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The effect of higher capital requirements on bank lending: the capital surplus matters

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Abstract
The existing literature has displayed mixed results in terms of the relationship between tighter bank capital regulation and lending, which may be due to poor approximation of capital requirements. We emphasise the crucial role of the excess of bank capital over the minimum capital requirement, the capital surplus, in the transmission of more stringent capital regulation. Specifically, we explore the effect of higher capital requirements on bank credit growth in the Czech Republic, drawing on a unique confidential bank-level dataset. Our results indicate that higher additional capital requirements have a negative effect on the credit supply of banks maintaining lower capital surplus. We estimate the effect on annual credit growth to be between 1.2 and 1.8 pp, using a wide range of model specifications and estimation techniques. Furthermore, the relationship between the capital surplus and credit growth proves to be significant also at times of stable capital requirements, i.e., the capital surplus does not serve only as an intermediate channel of higher capital requirements.

Keywords Capital regulation · Capital surplus · Confidential bank-level data · Credit growth

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1 Introduction

The importance of quantifying the relationship between banks' capital, capital requirements and lending has been one of the most important research questions for almost two decades. The topic has received greater attention following the wake of the Global Financial Crisis (GFC) of 2007–2009 and then again in the light of increasing use of macroprudential policy instruments. However, the literature has not been entirely successful in consistently quantifying the relationship and it has displayed mixed results in terms of the estimated coefficients (see, for example, Malovaná et al. 2021).

In principle, banks can react to higher capital requirements in several ways, depending on their overall capitalisation. On the one hand, a bank can use capital in excess of the minimum capital requirement—the capital surplus—to cover higher capital requirements. Under such circumstances, the impact on the credit supply would be limited. However, even banks maintaining sufficiently high capital surplus can be expected to change their lending behaviour to some extent. Banks face internal costs of funds, or implicit costs of funds, which are set on a consolidated basis. Further, banks often set up internal capital ratio targets above the minimum required level (Berrospide and Edge 2010b; Malovaná 2017). On the other hand, if the capital surplus is not sufficiently high, a bank is expected more likely to dampen its lending activity or change the risk composition of its portfolio. Another way to satisfy higher capital requirements would be to raise equity, for example, by raising stated or issued capital, increasing interest rate margins or postponing dividend payouts.[1]

One of the crucial factors influencing the particular way a bank chooses to adjust its capital adequacy ratio is the state of the economy and the prospects for the near future (Brei and Gambacorta 2016). Under favourable economic conditions, banks may be more likely to increase their capital adequacy ratios through higher interest rate margins or by issuing equity, while in worse economic conditions, they may prefer to shift their asset structure towards a less risky composition (for example, government securities) or to reduce their total exposures (Dahl and Shrieves, 1990; Jackson 1999; Heid et al. 2004; Brei and Gambacorta 2016).

In this paper, we study the impact of higher capital requirements (capital buffers and Pillar 2 add-ons) on bank lending in the Czech Republic, drawing on a unique supervisory panel dataset. The detailed information on individual banks allows us to take into consideration heterogeneity among banks and to control for different effects with respect to banks' characteristics. The Czech National Bank (CNB) is a macroprudential authority responsible for setting capital requirements. Since 2014,

[1] The importance of capital surplus from a theoretical point of view was discussed in a model by Goel et al. (2020), who study how a bank allocates capital across its business units when facing constraints. For example, if a capital constraint tightens because of, for example, stricter regulation, capital flows to the more efficient unit, i.e. the unit offering a higher marginal return on required capital, causing spillovers between banks' business units.

the CNB has applied three capital buffers—a conservation buffer, a systemic risk buffer and a countercyclical capital buffer—and an additional Pillar 2 requirement.

Our results show that the effect of higher capital requirements is negative and significant across various model specifications, with the negative relationship being driven primarily by less-capitalised banks. Quantitatively, a 1 pp increase in the capital requirements depresses annual credit growth by 1.2–1.8 pp. Furthermore, we take into account banks' internal capital target and differentiate between intentionally and unintentionally formed capital surplus, showing that the change in capital requirements is transmitted almost exclusively via the intentional capital surplus.

Our paper fits into the broad field of literature on the relationship between bank capital, capital regulation and lending. A noticeable feature of this group of studies is the fact that bank capital can change due to various reasons, ranging from regulatory to economic and managerial. This aspect affects the practical significance of these studies for policymakers, who are primarily concerned with the effects of capital regulation. Unsurprisingly, many studies have focused on analysing the impact of changes in banks' *capitalisation* rather than the *capital requirements* themselves (see, for example, Bernanke et al. 1991; Albertazzi and Marchetti 2010; Fonseca et al. 2010; Jiménez et al. 2017). The reason is usually a lack of observable changes in capital requirements in past data or limited access to such data.[2]

Most of the pre-crisis studies only cover the links between bank lending and capital (not capital requirements) and are mostly focused on credit crunches during the early 1990s crisis period (Bernanke et al. 1991; Hancock and Wilcox 1993, 1994; Peek and Rosengren 1995). A pioneering work in the empirical literature examining the nexus between capital and lending is Bernanke et al. (1991). The authors find that insufficient capitalisation of U.S. banks limited their ability to provide loans, leading to a credit crunch in the early 1990s. As the shortage of bank capital contributed to the emergence of the crisis, the authors coin the term "capital crunch". The capital crunch is also described by Peek and Rosengren (1995), who formulate a theoretical model stating that banks behave differently if the loss of bank capital results in binding capital requirements as compared to when the requirements are not binding. Other pre-crisis studies include, for example, Hancock and Wilcox (1993) and Hancock and Wilcox (1994), who measure the effect of loan demand and bank capital on credit growth.

