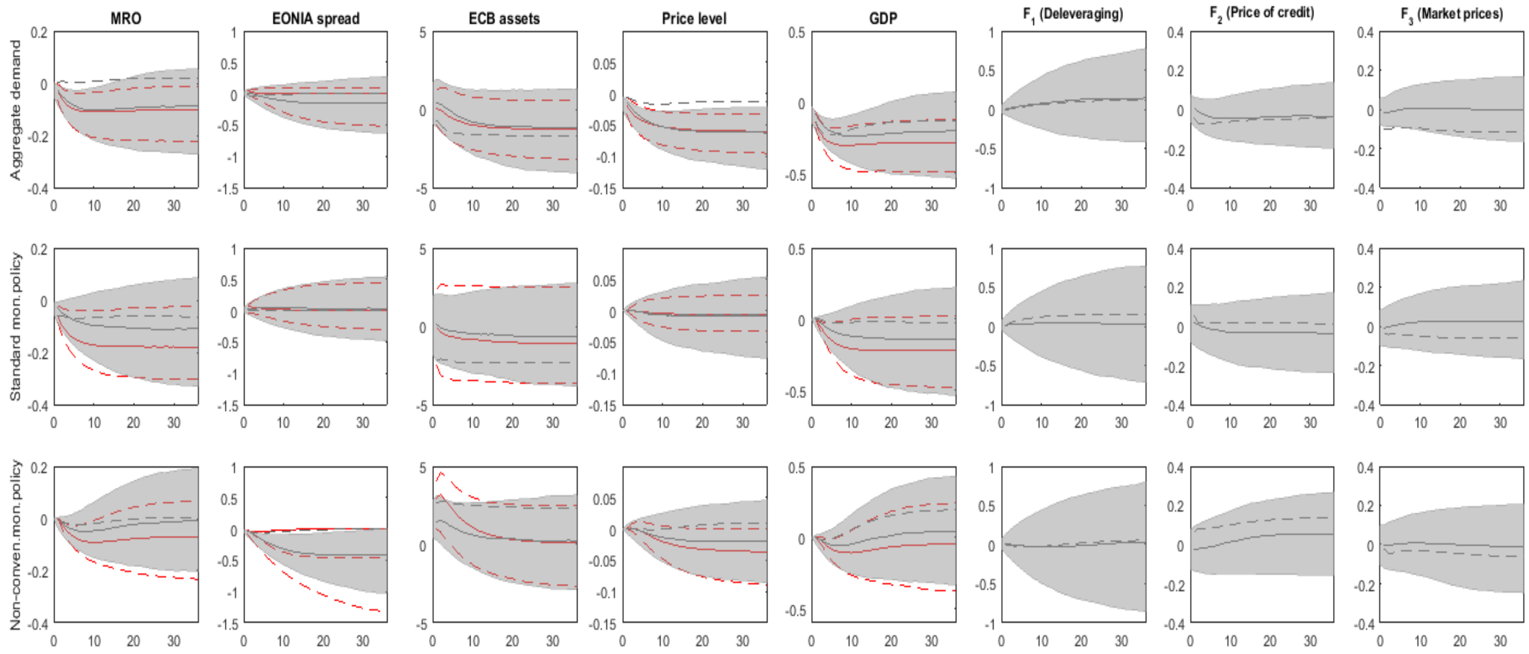
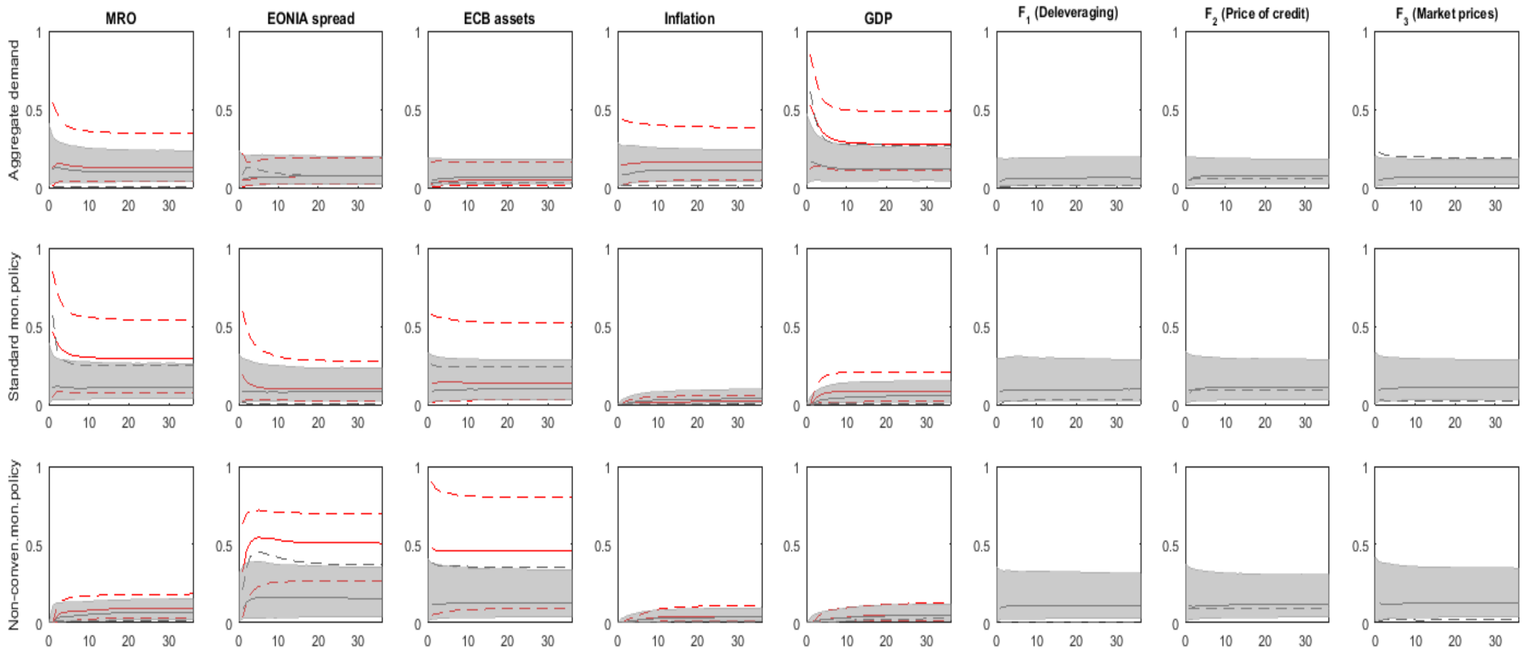


Figure 7: Impulse response functions to main structural shocks: FAVAR vs. VAR specification



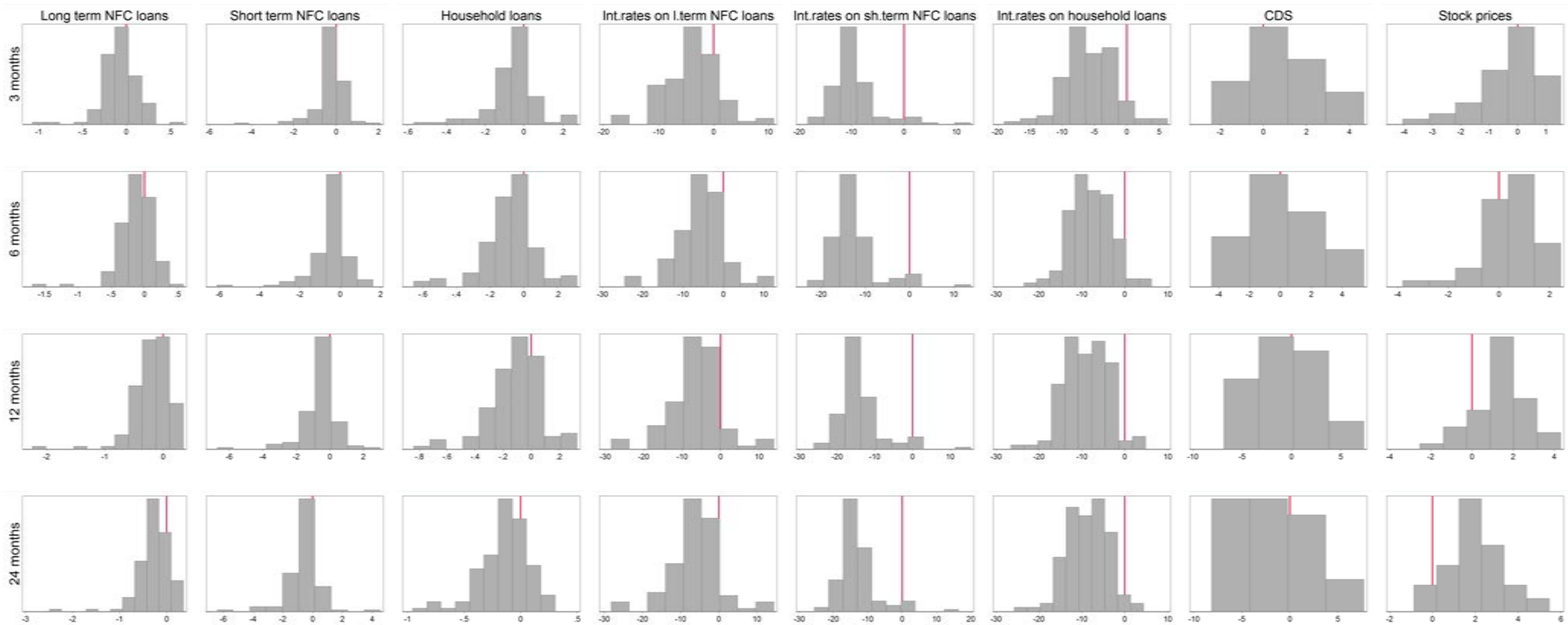
Legend: MRO rate, EONIA spread in perc. point deviation from the baseline. The ECB assets, GDP deflator and GDP levels in perc. deviation from the baseline. Grey shaded areas represent 70% uncertainty bands for the posterior density of impulse response functions from the benchmark FAVAR model. Grey solid line represents the median of the corresponding impulse response distributions. Grey broken line represents the impulse response functions from the model with impulse response functions closest to the median. Red broken lines mark uncertainty bands covering 70% posterior density of impulse response functions from a VAR model including the same set of observed macro variables as the benchmark FAVAR model. The red solid line represents the medians of the corresponding distributions.

