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The benefits and costs of adjusting bank capitalisation: evidence from euro area countries

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Abstract:

The paper proposes a framework for assessing the impact of system-wide and bank-level capital buffers. The assessment rests on a factor-augmented vector autoregression (FAVAR) model that relates individual bank adjustments to macroeconomic dynamics. We estimate FAVAR models individually for eleven euro area economies and identify structural shocks, which allow us to diagnose key vulnerabilities of national banking systems and estimate short-run economic costs of increasing banks' capitalisation. On this basis, we run a fully-fledged cost-benefit assessment of an increase in capital buffers. The benefits are related to an increase in bank resilience to adverse shocks. Higher capitalisation allows banks to withstand negative shocks and moderates the reduction of credit to the real economy that ensues in adverse circumstances. The costs relate to transitory credit and output losses that are assessed both on an aggregate and bank level. An increase in capital ratios is shown to have a sharply different impact on credit and economic activity depending on the way banks adjust, i.e. via changes in assets or equity.

JEL: E51, G21, G28

Keywords: FAVAR, capital regulation, cost-benefit analysis, banking system resilience

Non-technical summary

This paper explores the merits of a structural factor-augmented vector autoregression (FAVAR) model for the assessment of macroprudential policies. The FAVAR model ties together a rich set of individual bank-level data with key macroeconomic aggregates, such as GDP and residential and commercial property prices. It is estimated on national data for eleven euro area countries: Belgium, Cyprus, France, Ireland, Italy, Finland, Lithuania, the Netherlands, Portugal, Slovenia, and Spain, and employed to assess: (i) structural vulnerabilities of national banking systems and individual banks, (ii) long-term benefits from capital-based regulation, and (iii) short-term costs of the tightening of capital-based regulation.

Combining micro- and macroeconomic data within a FAVAR framework has several advantages from the policy perspective. First, we can use the model to gauge both macroeconomic effects, i.e. how much total credit or GDP of a country are affected, and bank-level reactions to a structural shock or a policy change. As such, a FAVAR-based analysis provides more than system-wide insights and helps diagnose the vulnerabilities of single institutions depending on their business model, ownership or exposure structure. Second, a FAVAR analysis informs about the distributional effects of shocks and policy actions. Third, a FAVAR model may be employed to look at the propagation of shocks affecting only selected institutions in the system. Last, irrespective of its complexity, the model remains very flexible and can be applied to a broad range of policy questions.

Three different specifications of a FAVAR model are employed to address three types of policy questions. The first exercise evaluates the role of capital buffers in the propagation of macroeconomic shocks into bank lending. The second exercise assesses the effects of changes in the average capitalisation level of banks on their lending, and later on economic activity. The third exercise distinguishes between the effects of changes in bank-level capital ratios accommodated either by an adjustment of banks assets or by an adjustment in the level of banks' capital. The last simulation presents the effects of capital shocks which affect the majority of banks in the system.

The first exercise is designed to inform about the long-run benefits from high bank capitalisation. We choose the specification of a FAVAR model which describes the propagation of aggregate demand and real property prices into bank lending, credit risk, capitalisation and profits. This specification of FAVAR allows us to assess system-wide and bank-level vulnerabilities. As the next step, we link the differences in banks' responses to structural shocks to their initial capitalisation levels in a series of bank-level regressions. The regression estimates point to a moderating impact of higher capital buffers on the propagation of structural shocks.

Our notion of benefits from capital regulation relates to the impact of banks' capital on their resilience, i.e. their ability to withstand adverse shocks originating outside the banking system with minimum impact on the supply of credit to the private sector. While assessing the benefits from capital regulation, we derive the difference between the reduction in credit by highly capitalised and lower capitalised banks in response to a combination of adverse structural shocks. This difference is a measure of the benefits from holding higher capital buffers. As a numerical example, we consider the benefits related to building-up of capital buffers as in 2015, starting from their 2010 levels and the reference level of 8.5% of Tier1 ratio.

The costs of an increase in bank capitalisation relate to short-term losses in credit and GDP. In our second exercise, we look at the consequences of an immediate increase in the average (system-wide) capital ratio, which is assumed to have a negative impact on banks' assets and a positive effect on lending spreads. This specification emphasises that an increase in capital requirements can trigger deleveraging, and banks will aim at reducing risk-weighted assets (the denominator of the capital ratio) by shrinking their balance sheet or shifting the risk profile of their assets towards less risky exposures. Banks' deleveraging limits the availability of bank credit for the real economy. If other financial intermediaries or forms of financing (bonds issuance by firms) do not substitute this shortfall in bank credit, the cost of financing for the private sector will increase and ultimately harm aggregate output. In order to separate the capital shock from other credit supply shocks, we additionally assume that it involves an immediate fall in banks' financing costs (deposit spreads or CDS).

The alternative avenue of estimating short-term costs involves restrictions on the bank-level impact of structural capital shocks. We extend the structural shock identification and express an increase in a system-wide capital buffer as a series of capital increases on a bank-level rather than an increase in the average capitalisation level. This approach allows us to explore bank-level information more comprehensively and increases the precision of structural identification in cases when we know that an increase in capital buffers affects only selected banks (e.g. the imposition of an O-SII buffer).

In the specification with the bank-level identification of structural shocks, we recognise that an increase in capital ratios can have a different impact on credit supply and economic activity depending on the way banks adjust their assets versus capital. To this end, we distinguish between a deleveraging shock, where an increase in capital ratios is accommodated by a reduction in bank assets, and a 'beefing-up' capital shock, where an increase in capital ratios is accommodated by an increase in regulatory capital (with no initial effect on assets).

Our empirical results suggest that higher bank capitalisation smoothens the supply of credit to the economy over the business cycle. Further, we document a different relationship between banks' capitalisation and their reaction to structural shocks for large (G-SII and O-SII) banks and other (medium and small size) banks. In particular, the moderating effect of higher bank capitalisation on the propagation of shocks originating in the real economy is more pronounced and longer-lasting for large banks.

A permanent increase in a system-wide Tier1 ratio triggers significant though country-specific effects. Our estimates suggest that following an increase in the average system-wide capital ratio by 1pp accommodated by banks' deleveraging leads to a fall in credit to the non-financial private sector by 1-3% and in output by 0-2% (depending on the country). However, an increase in capital ratios will have an expansionary effect on credit and economic activity if most of the banks in the system adjust their balance sheets by beefing up capital rather than reducing assets. Irrespective of banks adjustment path, an increase in capital ratios is likely to increase lending and reduce deposit margins.

1 Introduction

Last years witnessed an increased use of macroprudential instruments by European supervisory authorities. This trend boils down to two factors: an increased awareness of systemic risks, and the availability of the standardised macroprudential toolbox in all European countries, that followed the implementation of Basel III (Basel Committee on Banking Supervision, 2011) into the European framework. The increased use of macroprudential instruments urges the assessment of their effectiveness and transmission channels.

This paper explores the merits of a structural factor-augmented vector autoregression (FAVAR) model for the assessment of macroprudential policies. The FAVAR model ties together a rich set of individual bank-level data with key macroeconomic aggregates, such as GDP and residential and commercial property prices. It is estimated on national data for eleven euro area countries: Belgium, Cyprus, France, Ireland, Italy, Finland, Lithuania, the Netherlands, Portugal, Slovenia, and Spain, and employed to assess: (i) structural vulnerabilities of national banking systems and individual banks, (ii) long-term benefits from capital-based regulation, and (iii) short-term costs of capital-based regulation.

Combining micro- and macroeconomic data within a FAVAR framework has several advantages from the policy perspective. First, we can use the model to gauge both macroeconomic effects, i.e. how much total credit or GDP of a country are affected, and bank-level reactions to a structural shock or a policy change. As such, a FAVAR-based analysis provides more than system-wide insights and helps diagnose the vulnerabilities of single institutions depending on their business model, ownership or exposure structure. Second, a FAVAR analysis informs about the distributional effects of shocks and policy actions. Third, a FAVAR model may be employed to look at the propagation of shocks affecting only selected institutions in the system. Last, irrespective of its complexity, the model remains very flexible and can be applied to a broad range of policy questions.

Applications of FAVAR models to banking data are a relatively small but fast expanding literature. Closest to ours are the papers by Buch et al. (2014), who use US data (‘Call reports’), and Jimborean and Mésonnier (2010), who use confidential French data in an application to monetary policy. Another paper sharing methodological similarities with this paper is Budnik and Bochmann (2017) who discuss how macroprudential and monetary policy impact the lending and interest rates of euro area banks.

Three different specifications of a FAVAR model are employed to address three types of policy questions. The first exercise evaluates the role of capital buffers in the propagation of macroeconomic shocks into bank lending. The second exercise assesses the effects of changes in the average capitalisation level of banks on their lending, and later on economic activity. The third exercise distinguishes between the effects of changes in bank-level capital ratios accommodated either by an adjustment of banks' assets or by an adjustment in the level of banks' capital. The last simulation describes the effects of capital shocks which affect the majority of banks in the system.

The first exercise is designed to inform about the long-run benefits from high bank capitalisation. We choose the specification of a FAVAR model which describes the propagation of aggregate demand and real property prices into bank lending, credit risk, capitalisation and profits. This specification of FAVAR allows us to assess system-wide and bank-level vulnerabilities. As the next step, we link the differences in banks' responses to structural shocks to their capitalisation levels in a series of bank-level regressions. The regression estimates point to a moderating impact of higher capital buffers on the propagation of structural shocks.

Our notion of benefits from capital regulation relates to the impact of banks' capital on their resilience, i.e. their ability to withstand adverse shocks originating outside the banking system with minimum impact on the supply of credit to the private sector. While assessing the benefits from capital regulation, we derive the difference between the reduction in credit by highly capitalised and lower capitalised banks in response to a combination of negative structural shocks. This difference is a measure of the benefits from holding higher capital buffers. As a numerical example, we consider the benefits related capital buffers as in 2015 compared to their 2010 levels and compared to the reference level of 8.5% of Tier1 ratio.

In our assessment, the benefits from capital buffers correspond with additional credit granted by banks under an adverse scenario. This approach deviates from the empirical literature discussing the long-term benefits of higher capital buffers related to reducing the probability of bank insolvency and banking crisis. Miles et al. (2013) measure the benefits of higher capital buffers as the product of a change in the probability of insolvency and the cost of insolvency resulting from banks holding more equity. The Basel Committee on Banking Supervision's long-term economic impact exercise (Macroeconomic Assessment Group, 2010) and later Behn et al. (2016) measure the gains of capital regulation as the expected output increase associated with the reduction in the likeliness and severity of banking crises. Arregui et al. (2013) also assume that changes in the regulation affect the expected probability of a crisis. The cost-benefit analysis takes place through a comparison of the 2-step-ahead output forecasts: one in a scenario with and another in a scenario without policy implementation.

The costs of bank capitalisation correspond with short-term losses in credit and GDP. In our second exercise, we look at the consequences of an immediate increase in the average system-wide capital ratio, which is assumed to have a negative impact on banks' assets and a positive effect on lending spreads. This specification emphasises that an increase in capital requirements can trigger deleveraging, and banks will aim at reducing risk-weighted assets (the denominator of the capital ratio) by shrinking their balance sheet or shifting the risk profile of their assets towards less risky exposures. Accordingly, bank credit for the real economy becomes scarcer. If other financial intermediaries or forms of financing (bonds issuance by firms) do not pick this shortfall in bank credit, it will drive an increase in the cost of financing for the private sector and ultimately harm aggregate output. In order to separate the capital shock from other credit supply shocks, we assume that it involves an immediate fall in banks' financing costs (deposit spreads or CDS).

An aggregate bank capital shock is specified similarly to other VAR-based studies. Meeks (2017) applies a Bayesian VAR with 11 variables to UK data and explores the information on actual and prudential capital ratios. His main result is that an increase in capital requirements lowers lending to firms and households, reduces aggregate expenditures and raises credit spreads. Noss and Toffano (2016) use a five-variable VAR and impose a set of directional constraints on the responses of macroeconomic variables to capital requirement shocks. Following an exogenous increase in capital, bank lending falls, non-financial corporates substitute bank capital by bonds, bank returns fall relative to market returns. The authors find that a positive capital shock has a significant negative effect on bank lending but not on GDP. The analysis conducted by the Macroeconomic Assessment Group (2010) also falls under this category and infers the macroeconomic impact of increases in capital requirements under the assumption that higher capital requirements would raise the weighted average cost of capital and prompt an increase in lending spreads. Their results point to small effects of capital requirements on output (see also Cecchetti, 2014).

Our alternative approach to estimating short-term costs of increasing capital buffers explores bank-level impact restrictions. We extend the structural shock identification in a FAVAR framework beyond what has been presented in the literature. An increase in a system-wide capital buffer corresponds to a series of capital increases on a bank-level rather than an increase in the average capitalisation level. Such an identification scheme allows us to explore bank-level information more efficiently and increases the precision of structural identification in cases when an increase in capital buffers affects only selected banks (e.g. the imposition of an O-SII buffer).

In the last specification involving bank-level identification of structural shocks, we also recognise that an increase in capital ratios can have a different impact on credit supply and economic activity depending on the way banks adjust their assets versus capital. The evidence collected by Cohen and Scatigna (2014) shows that between 2009 and 2013 euro area banks used a mix of deleveraging and equity issuance to meet higher capital requirements. Banks based in the US and European countries reached higher capital ratios by raising equity, at the same time increasing rather than reducing assets. Two-thirds of an increase in equity attributes to retaining of earnings, the remaining one-third to issuing new equity. Accordingly, we distinguish between a deleveraging shock, where banks accommodate an increase in capital ratios by a reduction in bank assets, and a 'beefing-up' capital shock, where banks accommodate an increase in capital ratios by an increase in regulatory capital (with no initial effect on assets).

Our empirical results suggest that higher bank capitalisation smoothens the supply of credit to the economy over the business cycle. Further, we document that the relationship between banks' capitalisation and their reaction to structural shocks differs for large (G-SII and O-SII) and other (medium and small size) banks. In particular, the moderating effect of higher bank capitalisation on the propagation of real economic shocks is more pronounced and long-lasting for large banks.

A permanent increase in Tier1 ratio triggers significant though country and adjustment specific effects. Our estimates suggest that following an increase in the system-wide capital ratio by 1pp accommodated predominantly via banks' deleveraging, there is a fall in credit to the non-financial private sector by 1-3% and in output by 0-2% (depending on the country). However, an increase in capital ratios will have an expansionary effect on credit and economic activity as long as most of the banks in the system adjust by beefing up capital rather than reducing assets. Irrespective of a banks' adjustment profile an increase in capital ratios is likely to increase lending margins and reduce deposit margins.

Our study contributes to the emerging literature on the effects of capital regulation. Other authors have assessed the macroeconomic effects of changes in capital requirements using micro-level bank data. Aiyar et al. (2014a, 2014b) find that banks that were subject to UK capital regulation between 1998 and 2007 responded by reducing by more than 5pp the rate of growth of lending. Bridges et al. (2014) refine the study by Aiyar et al. (2014a) and find that in the year following an increase in capital requirements, banks cut loans backed by commercial property more than other loans to corporates and households. Berrospide and Edge (2010) find minimal effects of capital changes on bank lending. Using a similar setup, but extending the sample to a large number of advanced and emerging countries, De Nicolò (2015) finds significant and negative short-run, and long-run impact of an increase in capital requirements on bank lending. Other studies exploit the announcement of higher capital needs by the European Banking Authority in 2012. Applying this approach Mésonnier and Monks (2014) find that an increase in the regulatory ratio by 1pp reduced bank credit growth in a sample of euro area banks by 1.2%. Fraisse et al. (2015) extend the analysis to study the impact on corporate borrowing and business activity. In their analysis, a 1 pp increase in capital requirements is found to lead to a reduction in lending between 3 and 8 per cent, and reduce firms' investment and employment.

The paper is structured as follows. The next two sections discuss the methodology and the datasets employed in the analysis. Section 4 provides a summary of the results on the transmission of business and housing cycle shocks into bank-level variables. Elaborating on these results, Section 5 presents the assessment of benefits from capital regulation. Finally, Sections 6 and 7 discuss two different approaches to measurement of short-term costs of imposing higher capital buffers. Section 8 concludes.

2 FAVAR model and its application to bank-level data

A factor-augmented vector autoregressive model (FAVAR) augments a standard VAR with a set of latent variables. The latter variables are called unobserved factors and commonly summarise a large amount of additional information. Bernanke et al. (2005) and later Boivin and Giannoni (2007) proposed the model to overcome potential misspecification error in cases when only a narrow set of variables are perfectly observable in a data-rich environment.

The advantage of the FAVAR model that we exploit is its ability to summarise the behaviour of a large dataset of bank-level information. The model captures the co-movements of hundreds of these variables in a limited number of common factors, only moderately increasing the number of estimated VAR model parameters. Thus, the FAVAR approach allows us to model the banking system in detail while preventing the curse of dimensionality. [1]

Endogenous variables in a FAVAR include a narrow set of observable variables ${F^y}_t$ and a set of latent factors F_t^x. Let $F_t = [F_t^{y\prime}\ F_t^{x\prime}]$' be the $(M + K)$ x 1 vector which collects both the M x 1 vector of observed variables and the K x 1 vector of unobserved common factors F_t^x. The structural VAR model can be expressed as:

$$AF_t = \Gamma(L)F_{t-1} + e_t \quad (1)$$

where $\Gamma(L)$ is a lag polynomial of order p and $e_t \sim i.i.d.(0, \Omega)$ is a $(M + K)$ x 1 vector of structural shocks with mean zero and diagonal covariance matrix Ω. The VAR model can also be expressed in its reduced-form representation as:

$$F_t = \phi(L)F_{t-1} + \epsilon_t \quad (2)$$

where $\phi(L) = A^{-1}\Gamma(L)$ and vector of reduced form innovation $\epsilon_t = A^{-1}e_t \sim N(0, \Sigma)$ with $\Sigma = A^{-1}\Omega(A^{-1})'$.

[1] In the original application of Boivin and Giannoni (2007) the policy instrument of the central bank is perfectly observable and the underlying dynamics of the economy are less perfectly observable.

The latent factors F_t^x are computed on the basis of a large set of N time series contained in X_t. The observation equation links the N x 1 vector X_t of observable variables to both observed and unobserved factors in F_t:

$$X_t = \Delta^y F_t^y + \Delta^x F_t^x + u_t = \Lambda F_t + u_t \tag{3}$$

where Δ^y and $\Delta^x$are, respectively, N x M and N x K matrices of factor loadings, which measure the sensitivity of the individual variables in X_t to each common factor (observed and unobserved), and u_t is a N x 1 vector of idiosyncratic disturbances that are normally distributed with mean zero and diagonal covariance matrix H.[2] Furthermore, it is assumed that:

- latent factors F_t^x are orthogonal to the observed variables F_t^y;
- latent factors are mutually orthogonal;
- disturbances are uncorrelated with the factors, $E[u_{i,t}\, F_t] = 0, \forall i = 1 \dots N$;
- disturbances are not serially or cross-sectionally correlated:

$$E[u_{i,t}\, u_{j,s}] = 0, \forall i, j = 1 \dots N \; and \; \forall t, s = 1, \dots T, t \neq s.$$

In our application, X_t consists of N bank-level variables that are assumed to be covariance-stationary. Hence, $K \ll N$ unobserved factors in F_t^x reflect the common dynamics of the bank-level variables in each period t after controlling for the evolution of observed factors. Equations (2) and (3) taken together summarise the structure of a FAVAR model.

The structural FAVAR is estimated in three steps as in e.g. Boivin and Giannoni (2007). First, we select the observed macroeconomic variables F_t^y and a set of bank level variables X_t and estimate the latent factors F_t^x as in (3). Second, we replace F_t^x in equation (2) by the latent factors estimated in the first step, and estimate the reduced-form VAR model. Third, we search for a set of structural shocks e_t by imposing zero and sign impact restrictions.

For the purpose of deriving F_t^x we apply the algorithm described by Budnik and Bochmann (2018). We regress X_t on F_t^y, and derive the latent factors as the first principal components (PC) of the full set of regression residuals. Further, we impose a standard normalization restriction on factor loadings to uniquely identify the unobserved factors (up to a sign). When choosing the number of unobserved factors, K, we aim at explaining at least 50% of the contemporaneous variation in bank-level variables (on average).

[2] Bai and Ng (2002) and Stock and Watson (2002) refer to this equation as an approximate dynamic factor model, which means that F_t^x can include lags of fundamental factors.

In the next step, we estimate reduced form VAR model applying Bayesian methods. We use Gibbs sampler and the independent Normal-Wishart prior with mean VAR coefficients set at zero (with no shrinkage). The number of lags, p, is set based on a set of standard lag selection criteria (AIC, BIC).