The post-crisis empirical literature shows a high degree of heterogeneity in terms of the relationship between bank capital and lending.[3] These differences, however, can be seemingly well explained by the initial choice of the researcher on how to express the bank capital ratio used in the empirical exercise (see Table 1). In particular, Malovaná et al. (2021) show, in their meta-analytic study, that the relationship between capital requirements and bank lending growth is strongly negative while the effect of

[2] Some researchers focus on the overall macroprudential stance (i.e. the mix of macroprudential policies) instead of the capital requirements (see, for example Cerutti et al. 2017; Bruno et al. 2017; Gambacorta and Murcia 2017; Akinci and Olmstead-Rumsey 2018). In general, their results show that macroprudential policy tightening is associated with lower bank credit growth and house price inflation.

[3] We discuss predominantly empirical literature; there are also a few theoretical studies building dynamic models and analysing the impact of higher capital requirements. These are, however, less relevant for this paper. We therefore do not mention them, or devote only limited attention to them.

Table 1 The effect of 1 pp increase in capital ratio on annual credit growth—literature overview

Article	No. estim.	Mean	Median	Min	Max
Capital-to-asset ratio					
Auer et al. (2017)	7	− 2.27	− 2.27	− 2.27	− 2.27
Berrospide and Edge (2010b)	2	3.04	3.04	2.11	3.97
Berrospide and Edge (2010a)	2	− 2.27	− 2.27	− 2.27	− 2.27
Carlson et al. (2011)	17	0.39	0.27	0.05	1.25
Carlson et al. (2013)	25	0.38	0.4	− 0.04	1.26
Deli and Hasan (2017)	49	0.24	0.24	− 0.56	1.08
Galac (2010)	1	3.97	3.97	3.97	3.97
Gambacorta and Marques-Ibanez (2011)	8	0.24	0.37	− 0.23	0.78
Gambacorta and Shin (2018)	1	0.60	0.60	0.60	0.60
Kim and Sohn (2017)	12	− 0.64	− 0.17	− 2.27	0.67
Labonne and Lamé (2014)	24	3.76	3.97	2.86	3.97
Malovaná and Frait (2017)	6	0.38	0.08	− 2.27	3.97
Mésonnier and Stevanovic (2017)	2	1.66	1.66	− 0.65	3.97
Naceur et al. (2018)	208	0.11	0.52	− 2.27	2.93
Olszak et al. (2014)	84	0.09	0.25	− 2.27	2.5
Roulet (2018)	48	0.00	0.06	− 1.74	1.81
Watanabe (2010)	18	2.13	2.95	− 2.27	3.97
Weighted	*514*	*0.89*	*0.53*	*− 2.27*	*3.97*
Capital-to-risk-weighted exposures ratio					
Berrospide et al. (2016)	4	0.90	1.00	0.40	1.20
Brei et al. (2013)	44	0.39	0.70	− 2.27	1.57
Carlson et al. (2011)	34	0.16	0.10	− 0.08	1.10
Carlson et al. (2013)	61	0.23	0.20	− 0.13	1.54
Cohen (2013)	3	− 0.13	− 0.28	− 2.27	2.17
Cohen and Scatigna (2016)	3	1.03	− 0.18	− 0.7	3.97
Drehmann and Gambacorta (2012)	4	3.97	3.97	3.97	3.97
Gambacorta and Marques-Ibanez (2011)	8	0.73	0.74	0.27	1.18
Huang and Xiong (2015)	5	− 0.35	− 0.32	− 0.45	− 0.21
Kanngiesser et al. (2017)	5	− 0.33	− 0.26	− 0.60	− 0.22
Kim and Sohn (2017)	66	− 0.19	0.07	− 2.27	0.68
Kolcunová et al. (2019)	52	0.53	0.21	− 0.31	2.39
Košak et al. (2015)	96	0.42	0.42	− 1.43	1.63
Malovaná and Frait (2017)	4	0.05	− 0.04	− 0.23	0.51
Mora and Logan (2012)	1	0.20	0.20	0.20	0.20
Naceur et al. (2018)	208	− 0.07	0.15	− 2.08	1.08
Roulet (2018)	48	− 0.22	− 0.18	− 0.84	0.63
Wang and Sun (2013)	6	− 0.35	− 0.41	− 1.03	0.59
Weighted	*652*	*0.44*	*0.20*	*− 2.27*	*3.97*
Capital requirements					
Bridges et al. (2015)	40	− 3.98	− 2.23	− 11.70	1.10
De Jonghe et al. (2016)	68	− 1.05	− 0.98	− 4.45	1.10

Table 1 (continued)

Article	No. estim.	Mean	Median	Min	Max
De Jonghe et al. (2020)	85	– 1.69	– 1.08	– 11.70	1.06
Kolcunová et al. (2019)	22	– 0.57	– 0.58	– 1.75	0.31
Meeks (2017)	14	– 0.80	– 0.58	– 4.36	1.10
Weighted	*229*	*– 1.79*	*– 1.04*	*– 11.70*	*1.10*

The table summarizes a dataset of 1,400 estimates from 32 studies on the relationship between bank capital, capital requirements and lending constructed by Malovaná et al. (2021). Each collected elasticity was adjusted to reflect the effect of 1 pp increase in capital ratio on bank annual credit growth. Simple capital-to-asset ratio represents a ratio between bank equity and total assets. Regulatory capital ratio then refers to a ratio between regulatory capital (Common Equity Tier 1, Tier 1 and Tier 2) and risk-weighted exposures. Capital requirements are defined as a ratio between various categories of capital requirements (minimum, Pillar 2 add-ons and capital buffers) and risk-weighted exposures.

higher capitalisation on the extension of loans is positive. Interestingly, they also find a few signs that the relationship between bank capital and lending has changed in recent years. Specifically, a prolonged period of low interest rates is shown to weaken the positive effect, owing to the argument that, in an environment of increasingly demanding bank capital regulation and subdued bank profitability, it may be difficult for banks to maintain voluntary capital buffers and any additional capital requirements may become binding, limiting banks ability to extend additional credit to the economy.

We perceive the contribution of this paper to be twofold. First, we emphasise the crucial role of bank capital surplus in the transmission of more stringent capital regulation. Moreover, we stress the importance of distinguishing between individual banks' regulatory capital requirements, capital adequacy ratio and capital surplus, which is an important prerequisite for reliably estimating the impact on the growth of loans. Second, we use the detailed supervisory dataset and a wide range of model specifications to provide a comprehensive picture of the transmission.