Figure 8: Forecast error variance decomposition: FAVAR vs. VAR specification



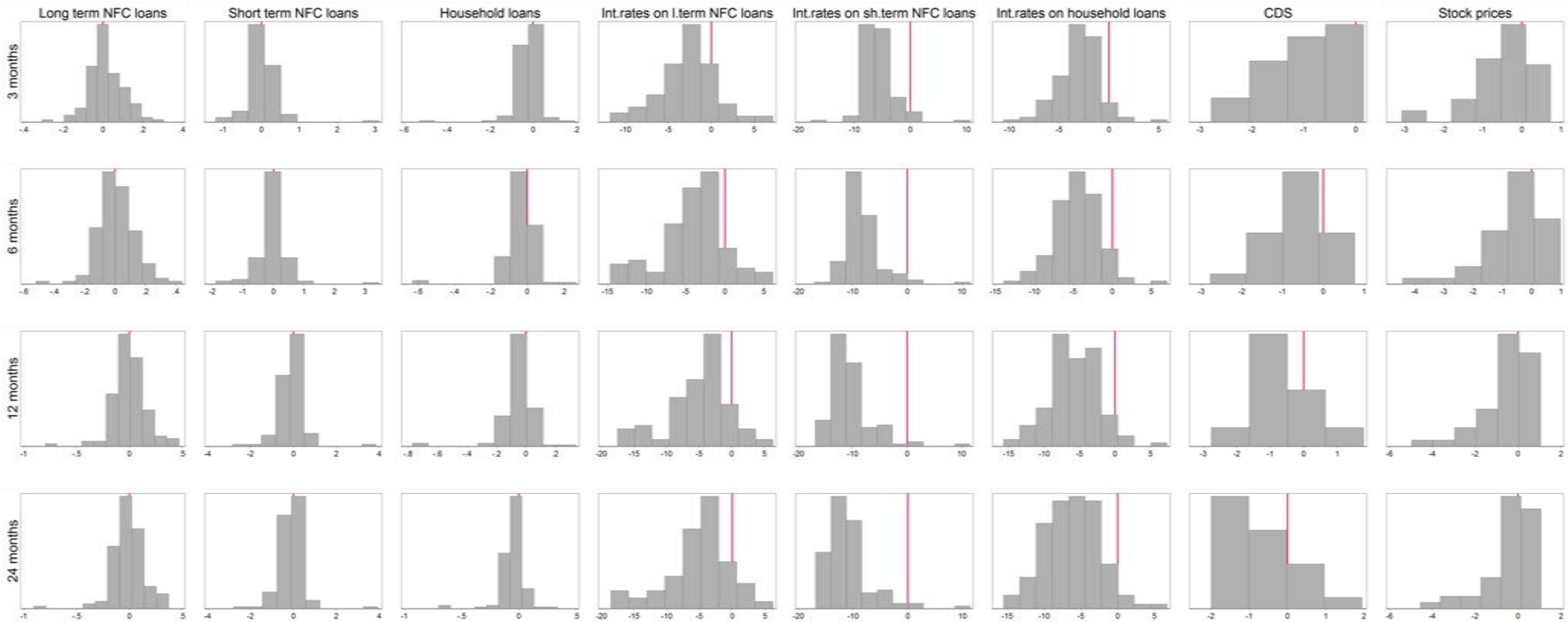
Legend: MRO rate in first differences, ECB assets, GDP and GDP deflator in m-o-m growth rates. Grey shaded areas represent 70% uncertainty bands from posterior density for the share of the variance of a variable explained by a structural shock. Grey solid line represents the median of the corresponding distribution. Grey broken line represents the share of variance for the model with impulse response functions closest to the median. Red broken lines mark uncertainty bands covering 70% posterior density of the share of the variance of a variable explained by a structural shock from a VAR model including the same set of observed macro variables as the benchmark FAVAR model. The red solid line represents the medians of the corresponding distributions.

Figure 9: The median cumulated IRFs of bank-level variables in response to a one standard deviation adverse aggregate demand shock (in perc. deviation from the baseline)



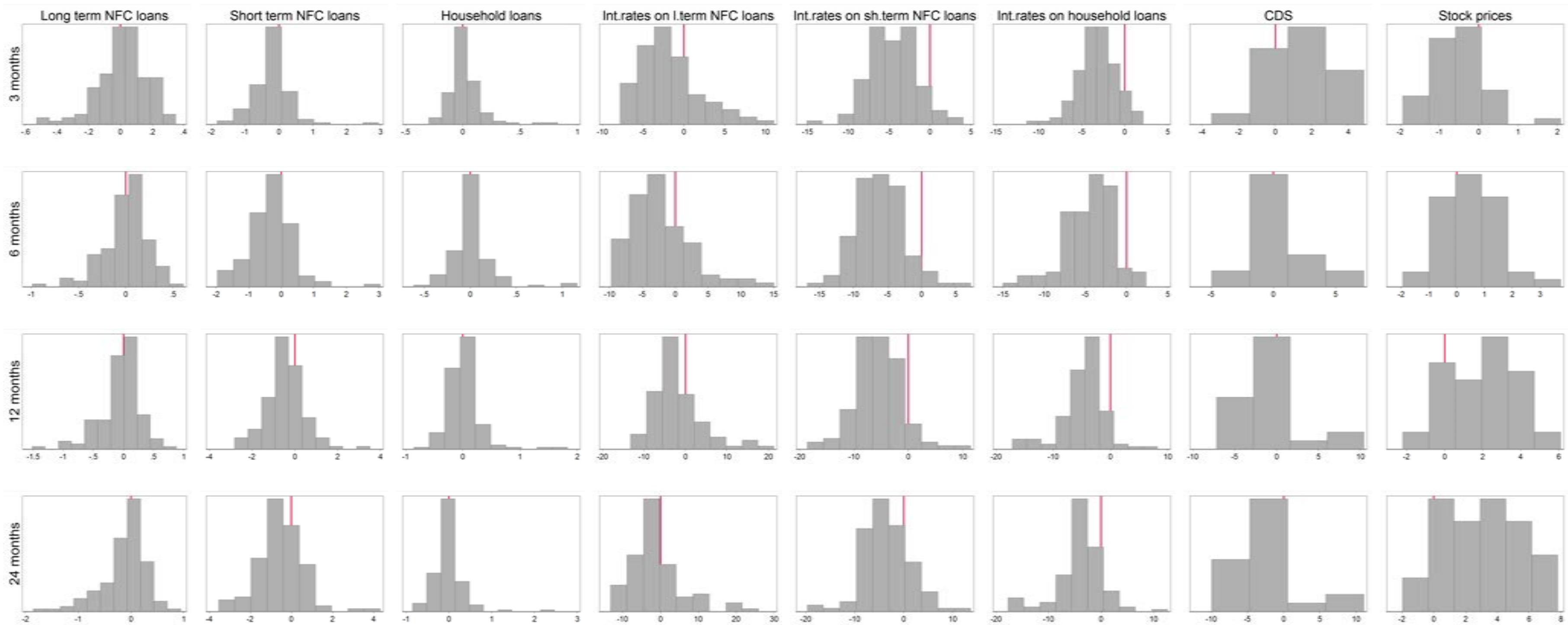
Legend: Red vertical line marks 0% on the x-axis. All non-financial private sector loans measured as notional stocks, interest rates as interest rates on new loans.

Figure 10: The median cumulated IRFs bank-level variables in response to a one accommodative standard monetary policy shock (in perc. deviation from the baseline)



Legend: Red vertical line marks 0% on the x-axis. All non-financial private sector loans measured as notional stocks, interest rates as interest rates on new loans.

Figure 11: The median cumulated IRFs bank-level variables in response to a one accommodative unconventional monetary policy shock (in perc. deviation from the baseline)



Legend: Red vertical line marks 0% on the x-axis. All non-financial private sector loans measured as notional stocks, interest rates as interest rates on new loans.

Table 8: The median values of bank-level responses as perc. change in the underlying variable (standardised and non-standardised)

	Hor.	*LoanNFClong*		*LoanNFCshort*		*LoanHH*		*InterestNFClong*		*InterestNFCshort*		*InterestHH*		*CDS*		*Stockprice*	
Measure		% of SD	%	% of SD	%	% of SD	%	% of SD	%	% of SD	%	% of SD	%	% of SD	%	% of SD	%
Adverse aggregate demand	3m	-7.29	-0.05	-5.91	-0.22	-8.31	-0.04	-7.16	-3.49	-25.93	-10.39	-23.43	-5.79	3.36	0.58	-1.93	-0.14
	6m	-11.47	-0.10	-8.98	-0.33	-13.56	-0.07	-9.94	-5.21	-34.57	-13.47	-31.12	-8.00	-0.07	-0.10	3.65	0.62
	1y	-18.54	-0.16	-12.90	-0.49	-22.77	-0.10	-11.62	-6.12	-37.88	-14.77	-34.03	-8.97	-7.63	-1.32	11.75	1.42
	2y	-23.22	-0.23	-15.01	-0.53	-25.11	-0.12	-10.40	-6.02	-35.69	-13.80	-32.81	-8.73	-12.63	-2.27	16.00	1.84
Accomm. standard monetary policy	3m	1.31	0.01	-0.30	-0.01	-3.64	-0.02	-4.93	-2.37	-16.38	-6.20	-18.37	-2.65	-4.79	-0.97	-1.18	-0.21
	6m	1.98	0.00	-0.83	-0.026	-5.60	-0.03	-7.15	-3.53	-21.97	-9.12	-17.15	-4.38	-4.24	-0.72	-1.17	-0.21
	1y	1.99	-0.00	-1.91	-0.085	-5.60	-0.03	-8.58	-4.16	-26.26	-11.25	-21.87	-5.80	-3.13	-0.76	-0.29	-0.10
	2y	2.22	-0.01	-2.14	-0.062	-5.90	-0.04	-8.76	-4.35	-27.88	-11.81	-23.08	-6.13	-4.00	-0.85	0.32	-0.07
Accomm. unconven-tional monetary policy	3m	3.304	0.03	-3.98	-0.16	1.49	0.00	-3.74	-2.28	-10.24	-4.95	-12.27	-3.02	7.93	1.38	-5.71	-0.52
	6m	2.73	0.03	-7.47	-0.31	0.56	0.00	-5.01	-2.93	-12.48	-6.48	-16.59	-4.08	1.10	-0.02	2.03	0.61
	1y	0.58	0.01	-11.15	-0.45	-1.00	0.00	-5.09	-2.76	-11.30	-6.10	-16.22	-4.15	-6.95	-1.52	14.19	1.99
	2y	-9.01	-0.04	-13.21	-0.50	-7.78	-0.02	-2.34	-1.62	-4.05	-3.98	-11.35	-3.74	-16.44	-3.01	23.63	3.20