The algorithm of Arias et al. (2014) offers an efficient way to draw from the unrestricted posterior of model parameters knowing the distribution of the reduced-form VAR parameters. We search for a set of structural shocks e_t imposing zero and sign restrictions motivated by the existing literature on impulse response functions (IRFs).

Last, we analyse impulse response functions of variables entering F_t and X_t. The IRFs of all common factors, observable and latent, are derived from the moving average representation of our VAR model, i.e. from $F_t = \Psi(L)\epsilon_t$=$\Psi(L)A^{-1}e_t$ where $\Psi(L) = I - \phi(L)$. The IRFs of bank-level variables entering X_t are derived conditional on the estimates of $\Psi(L)$ and Λ from $X_t = \Lambda\Psi(L)\epsilon_t + u_t = \Lambda\Psi(L)A^{-1}e_t + u_t$.[3]

3 Data

3.1 Macro variables

Macroeconomic variables stem from public data sources. These include GDP, GDP deflator, residential real estate prices, and commercial property prices, when available. We also use the aggregate measure of system-wide credit to the non-financial private sector, stock prices, CDS, lending and deposit rates.

3.2 Bank-level datasets

We reach to two different and confidential sources of information on bank-level variables.[4] These are: (i) supervisory reports consisting of the balance sheet and income statements collected by national authorities for supervisory purposes, and if the former were not available, (ii) monetary financial institutions (MFI)[5] balance sheet statistics collected by national central banks for monitoring monetary developments. Appendix A discusses the differences between these data sources and provides a detailed overview of country-level datasets.

Bank-level information is used mostly on a consolidated or semi-consolidated level (see Table 3.1). Exceptions are Belgium, Lithuania and Spain, where models refer to bank-level variables on a solo

[3] IRFs are computed as the partial derivative with respect to a structural shock.

[4] The confidentiality of bank-level datasets prohibited pooling of bank-level variables for different countries to estimate multi-country rather than single-country FAVAR models. This technical impediment made it impossible to e.g. study cross-border spillover effects.

[5] Monetary financial institutions' (MFI) balance sheet and interest rate statistics conform to international and European statistical standards, currently the European System of Accounts (ESA 2010).

level. For Lithuania, there is no difference between solo and semi-consolidated data. For Belgium and Spain, the intention of using solo data was to focus on banks' activity in the domestic market, and abstract from the relatively large international operations of national banking groups.

Table 3.1: Consolidation level of bank-level data

	BE	CY	ES	FI	FR	IE	IT	LT	NL	PT	SI
Institution level (solo)	•		•					•			•
Semi-consolidated					•	•	•		•	•	
Consolidated		•		•	•	•			•	•	

Legend: For Dutch, French and Portuguese models original consolidation level differs by data source. E.g. consolidated data is used for such variables as own funds and total assets, while semi-consolidated data for the remaining variables.

Relatedly, country datasets differ in the definition of loans to the non-financial private sector that may also include loans to non-residents (see Table 3.2).

Table 3.2: Treatment of loans to non-residents

	BE	CY	ES	FI	FR	IE	IT	LT	NL	PT	SI
Includes loans to residents	•	•	•	•	•	•	•	•	•	•	•
Includes loans to non-residents		•		•	•						

3.3 Bank-level variables

When selecting bank-level variables, we focus on the developments in the domestic non-financial private credit, credit risk, banks' profitability and capitalisation. Appendix A includes the full overview of bank-level variables.

We distinguish between loans to non-financial corporates (NFC) and households. If possible, we also separate loans for housing purposes (or loans to households backed by residential property) from loans for consumption and other purposes. For Belgium, the dynamics of mortgage credit is approximated by long-term loans to households, and consumption credit, by short-term loans to households. For countries, where the dynamics of long and short-term credit to NFC have been markedly different in a sample, we separate these two subcategories of credit. Last but not least, due to distinctively different dynamics of small and large volume loans to NFC in Italy, we distinguish between them in the Italian model. All credit variables are seasonally and outlier corrected and used in quarter-on-quarter growth rates.

To capture the evolution of credit risk, we include the share of non-performing loans to total non-financial private sector loans (NPLs ratios). The preferred measure of bank capital rests on the Tier1 definition, but for countries for which long enough time-series of Tier1 capital were not available, we rely on a broader definition of own funds. Both NPL and capital ratios are used in first quarter-on-quarter differences, whereas capital volumes in quarter-on-quarter growth rates.

3.4 Sample

Country bank-level datasets are representative for the domestic banking systems, covering from 66% to 92% of the overall banking assets. Concerning total credit to the non-financial private sector, country samples cover from 77% to 86% of the overall outstanding credit volumes (Table 3.3). The number of banks in country samples differs more widely, with relatively few banks in the Finnish and Dutch samples, more than 10 banks in the Spanish and over 40 in the Italian.

Further, the country datasets reflect the core characteristics of national banking systems. The size of the banking system measured as the ratio of banking assets in the sample to GDP in 2015 is largest in Cyprus (325% of GDP as reported in Table 3.3), followed by France and the Netherlands (around 300% of GDP), and smallest in Lithuania (53% of GDP). The relative number of foreign subsidiaries in country samples, over 50% for Finland and Lithuania, and 33% in Ireland and Belgium correspond well with a generally high degree of penetration of these national systems by foreign-controlled subsidiaries branches. According to the ECB Consolidated Banking Data, at the end of 2015, foreign-owned entities held 92% of the total banking sector assets in Lithuania, 68% in Finland, 49% in Belgium and 48% in Ireland.

Not less importantly, all major types of banking systems in the euro area enter our analysis. Traditional (with a high relative role of traditional banking activities) and predominantly domestically-oriented banking systems are represented by Italy and Portugal (marked by ①). Cross-border banking systems (that share the main features of 'traditional banking systems', though they are often larger and more open, i.e. with a higher share of exposures to foreign countries) are represented by Cyprus, Spain, France, and the Netherlands (marked by ②). Banking systems where banks' business models involve a relatively high share of non-traditional banking activities and where banks may face fiercer competition from other financial intermediaries in the domestic market are represented by Belgium, Ireland and Finland (marked by ③). Last, relatively small banking systems (compared to GDP) with a high share of foreign-owned banks, common in the new EU member states, are represented by Lithuania (marked by ④). [6]

[6] Other euro area countries not included in the analysis have been classified as: traditional banking systems - Germany and Greece, cross-border banking systems – Austria, non-traditional banking systems – Belgium, small banking systems – Estonia, Latvia Slovakia.

Table 3.2: Representativeness of the sample

	Sample span	Number of banks	Therein: subsidiaries of foreign groups	Therein: large (mostly G-SII or O-SII)[7]	% of total banking assets*	% of total banking assets (minimum-maximum range)	% of nominal GDP**	% of total credit
BE ③	2003Q3-2014Q4	6	2	6	81%	[4%; 23%]	179%	80% of total credit 82% of total credit to NFCs 79% of total credit to HHs
CY ②	2010Q4-2015Q4	6	0	4	75%	[0.6%, 34.4%]	325%	55% of total loans and advances
ES ②	2008Q1-2016Q2	13	0	6	80%	[1.1%; 18.7%]	204%	79% of total credit
FI ③	2005Q1-2016Q3	3	2	3	92%	[5.67%; 66.15%]	236%	86% of total credit
FR ②	1998Q3-2015Q4	5	0	5	79%	[8.0%; 23.6%]	282%	83% of total credit 77% of total credit to NFCs 91% of total credit to HHs
IE ③	2008Q1-2016Q2	6	2	4	66.1%	[2.88% ; 25.12%]	161.0%	77.05% of total credit
IT ①	2003Q1-2015Q2	41	2	4	72%	[0.1%; 21.5%]	161.5%	82% of total credit
LT ④	2004Q4-2015Q4	6	4	3	84.3%	[1.1%; 29.3%]	53%	78% of total credit
NL②	2008Q2-2016Q2	4	0	3	79%	[3%; 31%]	300%	79% of total credit 66% of total credit to NFC 90% of total credit to HH
PT ①	2003Q1-2014Q4	7	1	6	82%	[3.1%, 23.7%]	204%	83% of total credit
SI ④	2008Q3-2016Q4	16	7	6	88%	[5.2%, 23.8%]	79.9%	92% of total credit 89% of total credit to NFC 95% of total credit to HH

Legend: * End 2014. **2014. Types of banking systems described on the basis of partitional with K-means cluster analysis. The analysis included three groups of indicators that capture: (i) how important banks are for an economy (bank assets as % of GDP, bank assets as % of total assets of the financial system, assets of foreign subsidiaries and branches as % of GDP), (ii) what types of banks dominate the national system (loans to the private sector as % of bank assets, net interest income as % total operating income, foreign exposures as % of total assets, concentration as % of assets held by 5 largest banks, cost to income ratio), (iii) what are key banking system vulnerabilities (exposures to real estate as % total assets, market funding as % total liabilities, loan-to-deposit ratio). The reference date for all indicators is December 2015, the source the ECB Banking Structural Statistical Indicators, ECB Consolidated Banking Data and National Accounts (Eurostat).① 'traditional banking systems', ② 'cross-border banking systems', ③ 'non-traditional banking systems', ④ 'small banking systems'. Luxembourg and Malta form separate clusters.

[7] As a rule, large banks include G-SII and O-SII banks. There are single deviations from this rule: for one Italian bank which has been judged to be large compared to other banks in the sample, even though it has not been designated as an O-SII bank, and one Lithuanian O-SII bank and one Dutch bank, which have been judges as small compared to other banks in the sample.

Country sample length differs due to the availability of bank-level data. The sample starts as early as mid-1998 for France and as late as the end of 2010 for Cyprus. Importantly, for most of the countries, the sample begins before the recent 2007 global financial crisis. For a share of countries, the sample also covers a period of the acceleration and following a deceleration in the growth rate of real estate prices.

The bank-level data for all countries show a clear pattern of deleveraging with a marked reduction in the growth rate of banks' assets and credit to non-financial private sector between 2007Q3 and 2009Q4. After that, the growth rate of credit to NFC remains negative, whereas the growth rate of credit issued to households seems to stabilise in positive territory. The exception is the sustained positive credit growth rate to NFC in Belgium from the beginning of 2009.

At the same time, capital as a percentage of total assets shows a sustained increase over time. There is an early increase in capital levels in Portugal, Lithuania and Italy in 2008-2009 matching the implementation of Basel II and Basel II.5 capital standards. Later, we see an increase for nearly all countries in 2014-2015, i.e. the implementation period of Basel III. In turn, banks' profitability appears to follow the economic cycle. Appendix B provides the full overview of time dynamics of the bank-level variables included in the analysis.

4 Bank responses to macroeconomic shocks

4.1 Benchmark country models

The benchmark specification is tailored to assess the effects of structural shocks characterising the business and housing cycles. The observable variables include GDP, general price index and property price indices. The number of latent factors summarising the dynamics of bank-level variables is set so to explain possibly a high share of the contemporaneous variance in bank-level variables while keeping the size of the model reasonably small. In practice, we applied the rule-of-thumb criterion earlier advocated by Boivin and Giannoni (2007) of adding new latent factors until the point when the impact of adding more factors to the model on its impulse response functions (IRFs) is meagre. Table C.1 in Appendix C summarises the number of latent factors for each country model, indicating the average share of the variance of bank-level variables explained by observable variables versus latent factors.

Conveniently, in each country model, we can pin down the factor that captures a general slowdown in credit in euro area economies starting in 2008 (which we dub a 'deleveraging factor'). The 'deleveraging factor' is singled out as a latent factor which drives the dynamics of bank-level total assets and credit variables based on the analysis of factor loadings. It is the first factor in Cyprus, Finnish, Lithuanian, Dutch and Portuguese models while the second or third in Belgian, French and Irish models. Commonly the 'deleveraging factor' is also strongly related to banks' capitalisation.

4.2 Identification of structural shocks

Two types of structural shocks are particularly relevant for assessing the resilience of banks in adverse conditions. A positive aggregate demand shock is a shock that leads to an immediate increase in GDP and GDP deflator (e.g. Canova and de Nicolo, 2003, or Peersman and Straub, 2009). A positive residential house price shock is a shock that leads to an immediate increase in residential house prices when the general price level and output in the economy remain initially unaffected. Jarocinski and Smets (2008) or Buch et al. (2014) proposed a similar set of sign and zero restrictions.

Analogously, a positive commercial property price shock triggers an immediate increase in commercial property prices, with the general price level and output being initially unchanged. The proposed identification of the real estate shocks suggests that these arise on the demand side of the respective real estate markets, rather than on their supply side. Further, we define an aggregate supply shock as a shock that leads to an immediate increase in GDP and a concurrent fall in GDP deflator (e.g. Canova and de Nicolo, 2003, Buch et al., 2014).

In selected country models, we separate an additional structural shock that affects credit to the non-financial private sector, but at least contemporaneously, not economic activity ('deleveraging shock'). The shock is identified by imposing positive sign restrictions on 'deleveraging factors,' i.e. latent factors capturing a significant part of the variation in bank-level assets and credit to the non-financial private sector, and zero restrictions on the contemporaneous response of GDP. Adding this shock to the shock space has at many instances improved identification of aggregate demand shocks. Table 4.1 summarises sign and zero restrictions in country models. If not explicitly mentioned, all restrictions have been imposed only on horizon 0. [8]

Table 4.1: Identification of structural shocks via sign and zero restrictions in the benchmark model

Shock	GDP	General price level	Residential property prices	Commercial property prices	'Deleveraging' factor
Aggregate demand	+(1)	+(1)	(2)		0
Aggregate supply	+	-			0
Housing demand	0	0	+(1)	0	0
Commercial property demand	0	0	0	+	0
'Deleveraging' (3)	0				+

Legend: If not marked otherwise, all restrictions refer to the contemporaneous impact on a variable. (1) In Belgian model imposed in horizons 0-3. (2) In Belgian model zero restriction added in horizon 0. (3) A deleveraging shock has been included in models for Belgium, Cyprus, Finland, France, Ireland, Lithuania, Portugal and Slovenia.

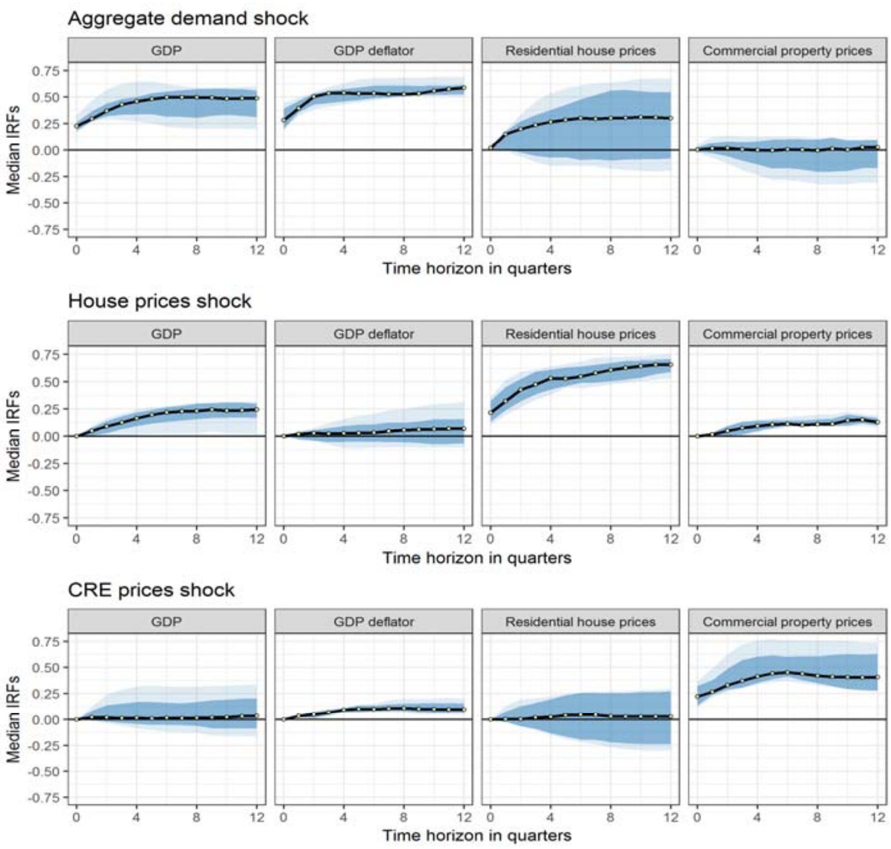
[8] Fry and Pagan (2009) report in their review of the sign restriction approach a consensus emerging in the literature that imposing contemporaneous restrictions only might be preferable to imposing restrictions on longer lags.

4.3 Impact of structural shocks on macroeconomic variables

Following a positive aggregate demand shock, output and general price level increase persistently (Figure 4.1). The effect of an aggregate demand shock on real estate prices is in most of the countries positive, whereas that commercial property prices, insignificant or negative.

In absolute terms, the effect of a one standard deviation aggregate demand shock on GDP is larger for small open economies, such as Lithuania, Cyprus or Belgium (see Table C.2 in Appendix C). It is the lowest for larger and less open economies, such as France and Italy. There are also sharp differences in the persistence of the resulting increase in GDP. The effect of an aggregate demand shock is most lasting in Lithuania and Portugal, followed by the Netherlands. At the other side of the spectrum are Finland and Ireland (and to a lesser degree Cyprus) where output growth returns to the baseline relatively quickly.

Figure 4.1: Median IRFs of standardised macroeconomic variables to a one standard deviation positive aggregate demand, residential house price and commercial house price shocks



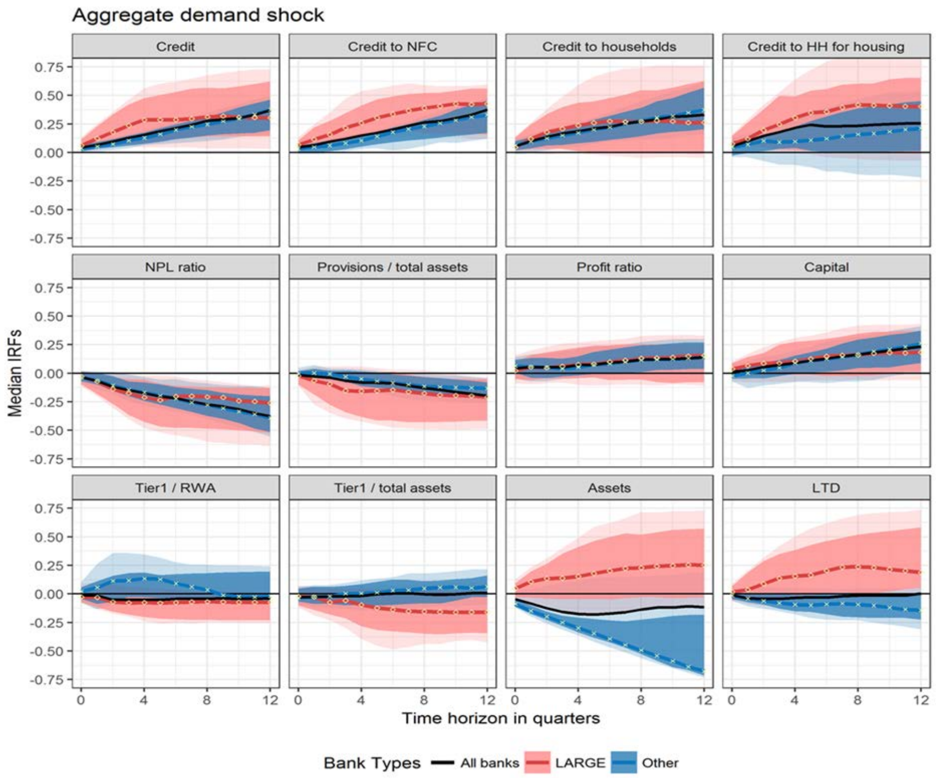
Legend: Figures are constructed on the basis of median responses of macrovariables from the country models. All IRFs correspond with the behaviour of standardised variables on a cumulative basis. Solid line marks the median euro area weighted average response (nominal GDP weights). Dark blue fan represents 50% and light blue 68% of the distribution of median responses of macrovariables on a country level. IRFs of commercial property prices and representing the response to structural shocks to commercial property prices are based on a narrower sample of countries: Finland, France, Ireland and the Netherlands.

4.4 Impact of structural shocks on bank-level variables

A positive aggregate demand shock triggers credit expansion in all loan segments of the non-financial private sector (Figure 4.2). The share of non-performing loans drops sharply for most of the banks. There is also a general increase in banks' profitability tied with a reduction in loan-loss provisioning. Notwithstanding, banks' capital ratio may deteriorate.

There is a substantial degree of heterogeneity in the magnitude and timing of banks' responses. Figure 4.2 suggests, for instance, that on average large banks (G-SII or O-SII) expand credit and total assets faster and stronger than other (medium-size and smaller) banks. They also increase the leverage more sharply following a positive shock.