The remainder of this paper is organised as follows. Section 2 presents the empirical framework and describes the data. Section 3 reports the estimation results and Sect. 4 concludes.

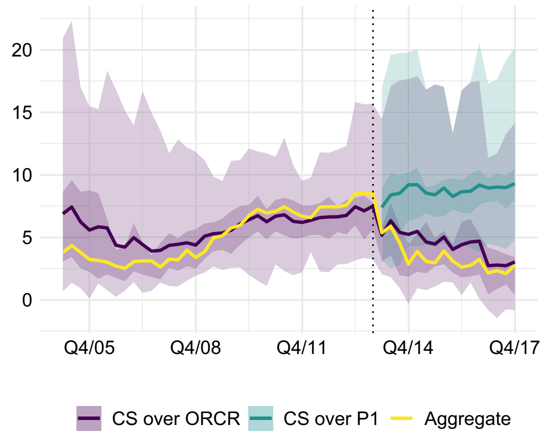
2 Econometric framework

2.1 Data and measurements

In order to examine the effects of capital requirements on bank lending, we will use confidential bank-level data for the Czech Republic. The data sample consists of 14 banks and bank groups on a consolidated basis,[4] which accounts for almost 90%

[4] At the end of 2017, the Czech banking sector consisted of 19 banks, 5 building societies and 21 foreign bank branches. ICBC Limited and Creditas were excluded from the analysis due to their very short data history; the Czech Export Bank and the Czech-Moravian Guarantee and Development Bank were excluded because they are wholly owned by the Czech state (which provides implicit state guarantees for their liabilities) and have different business models. The foreign bank branches are excluded from the analysis, as they are not subject to domestic capital regulation. Four building societies and two mortgage banks belong to the same bank group as five other domestic banks.

Fig. 1 Capital surplus (in % of RWE). *Note* The shaded areas show the min–max and 25–75% intervals; coloured lines are the averages across banks; aggregate line refers to the average over the whole banking sector

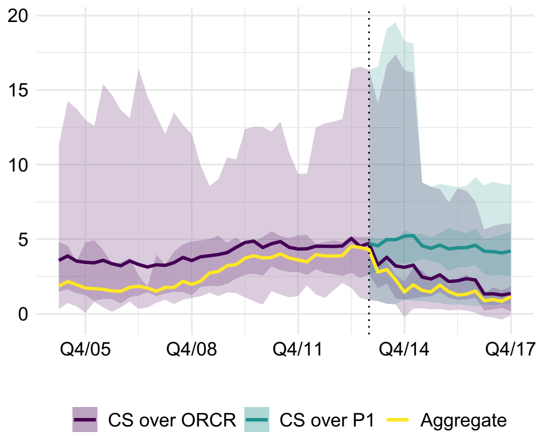


of the total assets of the whole banking sector as of December 2017. Consolidated bank statements are considered, because banks usually formulate their capital planning strategies at the whole-group level. In addition, the regulatory capital requirements in Pillar 2 are expressed on a consolidated basis. With respect to time span, the sample covers 56 quarters from 2004 Q1 to 2017 Q4, giving an unbalanced panel of 630 observations in total.[5] For part of the analysis, we use a restricted sample starting in 2013 Q1. The evolution of overall capital requirements is depicted in Fig. 5 in the Appendix.

Banks in the Czech Republic maintained their capital adequacy ratios well in excess of the regulatory minimum until 2014. The aggregated capital surplus was CZK 180 billion (8.4% of risk-weighted exposures and 4.3% of total assets, see Figs. 1 and 2) at its peak in 2013 Q4. Afterwards, capital requirements stemming from capital buffers and Pillar 2 add-ons were introduced. This led to a decrease in the aggregated capital surplus to CZK 67 billion (2.8% of risk-weighted exposures and 1.1% of total assets) as of 2017 Q4. While the minimum-maximum range is fairly wide (individual banks have held their surplus somewhere between zero and 18% over the last 3 years), the 25th–75th percentile range is relatively narrow at between 0.4% and 3.4% as of 2017 Q4. The average capital surplus across banks in relation to both risk-weighted exposures and total assets also decreased, reaching 3.0% and 1.3% respectively as of 2017 Q4.

[5] Bank-level data are obtained from the CNB's internal database (FINREP and COREP reporting statements). The capital adequacy ratio was adjusted for outliers, i.e. the unreliably high values of a few small banks in the first few quarters after they entered the market. The capital adequacy ratio of one medium-sized universal bank is adjusted for a structural break in its capital caused by an unusually high dividend payout in 2015; this payout did not constitute a permanent change in the bank's dividend policy, but was a one-time tax-related issue before an IPO.

Fig. 2 Capital surplus (in % of total assets). *Note* The shaded areas show the min–max and 25–75% intervals; coloured lines are the averages across banks; aggregate line refers to the average over the whole banking sector



The green area and the green line in Figs. 1 and 2 show the hypothetical evolution of the capital surplus had no capital requirements been introduced, i.e. the capital surplus over the minimum 8% Pillar 1 capital requirement, holding all else equal. It can be seen that the higher capital requirements have taken a significant part of banks' capital surplus; if they had not been introduced, the hypothetical average capital surplus over the Pillar 1 capital minimum would have reached almost 10% by the end of 2017. However, this additional increase in the capital surplus after 2014 is due to decreasing total implicit risk weights amid a stable or slightly decreasing ratio of capital to total assets.