Table 9: The correlation coefficients between responses of bank-level variables following an adverse aggregate demand shock a year after the shock

	Loans NFC long	*Loans NFC short*	*Loans HH*	*Interest NFC long*	*Interest NFC short*	*Interest HH*	*CDS*
LoansNFCshort	-0.002						
LoansHH	0.500***	0.350***					
InterestNFClong	−0.097	0.074	−0.107				
InterestNFCshort	0.066	−0.171*	−0.132	0.114			
InterestHH	0.015	0.017	0.088	0.175*	0.069		
CDS	0.137	-0.194	-0.311	-0.024	0.184	0.313	
Stockprice	0.174	0.081	0.108	0.344*	-0.226	-0.231	−0.005***

Legend: The correlations are derived on cumulated IRFs 12 months after a shock for a FAVAR model closest to the median as in Fry and Pagan (2005). Weights proportional to the percentage of variance captured by FAVAR observed variables and latent factors are applied. *** - statistically significant at below 1% level, ** - statistically significant at 5% level, * - statistically significant at 10% level.

Table 10: The correlation coefficients between responses of bank-level variables following an accommodative standard monetary policy shock a year after the shock

	Loans NFC long	*Loans NFC short*	*Loans HH*	*Interest NFC long*	*Interest NFC short*	*Interest HH*	*CDS*
LoansNFCshort	-0.090						
LoansHH	0.487***	0.015					
InterestNFClong	0.225**	0.197*	0.179*				
InterestNFCshort	0.104	0.121	0.082	−0.014			
InterestHH	0.058	−0.060	0.092	0.168	0.189**		
CDS	-0.317	0.308	0.426*	-0.341	0.337	0.043	
Stockprice	-0.062	-0.090	0.095	−0.134	0.424**	0.135	0.282

Legend: The correlations are derived on cumulated IRFs 12 months after a shock for a FAVAR model closest to the median as in Fry and Pagan (2005). Weights proportional to the percentage of variance captured by FAVAR observed variables and latent factors are applied. *** - statistically significant at below 1% level, ** - statistically significant at 5% level, * - statistically significant at 10% level.

Table 11: The correlation coefficients between responses of bank-level variables following an accommodative unconventional monetary policy shock a year after the shock

	Loans NFC long	*Loans NFC short*	*Loans HH*	*Interest NFC long*	*Interest NFC short*	*Interest HH*	*CDS*
LoansNFCshort	-0.009						
LoansHH	0.133	0.174*					
InterestNFClong	−0.023	−0.069	0.128				
InterestNFCshort	−0.027	0.110	0.037	0.338***			
InterestHH	0.210**	0.009	0.267***	0.153	0.335***		
CDS	0.089	0.456*	0.426**	0.290	-0.177	-0.214	
Stockprice	0.117	0.012	0.064	0.138	-0.115	-0.214	-0.161

Legend: The correlations are derived on cumulated IRFs 12 months after a shock for a FAVAR model closest to the median as in Fry and Pagan (2005). Weights proportional to the percentage of variance captured by FAVAR observed variables and latent factors are applied. *** - statistically significant at below 1% level, ** - statistically significant at 5% level, * - statistically significant at 10% level.

Table 12: The effect of Tier1 capital ratios on the response of bank-level loan volumes and interest rates on new loans to structural shock

	Horizon	1Q	2Q	1Y	2Y	1Q	2Q	1Y	2Y
	Explained	Long-term NFC loans				Interests on long-term NFC loans			
Adverse aggregate demand	$Tier1/RWA$	0.390*	1.080***	1.781***	2.071**	1.917***	2.102***	1.446***	0.292
		(0.164)	(0.264)	(0.434)	(0.683)	(0.129)	(0.171)	(0.239)	(0.350)
	Obs.	80	80	80	80	61	61	61	61
	$Adj.R^2$	0.054	0.039	0.023	0.012	0.312	0.294	0.194	0.085
		Short-term NFC loans				Interests on short-term NFC loans			
	$Tier1/RWA$	-0.895***	-0.317*	0.735***	1.718***	2.151***	2.724***	2.763***	2.328***
		(0.099)	(0.136)	(0.198)	(0.289)	(0.179)	(0.256)	(0.385)	(0.608)
	Obs.	75	75	75	75	75	75	75	75
	$Adj.R^2$	0.206	0.183	0.135	0.086	0.077	0.071	0.041	0.015
		Household loans				Interests on household loans			
	$Tier1/RWA$	-6.247***	-8.035***	-8.646***	-8.149***	0.613***	0.476**	0.257	0.002
		(0.209)	(0.332)	(0.536)	(0.831)	(0.129)	(0.179)	(0.260)	(0.399)
	Obs.	76	76	76	76	75	75	75	75
	$Adj.R^2$	0.068	0.053	0.036	0.022	0.151	0.132	0.076	0.029
Accomm. standard monetary policy		Long-term NFC loans				Interests on long-term NFC loans			
	$Tier1/RWA$	-0.232	-0.113	0.117	0.413	2.672***	3.496***	4.240***	4.560***
		(0.208)	(0.336)	(0.555)	(0.885)	(0.153)	(0.205)	(0.285)	(0.403)
	Obs.	80	80	80	80	61	61	61	61
	$Adj.R^2$	0.006	0.005	0.003	0.001	0.135	0.131	0.105	0.065
		Short-term NFC loans				Interests on short-term NFC loans			
	$Tier1/RWA$	1.324***	1.119***	1.032***	1.173***	1.652***	2.302***	2.893***	3.179***
		(0.111)	(0.156)	(0.234)	(0.349)	(0.249)	(0.352)	(0.509)	(0.740)
	Obs.	75	75	75	75	75	75	75	75
	$Adj.R^2$	0.029	0.023	0.014	0.007	0.016	0.017	0.014	0.008
		Household loans				Interests on household loans			
	$Tier1/RWA$	-3.692***	-5.345***	-6.769***	-7.261***	0.284	0.271	0.244	0.219
		(0.258)	(0.413)	(0.671)	(1.060)	(0.177)	(0.243)	(0.342)	(0.485)
	Obs.	76	76	76	76	75	75	75	75
	$Adj.R^2$	0.007	0.006	0.003	0.002	0.032	0.034	0.028	0.017
Accomm. unconven-tional monetary policy		Long-term NFC loans				Interests on long-term NFC loans			
	$Tier1/RWA$	2.837***	4.083***	5.397***	6.180***	1.629***	1.259***	-0.188	-2.270***
		(0.225)	(0.361)	(0.584)	(0.911)	(0.142)	(0.188)	(0.269)	(0.406)
	Obs.	80	80	80	80	61	61	61	61
	$Adj.R^2$	0.031	0.029	0.022	0.013	0.042	0.029	0.009	0.007
		Short-term NFC loans				Interests on short-term NFC loans			
	$Tier1/RWA$	1.838***	2.860***	4.400***	5.850***	0.727**	0.826*	0.230	-0.918
		(0.112)	(0.157)	(0.237)	(0.359)	(0.237)	(0.328)	(0.483)	(0.743)
	Obs.	75	75	75	75	75	75	75	75
	$Adj.R^2$	0.108	0.102	0.083	0.054	0.031	0.028	0.017	0.008
		Household loans				Interests on household loans			
	$Tier1/RWA$	1.218***	1.779***	3.819***	6.745***	-0.513**	-0.503*	-0.545	-0.626
		(0.281)	(0.445)	(0.709)	(1.093)	(0.172)	(0.231)	(0.328)	(0.491)
	Obs.	76	76	76	76	75	75	75	75
	$Adj.R^2$	0.021	0.020	0.017	0.011	0.045	0.036	0.021	0.013

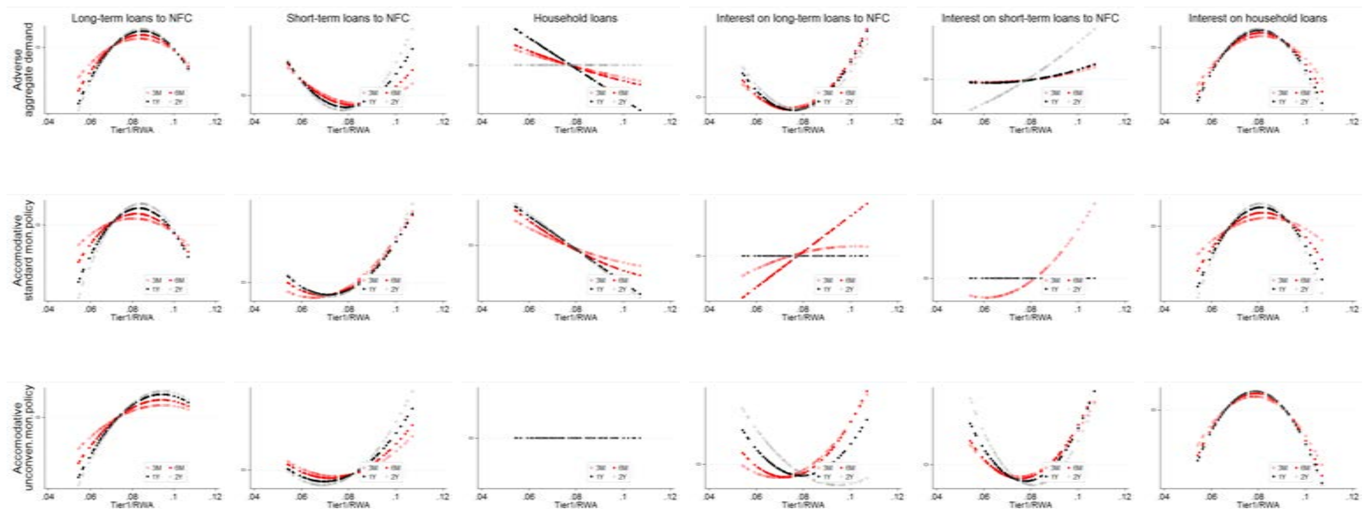
Legend: Based on weighted OLS estimator with weights proportional to the percentage of the variance of bank-level variables explained by observable and unobservable factors jointly in the FAVAR model. All regressions are controlled for bank's exposure-weighted country dummies, the size of total bank assets and the size of total bank assets squared. *** - statistically significant at below 1% level, ** - statistically significant at 5% level, * - statistically significant at 10% level.