Figure 4.2: Median IRFs of standardised bank-level variables to a one standard deviation positive aggregate demand shock: large (mostly G-SII and O-SII) banks, other banks, and all banks together



Legend: Large banks include mostly G-SII and O-SII banks. Figures are constructed on the basis of median responses of bank-level variables from the country models. All IRFs correspond with the behaviour of standardised variables on a cumulative basis. Red (blue) broken line marks the median response, and dark red (blue) fan represent 50% and light red (blue) 68% of the distribution of median responses of bank-level variables of G-SII and O-SII (other) banks. Solid black line marks the median response for the full sample of banks.

Banks' responses to a positive shock to residential house prices are qualitatively similar to their responses to an aggregate demand shock. Following a positive shock to residential house prices, banks expand credit to the private non-financial sector, mostly for housing purposes (Figure C.1 in Appendix C). The ratios of non-performing loans and provisions to total assets go down, while the profitability measures improve. Last, banks' capitalisation and liquidity position measured by loan-to-deposit ratio worsen for large banks.

Interestingly, banks' responses to a positive commercial property price shock are far weaker than those to residential house price shocks (Figure C.2 in Appendix C). Following the shock, a share of large banks expands credit to NFCs and households, while medium-sized and smaller banks cut credit. Both types of banks experience an increase in profitability.

5 Impact of bank capitalisation on the transmission of macroeconomic shocks

This section investigates how bank capitalisation affects bank lending following macroeconomic shocks. The earlier section has shown that banks react differently to similar macroeconomic shocks, and here we relate this heterogeneity to banks' capitalisation. We attempt to answer a more general question on the ability of capital buffers to insulate bank lending from business cycle and house price fluctuations. To this end, we run a series of cross-sectional regressions relating the lending reaction of banks to selected shocks with their solvency condition. At the end of the section, we quantify the benefits of capital regulation in terms of banks' ability to withstand crisis and continue to provide credit to the non-financial private sector.

Bank capitalisation can affect bank lending and financial stability at least via two channels. First, capital buffers reduce banks' incentives to take on excessive risks. They play a role of a 'skin in the game' and reduce the moral hazard problem related to the existence of fixed-rate deposit insurance schemes, shareholder limited liability (e.g. Kareken and Wallace, 1978), Benston et al., 1986, and Kane, 1989), explicit or implicit public guarantees (Furlong and Keeley, 1989). As such, they also contribute to the reduction of systemic risk-taking (Martinez-Miera and Suarez, 2014). Second, bank capital buffers increase banks' capacity to absorb losses ex post (Dewatripont and Tirole, 1994).

Selected empirical studies test for the impact of higher capital on bank risk-taking. De Haan and Klomp (2012) develop a factor model for 200 OECB banks and find that capital requirements reduce bank risk-taking.[9] Baker and Wurgler (2013) use the CAPM model and see that higher capitalised banks have a lower systematic and idiosyncratic risk.

Other studies recognise that both channels imply the smoothening of credit supply within the business or financial cycles. The risk-taking channel suggests that higher bank capitalisation limits the fluctuations in credit supply in both booms and busts, whereas the loss-absorption channel implies weaker credit contractions in economic busts. Gambacorta and Mistrulli (2004) show that well-

[9] De Haan and Klomp (2014) report similar results for a sample of 70 non-industrial countries in 2002-2008.

capitalised Italian banks were less affected by economic downturns between 1992 and 2001. Bernanke and Lown (1991) find a significant relationship between bank lending shortage and falling capital ratios during the 1990 recession in the United States. Albertazzi and Marchetti (2010) detect a similar relation in 2007-2009 for Italian banks. Based on Spanish supervisory data on loan applications, Jimenez et al. (2012) provide empirical evidence that lower capitalised banks reduce loans during an economic recession to a greater extent than higher capitalised banks. Finally, Berger and Bouwman (2013) show, based on US data, that higher capital of large- and medium-sized banks increases their probability of survival, allowing them to maintain their market share during a crisis.

5.1 Bank-level regressions

We run a series of cross-sectional regressions relating the reaction of bank-level variables to macroeconomic shocks to banks' capitalisation. We focus on bank-level variables that are the best comparable across country models: credit to the non-financial private sector, to NFCs, to households and credit to households for housing purposes. We evaluate the reaction of these variables to a (positive one standard deviation[10]) aggregate demand and residential house price shocks[11] against banks' initial capitalisation levels (at the beginning of the sample used for the FAVAR estimation) measured by Tier1 ratio. [12]

On the left-hand side of the cross-sectional regression, we use the cumulated IRFs of standardised bank-level variables and on the right-hand side banks' Tier1 ratios and Tier1 ratios squared. We also consider specifications where we add a set of control variables such as country and bank-type (commercial, corporate or saving) dummies. Regressions are run for all banks and then, separately, for large and other banks.

Regarding the estimation, we apply the weighted OLS estimator with robust standard errors to explain a subset of 100 draws from the posterior distribution of relevant IRFs. Observation weights are set proportional to the percentage of variable variance explained by a country model. Observation weighting addresses the heteroscedasticity of regression residuals and reflects a various degree of precision with which FAVAR models capture the variance of bank-level variables. We focus on a larger subset of draws from the posterior distribution acknowledging that different structural models may fulfil the same set of zero and sign restrictions (Budnik and Bochmann, 2018). Tables D.1 – D.2. in Appendix D present detailed regression results for a horizon of one year following a shock.

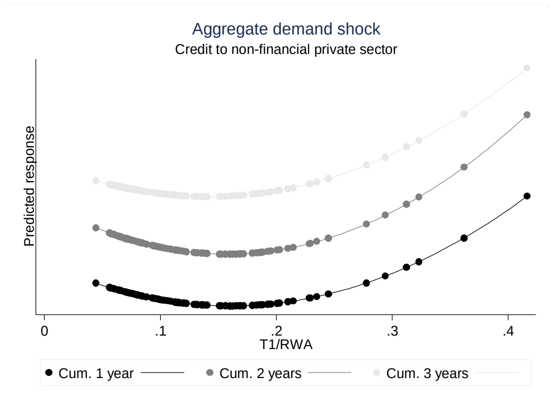
Non-linear regression specifications perform better than linear specifications in explaining the cross-sectional variance in bank-level IRFs of credit to aggregate demand shocks. Squared Tier1 ratios are

[10] The standardisation of IRF and structural shocks (one standard deviation shocks) ensures the comparability of results from different country and allow the estimation based on the pooled IRFs sample.
[11] Due the smaller sample size the regression analysis was not carried out for the commercial real estate shock.
[12] By relating banks' reaction to their initial rather than the sample average level of capitalisation we mitigate endogeneity concerns.

statistically significant in most of the regressions.[13] The relationship between bank-level credit and capitalisation appears convex at least for the overall non-financial private sector and household credit. Figure 5.1 illustrates the convexity of the estimated relationship by plotting the predicted responses of bank-level credit to the non-financial private sector. The X-axis marks the levels of capital ratios of all banks in the estimation samples. The series of dots represent the predicted values of accumulated bank responses a year, two and three years after the shock.

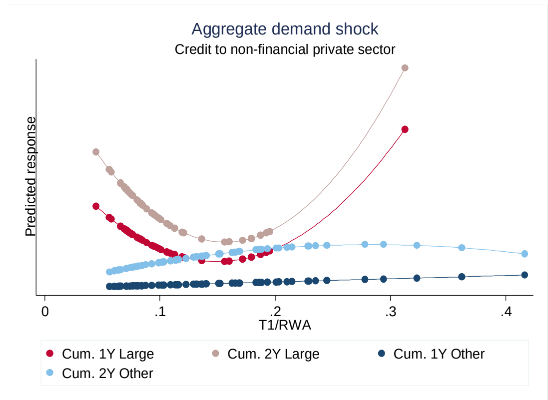
For moderate levels of bank capitalisation (below 20%), the relationship between Tier1 capital ratio and the expansion of credit following a positive aggregate demand shock is negative. Better capitalised banks expand credit less following a favourable shock than their lower capitalised peers. It holds for credit to the non-financial private sector and its subcomponents alike. The symmetric nature of our identification warrants that following an adverse aggregate demand shock, higher capitalised banks will contract credit by less. Ultimately, higher capitalised banks are better suited to absorb shocks originating in the real economy, without major disruptions in their credit supply.

Figure 5.1: Empirical relationship between the change in credit to non-financial private sector a year following a positive aggregate demand shocks and the initial level of banks' capitalisation



Legend: Estimates based on regressions of bank-level IRFs on the initial linear and squared Tier1 capital ratios. Dots mark the predicted values for the observations in the regression sample.

Figure 5.2: Empirical relationship between the change in credit to non-financial private sector a year following a positive aggregate demand shocks and the initial level of banks' capitalisation: large and other banks



Legend: Large banks: G-SII and O-SII banks. Estimates based on regressions of bank-level IRFs on the initial linear and squared Tier1 capital ratios. Dots mark the predicted values for the observations in the regression sample.

At very high bank capitalisation levels the negative relationship between credit sensitivity and bank solvency breaks. Capital ratios above a 20-25% threshold do not bring in additional gains of moderating the contraction of credit to the non-financial private sector in economic downturns. This finding corroborates the hypothesis that there exists a level of capital which maximises the resilience of banks to selected types of macro-financial shocks. This level will generally differ not only by the shock type but also credit component (in our estimates it is lower for NFC than household credit).

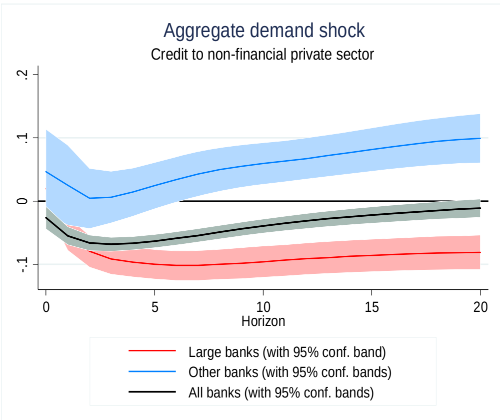
[13] The results for the linear specifications are not presented but are available upon request from the authors.

Different patterns of the relationship between banks' capitalisation and their response to aggregate demand shocks emerge for large versus other banks. The relationship between banks' capitalisation and the reaction of credit is convex for large banks, while concave for other banks (Figure 5.2). For large banks, the nick point at which increasing banks capital brings no additional gains regarding moderating the volatility of credit is lower than for the full sample of banks, 15% Tier1 ratio.

Figure 5.3 shows the relationship between banks' capitalisation and their reaction to aggregate demand shock over a five-year horizon. It plots the marginal effect on a change in credit to the non-financial private sector resulting from an increase in Tier1 capital ratio by one p.p. from the level of 8.5%. The choice of Tier1 capital ratio of 8.5% is arbitrary, and it corresponds with the minimum capital requirement under CRDIV including capital conservation buffer. Focusing on marginal effects rather than regression coefficients accommodates the non-linearity of the relationship between banks' capitalisation and their responses. A negative marginal effect of Tier1 capital suggests that a further increase in the capital ratio would result in lower credit expansion of credit by a bank, following a positive aggregate demand shock, or milder credit contraction following a negative aggregate demand shock.

The adverse effect of an increase in Tier1 capital ratio on credit expansion following a positive aggregate demand shock is strongest a year after the shock and slowly fades after that. Assessed based on the full sample of banks, the marginal effect of an increase in Tier1 capital ratio above 8.5% is negative and highly persistent, lasting up to five years for the overall credit to the non-financial private sector, somewhat shorter (three years) for NFC credit, and even longer (over five years) for credit to households (see Figures D.1 – D.2 in Appendix D).

Figure 5.3 The marginal effect of an increase in Tier1 ratio from the level of 8.5% on the cumulated change in credit to non-financial private sector following a positive aggregate demand shock: all, large (G-SII and O-SII) and other banks



Legend: Large banks: G-SII and O-SII banks. Estimates based on regressions of bank-level IRFs on the initial linear and squared Tier1 capital ratios. The confidence banks calculated with delta method.

The effect of bank capitalisation on moderating credit growth is more pronounced and longer lasting for large banks compared to all banks in the sample. In contrast, the impact of capitalisation on the credit growth of medium-sized and smaller banks is initially not statistically different than zero and turns positive after one and a half year following the shock. Hence, for other banks higher capitalisation exacerbates credit expansions and contractions. A possible interpretation of this discrepancy is the different access of large versus medium-size and smaller banks to wholesale debt markets. Large banks, having good access to wholesale debt financing, may adjust credit supply relatively fast by increasing their leverage. Bank capitalisation still affects the incentives of large banks to take on risk, and the dominant role of own funds is that of a 'skin in the game'. In this set-up higher bank capitalisation moderates their credit expansion in good times. Medium-sized and small banks have limited access to wholesale financing, and their credit supply depends on the availability of own funds. As a result, they are more likely to resort to capital accumulation to finance additional credit supply. It could explain both the lagged response of medium-sized and smaller banks and the fact that the better capitalised of them adjust credit faster in response to aggregate demand shocks.
Our regression results suggest that an increase in capital buffers of large banks can have a significant and positive impact on system-wide resilience. Improvements in the capitalisation of large banks will more likely pass-through into a smoothening of credit supply across the business cycle than increases in the capitalisation of medium-sized and small banks. These findings add up to arguments for maintaining high capitalisation of G-SII and O-SII banks.
The evidence on the relationship between bank capitalisation and their response to a positive residential house price shocks is generally weaker. The relationship between bank capitalisation and credit to the private non-financial sector is concave for all and large banks, while it is convex for medium-sized and smaller banks and statistically significant only for the first few quarters following a shock (see Figure D.3 in Appendix D). The effect on credit to households (and credit to households for housing purposes) is close to linear and positive for all and large banks and negative for medium-sized and smaller banks. For the latter, it turns not statistically significant already a year following a shock (see Figure D.4 in Appendix D).

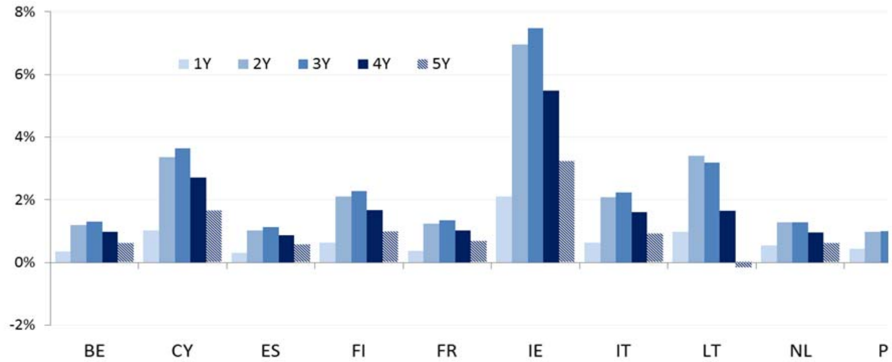
5.2 Benefits from high bank capitalisation: counterfactual simulations

To illustrate the quantitative implications of our regression results we run a series of counterfactual exercises. Our assessment focuses on the role of capital buffers in building banks' resilience to negative macroeconomic shocks and corresponds with our notion of benefits from higher banks' capital.

We attempt to measure a reduction in credit to the non-financial private sector that does not materialise under an adverse scenario owing to higher capital buffers. To this end, we choose an adverse scenario that has a similar probability of realisation across countries, in line with the assumptions commonly taken in EU-wide stress-test scenarios, and involves a six-quarter series of adverse aggregate demand shocks. In the scenario, the GDP falls sharply in the first two years, reaching 3.5% below the initial level on the euro area level at the end of the second year, and slowly rebounds after that. Credit to the non-financial private sector reacts with a lag and continues falling in the third and fourth year, reaching -4% below its initial level on the euro area level.[14] The scenario is relatively benign when benchmarked to the estimates of costs of a financial crisis by Laeven and Valencia (2012) or the experience of European countries during the recent crisis.[15]

For a start, we look at the impact of banks Tier1 capital ratios above 8.5% at the end of 2015. This way, we pin down the joint effect of Pillar 1 capital buffers (other than conservation buffer), Pillar 2 decisions and voluntary buffers. Figure 5.6 shows the current Tier1 capital buffers of euro area banks limit the reduction in credit to the private non-financial sector under the adverse scenario. The effects of higher bank capitalisation are most pronounced at the end of the second year, fading after that in line with the rebound in the economic activity. For Ireland, gains in credit to the non-financial private sector amount to 6 - 7% over a three-year horizon. For Slovenia, Lithuania and Cyprus benefits from the existing capital buffers are moderately lower (credit gains of 4.9%, 3.4% and 3.5% in the second year under an adverse scenario). For other countries, the benefits from having capital buffers above 8.5% are between 1-2% of the credit to the non-financial private sector at the end of the second year. All these effects are substantial in relative terms, amounting to (at minimum) around 10% of the overall reduction in credit reported under the adverse scenario for Lithuania and Portugal, around 20% for Belgium and Finland, close to 40% for Spain, and over 50% for remaining countries. Figures D.5 and D.6 in Appendix D present the impact of capital buffers on credit by sector.

Figure 5.6 The effect of Tier1 capital buffers at the end of 2015 above the level of 8.5% on the outstanding credit to non-financial private sector under the adverse scenario (at the end of a year)

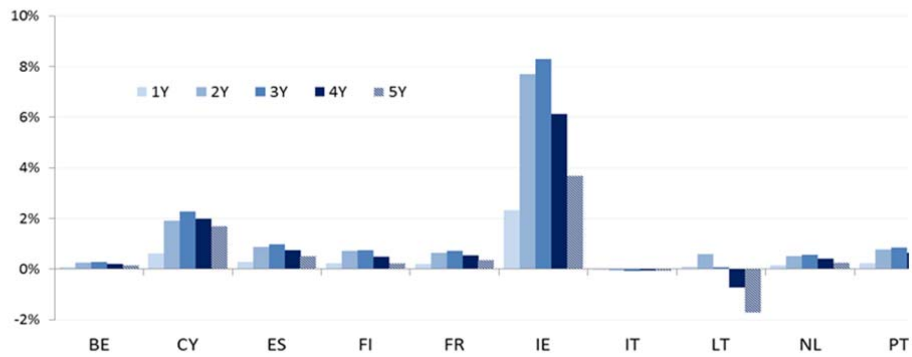


Legend: Estimates based on regressions of bank-level IRFs on the initial linear and squared Tier1 capital ratios for the full sample of banks.

[14] The euro area average (weighted by nominal GDP of a country) is calculated on the basis of outcomes for countries included in the analysis.
[15] For instance for Spain we assume 5.2% cumulative reduction in GDP at the end of the second scenario year, whereas according to Laeven and Valencia (2012) the estimates of bank crisis costs for Spain amount to -58.5% output loss. For Belgium the figures would be -9.3% versus -19%, for Finland -0.8% versus -69%, for France -1.3% versus -23%, for Ireland -2% versus -106%, for Italy -4.4% versus -32%, for the Netherlands -2.1% versus 23%, and for Portugal -5.7% versus -37%.

The assessment of the effect of changes in Tier1 capital compared to the levels prevailing in 2010 provides yet another perspective. Benchmarking against capitalisation levels in 2010 allows us to assess an actual increase in banks' resilience in recent years. Altogether, the phasing in of Basel III, supervisory interventions and accumulation of voluntary capital buffers resulted in the average increase in banks' capital buffers in our sample by 2.4pp. This increase has been unequal across banks and jurisdictions though. The variance coefficient of Tier1 ratio decreased from 42%, in 2010, to 36%, 2015 reflecting the fact that the least capitalised banks experienced the most significant increases in their capitalisation levels.

Figure 5.7. The effect of an increase in Tier1 capital buffers from the levels that prevailed in 2010 to the levels at the end of 2015 on the outstanding credit to non-financial private sector under the adverse scenario (at the end of a year)

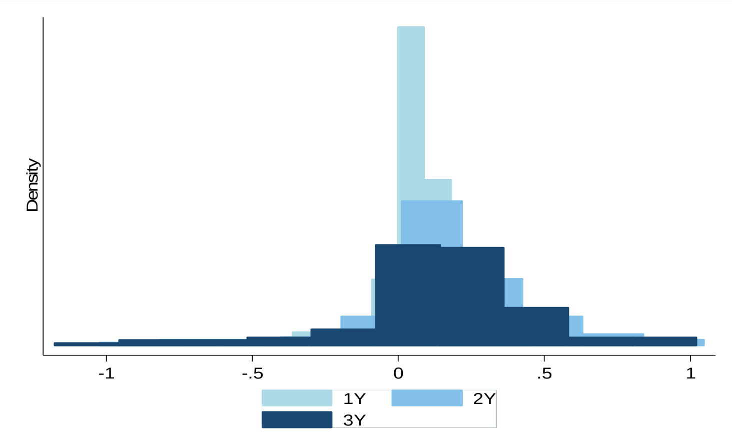


Legend: Estimates based on regressions of bank-level IRFs on the initial linear and squared Tier1 capital ratios for the full sample of banks.