In the Czech Republic, 5 out of 14 banks on a consolidated basis use the IRB approach. Those banks have a combined market share of approximately 80%. They switched gradually to the IRB approach between 2007 and 2011 but have kept some part of their asset portfolio under the STA approach. In terms of total exposures, the transition to the IRB approach was in some cases relatively abrupt and in other cases rather gradual. No bank was using solely the IRB approach as of 2017.[6] Figure 3 shows that the implicit risk weights of banks using solely the STA approach started to decrease slowly a few quarters later than those of banks using the IRB approach. In the case of STA banks, the decline can be explained by a change in the asset structure to less risky. The fall in the implicit risk weights of IRB banks, on the other hand, cannot be explained solely by a change in the asset structure, so migration to the IRB approach also played a role (for a more detailed discussion, see, for example, Malovaná 2018).

As for the credit growth, we use the year-on-year growth of loans to the private sector (excluding interbank loans). We exclude loans to the government and the central bank from our analysis, as they may be influenced by factors that are beyond

[6] While the STA approach takes into account the type of exposure, its external rating and the quality of collateral, the IRB approach is based on the internal ratings set by banks and takes into account the perceived risk of various asset classes in a given economic environment.

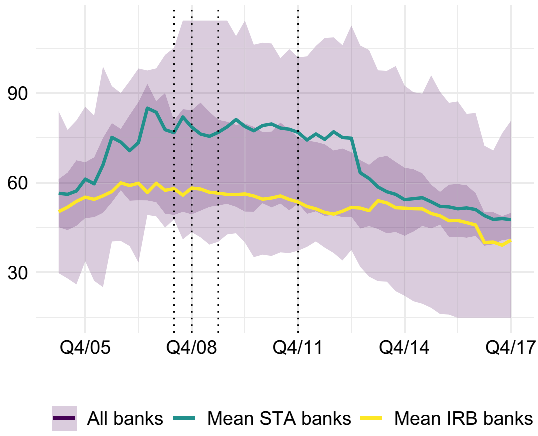


Fig. 3 Implicit risk weights. *Note* The shaded areas show the min–max and 25–75% intervals; coloured lines are the averages. Mean STA and mean IRB refer to banks using solely the STA approach or the IRB approach as of 2017 Q4. Vertical lines—banks' switches to the IRB approach

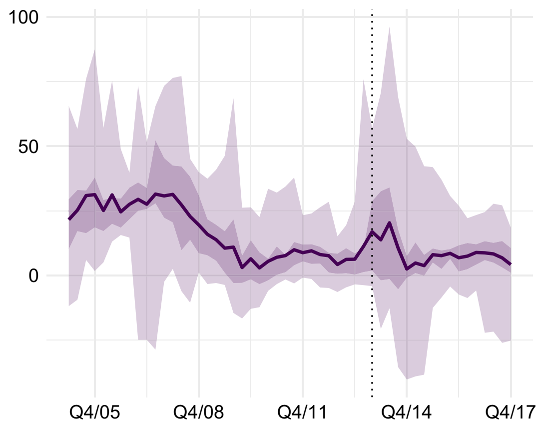


Fig. 4 Annual credit growth. *Note* The shaded areas show the min–max and 25–75% intervals; coloured line is the average

the scope of this paper (such as the exchange rate commitment of the CNB between 2013 and 2017). Figure 4 shows there is significant heterogeneity among banks; credit growth has been significant in the last decade for some of them, but close to zero or even negative for others. Nevertheless, we can see that credit growth has slowed noticeably since 2014 for some banks. A drop in the growth rate is apparent in 2014, i.e. when the capital requirements were introduced. Since then, the average growth rate seems to have been stable, but the dispersion has decreased significantly, i.e. the growth has continued to slow down after 2014 for some banks.

2.2 Main hypotheses and methodology

The fragmentation observed in the literature and discussed in the introduction has motivated us to empirically test the following hypotheses:

H1: Higher capital requirements have a direct negative effect on bank loan growth.

H2: Capital surplus plays an important role in the transmission. Specifically, higher capital requirements have a negative effect on capital surplus which translates to reduced credit supply.

H3: Banks overall capitalisation influences the relationship. Specifically, the negative effect of higher capital requirements on bank loan growth is stronger for less-capitalised banks for which tighter capital regulation is more likely to be binding.

Direct effect. In order to test the first hypothesis, we formulate the following baseline equation:

$$\%\Delta loans_{i,t} = \alpha\%\Delta loans_{i,t-1} + \beta ORCR_{i,t} + \gamma X_{i,t-1} + \nu_i + \epsilon_{i,t} \quad (1)$$

where $\%\Delta loans_{i,t}$ is the percentage year-on-year change in loans to the private sector excluding interbank loans; $ORCR_{i,t}$ are the overall regulatory capital requirements, consisting of the regulatory capital minimum, capital buffers and Pillar 2 capital add-ons; $X_{i,t-1}$ is a vector of control variables; ν_i stands for bank fixed effects; and $\epsilon_{i,t}$ is the error. We assume that the dependent variable reacts instantly to changes in the capital requirements. The justification of this assumption lies in the fact that changes in the capital requirements are usually announced in advance. Nevertheless, we also test for additional lags and leads.

The control variables in Eq. (1) comprise the usual bank-specific characteristics for credit risk (the ratio of loan loss provisions to assets) and leverage (the ratio of capital to total assets). Second, we assume that the amount of loans is affected by their price; thus, we include a proxy variable for banks' lending rate (the ratio of annualised interest income from loans to total loans). Third, we include real GDP growth, a proxy variable for the business cycle, as banks may expect higher capital requirements in response to the change in general economic conditions. The chosen set of control variables is in line with the bank-capital and bank-lending channel literature, which assumes that certain bank-specific characteristics influence banks' capital ratios, their choice of target capital ratios and their loan supply (see, for example, Malovaná 2017; Brei and Gambacorta 2016; Borio et al. 2017).[7] Summary statistics of all variables are provided in Table 7 in the Appendix.