Table 13: The effect of liquid assets to deposit ratios on the response of bank-level loan volumes and interest rates on new loans to structural shocks

	Horizon	1Q	2Q	1Y	2Y	1Q	2Q	1Y	2Y
	Explained	Long-term NFC loans				Interests on long-term NFC loans			
Adverse aggregate demand	*Liq.assets/Dep.*	0.189***	0.271***	0.384***	0.500***	-0.022***	-0.037***	-0.059***	-0.066***
		(0.010)	(0.016)	(0.026)	(0.040)	(0.005)	(0.007)	(0.010)	(0.014)
	Obs.	101	101	101	101	83	83	83	83
	$Adj.R^2$	0.043	0.032	0.020	0.012	0.294	0.283	0.191	0.086
		Short-term NFC loans				Interests on short-term NFC loans			
	Liq.assets/Dep.	0.104***	0.162***	0.223***	0.245***	0.009	0.008	0.013	0.018
		(0.004)	(0.006)	(0.009)	(0.013)	(0.007)	(0.010)	(0.015)	(0.024)
	Obs.	93	93	93	93	94	94	94	94
	$Adj.R^2$	0.200	0.178	0.132	0.083	0.049	0.047	0.028	0.010
		Household loans				Interests on household loans			
	Liq.assets/Dep.	0.072***	0.070***	0.041	0.009	0.057***	0.090***	0.124***	0.145***
		(0.011)	(0.018)	(0.028)	(0.044)	(0.007)	(0.010)	(0.014)	(0.021)
	Obs.	100	100	100	100	98	98	98	98
	$Adj.R^2$	0.060	0.055	0.046	0.035	0.120	0.104	0.059	0.022
Accomm. standard monetary policy		Long-term NFC loans				Interests on long-term NFC loans			
	Liq.assets/Dep.	0.072***	0.077***	0.084**	0.100	0.078***	0.084***	0.084***	0.080***
		(0.012)	(0.020)	(0.032)	(0.052)	(0.006)	(0.008)	(0.012)	(0.017)
	Obs.	101	101	101	101	83	83	83	83
	$Adj.R^2$	0.004	0.003	0.002	0.001	0.121	0.121	0.098	0.060
		Short-term NFC loans				Interests on short-term NFC loans			
	Liq.assets/Dep.	0.008	0.015*	0.031**	0.047**	-0.077***	-0.088***	-0.095***	-0.097***
		(0.005)	(0.007)	(0.010)	(0.015)	(0.010)	(0.014)	(0.020)	(0.029)
	Obs.	93	93	93	93	94	94	94	94
	$Adj.R^2$	0.028	0.022	0.014	0.007	0.011	0.012	0.010	0.006
		Household loans				Interests on household loans			
	Liq.assets/Dep.	0.043**	0.068**	0.085*	0.089	0.008	0.017	0.025	0.029
		(0.013)	(0.021)	(0.035)	(0.055)	(0.009)	(0.013)	(0.018)	(0.025)
	Obs.	100	100	100	100	98	98	98	98
	$Adj.R^2$	0.005	0.003	0.002	0.001	0.026	0.027	0.023	0.014
Accomm. unconventional monetary policy		Long-term NFC loans				Interests on long-term NFC loans			
	Liq.assets/Dep.	0.206***	0.263***	0.344***	0.444***	-0.025***	-0.066***	-0.122***	-0.158***
		(0.013)	(0.021)	(0.034)	(0.053)	(0.006)	(0.008)	(0.011)	(0.017)
	Obs.	101	101	101	101	83	83	83	83
	$Adj.R^2$	0.027	0.024	0.018	0.011	0.036	0.026	0.008	0.007
		Short-term NFC loans				Interests on short-term NFC loans			
	Liq.assets/Dep.	0.054***	0.136***	0.231***	0.283***	0.001	0.015	0.044*	0.071*
		(0.005)	(0.007)	(0.010)	(0.016)	(0.009)	(0.013)	(0.019)	(0.029)
	Obs.	93	93	93	93	94	94	94	94
	$Adj.R^2$	0.108	0.103	0.082	0.052	0.035	0.028	0.016	0.007
		Household loans				Interests on household loans			
	Liq.assets/Dep.	-0.004	-0.038	-0.116**	-0.190***	-0.062***	-0.046***	-0.029	-0.022
		(0.015)	(0.023)	(0.037)	(0.057)	(0.008)	(0.012)	(0.017)	(0.026)
	Obs.	100	100	100	100	98	98	98	98
	$Adj.R^2$	0.020	0.020	0.018	0.013	0.036	0.027	0.016	0.011

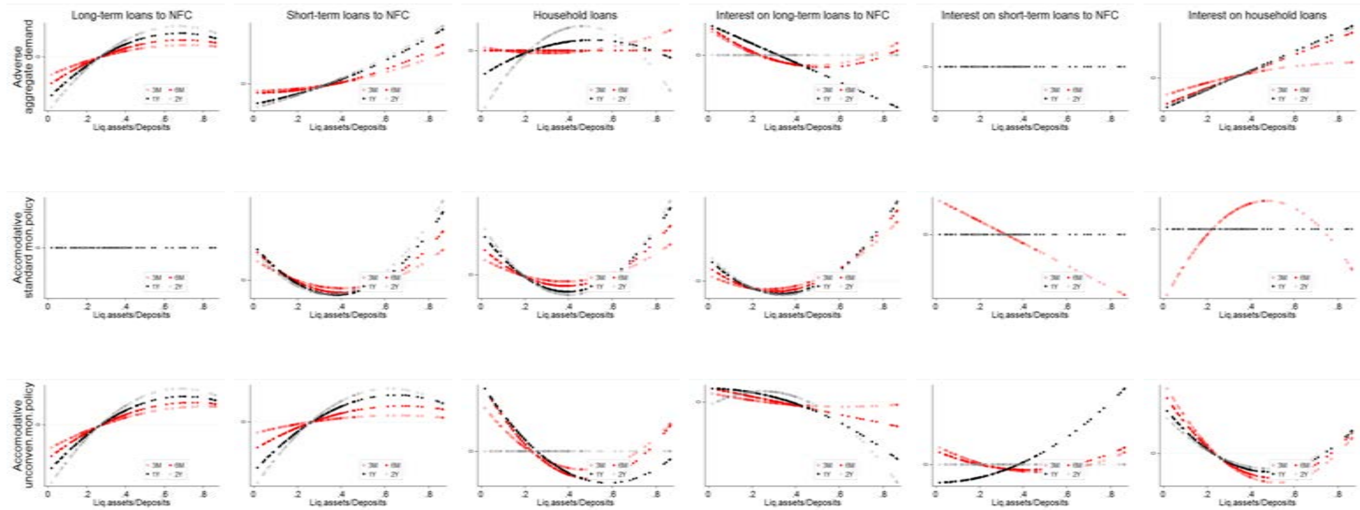
Legend: Based on weighted OLS estimator with weights proportional to the percentage of the variance of bank-level variables explaned by observable and unobservable factors jointly in the FAVAR model. All regressions are controlled for bank's exposure-weighted country dummies, the size of total bank assets and the size of total bank assets squared. *** - statistically significant at below 1% level, ** - statistically significant at 5% level, * - statistically significant at 10% level.

Figure 12: The non-linear effect of Tier1 to RWA ratio on the response of banks to structural shocks



Legend: Charts include demeaned predicted values of variable responses to a shock based on the actual Tier1 to RWA ratio and keeping all other exogenous variables in the regression at zero.

Figure 13: The non-linear effect of liquid assets to deposit ratio on the response of banks to structural shocks



Legend: Charts include demeaned predicted values of variable responses to a shock based on the actual liquid assets to deposit ratio and keeping all other exogenous variables in the regression at zero.

Appendix A Bank-level time series data

Notional stocks of loans

The information on balance sheet items in the MFI statistics is available in two formats: outstanding amounts at the end of period (stocks) and transactions (flows). Flows are derived as a difference between the amounts at the end of two consecutive periods net of the impact of non-transaction related effects. Non-transaction events include, among others, changes in prices of securities or exchange rates, write-offs of loans arising from defaults or reclassification of instruments. Transactions should capture the essence of economic interactions, namely the outcomes of mutual agreements between units and individuals. Similarly, as ECB (2012) and Colangelo and Lenza (2013), we base our empirical investigation on chain-linked notional stocks derived as:

$$I_t = I_{t-1}\left(1 + \frac{T_t}{L_{t-1}}\right) \tag{A.1}$$

where I_t is the index of notional stocks at the end of period t, T_t are transactions in period t and L_t are outstanding amounts at the end of period t. Notional stocks reflect an expansion or contraction of banks' activities rather than the evolution of their balance sheets over time.

The MFI interest rate statistics allows us as well to derive the volumes of new loans by sector. The latter variables are transformed into a corresponding chained-linked index which captures changes in new loans in relative terms, i.e. compared to outstanding loans. The indices are derived along with equation A.1 where T_t is replaced with the volume of new loans.

Screens and statistical adjustments of bank-level series

From the initial sample of 238 credit institutions in the MFI statistics, we selected those which continuously provided information on loans to the non-financial private sector starting from August 2007. This criterion resulted in dropping banks which did not report any loans to the non-financial private sector and 20 credit institutions which either entered the MFI sample after August 2007 or left it before March 2015 (therein credit institutions from new euro area members such as Estonia or Lithuania). Columns 2 and 3 of Table A.1 compare the number of credit institutions (by country) in the original and narrowed down sample. Banks resident in Germany account for around one-third of the total assets of all credit institutions in the sample. Banks resident in France, Italy and Spain jointly account for another third of the total assets. A.1 also shows marked heterogeneity in banks' size.