There was a pronounced increase in banks resilience especially in Ireland, Slovenia and Cyprus (Figure 5.7). Lower gains in resilience for the Lithuanian banking sectors correspond with an increase of capital buffers from relatively high 2010 levels, whereas similar results for Italy reflect limited increases in relatively low 2010 capitalisation levels.

Would further increase in capital buffers from the levels prevailing at the end of 2015 be warranted? The effects of an increase in Tier1 capital buffers of all banks by 1pp compared to 2015 levels are shown in Figure 5.8. A system-wide increase in capital buffer would result in a median gain in credit of 0.6pp at the end of the second year of the adverse scenario, therein 4.1pp gain for 10% of banks. On a country level, a further increase in capital buffers would contribute to the resilience of national banking systems in most of the countries, with (on average) relatively lowest gains in Ireland, Finland, Belgium, and relatively highest in Slovenia, Spain and Italy.

Figure 5.8. The effect of an increase in Tier1 capital buffers by 1pp compared to the levels that prevailed at the end of 2015 on credit to non-financial private sector under the adverse scenario



Legend: Estimates based on regressions of bank-level IRFs on the initial linear and squared Tier1 capital ratios for the full sample of banks. X-axis – percentage change in credit to the non-financial private sector.

6 Costs of capital-based macroprudential regulation: aggregate identification

In this section, we move to the assessment of the short-term costs of raising capital buffers in a FAVAR set-up. We quantify those as a reduction in credit growth and in economic activity occurring when the average level of capital in an economy is unexpectedly and exogenously increased. To this end, we modify the country FAVAR models to identify the effects of an aggregate bank capital shock similar to Meeks (2017). Then, we derive impulse response functions of the identified shocks and assess the impact of bank capital shocks via counterfactual simulations, assuming that bank capital increase is phased in over a 3-year horizon in same quarterly steps.

We differentiate between two types of shocks affecting the supply of credit: credit supply shocks and bank capital increases. It is aimed to provide a fair assessment of the likely impact of capital increases and better separate such shocks from shocks related to, e.g. funding during the crisis. The expected effects of raising capital requirements on lending margins and credit are similar to those of a negative credit supply shock. Banks subject to an increase of capital requirements are expected to raise their lending rates compared to the risk-free rate and contract credit to the private non-financial sector. Further, the reduction in book leverage related to an increase in capital requirements results in a reduction in the stock price valuation of banks compared to the rest of the market (Fornari and Stracca, 2012).

At the same time, better-capitalised banks should experience lower funding cost than other banks. When banks hold more capital, their creditors are better shielded from losses. It should in principle drive down their compensation, partially offsetting the costs of own capital based financing (Admati et al., 2010, Elliott, 2009, Hanson et al., 2010, and Osborne et al., 2010). Admati et al. (2010) and on the empirical side Gambacorta and Shin (2016) and Schmitz et al. (2016) provide supportive evidence that higher capitalised banks indeed enjoy a lower cost of funding due to reduced credit risk. In the case of supply disruption, when, e.g. banks experience losses, banks will be perceived as less safe, and markets would require a higher premium to lend to them. The response of banks' funding costs following a positive bank capital shock should be the opposite of the reaction following a negative credit supply shock. We use this feature to disentangle credit supply disruptions from a regulatory or voluntary capital built up.

6.1 Specification of country-level FAVARs with a capital shock

The country FAVAR models used in this section include five aggregate variables describing the dynamics of the banking system: total banking sector credit, lending margins, capital ratio, an equity ratio and a proxy for banks' funding costs. Following Schmitz et al. (2016) as well as Gambacorta and Shin (2016) we use banks' CDS, precisely the average banks' CDS (senior 5-year CDS), to approximate the credit risk associated with the overall banking system. However, for a group of countries in our sample banks do not have market evaluations and the coverage of the CDS information is limited: in such cases, we replace CDS with the spread between retail deposit rates and risk-free rates to proxy for higher confidence of depositors induced by stronger solvency positions.[16]

We disentangle three structural shocks utilising sign restrictions: credit demand, credit supply and bank capital (Table 6.1). A negative credit demand shock is associated with a decrease in both the quantity and the price of credit. A negative credit supply shock (e.g. associated with deleveraging pressures) shifts the credit supply curve upwards, making prices and volumes go in the opposite direction. At the same time, the different impact on banks' financing costs is what allows us to disentangle increasing capital requirement shocks from supply disruptions. [17] Finally, as in the case of previous analysis restrictions might be imposed at different horizons to accommodate country-specific issues better. The negative sign on the beta is imposed for both shocks, mainly because it allows disentangling both credit supply shocks and bank capital increases from the effects of non-conventional monetary policy. [18]

[16] From a theoretical perspective there are pros and cons of both using deposits and CDS. In some countries deposits are the main source of financing for banks. Yet, considering the sheer size of the funding base (i.e. retail depositors versus markets) might still mask the fact that banks receive their marginal source of funding from markets rather than retail investors. The latter are in fact supposed to be a more stable source of funding, see for example discussion in Shin (2009).

[17] We relax this restriction only for the case of Netherlands for which we are able to find no sensible impulse response functions using the restrictions. In terms of the conditional projection exercise results seem in line with expectations notwithstanding the relaxation of the restriction.

[18] Non-conventional monetary policy in fact can act as a 'stealth' recapitalisation of financial intermediaries (Brunnermeier and Sannikov, 2016) in so far as it increases the value of some assets held in banks' balance sheets. However, non-

Table 6.1: Zero and sign restrictions for a model with identification of short-run costs of capital buffers

Shock	Capital Ratio	Financing costs	Lending spreads	Beta (Ratio equity of banks compared to total market)	Total Credit
Credit demand			-		-
Credit supply		+	+	-	-
Bank capital	+	-	+	-	-

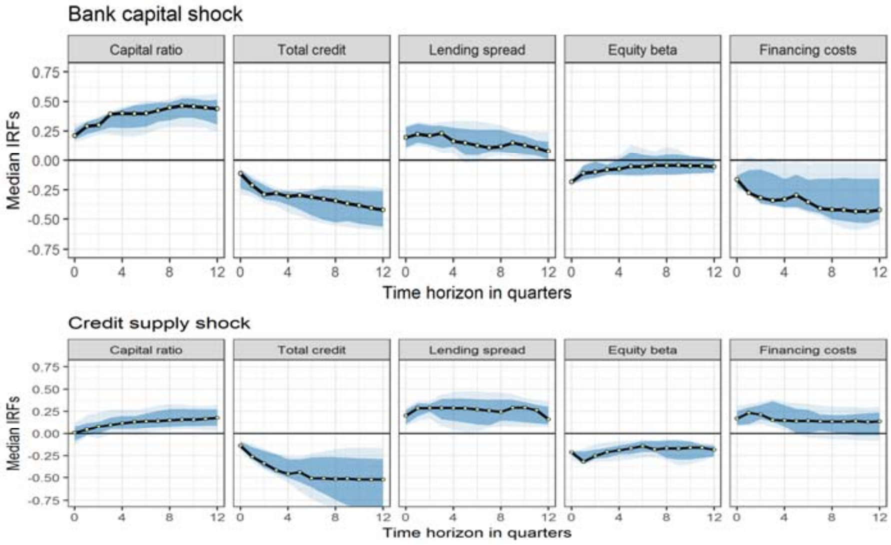
6.2 Banks' responses to a capital shock

Figure 6.1 reports the aggregate responses of capital ratios, total credit to the non-financial private sector, lending spreads, financing costs, and market risk following a non-anticipated increase of 1pp in the system-wide bank capital ratio. A positive capital shock increases banks' solvency, pushes us their lending spreads and depress credit volumes. In contrast, a credit supply shock is associated with an increase in banks' funding costs and has on average more negative effects on credit and lending rates. Following the latter, capital ratios barely move.

On impact, a 1pp increase in capital ratios corresponds to a contraction in total credit which ranges between 1 and 3pp depending on the country. The results are even more diverse regarding the response of lending spreads and GDP growth. In Table 6.2 we present the median and selected percentiles of the distribution of country-level impulse response function to bank capital shocks.

conventional monetary policy would likely imply an increase of the stock market evaluation of banks (i.e. the sign of the shock on the beta would be positive on impact) rather than a reduction.

Figure 6.1: Median IRFs of standardised macrovariables to a one standard deviation increase of aggregate bank capital versus a one standard deviation negative shock to credit supply



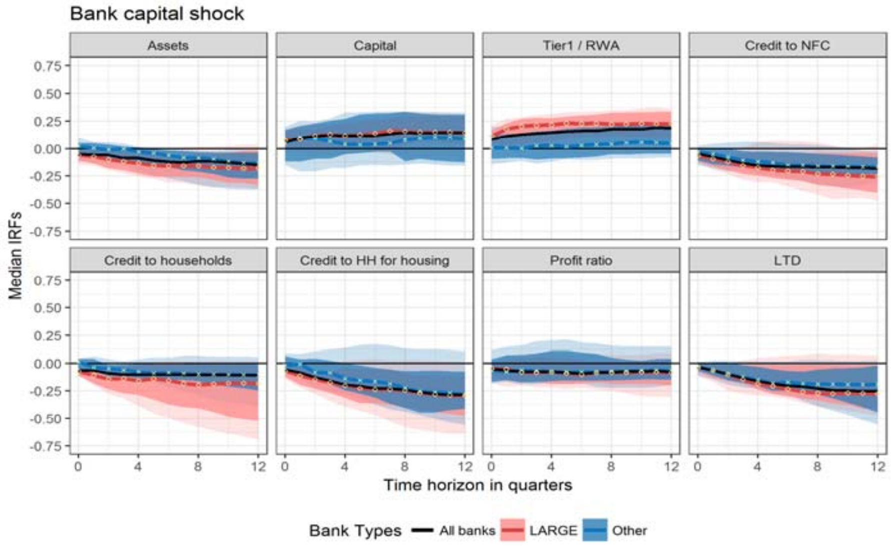
Legend: Figures are constructed on the basis of median responses of macrovariables from the country models. All IRFs correspond with the behaviour of standardised variables on a cumulative basis. Solid line marks the median euro area weighted average response (nominal GDP weights). Dark blue fan represents 50% and light blue 68% of the distribution of median responses of macrovariables on a country level. The capital ratio represents changes in the Tier1 ratio, financing costs are represented by log-changes of average CDS in an economy or spread between deposit rate and euribor3m; Lending spreads are measured by the difference between lending rates and deposit rates, except for France where the weighted spread between the MIR rate for new NFC loans and the swap rate with a maturity corresponding to the loan category initial period of rate fixation, and Spain where the difference between lending rates and a composite risk free rate, are used. Market risk is the ratio between the country-specific banking stock index and the overall stock index. Total credit stands for total credit to the private sector, sum of households' credit and credit to NFCs

Table 6.2: Effects of a 100 basis point bank capital shock on selected aggregate macro variables a quarter after the shock

	Credit to non-financial private sector %	Lending Spreads b.p.	GDP growth %
10% Pctile	-3.6	0.9	-1.8
50% Pctile	-1.2	10.9	-0.7
90% Pctile	0.0	58.2	0.0

These are mostly large banks experience an increase in Tier1 capital ratio (Figure 6.2). Composition effects may explain why the aggregate capital ratio moves consistently with the developments for largest banks in the sample, irrespectively of trends followed by other banks. A positive bank capital shock leads to a reduction in assets and credit to the non-financial private sector for most banks. A substantial share of banks also reports an increase in capital. In comparison to a bank capital shock, a negative credit supply shock tends to erode banks' equity (see Appendix E). Also the mortgage credit is differently affected by the two shocks.

Figure 6.2: IRFs of bank-level micro variables to a one standard deviation increase in aggregate bank capital



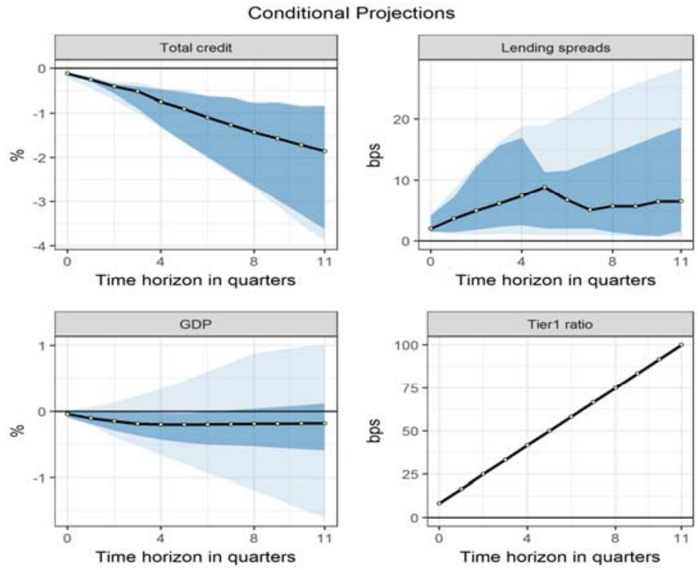
Legend: Large banks include mostly G-SII and O-SII banks. Figures are constructed on the basis of median responses of bank-level variables from the country models. All IRFs correspond with the behaviour of standardised variables on a cumulative basis. Red (blue) broken line marks the median response, and dark red (blue) fan represent 50% and light red (blue) 68% of the distribution of median responses of bank-level variables of G-SII and O-SII (other) banks. Solid black line marks the median response for the full sample of banks.

6.3 Conditional simulations for the costs of bank capital

Using the estimates reported above, we ask how much credit and GDP are negatively affected by a 1pp gradual increase in bank capital over a continuous phasing-in period of 12 quarters. The capital increase of 1 pp is assumed to be permanent and phased in gradually and by an equal amount each quarter over a 3-year schedule. We apply the algorithm of Waggoner and Zha (1998) for conditional simulations and present the results as deviations from the baseline which would have prevailed without shocks. [19]

[19] In the case of Belgium we renormalized the shock to take into account that the target capital ratio is expressed by capital over total (unweighted) assets by applying a renormalisation factor of 35%, which corresponds to the average ratio of risk weighted assets over assets in the sample.

Figure 6.4: Conditional projection of credit to the non-financial private sector, lending spreads, GDP, and the system-wide Tier1 capital ratio for a 100-basis point gradual increase in the Tier1 capital ratio over a 12 quarter horizon.



Legend: Cumulated deviations from the baseline, pp and basis points. Solid line marks the median euro area weighted average response (nominal GDP weights). Dark blue fan represents 50% and light blue 68% of the distribution of median responses of macrovariables on a country level.

The simulation results reveal substantial cross-country heterogeneity (Figure 6.4). Banks in Belgium, France and Portugal show a limited reduction in credit, standing between 1 and 3pp below baseline at the end of the three-year horizon. Banks in Italy reduce their credit volumes more sharply by over 4pp at the end of the horizon.

When looking at GDP results, the ordering of countries differs. In Portugal, the relationship between credit and GDP is less than one (i.e. for a 1% reduction in total credit the corresponding fall of GDP is about 1.5%), while in other countries credit contracts sharper than GDP. Taking all estimates together, Italy and Portugal show the most profound fall in economic activity, while countries such as France and Spain are intermediary cases. In the case of Belgium, the persistence of the effect of capital shocks on GDP is so limited that the fall of economic activity is almost negligible at the end of the horizon. In Ireland and Lithuania GDP actually increases. For Lithuania, this reflects the recent deleveraging process: a reduction of credit amid economic activity increases; for Ireland the effect may relate to the recent recapitalisation of the banking system.

7 Costs of capital-based macroprudential regulation: bank-level identification

In this section, we identify capital shocks by a set of sign restrictions imposed directly on bank-level variables. Bank-level identification scheme allows us to pin down a capital shock to an individual bank or a selected subset of banks. As we next show, this allows not only replicating system-wide ('carpet') regulation which applies to all banks in the sample but also evaluating the costs of capital buffers imposed on individual banks (i.e. O-SII or G-SII buffers).

Identification of a capital shock as an increase in the aggregate capital ratio can hide relevant information on the capitalisation of individual banks in the system. This problem will be the more pronounced, the less co-movement in bank-level capitalisation measures we observed in the sample. It may also pose interpretational challenges in policy exercises where we assume that capital buffers increase for all banks in the system (such as in the case of countercyclical capital buffer, CCyB).

In the section, we also identify two types of bank adjustments leading to an increase in their solvency rates: deleveraging and 'beefing-up' capital. By doing so, we can describe the differences between the two modes of adjustments regarding the impact of an increase in bank capitalisation on bank lending activity, and macroeconomic outcomes.

In reaction to an increase in capital requirements banks can raise their equity either by retaining earnings or by issuing new equity instead of deleveraging. Such a shift from debt to equity financing may increase the weighted average cost of capital (WACC) for banks. First, deposit insurance makes deposit financing cheaper by lowering the risk borne by deposit holders. Second, as interest payments on debt are tax-deductible, whereas return on equity is not, an implicit wedge arises between the costs of financing through debt versus equity. In imperfectly competitive markets, banks may make up for higher financing costs by increasing their lending spreads (the spread between the rate at which they lend and the average cost at which they finance themselves). Thus, higher financing costs can pass through into an increase in interest rates for firms and consumers and reduced demand for loans.

Between 2009 and 2013 banks used a mix of deleveraging and equity financing to meet higher capital requirements. The evidence collected by Cohen and Scatigna (2014) shows that euro area based banks not only adjusted their risk-weighted and total assets downwards but also increased equity. Banks based in the US and other European countries increased assets (which lowered capital ratios) and achieved higher capital ratios by raising capital holdings. Two-thirds of increases in equity holdings relate to earnings retention, the remaining third to issuing new equity.

7.1 A FAVAR model with a bank-level identification of structural shocks

We extend the benchmark model from Section 3 to allow the identification of two types of structural shocks involving an increase in bank-level capital ratios (Table 7.1). Structural shocks to aggregate demand, supply and real estate prices are likely to capture credit demand developments (i.e. play a similar role as a credit demand shock in the previous section). A structural shock to a capital ratio accommodated via a reduction of assets is assumed to lead to an increase in bank-level capital ratios and a decrease in bank-level total assets. In contrast, a ‘beefing up capital’ shock is assumed to trigger an increase in both bank-level capital ratios and bank-level capital volumes. Both types of capital shocks reduce funding costs of banks, which is captured by a series of negative sign restrictions on bank-level deposit margins and bank-level CDS. Last, both types of shocks are expected to increase the costs of credit to the non-financial private sector (lending margins) and reduce banks’ value (stock prices).

Table 7.1: Identification of structural shocks via sign and zero restrictions

Shock	GDP	General price level	Residential property prices	Commercial property prices	Bank-level Tier1 ratio	Bank level Tier1 capital	Bank-level total assets	Bank-level deposit margins	Bank-level lending margins	Bank-level CDS	Bank-level beta
Aggregate demand	+	+									
Aggregate supply	+	-									
Housing demand	0	0	+	0							
Commercial real estate demand	0	0	0	+							
Bank-level capital shock (adjusting assets)	0				+		-	-	+	-	-
Bank-level capital shock (‘beefing-up’)	0				+	+	+	-	+	-	-
Bank-level funding shock	0						-	+	+	+	-

Legend: If not marked otherwise all restrictions refer to the contemporaneous impact on a variable. A funding shock has been specified only in the Dutch model. Sign restrictions on bank-level CDS have been imposed in the Dutch and French models, whereas the restrictions on beta have been imposed only in the Dutch model.

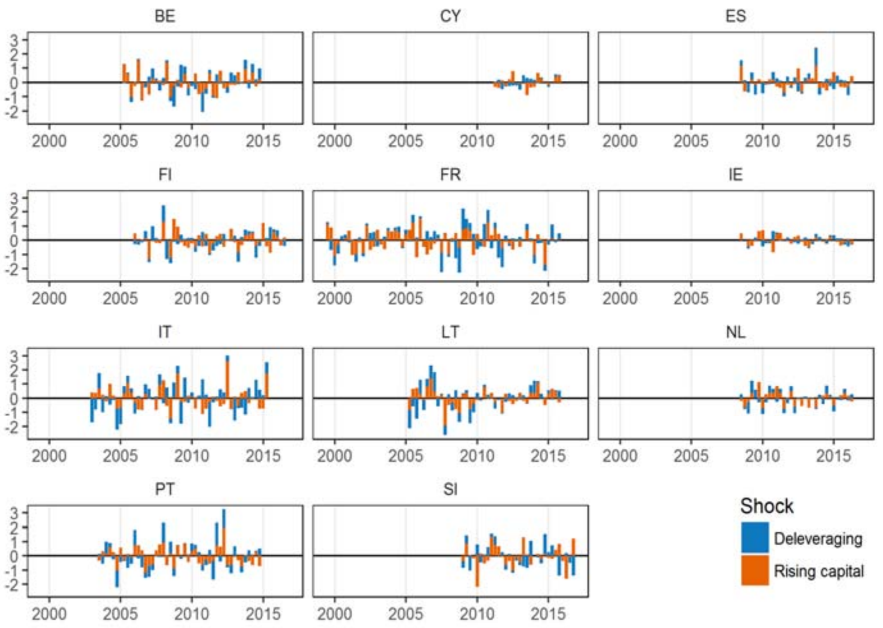
We allow a certain degree of flexibility while specifying country models. In cases where we expect that bank funding distortions played an essential role in the sample period, we add a bank-level funding shock to the model (which links to a credit supply shock in the previous section). Following a positive bank funding shock, the costs of bank funding increase (CDS and deposit rates), bank assets are reduced, lending rates increase, and the price of banks’ equity (and banks’ profits) falls.