Indirect effect via capital surplus. Next, in order to test the second hypothesis, we examine in more detail the relationship between the capital requirements, the capital surplus and credit growth, employing simultaneous estimation via a system of equations. In a two-equation model, we assume that higher capital requirements affect bank credit growth indirectly via the capital surplus, defined as the excess of regulatory capital (Tier 1 capital plus Tier 2 capital) over the capital requirements in relation to risk-weighted exposures. While we assume that the capital requirements affect the surplus contemporaneously, the reaction of bank credit growth to the change in the capital surplus is delayed by one quarter:

[7] In addition, we conducted a few sensitivity analyses including proxy variables for monetary policy and monetary conditions (the 3-month interbank rate, the real monetary conditions index, the estimated shadow rate and the spread described above), but we did not obtain a statistically significant relationship.

$$CS_{i,t} = \alpha_1 CS_{i,t-1} + \beta_1 ORCR_{i,t} + \gamma_1 X_{i,t-1} + \nu_{1,i} + \epsilon_{1,i,t} \tag{2}$$

$$\%\Delta loans_{i,t} = \alpha_2 \%\Delta loans_{i,t-1} + \beta_2 CS_{i,t-1} + \gamma_2 X_{i,t-1} + \nu_{2,i} + \epsilon_{2,i,t} \tag{3}$$

where $CS_{i,t-1}$ is the capital surplus. The set of control variables $X_{i,t-1}$ is different for capital surplus Eq. (2) than the set of control variables for the loan equation.

Capital surplus can be influenced by banks' profitability, credit risk, the macroeconomic situation and the situation on the financial markets. Therefore, we use five control variables: return on assets (ROA, the ratio of net profit to total assets), the ratio of loan loss provisions to total assets, real GDP growth, PX stock index growth and the spread between the 10-year Czech government bond yield and the 3-month interbank rate (3-month Pribor). We also include the control variables capturing banks' financial asset structure and a dummy variable which takes the value of 1 if the bank uses the IRB approach for at least some part of its exposures and 0 if it uses solely the STA approach in the given quarter.[8] We include those variables in Eq. (2) since the capital surplus depends on risk-weighted exposures (it is the denominator of the formula for the capital surplus).

There are also other hypothetical control variables that could be examined. First, if bank management could observe that the supervisory authority imposed additional capital buffers on other banks, they could predict the imposition on their bank better and react in advance, for example, by increasing equity. Including a control variable for that would likely alter the results. We believe it is not an issue in our setting, as the only individual bank capital requirements are Pillar 2 add-ons and the buffer for systemically important institutions (O-SII buffer). However, neither of these two can be observed by competing banks in advance as their setting is confidential. Further, the set of banks considered to be systemically important is reasonably stable over time, which again limits a strategic advantage for other banks. Second, an internal capital market can play an important role when assessing the significance of capital surplus in the transmission of capital requirements. Therefore, we perform the estimation on the consolidated level in the first place, making the internal capital flows irrelevant for our analysis. Given that large foreign-owned banks in our sample are relatively well capitalised, the relevance of the internal capital market is limited also from the international point of view, i.e. the banks are not likely to need a capital injection from their parent banks during the period examined.

Capitalisation. We define an interaction variable between the overall regulatory capital requirements and a dummy for less-capitalised banks to test the third hypothesis. The single-equation specification is formulated as follows:

[8] The transition between the STA approach and the IRB approach can be gradual; in that case, the binary dummy variable might be a reasonable approximation rather than a precise indicator. The use of this dummy is supported by the fact that banks in the Czech Republic in many cases switched abruptly to the IRB approach (in terms of total exposures on a consolidated basis) and only one bank made a gradual transition.

$$\%\Delta loans_{i,t} = \alpha\%\Delta loans_{i,t-1} + \beta_1 ORCR_{i,t} * dLowCS + \beta_2 ORCR_{i,t} * (1 - dLowCS) + \gamma X_{i,t-1} + \nu_i + \epsilon_{i,t} \quad (4)$$

where *dLowCS* is a dummy variable which equals 1 for the five banks with the lowest total capital surplus in the period after 2014, i.e. after the introduction of capital buffers and Pillar 2 add-ons.[9]

We introduce the interaction terms with *dLowCS* also in the two-equation model:

$$CS_{i,t} = \alpha_1 CS_{i,t-1} + \beta_1 ORCR_{i,t} * dLowCS + \beta_2 ORCR_{i,t} * (1 - dLowCS) + \gamma_1 X_{i,t-1} + \nu_{1,i} + \epsilon_{1,i,t} \quad (5)$$

$$\%\Delta loans_{i,t} = \alpha_2\%\Delta loans_{i,t-1} + \beta_3 CS_{i,t-1} * dLowCS + \beta_4 CS_{i,t-1} * (1 - dLowCS) + \gamma_2 X_{i,t-1} + \nu_{2,i} + \epsilon_{2,i,t} \quad (6)$$

As discussed above, an increase in the capital requirements might be expected to have a limited effect on banks' capital adequacy ratio if banks have a high capital surplus, simply because they would use the extra capital and shrink the surplus. But if banks intentionally target a higher capital adequacy ratio than the level required by their regulator and form an intentional capital surplus—for example in order to match a planned future asset expansion or change in asset structure[10]—higher capital requirements could actually lead them to increase their capital adequacy ratio in an effort to preserve the existing surplus. Therefore, it may be important to distinguish between intentionally and unintentionally formed capital surplus.

We can expect various responses with respect to intentional and unintentional capital surplus and with respect to time. On the one hand, if a bank maintains a sufficiently large unintentional capital surplus, simply due to the long-run accumulation of high earnings, it can use it to maintain its intentional capital surplus. On the other hand, if the unintentional capital surplus is not sufficiently large, the bank may react by increasing its capital adequacy ratio via a combination of the responses listed above. Moreover, if the bank forms an intentional capital surplus in order to match a planned increase in credit supply, then higher capital requirements may slow down or even decrease lending growth via its effect on the intentional capital surplus. The bank may tend to re-build the intentional capital surplus in the long run and to restore the lending growth, as shown, for example, by Bridges et al. (2015); Berrospide and Edge (2010b); Adrian and Shin (2010).

[9] The number of banks characterized as low capital surplus banks was chosen arbitrarily. These banks also exhibit a relatively large change in their average capital surplus in the period of changing overall regulatory capital requirements as compared to the previous period. The results were tested to the inclusion of slightly different number of banks characterized as those with low capital surplus and remained robust.