Originally MFI statistics includes the institutions selected on the basis of their residenship and includes resident headquarters, branches or subsidiaries of institutions headquartered abroad but exclude foreign subsidiaries or branches of resident institutions. We semi-consolidate MFI balance sheet and interest rate information pooling together credit institutions that belonged to the same banking group in 2008. Note that the resulting semi-consolidated data do not cover

Table A.1: The sample of credit institutions by country of residence

Country	N. of banks (original sample)	N. of banks (selected institutions)	Avg. size of bank to country GDP	Min size of bank to country GDP	Max size of bank to country GDP
AUSTRIA	9	9	0.11	0.04	0.38
BELGIUM	10	10	0.16	0.01	0.43
FINLAND	5	5	0.28	0.01	1.00
FRANCE	36	30	0.07	0.00	0.33
GERMANY	65	65	0.02	0.00	0.16
GREECE	4	4	0.45	0.40	0.55
IRELAND	11	11	0.19	0.03	0.53
ITALY	24	23	0.06	0.01	0.28
LUXEMBOURG	11	11	0.60	0.09	1.78
NETHERLANDS	10	7	0.32	0.01	1.02
PORTUGAL	6	6	0.28	0.01	0.52
SLOVENIA	5	5	0.12	0.07	0.29
SPAIN	23	20	0.10	0.00	0.40
ALL	219	206	0.13	0.00	1.78

Note: The size of a bank is expressed as a value of its assets at the end of 2014 to nominal annual GDP in a country.

all entities entering a banking group, but only a subset of these entities which are included in our MFI sample.

In the next step, and similarly to Buch, Eickmeier, and Prieto (2014), we apply a number of further screens in order to exclude implausible observations. We exclude entities with: (i) negative or missing values for total assets outstanding, (ii) negative or missing values for capital and reserves outstanding, (iii) capital to asset ratios larger than one. This reduces the sample size from 143 to 131 institutions.

For each of 131 preselected institutions we only use loan volumes and interest rate series with not more than 12 consecutive months of missing observations and less than 10 detected outliers[13]. Then, we aggregate bank-level interest rates on new loans to arrive at the effective

[13]The dynamics of notional stock series derived from the MFI balance sheet statistics may be influenced inter alia by mergers and acquisitions, or by significant reclassification of assets and liabilities. We have experimented with correction procedures with ex-ante definition of outliers based the information about mergers, acquisitions and significant reclassification which national central banks transmit to the ECB. However, the outcomes were not satisfactory and we concluded that the information on factors significantly affecting individual balance-sheets

interest rate on new short-term corporate loans, new long-term corporate loans and household loans (originally the data includes break-downs by counter-party, i.e. households and non-financial corporations, size of a loan, i.e. up to 1 million and over 1 million, and purpose, i.e. housing, consumption and other). Finally, the series are transformed to ensure their stationarity, seasonally adjusted, corrected for outliers and extrapolated for missing data points. To this end, we apply X-12-ARIMA, allowing for additive and temporary shift outliers (which are excluded from the final series).

of MFI must not be complete. Instead, we applied statistical outlier detection procedures.

Appendix B The co-movement of bank-level variables

Here we assess the degree of co-movement in bank-level variables. First, we apply the Principal Component Analysis (PCA) *across the individual banks* for each of the variables listed in Table 2.[14] Second, we inspect the correlations *across bank-level variables* using the derived first Principal Components (PCs).

Table B.1 shows the percentage of variance explained by the first ten principal components extracted separately for each type of bank-level series.

Table B.1: The cumulative variance shares explained by first 10 principal components for bank-level variables

PC	*Loans NFC long*	*Loans NFC short*	*Loans HH*	*Interest NFC long*	*Interest NFC short*	*Interest HH*	*CDS*	*StockPrice*	All
1	0.159	0.057	0.273	0.051	0.191	0.122	0.302	0.435	0.089
2	0.206	0.102	0.347	0.100	0.239	0.168	0.349	0.514	0.143
3	0.241	0.141	0.409	0.143	0.277	0.204	0.388	0.562	0.173
4	0.272	0.177	0.451	0.186	0.310	0.236	0.417	0.602	0.199
5	0.301	0.212	0.487	0.225	0.341	0.265	0.444	0.639	0.223
6	0.327	0.244	0.514	0.263	0.369	0.293	0.470	0.670	0.244
7	0.353	0.275	0.538	0.298	0.397	0.317	0.494	0.701	0.264
8	0.378	0.304	0.559	0.330	0.423	0.342	0.519	0.727	0.283
9	0.402	0.331	0.579	0.363	0.449	0.366	0.541	0.751	0.301
10	0.426	0.357	0.598	0.394	0.473	0.388	0.562	0.774	0.318

The correlation between PC of loan volumes and of interest rates is close to zero (see Table B.2). There are two distinct correlation clusters in the bank-level data, of loan volumes, and of interest rates. This calls for a careful choice of the number of factors in the model, which should be sufficient to capture the dynamics of both loan volumes and interest rates.

Table B.2: The correlation coefficients between first principal components of bank-level variables

	LoansNFClong	*LoansNFCshort*	*LoansHH*	*InterestNFClong*	*InterestNFCshort*	*InterestHH*	*CDS*	*StockPrice*
LoansNFClong	1							
LoansNFCshort	0.244	1						
LoansHH	0.942	0.295	1					
InterestNFClong	0.035	0.080	0.064	1				
InterestNFCshort	-0.098	0.088	-0.014	0.552	1			
InterestHH	-0.017	0.094	0.044	0.612	0.803	1		
CDS	0.246	0.166	0.236	0.033	-0.064	-0.061	1	
StockPrice	-0.248	-0.255	-0.172	-0.026	0.065	0.097	-0.588	1

[14] The variables have been additionally demeaned and standardized to unit variance.

Appendix C Robustness check: substituting notional stocks with the volumes of new loans to non-financial private sector

Table C.1: Descriptive statistics of bank-level variables 2007 – 2015 incl. the volumes of new loans

Variables	N. of series	Mean	Std.dev.	5th quantile	95th quantile	Transformation
NewLoanNFClong	91	0.887	1.064	0.017	2.713	m-o-m growth rate in%
NewLoanNFCshort	105	22.066	27.900	2.423	58.480	m-o-m growth rate in%
NewLoanHH	115	1.739	1.218	0.302	3.902	m-o-m growth rate in%
InterestNFClong	98	-0.031	0.776	-1.189	1.064	m-o-m change in pp.
InterestNFCshort	114	-0.031	0.558	-0.837	0.697	m-o-m change in pp.
InterestHH	118	-0.027	0.370	-0.510	0.419	m-o-m change in pp.
CDS	22	1.720	24.319	-27.606	35.548	m-o-m growth rate in%
StockPrice	43	-2.166	16.763	-25.232	18.435	m-o-m growth rate in %

Figure C.1: First Principal Component for new bank-level credit (3 month moving average)

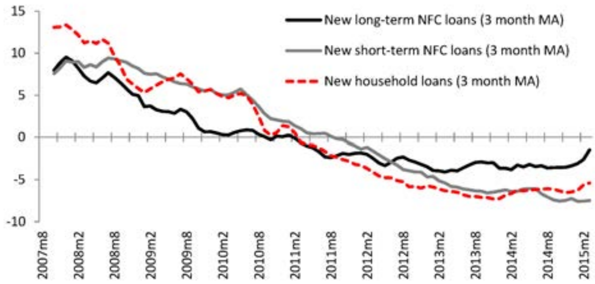
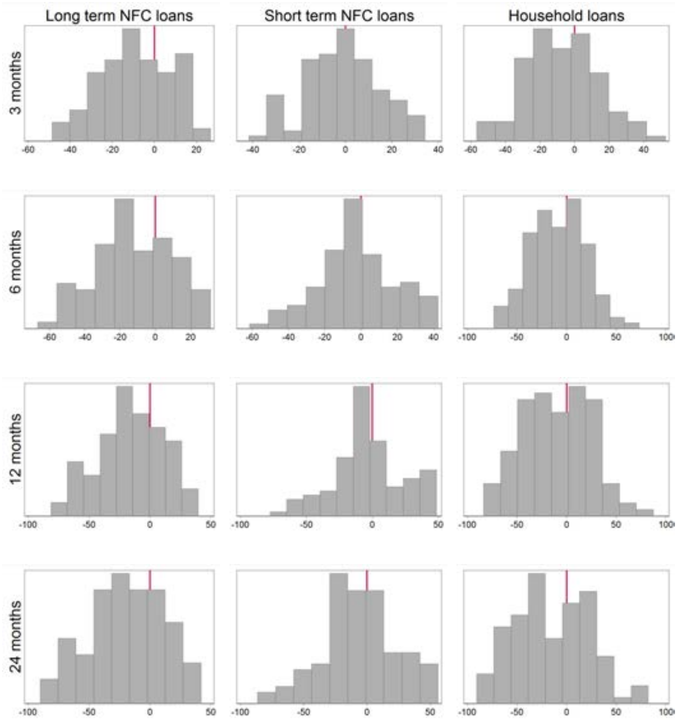
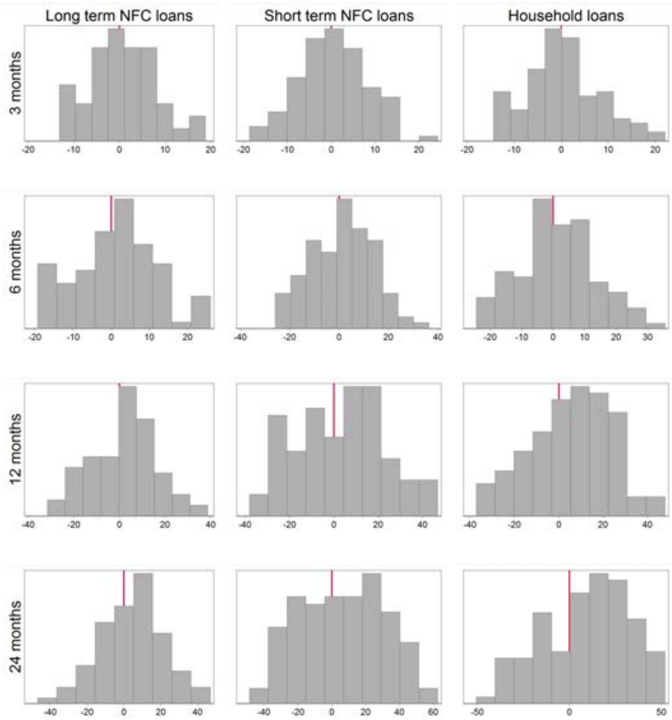