To illustrate the effects of system-wide capital regulation we identify the two capital shocks under the assumption that each of them contemporaneously affects at least 80% of banks in the sample. This assumption corresponds with the effects of any ‘carpet’ regulation such as

CCyB or system-wide Structural Risk Buffer (SRB). Permitting 20% banks not to adjust capital buffers immediately after the shock reflects that even in the past system-wide regulatory capital increases may have failed to triggered adjustment of some banks, e.g. because of their substantial voluntary buffers at the onset.

Figure 7.1 builds an intuition about the relative role of two types of capital shocks in the sample period. It supports the notion that two kinds of shocks played a significant role in the sample period, often acting in the same direction.

Figure 7.1: Median standardised capital shocks in the sample

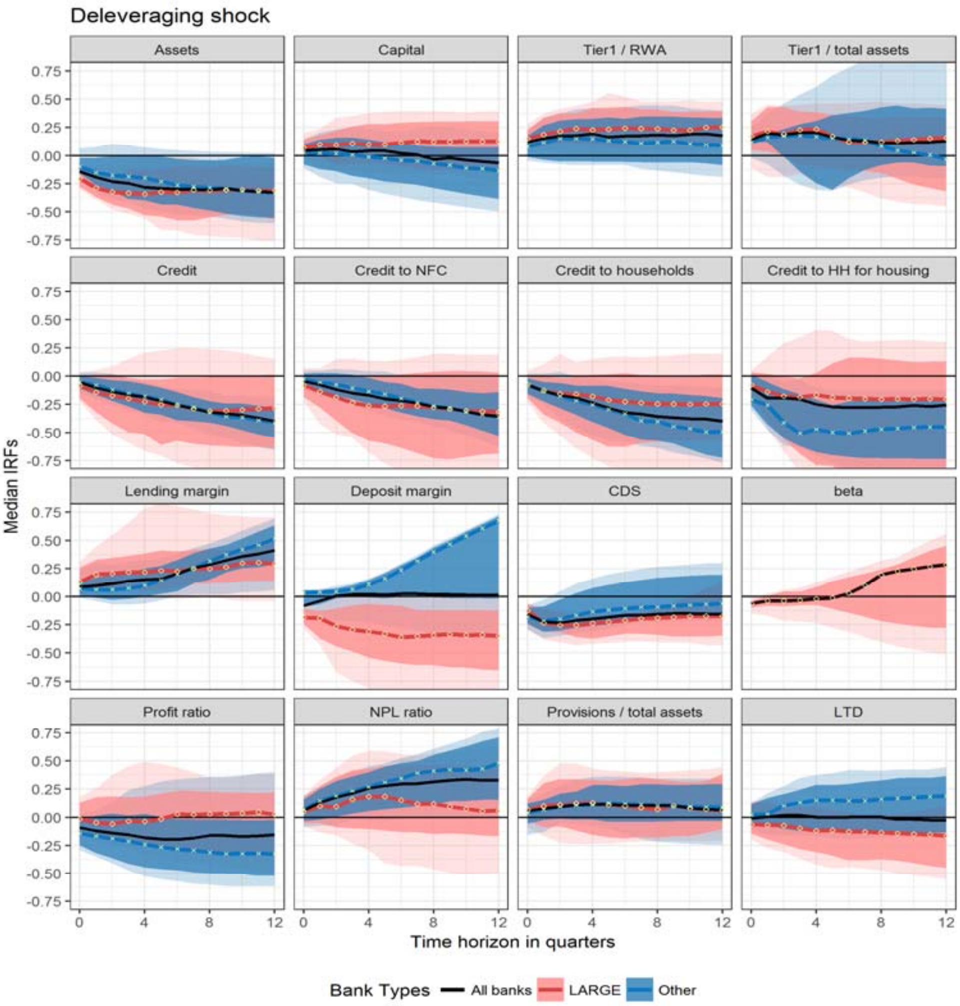


Legend: For each period, charts illustrate the median size of structural shocks to bank capital resulting in deleveraging versus capital increases. Blue bars in positive area stand for an increase in capital ratio which causes banks to deleverage. Red bars in positive area mean an increase in capital ratio which are coupled with the accumulation of capital. Units on Y-axis are the multiples of the standard deviation of each shock.

7.2 Banks’ responses to a capital shock involving an adjustments in bank assets versus beefing-up of capital

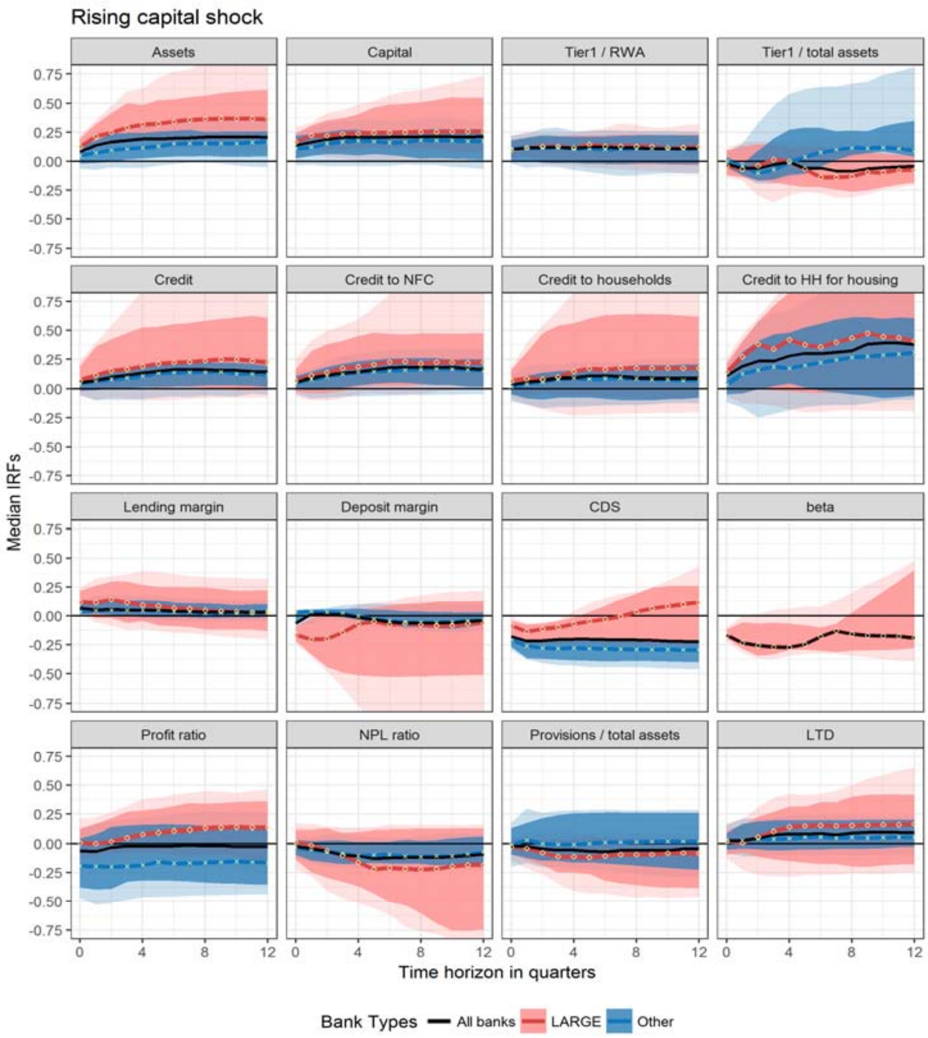
Figures 7.2 and 7.3 report the impact of the two capital shocks affecting at least 80% of banks in the sample on bank-level variables. Banks that increase their capitalisation by deleveraging experience a substantial and prolonged reduction in total assets and credit to the non-financial private sector. In Spain, Italy and Portugal, there is also an apparent increase in non-performing loan ratio, possibly reflecting adverse second-round effects or reflecting the fact that the recent reduction in banks’ assets in these countries occurred during periods of economic recession.

Figure 7.2: IRFs of standardised bank-level **variables** to an increase in bank-level capital ratios accommodated via adjustment of assets



Legend: Large banks include mostly G-SII and O-SII banks. Figures are constructed on the basis of median responses of bank-level variables from the country models. All IRFs correspond with the behaviour of standardised variables on a cumulative basis. Red (blue) broken line marks the median response, and dark red (blue) fan represent 50% and light red (blue) 68% of the distribution of median responses of bank-level variables of G-SII and O-SII (other) banks. Solid black line marks the median response for the full sample of banks.

Figure 7.3: IRFs of standardised bank-level **variables** to an increase in bank-level capital ratios accommodated via beefing-up of capital



Legend: Large banks include mostly G-SII and O-SII banks. Figures are constructed on the basis of median responses of bank-level variables from the country models. All IRFs correspond with the behaviour of standardised variables on a cumulative basis. Red (blue) broken line marks the median response, and dark red (blue) fan represent 50% and light red (blue) 68% of the distribution of median responses of bank-level variables of G-SII and O-SII (other) banks. Solid black line marks the median response for the full sample of banks.

Instead, if banks adjust by beefing up capital, they also persistently increase total assets and credit to non-financial private sector. An increase in credit is broad-based, with credit to NFC and households growing simultaneously. If banks adjust via issuing equity or retaining profits, we also do not observe an increase in the NPLs in the medium-run.

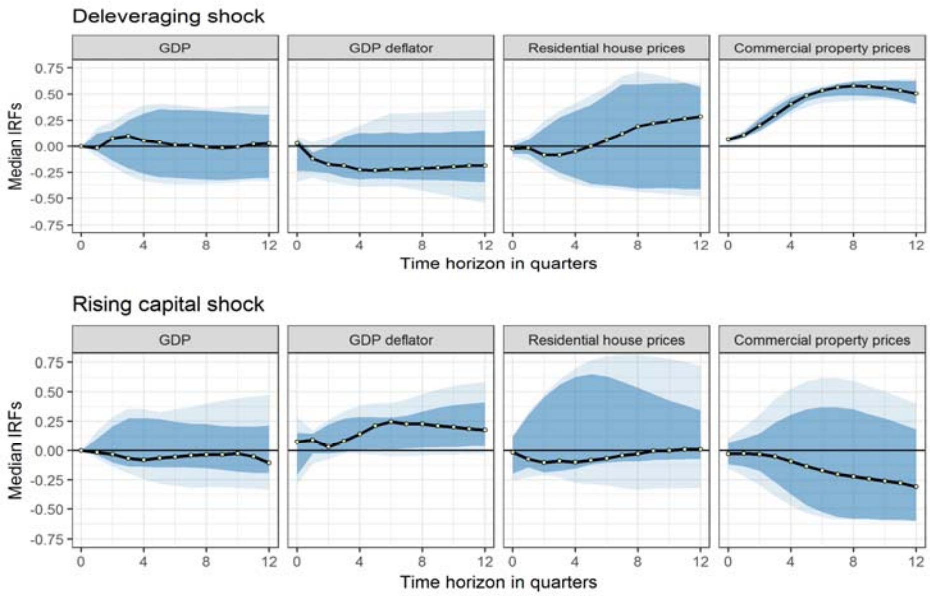
Otherwise, deleveraging and beefing up of capital trigger similar adjustments in lending margins and financing costs of banks. For the majority of banks, profitability improves, lending margins increase, while the costs of financing (deposit margins, or in France and Portugal also CDS), go down.

From a policy perspective, a capital shock that triggers a reduction of assets will deliver an upper estimate of economic costs of stricter capital regulation. A capital shock absorbed by retaining profits or issuing equity by banks (and at least initially no reduction in assets) provides, in turn, a bottom estimate of the economic costs. Disentangling the two shocks provides the estimate of a full range of possible economic outcomes.

7.3 Aggregate responses to a capital shock involving an adjustment in bank assets versus beefing-up of capital

The principal way along which banks choose to increase their capital ratios shapes the macroeconomic outcomes. Figure 7.4 shows that if banks adjust to higher capital requirements by beefing up of capital, the effect on output is more benign (the lower band for the impact on GDP following a beefing-up shock is above the one following a deleveraging shock). The results for Belgium, Italy and Portugal drive this pattern. There, if banks reduce their assets, output drops sharply, whereas if they beef up their capital volume, output increases (or contracts only very moderately in Belgium). Interestingly, for France and Lithuania, output increases under both circumstances.

Figure 7.4: IRFs of standardised bank-level assets to an increase in bank-level capital ratios accommodated via beefing-up of capital



Legend: Figures are constructed on the basis of median responses of macrovariables from the country models. All IRFs correspond with the behaviour of standardised variables on a cumulative basis. Solid line marks the median euro area weighted average response (nominal GDP weights). Dark blue fan represents 50% and light blue 68% of the distribution of median responses of macrovariables on a country level.

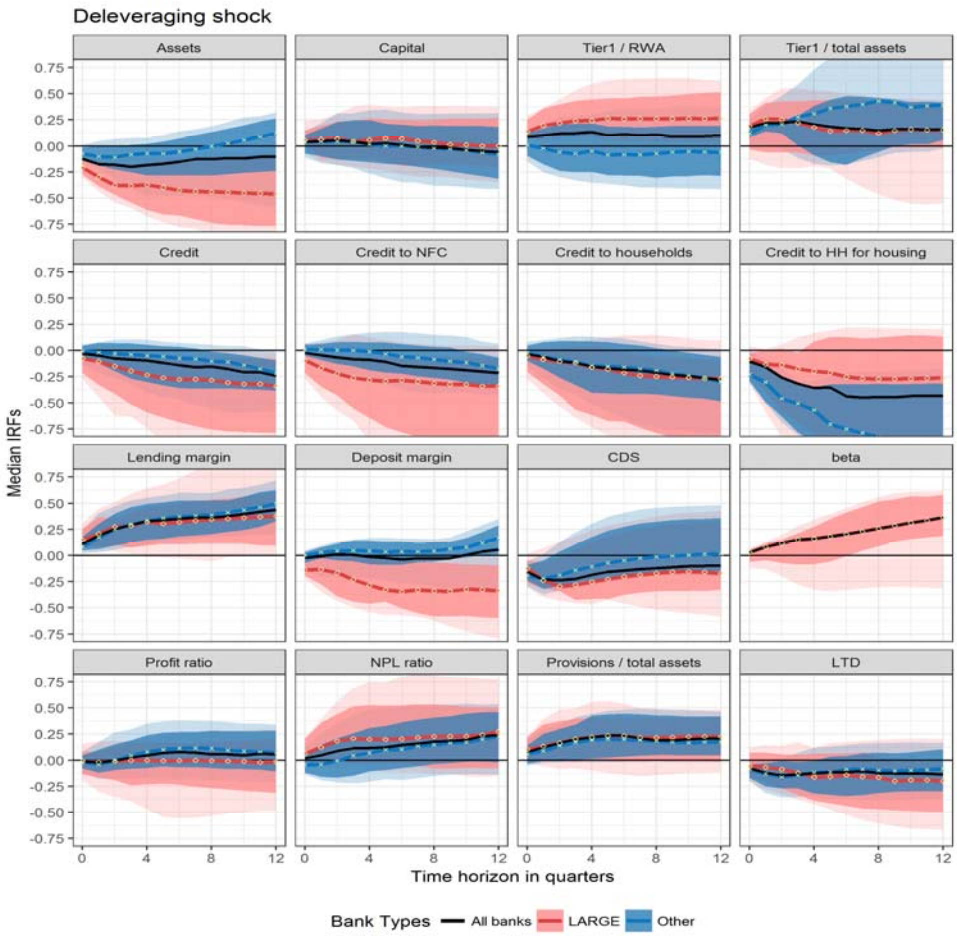
7.4 The effects of an increase in capital buffers of systematically important institutions (G-SII and O-SII)

To illustrate the merits of bank-level identification of capital shocks, we consider structural shocks that result in a selective increase in capital ratios of G-SII and O-SII banks.[20] Figure 7.5 illustrates the effects of an increase in capital ratios of G-SII and O-SII banks (affecting 80%-100% of G-SII and O-SII banks included in the sample) accommodated by a reduction in their assets. The capital ratios increase and assets decline persistently for most of the systematically important banks. The decline in assets is shallower and shorter lasting for Irish and Dutch G-SII and O-SII banks.

Interestingly, though the capital shock is assumed to affect G-SII and O-SII banks, a share of less systematically important banks is also found to increase their capital ratios and reduce assets. It reflects the co-movement of bank variables in the sample and corroborates the hypothesis that the stronger capital position of larger banks forces smaller banks to improve their capitalisation levels too, e.g. out the fear of loss of competitiveness against larger players in the wholesale funding and deposit markets.

[20] O-SII / G-SII buffers are typically proportional to the size/systemically importance of an institution, which is not reflected in our exercise. Furthermore, this exercise does not take into account bank-specific phasing-in periods which are tailored to allow banks accommodate increases in regulatory requirements.

Figure 7.5: IRFs of standardised bank-level capital volumes to an increase in a capital ratio accommodated via adjustment of assets large banks only



Legend: Large banks include mostly G-SII and O-SII banks. Figures are constructed on the basis of median responses of bank-level variables from the country models. All IRFs correspond with the behaviour of standardised variables on a cumulative basis. Red (blue) broken line marks the median response, and dark red (blue) fan represent 50% and light red (blue) 68% of the distribution of median responses of bank-level variables of G-SII and O-SII (other) banks. Solid black line marks the median response for the full sample of banks.

8 Conclusions and policy implications

This paper explores the structural FAVAR methodology for modelling the joint behaviour of macroeconomic and bank-level variables. The advantage that structural FAVAR models share with many other macroeconomic approaches is that they allow for endogenous feedback effects between the real economy and banking variables. At the same time, and in contrast to most macroeconomic approaches, FAVAR models offer a much richer picture of bank heterogeneity and distributional effects of structural shocks.

We compared eleven country-level structural FAVAR models, covering a sample of more than a hundred banks in the euro area. These country models cover four main types of banking systems represented in the euro area. The Italian and Portuguese banking systems are characterised by the predominance of 'traditional' banks which specialise in the provision of credit to the domestic non-financial private sector. The Cypriot, Spanish, French and Dutch banking systems have a significant share of internationally active banks. The Belgian, Finnish and Irish systems are characterised by a non-negligible share of 'non-traditional' bank activities, whereas the Lithuanian and Slovenian banking system, with their relatively small size compared to country GDP, are representative of banking systems in the new EU member states.

The estimation of FAVAR models involved the construction of eleven comprehensive bank-level datasets with different time-series dimensions, going as far back as 1998 for France and, on the other side of the spectrum, back to 2010 for Cyprus. The underlying supervisory and monetary data are confidential and were often affected by changes in reporting standards. These two factors discouraged earlier efforts to build analogous datasets and had to be overcome to complete the present study. The scope of the resulting national datasets is largely comparable across countries, though the full harmonisation of variable definitions and coverage has not been possible.

Combining the results from the FAVAR model and the bank-level regressions allows us to validate a moderating impact of higher capital buffers on the propagation of business cycle fluctuations into banks' lending. Our empirical results support that high bank capitalisation contributes to building banks' resilience - preventing cuts in credit and the kicking-in of adverse second-round effects.

We then show that the resilience of euro area banking systems increased over the last decade. Under a stylised adverse scenario consisting of a series of negative aggregate demand shocks, banks in 2015 would reduce their credit to the non-financial private sector 10% less than in 2010, and 20% less than if they had maintained 8.5% Tier1 ratio only. It is worth a mention that though statistically intuitive, the scenario is not tailored to individual country vulnerabilities. For actual policy exercises, a more fine-tuned approach to the design of country-specific scenarios can be warranted.

The short-term costs of a permanent 1pp increase in banks' Tier1 capital ratios amount to 1-3% reduction in credit to the non-financial private sector. The corresponding output losses amount to 0-2%. However, we also show that these estimates are likely to be very conservative. An increase in capital ratios can have a sharply different impact on credit supply, depending on the way banks adjust their assets versus capital. An increase in capital ratios can have an expansionary effect on credit as long as most of the banks in the system fit their balance sheets by beefing up capital buffers rather than reducing assets. Furthermore, banks are shown to use both ways of adjusting their capital ratios, rather than only deleveraging.