[10] A bank may also target a higher capital adequacy ratio than that required by the regulator as a consequence of its dividend policy.

In line with the discussion, we further differentiate between intentional and unintentional capital surplus following Malovaná (2017). The author estimates individual bank-specific capital targets for banks in the Czech Republic using a partial-adjustment model. The intentional capital surplus (ICS) is then defined as the difference between the target capital ratio and the overall regulatory capital requirements, while the unintentional capital surplus (UCS) is defined as the difference between the capital adequacy ratio and the target capital ratio.[11] A three-equation system then looks as follows:

$$ICS_{i,t} = \alpha_1 ICS_{i,t-1} + \beta_1 ORCR_{i,t} + \gamma_1 X_{i,t-1} + \nu_{1,i} + \epsilon_{1,i,t} \tag{7}$$

$$UCS_{i,t} = \alpha_2 UCS_{i,t-1} + \beta_2 ORCR_{i,t} + \gamma_2 X_{i,t-1} + \nu_{2,i} + \epsilon_{2,i,t} \tag{8}$$

$$\%\Delta loans_{i,t} = \alpha_3 \%\Delta loans_{i,t-1} + \beta_3 ICS_{i,t-1} + \beta_4 UCS_{i,t-1} + \gamma_3 X_{i,t-1} + \nu_{3,i} + \epsilon_{3,i,t} \tag{9}$$

The set of control variables in the equation for the ICS is the same as in the equation for the total capital surplus. On the other hand, the control variables in the equation for the UCS are chosen to capture its different nature. The UCS is assumed to be a result of shifts in accumulated earnings or other factors unintentionally changing the level of capital held, in particular profitability and cost ratios.

2.3 Identification

Examining the effect of more stringent capital regulation on bank credit growth is a complicated task that needs to be handled with care. The difficulties stem from the risk of not sufficiently addressing multiple endogeneity issues—in our case, reverse causality (or simultaneity) bias and omitted-variable bias.

Regarding the reverse causality problem, most changes in capital requirements are exogenous because they are dictated by international regulation, which sets the minimum requirements and the upper limits for capital buffers. Moreover, most macroprudential capital buffers are not bank-specific, limiting the concerns for endogeneity related to bank characteristics. Nevertheless, the countercyclical capital buffer is set in response to the position in the economic cycle, which can create a possible concern that past credit growth can explain changes in the stringency of capital regulation. If true, this bias could somewhat inflate our estimated parameters, making them the upper bound of the true relationship. However, we have reasons to believe that reverse causality issues are limited. First, we use a set of different macrofinancial control variables, which should significantly limit the potential bias since credit shocks would impact financial and economic variables with a different lag. Second, the model is estimated at a relatively high frequency (quarterly), while

[11] For more details on the estimation of the target capital ratio and the intentional and unintentional surplus, see Malovaná (2017).

changes to capital regulation attributable to macrofinancial shocks (i.e. changes in countercyclical capital buffer) are less frequent.

We address the omitted-variable bias by considering a dynamic regression specification. Since our panel data units (banks) probably differ systematically in unobserved ways that affect the outcome of interest, we also use bank fixed effects to eliminate all between-unit variation. In addition, we follow Cetorelli and Goldberg (2012), Caglayan and Xu (2016) and Gric et al. (2022) and consider several bank-specific characteristics to control for the supply side. We also include demand-side proxies in order to eliminate omitted variable problem as much as possible.

2.4 Estimation techniques

The single-equation specifications are estimated using the standard least square dummy variable (LSDV) estimator and the bootstrap-based bias-corrected (BBBC) estimator proposed by De Vos et al. (2015).[12] A dynamic panel is used to control for potential persistence in the relationships. However, as shown by Nickell (1981), there is potential for endogeneity bias in dynamic panels. The Nickel bias is introduced by applying the within (demeaning) transformation in an attempt to remove unobserved heterogeneity in the panel data—subtracting the individual's mean from the relevant variable creates a correlation between the regressor and the error term. Endogeneity bias becomes especially serious in panels with a high number of individuals (large N) and a low number of time periods (low T). This bias, however, shrinks substantially with higher T. Simulations by Judson and Owen (1999) suggest that the bias is minor in panels with more than 30 observations. In our case, the short data sample consists of 14 individuals and 20 time periods, which creates potential for a minor bias. We use the BBBC estimator, which, as advocated by De Vos et al. (2015) and Everaert and Pozzi (2007), is suitable to deal with Nickel bias. Specifically, Everaert and Pozzi (2007) show that for panels with a short to moderate time span, the procedure provides a good alternative for existing dynamic panel data estimators.

A frequently used techniques, the difference-GMM by Arellano and Bond (1991) or the system-GMM by Arellano and Bover (1995), are asymptotically unbiased when cross-sectional dimension N goes to infinity and time dimension T is finite. However, as stressed by De Vos et al. (2015), Ziliak (1997) and Bun and Kiviet (2006), GMM estimators tend to have poor small sample properties due to weak instruments (the methods use instrumental variables to control for dynamic panel data bias). Further, as pointed out by Roodman (2009), when T is relatively large compared with N, many valid instruments are available, but the high number of instruments may lead to the GMM estimator being invalid even though instruments are individually valid. Thus, the GMM estimator can be more suitable in case of large N and smaller T, while for smaller N and larger T—which is exactly our case—the BBBC estimator is more suitable.

[12] The estimator is implemented by the *xtbcfe* Stata routine. For more details on the implementation of this routine and a description of the methodology, see De Vos et al. (2015).