Figure C.2: The sample distributions of the cumulated median IRFs bank-level new loan volumes in response to a one standard deviation negative aggregate demand shock (in perc. deviation from the baseline)



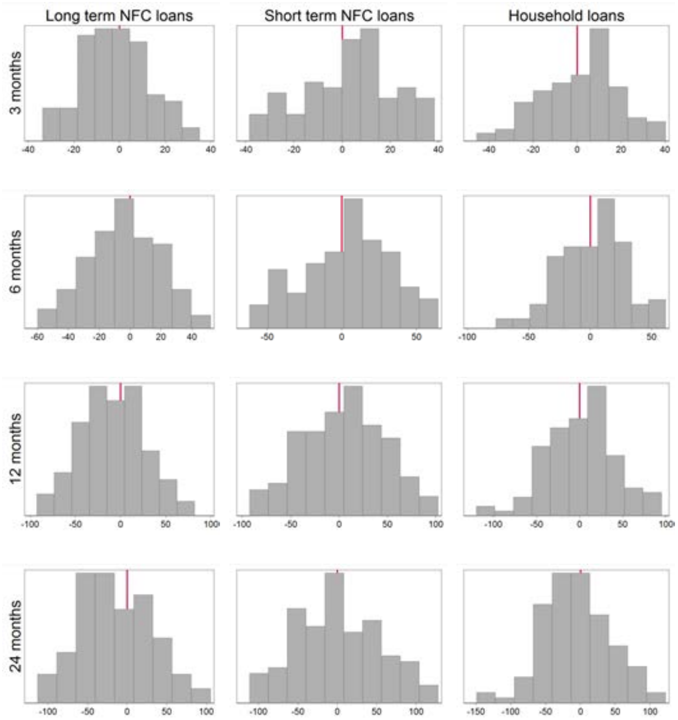
Legend: Red vertical line marks 0% on the x-axis. All non-financial private sector loans measured as volumes of new loans.

Figure C.3: The sample distributions of the cumulated median IRFs bank-level new loan volumes in response to a one standard deviation accommodative standard monetary policy shock (in perc. deviation from the baseline)



Legend: Red vertical line marks 0% on the x-axis. All non-financial private sector loans measured as volumes of new loans.

Figure C.4: The sample distributions of the cumulated median IRFs bank-level new loan volumes in response to a one standard deviation accommodative unconventional monetary policy shock (in perc. deviation from the baseline)



Legend: Red vertical line marks 0% on the x-axis. All non-financial private sector loans measured as volumes of new loans.

Table C.2: The effect of Tier1 capital and liquid assets to deposit ratios on the response of new loan volumes to structural shocks

	Horizon	1Q	2Q	1Y	2Y	1Q	2Q	1Y	2Y	1Q	2Q	1Y	2Y
	Explained	Long-term NFC loans				Short-term NFC loans				Household loans			
Adverse aggregate demand	$Tier1/RWA$	9.167***	12.908***	16.445***	18.757***	-3.604***	-4.035***	-4.130***	-3.254***	0.025	0.422	1.382**	3.119***
		(0.210)	(0.346)	(0.592)	(1.010)	(0.179)	(0.291)	(0.493)	(0.829)	(0.176)	(0.292)	(0.498)	(0.838)
	Obs.	59	59	59	59	71	71	71	71	73	73	73	73
	R^2	0.112	0.088	0.053	0.026	0.034	0.024	0.015	0.009	0.076	0.051	0.028	0.014
	$Liq.assets/Dep.$	-0.079***	-0.108***	-0.105***	0.002	-0.023**	-0.058***	-0.123***	-0.198***	0.010	-0.007	-0.036	-0.057
		(0.008)	(0.014)	(0.022)	(0.036)	(0.008)	(0.014)	(0.023)	(0.039)	(0.009)	(0.014)	(0.023)	(0.038)
	Obs.	78	78	78	78	89	89	89	89	95	95	95	95
	R^2	0.063	0.051	0.034	0.019	0.031	0.022	0.013	0.008	0.084	0.059	0.034	0.018
Accomm. standard monetary policy	$Tier1/RWA$	1.854***	2.533***	2.856***	2.216	-1.286***	-1.947***	-3.489***	-6.313***	-0.986***	-1.859***	-3.174***	-4.502***
		(0.248)	(0.410)	(0.698)	(1.167)	(0.210)	(0.342)	(0.577)	(0.968)	(0.205)	(0.336)	(0.570)	(0.959)
	Obs.	59	59	59	59	71	71	71	71	73	73	73	73
	R^2	0.014	0.013	0.011	0.008	0.008	0.008	0.009	0.008	0.005	0.005	0.005	0.005
	$Liq.assets/Dep.$	-0.045***	-0.123***	-0.269***	-0.463***	0.083***	0.118***	0.152***	0.175***	0.038***	0.048**	0.060*	0.092*
		(0.009)	(0.015)	(0.025)	(0.041)	(0.010)	(0.016)	(0.027)	(0.045)	(0.009)	(0.015)	(0.026)	(0.044)
	Obs.	78	78	78	78	89	89	89	89	95	95	95	95
	R^2	0.010	0.009	0.008	0.007	0.007	0.007	0.007	0.007	0.003	0.003	0.004	0.004
Accomm. unconventional monetary policy	$Tier1/RWA$	5.590***	8.944***	12.734***	16.408***	-1.974***	-4.221***	-6.540***	-6.578***	1.297***	2.514***	4.880***	8.651***
		(0.263)	(0.438)	(0.751)	(1.261)	(0.238)	(0.386)	(0.646)	(1.067)	(0.226)	(0.373)	(0.633)	(1.059)
	Obs.	59	59	59	59	71	71	71	71	73	73	73	73
	R^2	0.044	0.041	0.030	0.018	0.028	0.027	0.022	0.013	0.033	0.031	0.023	0.013
	$Liq.assets/Dep.$	-0.145***	-0.214***	-0.233***	-0.067	-0.054***	-0.133***	-0.271***	-0.436***	0.060***	0.084***	0.102***	0.107*
		(0.011)	(0.017)	(0.028)	(0.046)	(0.011)	(0.018)	(0.030)	(0.050)	(0.011)	(0.017)	(0.029)	(0.048)
	Obs.	78	78	78	78	89	89	89	89	95	95	95	95
	R^2	0.025	0.028	0.027	0.021	0.023	0.021	0.016	0.009	0.014	0.014	0.011	0.007

Legend: Based on weighted OLS estimator with weights proportional to the percentage of the variance of bank-level variables explaned by observable and unobservable factors jointly in the FAVAR model. All regressions are controlled for bank's exposure-weighted country dummies, the size of total bank assets and the size of total bank assets squared. *** - statistically significant at below 1% level, ** - statistically significant at 5% level, * - statistically significant at 10% level.

Appendix D Robustness check: Regressions with alternative measures of bank capitalisation and liquidity

Table D.1: The effect of alternative bank capitalisation and liquidity measures on the response of bank-level variables to adverse aggregate demand shocks

Horizon	1Q	2Q	1Y	2Y	1Q	2Q	1Y	2Y
Explained	Long-term NFC loans				Interests on long-term NFC loans			
CAR	0.695***	1.132***	1.526***	1.683**	0.510***	0.528***	0.536***	0.531**
	(0.149)	(0.237)	(0.386)	(0.610)	(0.070)	(0.090)	(0.123)	(0.171)
Obs.	81	81	81	81	64	64	64	64
R^2	0.006	0.005	0.003	0.001	0.132	0.129	0.103	0.064
Tier1/TA	-1.266***	-1.845***	-2.665***	-3.273***	-0.559***	-0.993***	-1.563***	-2.153***
	(0.161)	(0.257)	(0.419)	(0.654)	(0.102)	(0.138)	(0.192)	(0.281)
Obs.	74	74	74	74	58	58	58	58
R^2	0.058	0.041	0.024	0.012	0.342	0.320	0.210	0.093
Liq.assets/TA	-0.031	0.008	0.112**	0.273***	-0.169***	-0.241***	-0.295***	-0.293***
	(0.016)	(0.026)	(0.043)	(0.066)	(0.011)	(0.014)	(0.020)	(0.031)
Obs.	109	109	109	109	86	86	86	86
R^2	0.050	0.036	0.021	0.012	0.289	0.279	0.188	0.084
Inv.LTD	0.224***	0.309***	0.393***	0.451***	-0.077***	-0.095***	-0.099***	-0.084***
	(0.008)	(0.012)	(0.020)	(0.031)	(0.004)	(0.006)	(0.008)	(0.012)
Obs.	98	98	98	98	76	76	76	76
R^2	0.066	0.048	0.028	0.015	0.295	0.284	0.191	0.086
	Short-term NFC loans				Interests on short-term NFC loans			
CAR	-1.580***	-1.845***	-1.818***	-1.444***	0.737***	1.068***	1.207***	1.052**
	(0.057)	(0.082)	(0.124)	(0.187)	(0.095)	(0.137)	(0.207)	(0.329)
Obs.	77	77	77	77	76	76	76	76
R^2	0.210	0.186	0.135	0.085	0.074	0.068	0.040	0.015
Tier1/TA	0.186*	-0.703***	-1.634***	-2.054***	0.710***	1.354***	1.726***	1.681***
	(0.083)	(0.119)	(0.182)	(0.274)	(0.131)	(0.188)	(0.285)	(0.451)
Obs.	72	72	72	72	71	71	71	71
R^2	0.222	0.194	0.141	0.089	0.068	0.063	0.037	0.014
Liq.assets/TA	0.038***	0.119***	0.261***	0.366***	0.132***	0.183***	0.219***	0.223***
	(0.010)	(0.013)	(0.020)	(0.029)	(0.015)	(0.021)	(0.031)	(0.048)
Obs.	100	100	100	100	101	101	101	101
R^2	0.207	0.184	0.135	0.084	0.050	0.048	0.029	0.011
Inv.LTD	-0.006	-0.032***	-0.071***	-0.088***	0.008	0.028**	0.035**	0.029
	(0.005)	(0.006)	(0.009)	(0.014)	(0.006)	(0.009)	(0.014)	(0.022)
Obs.	92	92	92	92	94	94	94	94
R^2	0.214	0.188	0.135	0.082	0.048	0.045	0.027	0.010
	Household loans				Interests on household loans			
CAR	-0.420*	-0.482	-0.136	0.226	2.428***	2.930***	2.845***	2.291***
	(0.164)	(0.258)	(0.413)	(0.637)	(0.103)	(0.143)	(0.206)	(0.314)
Obs.	79	79	79	79	78	78	78	78
R^2	0.053	0.043	0.031	0.020	0.150	0.130	0.074	0.027
Tier1/TA	-5.761***	-7.645***	-8.898***	-9.344***	-1.175***	-1.427***	-1.731***	-2.001***
	(0.224)	(0.358)	(0.579)	(0.898)	(0.109)	(0.153)	(0.224)	(0.346)
Obs.	70	70	70	70	71	71	71	71
R^2	0.062	0.050	0.034	0.021	0.080	0.072	0.042	0.016
Liq.assets/TA	0.095***	0.124***	0.162***	0.244**	-0.184***	-0.233***	-0.232***	-0.184***
	(0.019)	(0.030)	(0.049)	(0.076)	(0.015)	(0.021)	(0.030)	(0.046)
Obs.	106	106	106	106	105	105	105	105
R^2	0.069	0.061	0.049	0.036	0.120	0.103	0.058	0.021
Inv.LTD	0.088***	0.128***	0.179***	0.219***	-0.007	-0.010	0.003	0.025
	(0.009)	(0.015)	(0.024)	(0.038)	(0.005)	(0.007)	(0.010)	(0.015)
Obs.	94	94	94	94	93	93	93	93
R^2	0.072	0.061	0.047	0.032	0.131	0.115	0.065	0.025