The rich set of policy conclusions derived in the paper shows the broad scope of application of FAVAR models for financial stability purposes. FAVAR models are flexible and easily extendable. Aggregate and bank-level variables can be added to existing specifications, as well as new structural shocks, depending on a policy question. For instance, our methodology of cost-benefit assessment is also applicable to liquidity-based or real estate policies. The FAVAR accounts for the heterogeneity of banks and makes it possible to observe the propagation of common shocks into a cross-section of banks. Exploring micro-level dimension of a FAVAR, we also show how structural shocks can be defined via a set of bank-level sign restrictions and apply such an identification scheme to delineate the effects of an increase in capital buffers of G-SII and O-SII banks. Small and compact, but not compromising the endogeneity of macroeconomic and bank-level variables, FAVAR models may also complement existing and generally complex top-down stress-test infrastructures, providing a relatively detailed picture of the effects of adverse scenarios on bank level outcomes.

The main caveats of structural FAVAR models for policy applications are concerned with their data and sample dependency. First, structural FAVAR models require the construction of a sufficiently long and consistent time-series of bank-level variables. Second, rare events or structural breaks in the sample period or omitted variables will hinder the correct identification of structural shocks. Moreover, the results derived from FAVAR models can project the future only to the extent to which past trends are likely to continue.

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Appendices

Appendix A: Comparison of bank-level datasets

The supervisory reporting was developed to monitor risk to which a bank is exposed and to assess the adequacy of its capital given these risks. It has been initially developed independently in each jurisdiction leading to datasets heterogeneity in terms of: (i) timespan (some countries have been using supervisory reporting since the 1980s while others started in the early 2000s), (ii) frequency (which can differ across countries for the same type of information, and across variables for the same country), (iii) consolidation level, and (iv) type of reporting institutions (some focus only on credit institutions, while others include a broader scope of entities). The granularity of the information collected could also vary across countries, as well as in time. Finally, the accounting standards used for the different templates could exhibit some country specificities.

In parallel to the country-specific reporting, a harmonised reporting system has been established at the EU level. Different types of reporting have emerged, and among them, two have been extensively used in this study: the reporting requirements relating to financial information compliant with international accounting standards (FINREP), and the one on own funds and requirements (COREP), both starting in 2007. Credit institutions subject to International Financial Reporting Standards (IFRS) are required to use FINREP templates to submit consolidated financial information in a harmonised format. Moreover, all credit institutions and investment firms (according to the CRR definition) are required to report COREP templates. Both reporting standards, in particular, COREP, have been evolving since their establishment and are currently being reported on a quarterly basis.

The Balance Sheet Statistics (BSI) type datasets were developed to monitor monetary liabilities and credit extended by monetary financial institutions. The emphasis is put on the counterparties (on who borrows the money) of credit institutions rather than on the institutions themselves because it is their spending and saving decisions which influence economic developments. The data are commonly reported on a monthly basis and cover all resident monetary financial institutions.

Although statistical and supervisory reporting has much in common, different objectives limit their comparability. One of the main differences concerns the consolidation level of the reported data. Under monetary policy oriented reporting, institutions report their activity in the reference country and exclude the operation of their foreign subsidiaries and branches; under supervisory reporting, institutions may include their cross-border and cross-sector activities. Cross-border means that data on branches and subsidiaries located outside the domestic market are included in the data reported by the parent institution. Cross-sector means that branches and subsidiaries of banks that can be classified as non-bank financial institutions are also included (except insurance corporations).

Another critical difference is the scope of the reported information. While information on loans to the private sector, deposits, and other major balance sheet items are available under both types of reporting schemes, variables related to concepts such as asset quality, prudential and solvency indicators are included only in supervisory reporting. Finally, rules concerning the valuation of assets and liabilities, the timing of recording of transactions, and whether or not certain items are recorded on the balance sheet, may differ between supervisory and statistical standards, and across supervisory reports.

Table A.1: Comparison of bank-level datasets

	Supervisory dataset	Individual BSI type of datasets (monetary policy purposes)	Individual MIR (interest rates)	Other
BE	The Common Reporting (COREP) framework is used to collect data on Tier1 capital from 2008 onwards.	Individual banks' balance sheet items (also called "Scheme A" in Belgium) are used to collect data on bank credit to non-financial corporations (NFCs) and households, non-performing loans, profits, provisions, and total assets. Historical capital data are drawn from Scheme A.	Individual MFI Interest Rate (iMIR) data for bank-level lending rates.	-
CY	FINREP (2010-2015)	-	Individual MFI Interest Rate (iMIR) data for bank-level lending and deposit rates.	-
ES	Balance sheets and income statements, as well as complementary files, that individual banks (non-consolidated) report to the Banco de España.	-	-	-
FI	FIN-FSA supervisory database based on the COREP/FINREP framework.	-	-	-
FR	BAFI (1998-2010), SURFI (2010-onwards) for solo data; BAFI (1998-2007) and FINREP (2007-onwards) for consolidated accounting data; BAFI (1998-2007) and COREP (2007-onwards) for consolidated prudential data.	-	Individual MFI Interest Rate (iMIR) data for bank-level lending and deposit rates.	GEA and REGAFI databases for changes and mergers and acquisitions. Public data from the annual reports were used for additional corrections (mainly to correct few large securitization events, and changes in accounting norms).
IE	The banking data are taken from the Central Bank of Ireland's Macro Prudential monitoring return including loan, borrower and collateral data.	The banking data are taken from the Central Bank of Ireland's Macro Prudential monitoring return including loan, borrower and collateral data.	Individual MFI Interest Rate (iMIR) data for bank-level lending rates.	Non-Performing loan data is taken from the Quarterly Summary Financial Return database (QSFR)
IT	The bank data are taken from Bank of Italy supervisory database, which includes data on prudential, financial and accounting information.	The bank data are taken from Bank of Italy supervisory database, which includes together both data collected basically for monetary policy purposes i.e. BSI .	The bank data are taken from Bank of Italy supervisory database, which includes together both data collected basically for monetary policy purposes i.e. MIR statistics.	N/A
LT	Other bank-level variables (Total assets, operating profit, Impairments on loans, provisions, CAR) are taken from individual bank financial reports (FINREP/COREP).	N/A	Information on bank-level new loan levels and new loan interest rates are taken from Monetary Financial Institutions (MFI) Interest Rates on Loans and Deposits Statistics.	N/A
NL	Supervisory reports equivalent to FINREP/COREP reports are used to collect bank-level data on total assets, capital, regulatory capital, net operating income, impairments.	The Monetary and Financial Statistics covers credit to non-financial privat sector.	Individual MFI Interest Rate (iMIR) data for bank-level lending and deposit rates.	
PT	Supervisory reports equivalent to the new FINREP/COREP reports are used to collect bank-level data on total assets, capital, regulatory capital, net operating income, impairments and loan to deposits ratio between 2000 and 2013. FINREP/COREP reports are used to collect the same information from 2014 onwards.	The Monetary and Financial Statistics database compiled by Banco de Portugal covers balance-sheet items.	The Monetary and Financial Statistics database compiled by Banco de Portugal covers interest rates relating loans and deposits of monetary financial institutions.	N/A
SI	Data are collected from a Bank of Slovenia database that draws aggregated, solo (non-consolidated) bank level variables from Bank of Slovenia supervisory databases.	-	Individual MFI Interest Rate (iMIR) data for bank-level lending and deposit rates.	-

Table A.2: Selection and transformations of bank-level balance sheet variables

	Measures of credit to NFC	Measures of credit to households	Bank capital ratio	Bank capital volume	Banks' profitability	Asset impairments	Provisions	Banks' liquidity	Assets (and other)
Transformation	q-o-q growth rate	q-o-q growth rate	% of total assets/RWA q-o-q difference	q-o-q growth rate	% of total assets	% of loans q-o-q difference	% of total assets	% of deposits	q-o-q growth rate
BE	Total outstanding loans to NFCs(1) (3) (4) (5) Long-term outstanding loans to NFCs (initial maturity > 1 year) (1) (3) (4) (5)	Total outstanding loans to households(1) (3) (4) (5) Long-term outstanding loans to households (initial maturity > 1 year) (1) (3) (4) (5)	Before 2008: Tier1 type of total own funds. After 2008: Tier1 own funds (COREP 1.1) including eligible capital, eligible reserves, funds for general banking risks, other country-specific original own funds, and other deductions from original own funds. Tier1 capital / Total assets		(Gross profits - corrections for ordinary banking activities + extraordinary profits – taxes) / Total assets(6)	Non-performing loans to NFCs / Outstanding loans to NFCs Non-performing loans to households / Outstanding loans to households	Provisions: Net value adjustments on loans / Total assets(6)		Total assets (4) (5)
CY	Total outstanding loans to NFC. Over the period 2013 Q3 - 2014 Q3 the templates change and the data is composed of credit facilities to corporate legal entities & credit facilities to retail legal entities. (3) (4)	Outstanding loans to households for house purchase (3) (4) Outstanding loans to households for consumption. During the period 2013 Q3 - 2014 Q3 consist of consumer loans, credit cards, current accounts and credit facilities to sole traders (3) (4)	Tier1 capital / RWA: total original own funds for general solvency purposes / (capital requirements * 12,5) Tier1 capital / Total assets (excluding intangible assets).	Tier1 capital volume: total original own funds for general solvency purposes	Total profit (loss) before tax from continuing operations / Total assets (3) (4) (5)	Non-performing loans to NFCs / Outstanding loans to NFC. Non-performing loans are defined according to the applicable CBC directive at the time until December 2014. (3) (4) (5) Non-performing loans to households / Outstanding loans to households. Non-performing loans are defined according to the applicable CBC directive at the time until December 2014. (3) (4) (5)	The net value adjustment of loans / Total assets (3) (4) (5)		Total assets (3) (4) (5)
ES	Outstanding loans to NFCs incl. outstanding loans to individual entrepreneurs (5)	Outstanding housing loans to households(5) Outstanding other purpose loans to households(5)	Own funds / Total assets (7) Tier1 capital/RWA (consolidated)	Tier1 capital volume (consolidated)	Profit before taxes / Average Total assets	Non-performing loans to NFCs / Outstanding loans to NFCs Non-performing housing loans to households / Outstanding housing loans to households	Provisions / Total Assets	Total loans / Total deposits (6)	Total assets
FI	Total outstanding loans to NFCs	Total outstanding loans to households	Tier1 capital / RWA Tier1 capital / Total	T1 capital volume	Net operating profit / Total assets	Non-performing loans to NFCs / Outstanding loans to NFCs		Total loans / Total deposits	Risk-weighted assets volume

			assets			Non-performing loans to households / Outstanding loans to households			Total assets volume Total credit volume
FR	Short-term outstanding loans to NFCs (initial maturity < 1 year) (4) Long-term outstanding loans to NFCs (initial maturity > 1 year) (1) (4)	Outstanding mortgage loans to households Outstanding consumption loans to households	Own funds / Total assets (2) (5) (8) Tier1 capital / Risk weighted assets)	Tier1 Capital Volumes	Profit net of exceptional profit and taxes / Total assets (2)	Non-performing loans to NFCs / Outstanding loans to NFCs Non-performing loans to households / Outstanding loans to households	Total aggregated solo provisions / Total consolidated assets		Total assets, consolidated (2) (4) (7)
IE	Short-term outstanding loans to NFCs (initial maturity < 1 year) (4) Long-term outstanding loans to NFCs (initial maturity > 1 year) (4)	Outstanding mortgage loans to households(4) Outstanding consumption loans to households(4)	Tier1 capital / RWA (4)	Tier1 Capital Volumes(4) (6)		Non-performing loans to NFCs / Outstanding loans to NFCs(3) (4) Non-performing loans to households / Outstanding loans to households(3) (4)		Total Loans / Total Deposits(4) (6)	Total Assets(4)
IT	Outstanding loans to NFCs up to EUR 1 mln (8) (9) Outstanding loans to NFCs over an amount of EUR 1 mln	Outstanding loans to households (8) (9)	Own funds/Total assets CET1 / RWA Tier1 capital / RWA		RoE = Net profits / (Capital and reserves) (9) RoA = Net profits / Total assets (9)	Non-performing loans to private sector / Outstanding loans to private sector (9)		Total loans to the domestic private sector / Total deposits and retail bonds (Funding gap) (9)	Log of Total assets (9)
LT	Total outstanding loans (stock) to NFCs (4) (5)	Outstanding mortgage loans to households (4) (5) Outstanding consumption and other loans to households (4) (5)	Total regulatory capital / Risk weighted assets	Total regulatory capital	Operating profit/Total assets (4) (6)	Non-performing loans / Total loans to private sector (3) (4)	Provisions for loans/ Total assets (4)	Loan-to-deposit (6)	Total assets
NL	Short-term outstanding loans to NFCs (initial maturity < 1 year) (1) (4) Long-term outstanding loans to NFCs (initial maturity > 1 year) (1) (4)	Outstanding mortgage loans to households (1) (4) Outstanding consumption and other loans to households (1) (4)	Tier1 capital / RWA Tier1 capital / Total assets		Net operating income/Total assets	Non-performing loans to non-financial private sector/ Total loans to non-financial private sector		Loan-to-deposit	Total assets

PT	Total outstanding loans to NFC (index of notional stocks) (1) (3) (4) (5)	Housing loans to households (index of notional stocks) (1) (3) (4) (5) Loans to households for consumption and other purposes incl. loans to individual entrepreneurs (index of notional stocks) (1) (3) (4) (5)	Tier1 capital / RWA (3) (4) (5)	Regulatory Tier1 capital (3) (4) (5)	Net operating income /Total assets (3) (4) (5) (6) Flow of impairments / Total assets (3) (4) (5) (6)	Non-performing loans to NFCs* / Outstanding loans to NFCs (4) (5) (6) Non-performing loans to households for housing purposes* / Outstanding loans to households for housing purposes (4) (5) (6) Non-performing loans to households for consumption and other purposes * / Outstanding loans to households for consumption and other purposes (4) (5) (6) *Statistical concept of overdue and other doubtful loans		Loans net of impairments and including securitisations over deposits (3) (4) (5) (6)	Total assets (3) (4) (5)
SI	Short-term outstanding loans to NFCs (initial maturity < 1 year) (4) (5) Long-term outstanding loans to NFCs (initial maturity > 1 year) (4) (5)	Total outstanding loans to households (4) (5)	Tier1 capital / RWA (3) (4)	Tier1 capital volume (4)	RoA = Net profits / Total assets		Provisions for loans/ Total assets (6)	Total loans / Total deposits (6)	Total assets (4) (5)

Legend: If not marked otherwise, all credit volumes are measured by loans outstanding at the end of a quarter, and are included in a model on quarter-on-quarter basis. (1) Adjusted for write-offs, securitisation and reclassifications, (2) Corrected for changes in accounting standards. (3) Intrapolated for missing observations. (4) Outlier correction. (5) Seasonally adjusted (e.g. X-12 ARIMA) (6) Quarter-on-quarter difference. (7) Ratio level. (8) Before 2008: Tier1 type of total own funds. After 2008: Tier1 own funds (COREP 1.1) including eligible capital, eligible reserves, funds for general banking risks, other country specific original own funds, and other deductions from original own funds.

Table A.3: Selection and transformations of other bank-level variables

	Lending margin	Deposit spreads	CDS or similar	Beta (stock prices)
Transformation	Level	Level	Level	Level
BE	Interest rate on new loans – Deposit rate on new deposits (both to the non-financial private sector) (1)	Deposit rate on new deposits to non-financial private sector – EONIA (2)		
CY	Interest rate on new loans – Deposit rate on new deposits (both to the non-financial private sector) (1)	Deposit rate on new deposits to non-financial private sector – EONIA (2)	-	Bank level Stock Prices /Stock market index (Cyprus General Price index)
ES	Interest rate on new loans – Deposit rate on new deposits (both to the non-financial private sector) (1)	Deposit rate on new deposits to non-financial private sector – EONIA (2)	-	-
FI	Interest rate on new loans – Deposit rate on new deposits (both to the non-financial private sector) (1)	Deposit rate on new deposits to non-financial private sector – EONIA (2)	-	-
FR	Interest rate on new loans – Deposit rate on new deposits (both to the non-financial private sector) (1)	Deposit rate on new deposits to non-financial private sector – EONIA (2)	CDS EUR Senior Debt 5-year	Bank Equity Index / Market Equity Index
IE	Interest rate on new loans – Deposit rate on new deposits (both to the non-financial private sector) (1)	Deposit rate on new deposits to non-financial private sector – EONIA (2)	-	-
IT	Interest rate on new loans – Deposit rate on new deposits (both to the non-financial private sector) (1)	Deposit rate on new deposits to non-financial private sector – EONIA (2)		
LT	Loans interest rate – deposit interest rate	Deposit interest rate – EONIA (3)	-	-
NL	Interest rate on new loans – Deposit rate on new deposits (both to the non-financial private sector) (1)	Deposit rate on new deposits to non-financial private sector – EONIA (2)	-	-
PT	Difference between the interest rate on new loans (to non-financial private sector) and the interest rate on new deposits (from non-financial private sector) (3)	Difference between the interest rate on new deposits (from non-financial private sector) and the 3-month euribor (3)	CDS EUR Senior Debt 5-year (3)	Bank level Stock Prices /Stock market index (3)
SI	Interest rate on stock of loans – Deposit rate on stock of deposits (both to the non-financial private sector) (1) (3)	Deposit rate on stock of deposits to non-financial private sector – EONIA (2) (3)	-	-

Legend: (1) Interest rate on new loans to non-financial private sector are weighted across different initial interest fixation periods. Deposit rate on new deposits to non-financial private sector are weighted across different maturities. They cover overnight deposits, deposits redeemable at notice and deposits with agreed maturity; does not include repurchase agreements). (2) Deposit rate on new deposits to non-financial private sector are weighted across different maturities, covering overnight deposits, deposits redeemable at notice and deposits with agreed maturity; does not include repurchase agreements. EONIA (EMMI EURO OverNight Index Average). (3) Quarter-on-quarter difference.

Table A.4 : Overview of bank-level variables in country models

		BE	CY	ES	FI	FR	IE	IT	LT	NL	PT	SI
Total assets		●	●	●	●	●	●	●	●	●	●	●
Total lending		○	○	○	○	○	○	●	○	○	○	○
Measures of credit to non-financial corporations	Total outstanding loans	●	●	●	●	○	○	○	●	○	●*	○
	Therein: initial maturity > 1 year	●				●	●			●		●
	Therein: Initial maturity < 1 year					●	●			●		●
	Therein: large							●				
	Therein: small							●				
Measures of credit to households	Total outstanding loans	●	○	○	●	○	○	●	○	○	○	●
	Therein: initial maturity > 1 year	●										
	Therein: Initial maturity < 1 year											
	Mortgage loans/loans for housing purposes outstanding		●	●		●	●		●	●	●*	
	Consumption and other loans outstanding		●	●		●	●		●	●	●*	
Non performing loans	Total NPLs / Total outstanding loans		○	○	○	○	○	●	●	●	○	●
	NPLs to NFCs / Outstanding loans to NFCs	●	●	●	●	●	●				●	
	NPLs to HHs / Outstanding loans to HHs	●	●	●	●	●	●				○	
	NPLs to HHs (housing) / Outstanding loans to HHs (housing)										●	
	NPLs to HHs (consumption and other purposes) / Outstanding loans to HHs (consumption and other purposes)										●	
Impairments on loans and provisions	Impairment on loans / Total assets									●	●	
	Provisions / Total assets	●	●	●		●			●			●
Bank capitalisation	Tier1 capital	●	●	●$^{\times}$	●	●	●	●		●	●	●
	Own funds						●		●			
	Tier1/ Total assets	●	●		●			●		●		
	Own funds / Total assets			●$^{\times\times}$	●	●	●					
	Tier1/ Total RWAs		●	●$^{\times}$	●	●	●			●	●	●
	Own funds / RWAs								●			
Bank liquidity	Loan to deposits ratio	●		●	●		●	●	●	●	●	●
Bank profitability	Profit net of extr. profit and taxes / Total assets				●	●						
	Profit before taxes / Total assets		●	●								
	Operating profit / Total assets								●	●	●	
	ROA	●						●			●$^{\times}$	●
Interest rates$^{\times}$	Lending margins to non-financial private sector	●	●	●	●	●	●	●	●	●	●	●
	Deposit margins for non-financial private sector		●	●	●	●	●	●	●	●	●	●
Market prices$^{\times}$	CDS				●	●				●	(●)	●
	Stock prices (betas)		●			●				●	(●)	

Legend: $^{\times}$ bank-level variables used only in the estimation of models reported in chapter 10. $^{\times\times}$ bank-level variables used only in the estimation of models reported in chapters 7-8. ● Variable used in the estimation. ○ An auxiliary variable derived after the estimation. * Index of notional stocks. ** OAS. ** Lending margins on loans to NFC. (●) Variable used in the estimation but available only for a subset of banks in a sample.