In addition to the LSDV and BBBC estimators, the two- and three-equation systems are estimated using the three-stage least squares (3SLS) procedure.[13] 3SLS can be interpreted as a combination of two-stage least squares, used to account for the endogeneity of left and right-hand side variables, and seemingly unrelated regression (SUR), used to account for correlation of errors across equations. The reason why we estimate the system of equations simultaneously stems from the potential endogeneity of the variables. For example, Eq. (2) contains different types of loans to control for the bank's asset structure as explanatory variables. In Eq. (3), credit growth depends on the capital surplus, so the capital surplus might well be assumed to be endogenous, i.e. correlated with the error term in Eq. (3). Typically, the endogenous explanatory variables are dependent variables from other equations in the system.

Suggestions whether to estimate two equations separately or jointly differ within the literature with respect to the exact specification and data used. We test for endogeneity using the Hausman procedure, as described in Wooldridge (2015): we save the residuals from the reduced form of Eq. (2) (with all exogenous variables on the right-hand side) estimated as a single-equation fixed-effects regression, and test the significance of these residuals when included as another variable in Eq. (3). The residuals prove to be significant, pointing to a need for two-stage least squares. The covariance between the error terms of the two equations obtained from the variance–covariance matrix is different from zero, pointing to a need for seemingly unrelated regression. In each case, we provide sensitivity checks by estimating the system both simultaneously and equation by equation. The results are mostly similar.[14]

3 Empirical results

We estimate all specifications using a shorter data sample ranging from 2013 Q1 to 2017 Q4, i.e. covering only the period of some variation in capital requirements plus four quarters before. The four additional quarters are being considered because higher capital requirements are announced at least one year before they become effective. In addition, we estimate the two- and three-equation specifications, which include the capital surplus, also on a longer data sample ranging from 2004 Q1 to 2017 Q4. This is possible because there is sufficient variation in the capital surplus throughout the period to aid identification. It can help us to better estimate the transmission of higher capital requirements via through the capital surplus and also

[13] 3SLS is a default option in the *reg3* STATA command. The command is meant to estimate a system of structural equations where some equations contain endogenous variables among the explanatory variables.

[14] The Hausman test does not reject the null hypothesis of no systematic differences when comparing the OLS, 2SLS and 3SLS estimates, though, suggesting that OLS is both consistent and more efficient than 2SLS. The previous evidence of correlation of errors and the procedure suggested by Wooldridge (2015), however, yields a different outcome. We thus provide both OLS and 3SLS estimates, as well as bootstrap-based bias-corrected estimates, and compare.

Table 2 The effect of higher capital requirements on credit growth

Estimation technique:	(1) BBBC	(2) BBBC	(3) LSDV	(4) LSDV
Credit growth (*t* – 1)	0.852***	0.848***	0.756***	0.749***
	(0.057)	(0.060)	(0.037)	(0.047)
ORCR	– 0.737**		– 1.027**	
	(0.354)		(0.409)	
ORCR*dLowCS		– 1.193*		– 1.751***
		(0.674)		(0.576)
ORCR*(1-dLowCS)		– 0.488		– 0.606
		(0.327)		(0.365)
LLPA (*t* – 1)	0.437	0.496	– 0.022	0.166
	(0.575)	(0.542)	(0.270)	(0.263)
CA (*t* – 1)	1.593***	1.449***	1.926**	1.794**
	(0.493)	(0.505)	(0.754)	(0.695)
Lending rate (*t* – 1)	– 1.269*	– 1.219*	– 1.521**	– 1.501***
	(0.669)	(0.666)	(0.534)	(0.442)
Real GDP growth	– 0.121	– 0.104	– 0.120	– 0.084
	(0.329)	(0.347)	(0.257)	(0.295)
Observations	276	276	276	276

The table presents estimation results of Eqs. (1) and (4). The data sample covers 20 quarters from 2013 Q1 to 2017 Q4. Bank fixed effects are included. dLowCS—a dummy variable which equals 1 for the five banks with the lowest total capital surplus in the period after 2014, i.e. after the introduction of capital buffers and Pillar 2 add-ons; BBBC—bootstrap-based bias-corrected estimator; LSDV—least square dummy variable estimator with robust (clustered) standard errors. Standard errors are reported in parentheses

***, ** and * denote the 1%, 5% and 10% significance levels

identify the relationship between the capital surplus and lending driven by factors other than tighter capital regulation. We cannot use the longer data sample for the single-equation model with overall regulatory capital requirements simply because there is not enough variation in earlier periods. For the sake of brevity, we present only selected estimation results while the rest is presented in the Appendix or available upon request.

3.1 Direct effect of higher capital requirements

The effect of higher capital requirements on the credit growth is negative and both statistically and economically significant, regardless of the model specification and estimation technique. Specifically, in response to a 1 pp increase in the capital requirements, the annual credit growth falls by around 0.74 pp (Table 2). Given the coefficient estimate on the lagged dependent variable, the cumulative long-run effect is between − 5 and − 7 pp, depending on the estimation technique.[15] It takes about 5 to 6 years for the initial effect on credit growth to disappear. The cumulative effect after 1 and 2 years is around − 2.4 to − 3.8 pp.[16]

In terms of the coefficients on the control variables, the lending rate is significant in explaining bank credit growth with a negative sign. There is also a positive and significant effect of the capital-to-assets ratio, indicating that credit growth is higher for banks with a greater amount of regulatory capital. The intuition is the following: a higher capital-to-assets ratio provides more space for balance sheet expansion, while a higher capital requirement, holding the capital-to-assets ratio constant, reduces the capital surplus and thus reduces the space for balance sheet expansion. Moreover, changing the capital requirements while holding capital-to-assets constant is not an unreasonable condition, as we have seen that the effect of the ORCR on the capital-to-assets ratio is almost zero and not statistically significant.

Capitalisation. Even though we cover only a relatively small sample of banks located in one country, there is still noticeable heterogeneity with respect to the capital surplus held (see Fig. 1). Columns 2 and 4 of Table 2 reports the results of Eq. (4). The relationship between the overall capital requirements and bank credit growth remains statistically significant only for less-capitalised banks, confirming the third hypothesis. In terms of size, the effect for less-capitalised banks is 60% stronger than the effect for all banks.