Legend: Based on weighted OLS estimator with weights proportional to the percentage of the variance of bank-level variables explaned by observable and unobservable factors jointly in the FAVAR model. All regressions are controlled for bank's exposure-weighted country dummies, the size of total bank assets and the size of total bank assets squared. *** - statistically significant at below 1% level, ** - statistically significant at 5% level, * - statistically significant at 10% level.

Table D.2: The effect of alternative bank capitalisation and liquidity measures on the response of bank-level variables to accommodative standard monetary policy shocks

Horizon	1Q	2Q	1Y	2Y	1Q	2Q	1Y	2Y
Explained	Long-term NFC loans				Interests on long-term NFC loans			
CAR	0.695***	1.132***	1.526***	1.683**	0.510***	0.528***	0.536***	0.531**
	(0.149)	(0.237)	(0.386)	(0.610)	(0.070)	(0.090)	(0.123)	(0.171)
Obs.	81	81	81	81	64	64	64	64
R^2	0.006	0.005	0.003	0.001	0.132	0.129	0.103	0.064
Tier1/TA	-0.438*	-0.358	-0.410	-0.640	-2.169***	-2.270***	-2.348***	-2.408***
	(0.200)	(0.321)	(0.526)	(0.837)	(0.118)	(0.164)	(0.232)	(0.332)
Obs.	74	74	74	74	58	58	58	58
R^2	0.006	0.004	0.003	0.001	0.130	0.127	0.102	0.062
Liq.assets/TA	0.015	-0.016	-0.047	-0.043	0.073***	0.045*	0.011	-0.011
	(0.020)	(0.033)	(0.054)	(0.085)	(0.013)	(0.018)	(0.025)	(0.036)
Obs.	109	109	109	109	86	86	86	86
R^2	0.004	0.003	0.002	0.001	0.121	0.120	0.097	0.060
Inv.LTD	0.017	0.044**	0.071**	0.091*	0.021***	0.006	-0.010	-0.021
	(0.010)	(0.016)	(0.025)	(0.040)	(0.005)	(0.007)	(0.010)	(0.014)
Obs.	98	98	98	98	76	76	76	76
R^2	0.004	0.003	0.002	0.001	0.122	0.121	0.098	0.061
	Short-term NFC loans				Interests on short-term NFC loans			
CAR	-0.146*	-0.428***	-0.727***	-0.885***	0.976***	1.232***	1.473***	1.576***
	(0.062)	(0.093)	(0.146)	(0.226)	(0.129)	(0.187)	(0.275)	(0.404)
Obs.	77	77	77	77	76	76	76	76
R^2	0.027	0.022	0.014	0.007	0.015	0.016	0.013	0.008
Tier1/TA	-0.743***	-0.962***	-1.257***	-1.511***	1.055***	1.493***	1.925***	2.201***
	(0.097)	(0.143)	(0.221)	(0.339)	(0.180)	(0.259)	(0.378)	(0.553)
Obs.	72	72	72	72	71	71	71	71
R^2	0.033	0.025	0.015	0.008	0.015	0.016	0.013	0.008
Liq.assets/TA	-0.010	-0.054***	-0.074**	-0.055	-0.088***	-0.065*	-0.041	-0.028
	(0.012)	(0.016)	(0.024)	(0.036)	(0.020)	(0.028)	(0.041)	(0.059)
Obs.	100	100	100	100	101	101	101	101
R^2	0.026	0.022	0.015	0.008	0.011	0.011	0.009	0.006
Inv.LTD	0.001	0.009	0.009	0.002	0.007	0.024	0.039*	0.043
	(0.005)	(0.008)	(0.012)	(0.017)	(0.009)	(0.012)	(0.018)	(0.027)
Obs.	92	92	92	92	94	94	94	94
R^2	0.030	0.024	0.016	0.008	0.009	0.010	0.008	0.005
	Household loans				Interests on household loans			
CAR	-0.986***	-1.479***	-1.798***	-1.745*	1.392***	2.050***	2.626***	2.843***
	(0.196)	(0.314)	(0.511)	(0.809)	(0.137)	(0.190)	(0.269)	(0.383)
Obs.	79	79	79	79	78	78	78	78
R^2	0.005	0.004	0.002	0.001	0.035	0.037	0.030	0.018
Tier1/TA	-2.266***	-3.455***	-4.504***	-4.953***	-0.208	-0.254	-0.319	-0.346
	(0.278)	(0.446)	(0.726)	(1.146)	(0.151)	(0.209)	(0.295)	(0.421)
Obs.	70	70	70	70	71	71	71	71
R^2	0.005	0.004	0.002	0.001	0.028	0.026	0.020	0.012
Liq.assets/TA	0.009	0.024	0.025	0.017	-0.154***	-0.213***	-0.270***	-0.301***
	(0.023)	(0.037)	(0.061)	(0.097)	(0.020)	(0.028)	(0.040)	(0.057)
Obs.	106	106	106	106	105	105	105	105
R^2	0.004	0.003	0.002	0.001	0.027	0.029	0.024	0.014
Inv.LTD	-0.048***	-0.047*	-0.043	-0.038	-0.013*	-0.029**	-0.044***	-0.049**
	(0.012)	(0.019)	(0.030)	(0.048)	(0.007)	(0.009)	(0.013)	(0.018)
Obs.	94	94	94	94	93	93	93	93
R^2	0.005	0.004	0.002	0.001	0.027	0.029	0.024	0.015

Legend: Based on weighted OLS estimator with weights proportional to the percentage of the variance of bank-level variables explaned by observable and unobservable factors jointly in the FAVAR model. All regressions are controlled for bank's exposure-weighted country dummies, the size of total bank assets and the size of total bank assets squared. *** - statistically significant at below 1% level, ** - statistically significant at 5% level, * - statistically significant at 10% level.

Table D.3: The effect of alternative bank capitalisation and liquidity measures on the response of bank-level variables to accommodative unconventional monetary policy shocks