Appendix B: Trends in the data

Figure B.1: GDP growth rate (year-on-year)

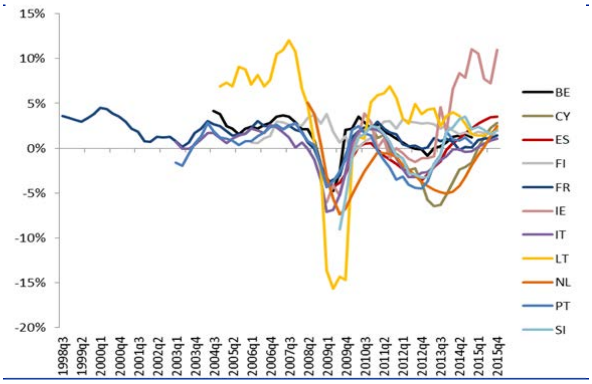
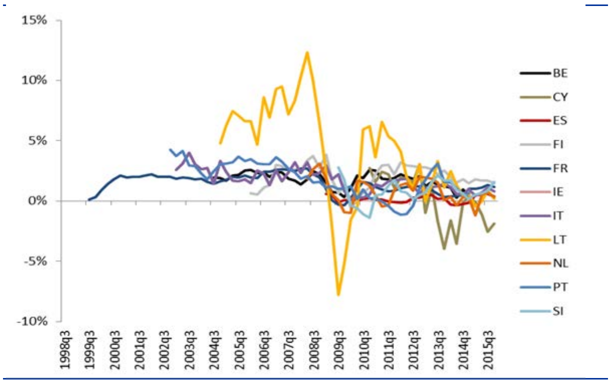


Figure B.2: GDP deflator growth rate (year-on-year)



Legend: Real GDP series, chained-linked volumes, or indices.

Figure B.3: Nominal growth rate in residential house price indices (year-on-year)

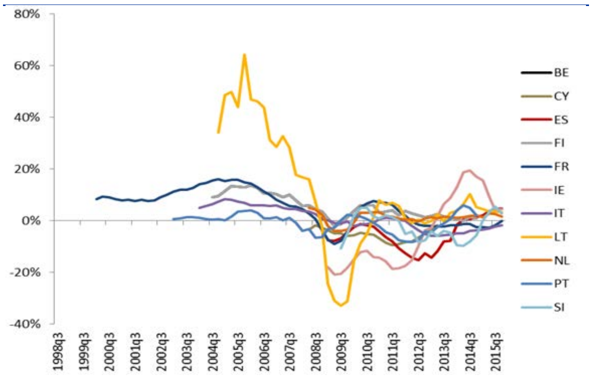


Figure B.4: Nominal growth rate in commercial property price indices (year-on-year)

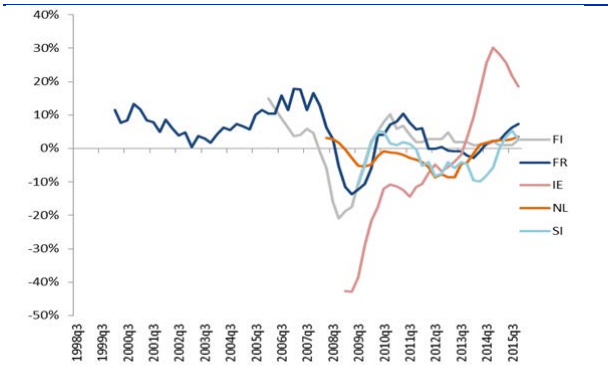
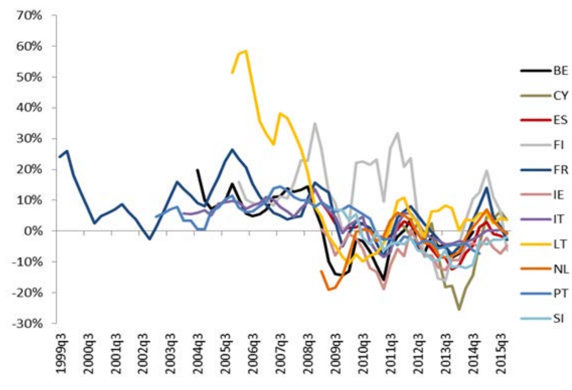
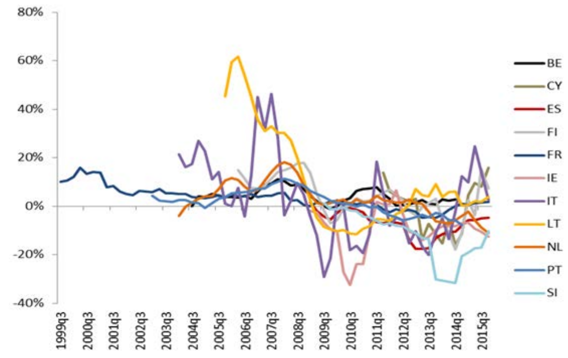


Figure B.5: Total outstanding assets growth rate (year-on-year)



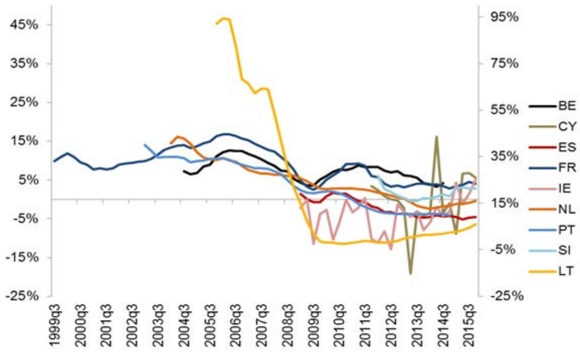
Legend: Total assets at the end of a quarter.

Figure B.6: Total outstanding credit issued to NFCs growth rate (year-on-year)



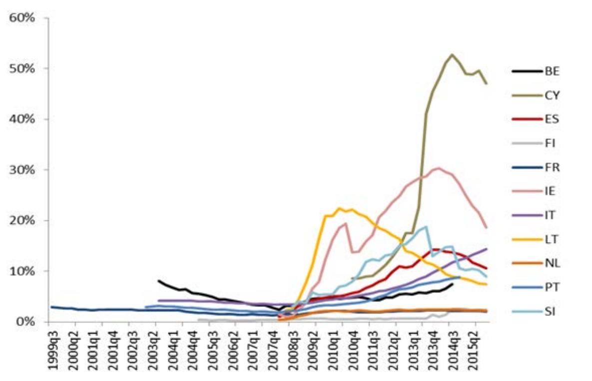
Legend: Credit outstanding at the end of a quarter. For Portugal, notional stocks.

Figure B.7: Mortgage (or for housing purposes) outstanding credit issued to households (year-on-year)



Legend: Left hand axis: all countries except Lithuania, right hand side: Lithuania. Credit outstanding at the end of a quarter. For Belgium long-term (initial duration above a year) household credit. For Portugal notional stocks.

Figure B.8: Non-performing loans as a percentage of total loans to the private sector



Legend: For France NPLs net of provisions.

Figure B.9: Provisions as a percentage of total assets

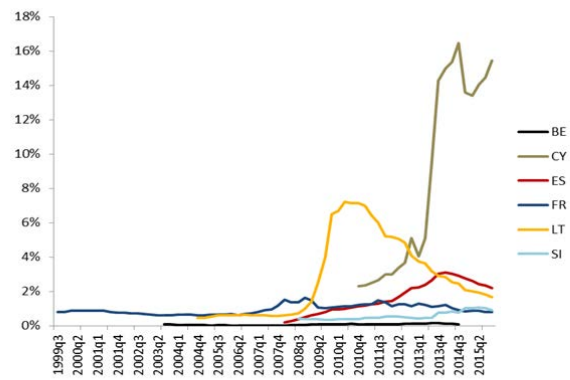
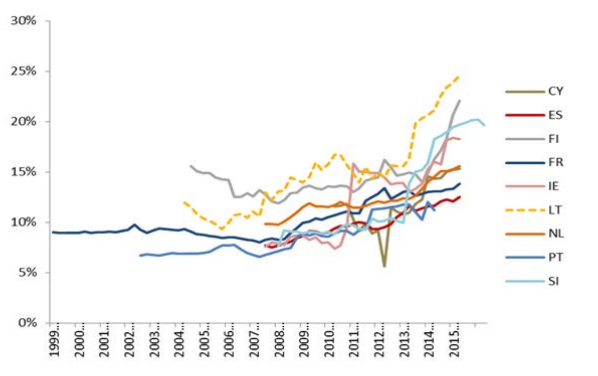
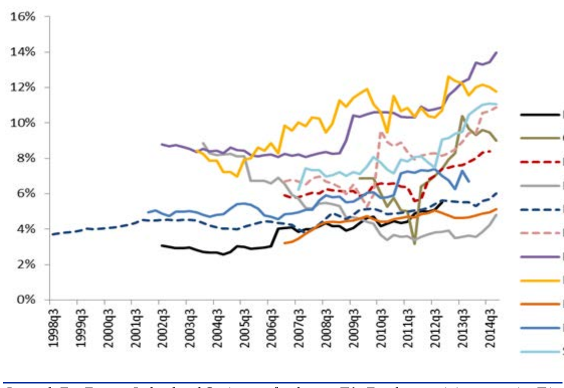


Figure B.10: Tier1 (own funds) over RWA



Legend: For Lithuania own funds over RWA. For the remaining countries T1 capital over RWA.

Figure B.11: Tier1 (own funds) over total assets: non-RWA based concepts



Legend: For France, Ireland and Spain own funds over TA. For the remaining countries T1 capital over TA.

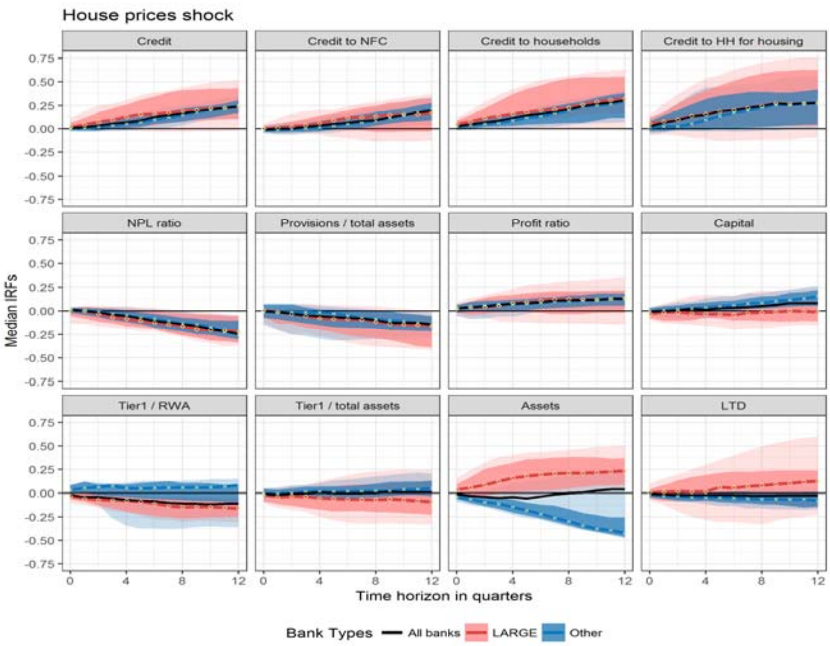
Appendix C: Additional information on the benchmark country models

Table C.1: Overview of variables in benchmark country models

	GDP(1)	GDP deflator(2)	Property prices: RRE price index(3)	Property prices: CRE price index(2)	Number of unobserved factors	Avg. % of explained variance by observed variables	Avg. % of explained variance by unobserved factors	Number of lags of endogenous variables	Exogenous variables
BE	•	•	•		4	13.0%	28.5%	1	None
CY	•	•	•		3	33.6%	49.1%	1	None
ES	•	•	•		2	25.5%	40.4%	1	None
FI	•	•	•	•	3	12.6%	37.9%	1	None
FR	•	•	•	•	4	21.7%	35.3%	1	None
IE	•	•	•	•	5	35.5%	48.6%	1	None
IT	•	•	•		3	39.3%	13.5%	1	None
LT	•	•	•		3	34.5%	26.0%	1	Dummy 2009Q1
NL	•	•	•	•	4	35.5%	41.7%	1	None
PT	•	•	•		6	16.4%	41.1%	1	None
SI	•	•	•		2	20.2%	21.5%	1	None

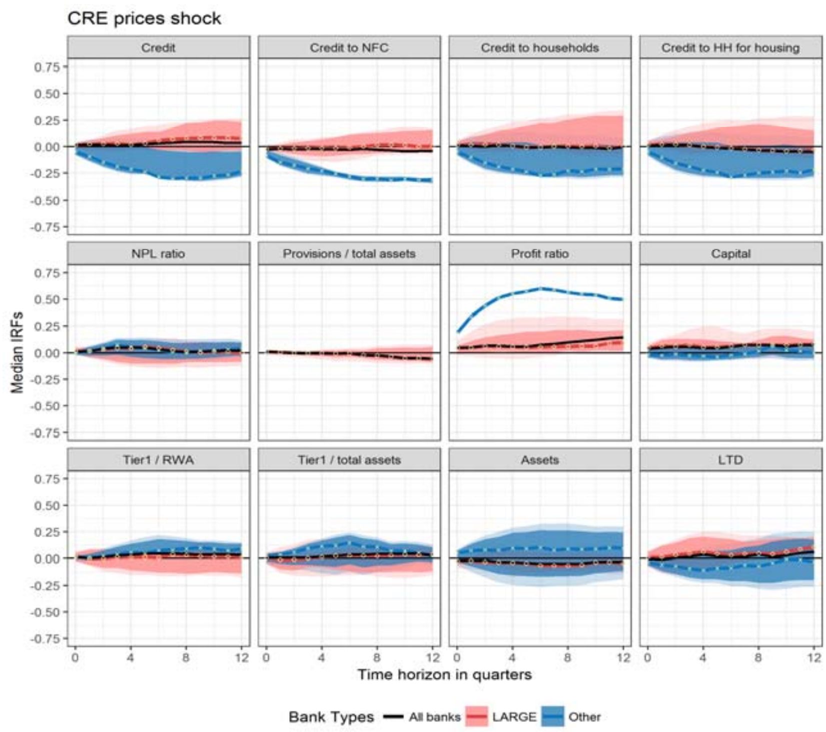
Legend: (1) Real GDP, chain-linked volume, seasonally adjusted, log q-o-q. (2) Seasonally adjusted q-o-q. (3) Belgium: nominal house price index (all dwellings, end of quarter), Italy: residential property prices index compiled internally at the Bank of Italy, Portugal: nominal house price index based on sales of newly-built and existing dwellings; all types of dwellings (2010=100). All: seasonally adjusted log q-o-q.

Figure C.1. Median IRFs of standardised bank-level variables to a one standard deviation positive residential house price shock: large (mostly G-SII and O-SII) banks, other banks, and all banks together



Legend: Large banks include mostly G-SII and O-SII banks. Figures are constructed on the basis of median responses of bank-level variables from the country models. All IRFs correspond with the behaviour of standardised variables on a cumulative basis. Red (blue) broken line marks the median response, and dark red (blue) fan represent 50% and light red (blue) 68% of the distribution of median responses of bank-level variables of G-SII and O-SII (other) banks. Solid black line marks the median response for the full sample of banks.

Figure C.2. Median IRFs of standardised bank-level variables to a one standard deviation positive commercial property price shock: large (mostly G-SII and O-SII) banks, other banks, and all banks together



Legend: Large banks include mostly G-SII and O-SII banks. Based on the data for Ireland, Finland, France, the Netherlands. Figures are constructed on the basis of median responses of bank-level variables from the country models. All IRFs correspond with the behaviour of standardised variables on a cumulative basis. Red (blue) broken line marks the median response, and dark red (blue) fan represent 50% and light red (blue) 68% of the distribution of median responses of bank-level variables of G-SII and O-SII (other) banks. Solid black line marks the median response for the full sample of banks. Based on the results for four countries: Finland, France, Ireland and the Netherlands.

Table C.2: The median cumulated effects of a one standard deviation positive aggregate demand shock on GDP, real estate prices and credit aggregates a year and two years after the shock

	GDP		RRE prices		CRE prices		Credit to the non-financial private sector		Credit to NFC		Credit to households		Credit to households for housing	
	After a year	After 2 years	After a year	After 2 years	After a year	After 2 years	After a year	After 2 years	After a year	After 2 years	After a year	After 2 years	After a year	After 2 years
BE	0.67%	0.64%	1.02%	1.12%			0.35%	0.42%	0.40%	0.52%	0.40%	0.47%	0.36%	0.40%
CY	0.67%	0.53%	0.51%	0.53%			-0.29%	-0.18%	-0.42%	-0.12%	-0.16%	-0.15%	0.10%	0.12%
ES	0.35%	0.40%	0.54%	0.69%			0.17%	0.22%	0.28%	0.36%	0.11%	0.15%	0.15%	0.19%
FI	0.11%	-0.02%	-0.23%	-0.20%	-1.02%	-1.30%	0.64%	0.79%	0.89%	1.05%	0.55%	0.69%		
FR	0.11%	0.07%	-0.20%	-0.34%	0.55%	0.35%	0.12%	0.10%	0.28%	0.33%	0.04%	0.01%	0.02%	-0.02%
IE	0.44%	0.36%	-0.73%	-1.25%	-0.27%	-0.62%	0.33%	0.34%	1.10%	1.21%	0.19%	0.18%	0.20%	0.21%
IT	0.30%	0.37%	0.46%	0.70%			0.21%	0.42%	0.21%	0.40%	0.29%	0.48%		
LT	0.82%	0.92%	1.84%	2.45%			1.53%	2.43%	1.26%	1.98%	1.90%	3.07%	1.91%	3.12%
NL	0.24%	0.23%	0.08%	0.05%	0.04%	0.08%	0.00%	0.00%	0.02%	0.04%	0.00%	-0.01%	0.00%	-0.01%
PT	0.38%	0.46%	0.31%	0.30%			0.73%	1.16%	0.68%	1.10%	0.90%	1.41%	0.96%	1.50%
SI	0.64%	0.59%	0.62%	0.68%			0.42%	0.51%	0.20%	0.39%	0.33%	0.36%		
EA avg.	**0.27%**	**0.27%**	**0.19%**	**0.22%**	**0.14%**	**0.06%**	**0.19%**	**0.26%**	**0.28%**	**0.39%**	**0.17%**	**0.23%**	**0.10%**	**0.12%**

Legend: 'EA average' is the weighted average of country-level outcomes, with weights proportional to nominal country GDP in 2015 for GDP, RRE prices and CRE prices, and nominal value of outstanding credit volumes along with BIS statistics at the end of 2015 for credit variables.

Table C.3 The median cumulated effects of a one standard deviation positive shock to residential real estate prices on GDP, real estate prices and credit aggregates a year and two years after the shock

	GDP		RRE prices		CRE prices		Credit to the non-financial private sector		Credit to NFC		Credit to households		Credit to households for housing	
	After a year	**After 2 years**	**After a year**	**After 2 years**	**After a year**	**After 2 years**	**After a year**	**After 2 years**	**After a year**	**After 2 years**	**After a year**	**After 2 years**	**After a year**	**After 2 years**
BE	0.10%	0.12%	1.36%	1.60%			0.20%	0.23%	0.13%	0.17%	0.27%	0.32%	0.23%	0.26%
CY	-0.45%	-0.47%	0.43%	0.27%			0.47%	0.48%	1.32%	1.11%	-0.11%	-0.04%	-0.02%	0.00%
ES	0.16%	0.21%	1.05%	1.25%			0.08%	0.13%	0.11%	0.19%	0.06%	0.10%	0.06%	0.10%
FI	0.43%	0.45%	0.86%	0.86%	0.32%	0.21%	0.44%	0.67%	0.34%	0.64%	0.45%	0.67%		
FR	0.10%	0.11%	0.89%	1.16%	0.46%	0.74%	0.31%	0.47%	0.20%	0.41%	0.36%	0.52%	0.43%	0.61%
IE	0.30%	0.37%	1.82%	1.95%	0.31%	0.71%	-0.37%	-0.27%	-0.80%	-0.74%	-0.23%	-0.15%	-0.23%	-0.17%
IT	0.11%	0.19%	0.35%	0.52%			0.03%	0.21%	0.04%	0.18%	0.11%	0.30%		
LT	0.19%	0.37%	2.63%	3.74%			3.07%	4.69%	2.45%	3.74%	3.83%	5.86%	3.92%	5.99%
NL	-0.02%	-0.03%	0.72%	0.84%	0.05%	0.10%	0.11%	0.17%	0.07%	0.08%	0.11%	0.15%	0.11%	0.16%
PT	0.21%	0.25%	0.58%	0.59%			0.03%	0.12%	-0.09%	0.00%	0.12%	0.29%	0.15%	0.30%
SI	0.29%	0.24%	2.30%	2.47%			0.96%	1.09%	1.61%	1.83%	0.45%	0.51%		
EA avg.	**0.11%**	**0.15%**	**0.80%**	**1.02%**	**0.17%**	**0.28%**	**0.17%**	**0.29%**	**0.13%**	**0.25%**	**0.20%**	**0.32%**	**0.20%**	**0.29%**

Legend: : 'EA average' is the weighted average of country-level outcomes, with weights proportional to nominal country GDP in 2015 for GDP, RRE prices and CRE prices, and nominal value of outstanding credit volumes along with BIS statistics at the end of 2015 for credit variables

Table C.4 Median cumulated effects of a positive shock to commercial real estate prices leading to a cumulated increase in country commercial real estate price index by 1% a year after the shock

	GDP		RRE prices		CRE prices		Credit to the non-financial private sector		Credit to NFC		Credit to households		Credit to households for housing	
	After a year	**After 2 years**	**After a year**	**After 2 years**	**After a year**	**After 2 years**	**After a year**	**After 2 years**	**After a year**	**After 2 years**	**After a year**	**After 2 years**	**After a year**	**After 2 years**
FI	0.85%	0.85%	0.37%	0.32%	2.54%	2.49%	0.10%	0.26%	-0.15%	0.20%	0.17%	0.33%	0.15%	0.30%
FR	0.02%	0.00%	-0.20%	-0.29%	0.84%	0.80%	-0.01%	-0.03%	0.03%	0.00%	-0.01%	-0.06%	0.00%	-0.07%
IE	0.16%	0.33%	0.58%	1.04%	2.27%	2.94%	-0.09%	-0.05%	-0.21%	-0.03%	-0.07%	-0.07%	-0.07%	0.00%
NL	-0.08%	-0.13%	-0.20%	-0.40%	0.41%	0.33%	0.13%	0.18%	0.14%	0.19%	0.12%	0.15%	0.11%	0.14%
EA avg.	**0.09%**	**0.07%**	**-0.15%**	**-0.24%**	**0.98%**	**0.95%**	**0.00%**	**0.00%**	**0.02%**	**0.02%**	**0.01%**	**-0.02%**	**0.01%**	**-0.03%**

Legend: 'EA average' is the weighted average of country-level outcomes, with weights proportional to nominal country GDP in 2015 for GDP, RRE prices and CRE prices, and nominal value of outstanding credit volumes along with BIS statistics at the end of 2015 for credit variables.

Appendix D: Regression results and additional information on benefit assessment

Table D.1.a: Effects of a positive one standard deviation aggregate demand shock (4Q following the shock)

	Credit						Credit to NFCs					
	ALL	ALL	LARGE	LARGE	OTHER	OTHER	ALL	ALL	LARGE	LARGE	OTHER	OTHER
T1RWA	-0.41	-0.50	-3.07	-4.10***	1.025231	-1.46***	-0.14	2.037***	-3.99	-0.49	1.95*	0.01
	(-0.49)	(-1.74)	(-1.53)	(-4.50)	1.35)	(-4.79)	(-0.16)	(6.70)	(-1.69)	-0.51	(2.57)	(0.05
T1RWA^2	1.20	2.21***	12.10*	18.54***	-1.69	2.88***	-0.42	-2.69***	14.57***	11.76***	-3.87*	-0.19
	(0.64)	(3.87)	(2.20)	(6.27)	(-1.06	(5.08)	(0.20)	(5.85)	(2.25)	(3.75)	(-2.36)	(-0.40)
LARGE		0.18***		-		-		0.16***		-		-
		(12.47)		-		-		(9.52)		-		-
COOP		-0.02		0.07*		-		-0.30***		-0.22***		-
		(-0.60)		(2.07)		-		(-7.04)		(-4.58)		-
SAVING		0.01		-0.02		0.033		-0.07**		-0.01		-0.18***
		(0.28)		(0.55)		(1.51)		(-2.34)		(-0.19)		(-7.20)
COUNTRY DUMMIES	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes
N	116	116	53	53	63	63	112	112	50	50	62	62
R^2	0.002	0.134	0.061	0.151	0.058	0.078	0.000	0.108	0.069	0.155	0.137	0.023

Legend: t-statistics under parameter estimates. Weighted Leas Square estimates with robust standard errors and observation weights proportional to the percentage of contemporaneous variance of variables explained by country models. LARGE – a dummy variable taking the value of 1 for large banks (mainly G-SII and O-SII). COOP – a dummy variable taking the value of 1 for cooperative banks. SAVING – a dummy variable taking the value of 1 for savings banks. * p<0.05; ** p<0.01; *** p<0.001.

Table D.1.b: Effects of a positive one standard deviation aggregate demand shock (4Q following the shock)

	Credit to households						Credit to households for mortgage purposes					
	ALL	ALL	LARGE	LARGE	OTHER	OTHER	ALL	ALL	LARGE	LARGE	OTHER	OTHER
T1RWA	-1.06	-2.28***	-1.60	-3.26**	-2.29***	-2.23***	-4.97	-7.42***	-6.29***	-8.18***	8.12**	8.125**
	(-1.06)	(-7.16)	(-1.54)	(-3.07)	(-7.00)	(-6.82)	(-1.35)	(-6.40)	(-4.95)	(-6.27)	(2.69)	2.69)
T1RWA^2	2.08	4.72***	2.13	6.82*	4.80***	4.69***	12.53***	16.42***	17.17***	22.87***	-44.17***	- 44.17***
	(0.87)	(7.31)	(0.66)	(2.04)	(7.35)	(7.17)	(1.26)	(4.86)	(4.75)	(6.13)	(-4.59)	(-4.59)
LARGE		0.08***		-		-		0.11***		-		-
		(5.19)		-		-		(4.89)		-		-
COOP		0.10***		0.21***		-		0.16***		0.29***		-
		(3.35)		(5.69)		-		(4.20)		(5.92)		-
SAVING		-0.06		-0.03		-0.16***		-0.04		-0.06		-
		(-1.66)		(-0.48)		(-5.58)		(-0.52)		(-0.93)		-
COUNTRY DUMMIES	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes
N	113	113	50	50	63	63	53	53	37	37	16	16
R^2	.01213981	0.143	0.162	0.169	0.084	0.086	0.044	0.128	0.128	0.139	0.150	0.150

Legend: t-statistics under parameter estimates. Weighted Leas Square estimates with robust standard errors and observation weights proportional to the percentage of contemporaneous variance of variables explained by country models. LARGE – a dummy variable taking the value of 1 for large banks (mainly G-SII and O-SII). COOP – a dummy variable taking the value of 1 for cooperative banks. COOP – a dummy variable taking the value of 1 for cooperative banks. SAVING – a dummy variable taking the value of 1 for savings banks. * p<0.05; ** p<0.01; *** p<0.001.

Table D.2.a: Effects of a one standard deviation positive residential real estate price shock (4Q following the shock)

	Credit						Credit to NFCs					
	ALL	ALL	LARGE	LARGE	OTHER	OTHER	ALL	ALL	LARGE	LARGE	OTHER	OTHER
T1RWA	1.10***	1.26***	1.63	1.87	0.30	0.36	0.07	0.04	0.19	-0.80	1.40***	1.194***
	(3.41)	(3.95)	(1.74)	(1.93)	(0.82)	(0.98)	(0.24)	(0.12)	(0.21)	(-0.80)	(4.91)	(4.18)
T1RWA^2	-2.05**	-2.40***	-0.87	-1.55	-061	-0.72	-0.63	-0.52	-1.35	1.71	-2.95***	-2.54***
	(-3.13)	(-3.71)	(-0.28)	(-0.48)	(-0.86)	(-1.02)	(-1.08)	(-0.85)	(-0.41)	(0.51)	(-5.21)	(-4.48)
LARGE		0.01		-		-		0.04*		-		-
		(0.50)		-		-		(2.45)		-		-
COOP		-0.09**		-0.03		-		0.03		0.14*		-
		(-2.74)		(-0.97)		-		(0.64)		(2.50)		-
SAVING		-0.06		.06		-0.38***		-0.15***		-0.03		-0.41***
		(-1.19)		(0.88)		(-21.29)		(-3.40)		(0.48)		(-21.23)
COUNTRY DUMMIES	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes
N	116	116	53	53	63	63	112	112	50	50	62	62
R^2	0.085	0.086	0.089	0.090	0.089	0.094	0.085	0.087	0.091	0.094	0.093	0.102

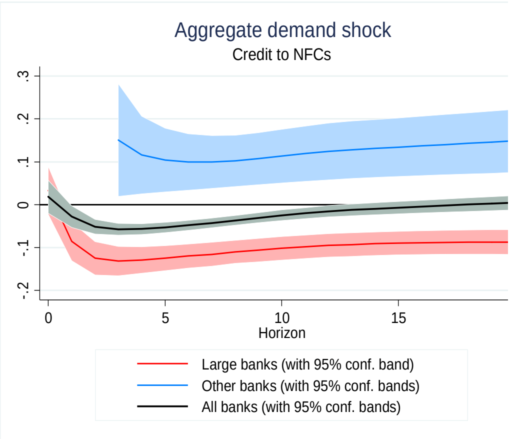
Legend: t-statistics under parameter estimates. Weighted Leas Square estimates with robust standard errors and observation weights proportional to the percentage of contemporaneous variance of variables explained by country models. LARGE – a dummy variable taking the value of 1 for large banks (mainly G-SII and O-SII). COOP – a dummy variable taking the value of 1 for cooperative banks. SAVING – a dummy variable taking the value of 1 for savings banks. * p<0.05; ** p<0.01; *** p<0.001.

Table D.2.b: Effects of a one standard deviation positive residential real estate price shock (4Q following the shock)

	Credit to households						Credit to households for mortgage purposes					
	ALL	ALL	LARGE	LARGE	OTHER	OTHER	ALL	ALL	LARGE	LARGE	OTHER	OTHER
T1RWA	0.85*	1.03**	1.14	1.78	-0.97*	-0.84*	1.06	1.68	2.72*	3.39**	-3.69	-3.69
	(2.20)	(2.71)	(1.05)	(1.59)	(-2.27)	(-1.96)	(0.90)	(1.41)	(2.10)	(2.61)	(-0.93)	(-0.93)
T1RWA^2	-1.17	-1.61	3.00	1.21	2.05	1.79	4.89	2.95	2.07	0.05	14.53	14.53
	(-1.35)	(-1.86)	(0.84)	(0.33)	(2.16)	(1.89)	(1.49)	(0.89)	(0.58)	(0.01)	(1.17)	(1.17)
LARGE		-0.02		-		-		-0.02		-		-
		(-1.34)		-		-		-0.89		-		-
COOP		-0.12***		-0.08*		-		-0.13**		-0.10		-
		(-3.63)		(-1.99)		-		(-2.980		(-1.93)		-
SAVING		-0.13**		0.08		-0.38		0.10		0.09		-
		(-2.80)		(0.95)		(-14.64)		(1.13)		(1.05)		-
COUNTRY DUMMIES	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes
N	113	113	50	50	63	63	53	53	37	37	16	16
R^2	0.065	0.068	0.087	0.088	0.062	0.072	0.085	0.087	0.106	0.108	0.060	0.060

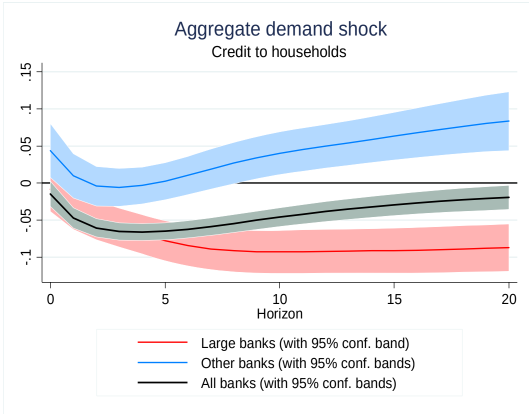
Legend: t-statistics under parameter estimates. Weighted Leas Square estimates with robust standard errors and observation weights proportional to the percentage of contemporaneous variance of variables explained by country models. LARGE – a dummy variable taking the value of 1 for large banks (mainly G-SII and O-SII). COOP – a dummy variable taking the value of 1 for cooperative banks. COOP – a dummy variable taking the value of 1 for cooperative banks. SAVING – a dummy variable taking the value of 1 for savings banks. * p<0.05; ** p<0.01; *** p<0.001.

Figure D.1. The marginal effect of an increase in Tier1 ratio from the level of 8.5% on the cumulated credit to NFCs following a positive aggregate demand shock (end of horizon): all, large and other banks



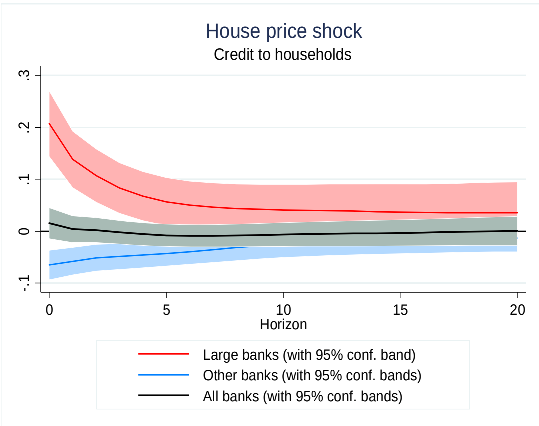
Legend: Large banks: G-SII and O-SII banks. Estimates based on regressions of bank-level IRFs on the initial linear and squared Tier1 capital ratios. The confidence banks calculated with delta method. For other banks the confidence bands are very broad for horizons 0-2 have and were not plotted to increase readability of the figure.

Figure D.2. The marginal effect of an increase in Tier1 ratio from the level of 8.5% on the cumulated credit to households following a positive aggregate demand shock (end of horizon): all, large and other banks



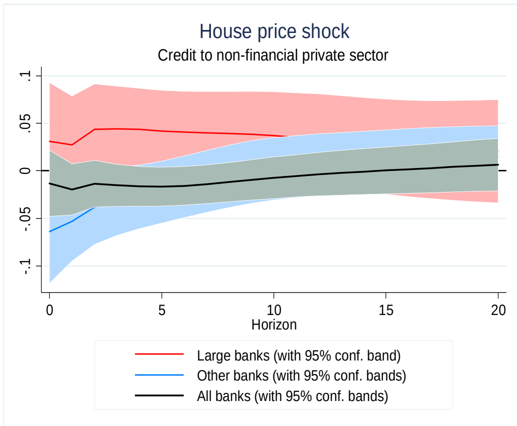
Legend: Large banks: G-SII and O-SII banks. Estimates based on regressions of bank-level IRFs on the initial linear and squared Tier1 capital ratios. The confidence banks calculated with delta method.

Figure D.3. The marginal effect of an increase in Tier1 ratio from the level of 8.5% on the cumulated credit to non-financial private sector following a positive residential house price shock: all, large (G-SII and O-SII) and other banks



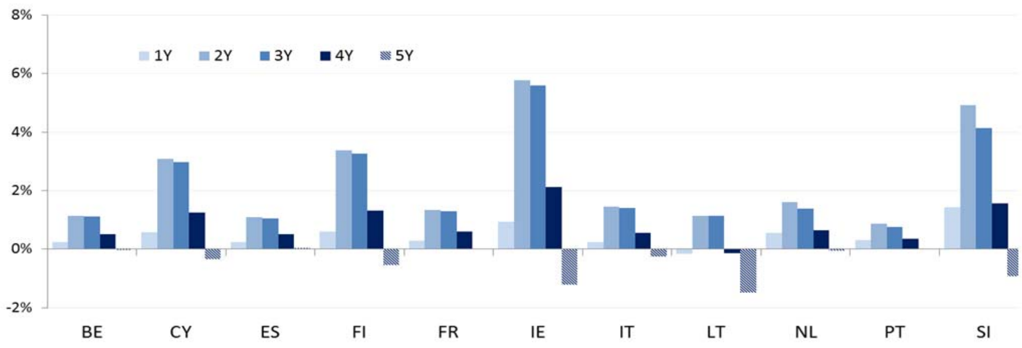
Legend: Large banks: G-SII and O-SII banks. Estimates based on regressions of bank-level IRFs on the initial linear and squared Tier1 capital ratios. The confidence banks calculated with delta method.

Figure D.4. The marginal effect of an increase in Tier1 ratio from the level of 8.5% on the cumulated credit to household sector following a positive residential house price shock: all, large (G-SII and O-SII) and other banks



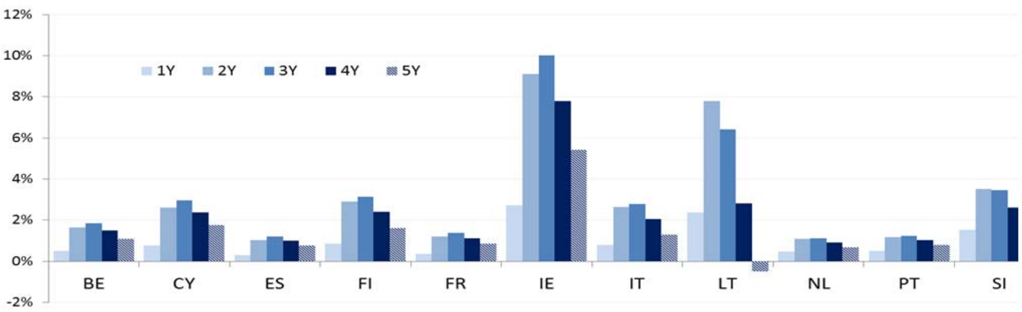
Legend: Large banks: G-SII and O-SII banks. Estimates based on regressions of bank-level IRFs on the initial linear and squared Tier1 capital ratios. The confidence banks calculated with delta method.

Figure D.5 The effect of Tier1 capital buffers at the end of 2015 above the level of 8.5% on the outstanding credit to NFCs under the adverse scenario (at the end of a year)



Legend: Estimates based on regressions of bank-level IRFs on the initial linear and squared Tier1 capital ratios for the full sample of banks.

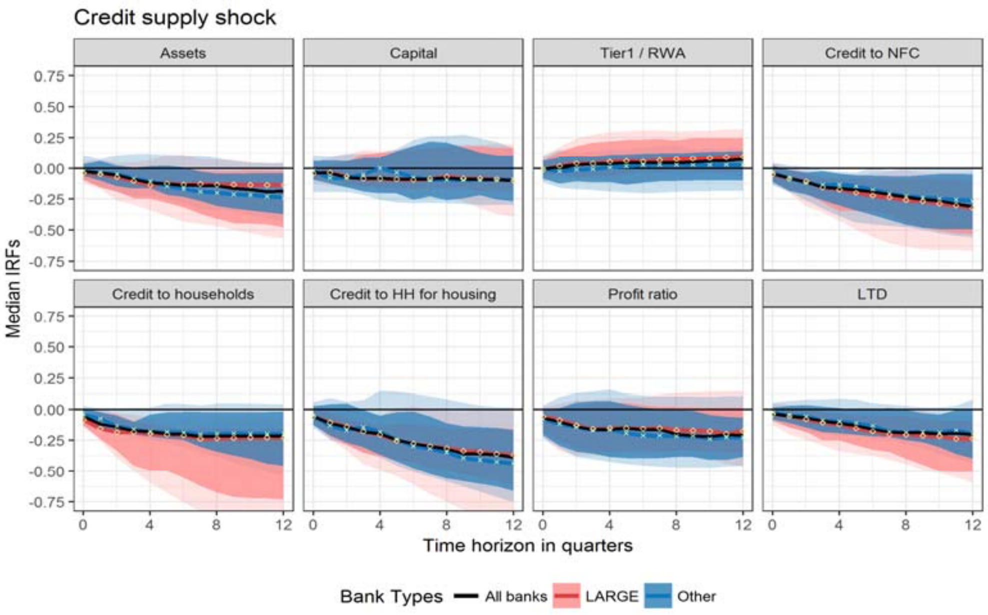
Figure D.6 The effect of Tier1 capital buffers at the end of 2015 above the level of 8.5% on the outstanding credit to households under the adverse scenario (at the end of a year)



Legend: Estimates based on regressions of bank-level IRFs on the initial linear and squared Tier1 capital ratios for the full sample of banks.

Appendix E: Bank-level IRFs to credit supply shocks

Figure E.1: IRFs of bank-level variables to a one standard deviation negative credit supply shock



Legend: Large banks include mostly G-SII and O-SII banks. Figures are constructed on the basis of median responses of bank-level variables from the country models. All IRFs correspond with the behaviour of standardised variables on a cumulative basis. Red (blue) broken line marks the median response, and dark red (blue) fan represent 50% and light red (blue) 68% of the distribution of median responses of bank-level variables of G-SII and O-SII (other) banks. Solid black line marks the median response for the full sample of banks.

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