Horizon	1Q	2Q	1Y	2Y	1Q	2Q	1Y	2Y
Explained	Long-term NFC loans				Interests on long-term NFC loans			
CAR	-0.086	-0.102	-0.600	-1.507*	0.487***	0.379***	0.318**	0.407*
	(0.161)	(0.254)	(0.406)	(0.629)	(0.068)	(0.088)	(0.121)	(0.177)
Obs.	81	81	81	81	64	64	64	64
R^2	0.027	0.026	0.020	0.012	0.041	0.028	0.008	0.007
Tier1/TA	-3.016***	-4.107***	-5.517***	-6.677***	-0.460***	-0.479**	-0.569**	-0.822*
	(0.215)	(0.343)	(0.552)	(0.860)	(0.108)	(0.149)	(0.218)	(0.331)
Obs.	74	74	74	74	58	58	58	58
R^2	0.030	0.029	0.022	0.013	0.039	0.031	0.008	0.004
Liq.assets/TA	0.219***	0.268***	0.365***	0.524***	-0.073***	-0.147***	-0.213***	-0.219***
	(0.022)	(0.035)	(0.056)	(0.088)	(0.012)	(0.016)	(0.024)	(0.036)
Obs.	109	109	109	109	86	86	86	86
R^2	0.025	0.024	0.019	0.011	0.036	0.026	0.008	0.007
Inv.LTD	0.107***	0.158***	0.205***	0.236***	-0.086***	-0.103***	-0.106***	-0.088***
	(0.010)	(0.017)	(0.027)	(0.042)	(0.005)	(0.007)	(0.009)	(0.014)
Obs.	98	98	98	98	76	76	76	76
R^2	0.027	0.026	0.019	0.011	0.037	0.026	0.008	0.007
	Short-term NFC loans				Interests on short-term NFC loans			
CAR	-0.811***	-1.009***	-0.925***	-0.452	-0.325**	-0.183	-0.245	-0.599
	(0.063)	(0.094)	(0.150)	(0.234)	(0.115)	(0.166)	(0.254)	(0.399)
Obs.	77	77	77	77	76	76	76	76
R^2	0.104	0.098	0.077	0.050	0.031	0.028	0.017	0.008
Tier1/TA	-0.357***	-1.401***	-2.491***	-2.941***	0.752***	1.313***	1.473***	1.062
	(0.098)	(0.146)	(0.227)	(0.349)	(0.165)	(0.234)	(0.353)	(0.549)
Obs.	72	72	72	72	71	71	71	71
R^2	0.116	0.106	0.083	0.053	0.032	0.029	0.017	0.008
Liq.assets/TA	0.131***	0.334***	0.626***	0.865***	-0.005	0.027	0.048	0.036
	(0.012)	(0.016)	(0.024)	(0.037)	(0.019)	(0.026)	(0.038)	(0.059)
Obs.	100	100	100	100	101	101	101	101
R^2	0.098	0.095	0.076	0.049	0.035	0.028	0.016	0.007
Inv.LTD	-0.050***	-0.110***	-0.193***	-0.251***	-0.039***	-0.037**	-0.049**	-0.076**
	(0.005)	(0.007)	(0.011)	(0.018)	(0.008)	(0.011)	(0.017)	(0.027)
Obs.	92	92	92	92	94	94	94	94
R^2	0.105	0.099	0.077	0.049	0.036	0.028	0.016	0.007
	Household loans				Interests on household loans			
CAR	2.656***	3.788***	5.537***	7.211***	0.229	0.067	-0.788**	-2.077***
	(0.214)	(0.339)	(0.540)	(0.835)	(0.129)	(0.176)	(0.254)	(0.385)
Obs.	79	79	79	79	78	78	78	78
R^2	0.020	0.020	0.017	0.011	0.044	0.035	0.022	0.015
Tier1/TA	-0.433	-0.490	0.282	1.579	-1.011***	-0.892***	-0.884**	-1.018*
	(0.302)	(0.480)	(0.766)	(1.181)	(0.150)	(0.203)	(0.288)	(0.430)
Obs.	70	70	70	70	71	71	71	71
R^2	0.024	0.023	0.019	0.013	0.045	0.036	0.021	0.011
Liq.assets/TA	-0.058*	-0.141***	-0.235***	-0.260**	-0.230***	-0.246***	-0.201***	-0.107
	(0.025)	(0.040)	(0.064)	(0.100)	(0.018)	(0.025)	(0.037)	(0.056)
Obs.	106	106	106	106	105	105	105	105
R^2	0.020	0.020	0.017	0.013	0.037	0.027	0.016	0.011
Inv.LTD	0.023	0.052**	0.095**	0.137**	-0.045***	-0.029***	0.006	0.052**
	(0.013)	(0.020)	(0.032)	(0.049)	(0.006)	(0.009)	(0.012)	(0.019)
Obs.	94	94	94	94	93	93	93	93
R^2	0.021	0.020	0.017	0.012	0.038	0.029	0.017	0.010

Legend: Based on weighted OLS estimator with weights proportional to the percentage of the variance of bank-level variables explaned by observable and unobservable factors jointly in the FAVAR model. All regressions are controlled for bank's exposure-weighted country dummies, the size of total bank assets and the size of total bank assets squared. *** - statistically significant at below 1% level, ** - statistically significant at 5% level, * - statistically significant at 10% level.

Appendix E Robustness check: Regressions including both bank capitalisation and liquidity measures

Table E.1: The effect of Tier1 capital and liquid assets to deposit ratios (included jointly in the regressions) on the response of bank-level to structural shocks

	Horizon	1Q	2Q	1Y	2Y	1Q	2Q	1Y	2Y
	Explained	Long-term NFC loans				Interests on long-term NFC loans			
Adverse aggregate demand	*Tier1/RWA*	0.898***	1.587***	2.092***	2.064*	3.250***	3.860***	3.394***	2.167***
		(0.196)	(0.318)	(0.526)	(0.830)	(0.137)	(0.184)	(0.262)	(0.393)
	Liq.assets/Dep.	0.177***	0.247***	0.327***	0.413***	-0.084***	-0.092***	-0.122***	-0.150***
		(0.012)	(0.020)	(0.032)	(0.050)	(0.007)	(0.009)	(0.012)	(0.017)
	Obs.	71	71	71	71	57	57	57	57
	R^2	0.044	0.033	0.020	0.011	0.337	0.317	0.209	0.093
		Short-term NFC loans				Interests on short-term NFC loans			
	Tier1/RWA	-0.794***	-0.785***	-0.354	0.267	1.735***	2.097***	1.965***	1.484*
		(0.104)	(0.143)	(0.206)	(0.300)	(0.199)	(0.285)	(0.429)	(0.677)
	Liq.assets/Dep.	0.134***	0.200***	0.265***	0.294***	-0.068***	-0.096***	-0.104***	-0.098***
		(0.005)	(0.008)	(0.012)	(0.018)	(0.009)	(0.012)	(0.018)	(0.029)
	Obs.	67	67	67	67	69	69	69	69
	R^2	0.219	0.191	0.138	0.086	0.075	0.069	0.040	0.015
		Household loans				Interests on household loans			
	Tier1/RWA	-6.587***	-8.566***	-9.308***	-8.678***	1.247***	1.314***	1.227***	1.024*
		(0.256)	(0.407)	(0.656)	(1.017)	(0.146)	(0.202)	(0.293)	(0.448)
	Liq.assets/Dep.	0.067***	0.047*	-0.002	-0.050	0.023*	0.041**	0.060**	0.074**
		(0.014)	(0.022)	(0.035)	(0.055)	(0.010)	(0.013)	(0.019)	(0.029)
	Obs.	68	68	68	68	68	68	68	68
	R^2	0.055	0.044	0.031	0.020	0.150	0.131	0.075	0.029
Accomm. standard monetary policy		Long-term NFC loans				Interests on long-term NFC loans			
	Tier1/RWA	-0.244	0.034	0.395	0.701	3.046***	4.206***	5.258***	5.709***
		(0.252)	(0.408)	(0.674)	(1.078)	(0.171)	(0.231)	(0.324)	(0.458)
	Liq.assets/Dep.	0.074***	0.094***	0.111**	0.127*	0.168***	0.192***	0.207***	0.204***
		(0.015)	(0.025)	(0.041)	(0.065)	(0.008)	(0.010)	(0.013)	(0.019)
	Obs.	71	71	71	71	57	57	57	57
	R^2	0.006	0.004	0.003	0.001	0.136	0.133	0.106	0.066
		Short-term NFC loans				Interests on short-term NFC loans			
	Tier1/RWA	0.624***	0.281	0.015	-0.011	1.421***	1.975***	2.460***	2.684**
		(0.117)	(0.163)	(0.242)	(0.362)	(0.278)	(0.393)	(0.567)	(0.825)
	Liq.assets/Dep.	0.003	0.020*	0.042**	0.057**	-0.138***	-0.168***	-0.193***	-0.204***
		(0.006)	(0.009)	(0.014)	(0.021)	(0.012)	(0.017)	(0.024)	(0.035)
	Obs.	67	67	67	67	69	69	69	69
	R^2	0.029	0.023	0.014	0.007	0.019	0.019	0.015	0.009
		Household loans				Interests on household loans			
	Tier1/RWA	-3.713***	-5.419***	-6.951***	-7.544***	0.948***	1.077***	1.168**	1.196*
		(0.316)	(0.505)	(0.821)	(1.298)	(0.200)	(0.274)	(0.383)	(0.541)
	Liq.assets/Dep.	0.040*	0.060*	0.073	0.074	0.012	0.021	0.027	0.026
		(0.017)	(0.027)	(0.044)	(0.069)	(0.013)	(0.017)	(0.025)	(0.035)
	Obs.	68	68	68	68	68	68	68	68
	R^2	0.007	0.006	0.003	0.001	0.032	0.033	0.027	0.017
Accomm. unconventional monetary policy		Long-term NFC loans				Interests on long-term NFC loans			
	Tier1/RWA	2.277***	3.317***	4.219***	4.472***	1.836***	1.490***	-0.214	-2.787***
		(0.273)	(0.438)	(0.710)	(1.108)	(0.158)	(0.211)	(0.303)	(0.460)
	Liq.assets/Dep.	0.159***	0.186***	0.209***	0.245***	-0.070***	-0.133***	-0.226***	-0.311***
		(0.017)	(0.027)	(0.043)	(0.067)	(0.007)	(0.009)	(0.013)	(0.019)
	Obs.	71	71	71	71	57	57	57	57
	R^2	0.032	0.029	0.022	0.012	0.044	0.031	0.011	0.009
		Short-term NFC loans				Interests on short-term NFC loans			
	Tier1/RWA	1.191***	1.588***	2.475***	3.591***	0.315	0.307	-0.371	-1.502
		(0.117)	(0.162)	(0.244)	(0.371)	(0.265)	(0.366)	(0.539)	(0.828)
	Liq.assets/Dep.	-0.014*	0.044***	0.106***	0.128***	-0.023*	-0.021	0.012	0.060
		(0.006)	(0.009)	(0.014)	(0.022)	(0.011)	(0.016)	(0.023)	(0.036)
	Obs.	67	67	67	67	69	69	69	69
	R^2	0.114	0.109	0.088	0.057	0.033	0.029	0.018	0.008
		Household loans				Interests on household loans			
	Tier1/RWA	0.613	0.725	2.310**	5.098***	-0.693***	-0.666*	-0.813*	-1.071
		(0.344)	(0.544)	(0.866)	(1.338)	(0.196)	(0.262)	(0.369)	(0.550)
	Liq.assets/Dep.	-0.000	-0.040	-0.118*	-0.196**	-0.099***	-0.110***	-0.126***	-0.141***
		(0.018)	(0.029)	(0.046)	(0.071)	(0.012)	(0.016)	(0.023)	(0.035)
	Obs.	68	68	68	68	68	68	68	68
	R^2	0.020	0.019	0.017	0.011	0.047	0.037	0.022	0.013

Legend: Based on weighted OLS estimator with weights proportional to the percentage of the variance of bank-level variables explaned by observable and unobservable factors jointly in the FAVAR model. All regressions are controlled for bank's exposure-weighted country dummies, the size of total bank assets and the size of total bank assets squared. *** - statistically significant at below 1% level, ** - statistically significant at 5% level, * - statistically significant at 10% level.

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