Different lags and leads. Higher capital buffers (such as the countercyclical capital buffer) are usually announced well in advance of them taking effect. On the other hand, Pillar 2 capital add-ons may be announced only a few months before they become effective. However, there may be a phase-in, or transitional, period during which banks are required to fulfil the higher Pillar 2 capital add-ons only partly. Banks can therefore react to the higher additional requirements in advance. They may also react with some delay after evaluating their own situation, the macroeconomic situation and the outlook for the near future. We, therefore, estimate the relationship between the overall capital requirements and bank credit growth with up to four lags or leads. The complete estimation results are presented in Table 9 in the Appendix. The effect for banks with higher capital surplus turns out to be not statistically significant, similarly to the previous results. Allowing for lags or leads reveals that banks tend to react at the time when the higher capital requirements become effective, or with a slight delay. The effect tends to be weaker with more lags and turns out to be not statistically significant for leads. The immediate effect, i.e. the reaction in the same quarter, remains the strongest. A richer lag or lead structure is, therefore, not necessary and does not help to explain the variation, as it does not capture the nature of the data (Table 3).[17]

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[15] The long-run effect is calculated as $\beta/(1-\alpha)$, where β is the coefficient on the overall capital requirements and α is the autocorrelation coefficient.

[16] Estimation results with additional bank-specific and macrofinancial control variables are quantitatively and qualitatively similar (see Table 8 in the Appendix).

[17] In addition, we introduce an interaction variable between the overall capital requirements and a dummy variable for four large banks accounting for about 75% of total consolidated banking sector assets as of 2017 Q4; the estimation results, however, remain similar for both groups, i.e. they do not yield any additional information, so we do not report them.

Table 3 How the effect changes with different lags and leads

No. of lags (−) or leads (+)	(1) BBBC	(2) LSDV
− 4	− 0.290	− 0.726
	(0.504)	(0.518)
− 3	− 0.563	− 1.097*
	(0.509)	(0.591)
− 2	− 0.830	− 1.367**
	(0.520)	(0.631)
− 1	− 1.053*	− 1.611**
	(0.539)	(0.710)
0	− 1.193*	− 1.751***
	(0.674)	(0.576)
1	− 0.528	− 1.071*
	(0.572)	(0.522)
2	− 0.255	− 0.819
	(0.596)	(0.483)
3	− 0.0829	− 0.536
	(0.729)	(0.722)
4	0.0697	− 0.717
	(0.825)	(0.862)

The table presents estimates of the coefficient on the interaction variable between ORCR and dLowCS (the dummy for banks with low capital surplus). The interaction variable enters the estimation equation with up to four lags or leads. The model also includes the interaction variable between ORCR and (1-dLowCS), which is not statistically significant in either specification. Complete results are given in Table 9 in the Appendix. The data sample covers 20 quarters from 2013 Q1 to 2017 Q4. Bank fixed effects are included. BBBC—bootstrap-based bias-corrected estimator; LSDV—least square dummy variable estimator with robust (clustered) standard errors. Standard errors are reported in parentheses

***, ** and * denote the 1%, 5% and 10% significance levels

3.2 Indirect effect via capital surplus

In this subsection, we present estimation results of the two- and three-equation models of higher capital requirements affecting bank credit growth indirectly via the capital surplus. This exercise helps us to gain more information on possible transmission channels. The stronger effect for the less-capitalised banks, identified in the previous subsection, highlights the importance of the capital surplus in the transmission of higher capital requirements.

The results obtained using the system of equations confirm those obtained using the single-equation model (see Table 4). Specifically, a 1 pp increase in the capital requirements depresses the total capital surplus by approximately 0.7 pp (regardless of banks' capitalisation; compare columns 1 and 3). As a result, annual credit

Table 4 How important is the capital surplus in transmission—system of two equations

Dependent variable:	(1) CS	(2) Credit growth	(3) CS	(4) Credit growth
Dependent variable ($t-1$)	0.516***	0.769***	0.519***	0.765***
	(0.040)	(0.0334)	(0.040)	(0.032)
ORCR ($t-1$)	− 0.702***			
	(0.063)			
CS ($t-1$)		0.197		
		(0.248)		
ORCR * dLowCS			− 0.668***	
			(0.084)	
ORCR * (1-dLowCS)			− 0.711***	
			(0.066)	
CS ($t-1$)*dLowCS				2.188***
				(0.445)
CS ($t-1$)*(1-dLowCS)				− 0.236
				(0.251)
ROA ($t-1$)	− 0.035		− 0.037	
	(0.170)		(0.172)	
LLPA ($t-1$)	− 0.531***	0.380	− 0.532***	− 0.053
	(0.106)	(0.654)	(0.106)	(0.629)
Interbank loans/A ($t-1$)	0.002		0.010	
	(0.036)		(0.037)	
Loans to CB&CG/A ($t-1$)	− 0.008		− 0.008	
	(0.011)		(0.011)	
Loans to PS excl. IL/A ($t-1$)	− 0.064***		− 0.061***	
	(0.019)		(0.019)	
Bonds/A ($t-1$)	0.015		0.016	
	(0.017)		(0.017)	
Lending rate ($t-1$)		− 0.853		− 0.973*
		(0.526)		(0.505)
CA ($t-1$)		1.901***		1.674***
		(0.500)		(0.479)
Real GDP growth	0.100*	− 0.681***	0.095*	− 0.390
	(0.056)	(0.262)	(0.056)	(0.256)
PX growth	0.028***		0.029***	
	(0.011)		(0.0108)	
Spread	− 1.058***		− 1.077***	
	(0.212)		(0.212)	
IRB dummy	− 0.891		− 1.373	
	(0.556)		(1.008)	
Observations	276	276	276	276

Table 4 (continued)

The table presents estimation results of the system of two Eqs. (2)–(3) and (5)–(6). The data sample covers 20 quarters from 2013 Q1 to 2017 Q4. Bank fixed effects are included. dLowCS—a dummy variable which equals 1 for the five banks with the lowest total capital surplus in the period after 2014, i.e. after the introduction of capital buffers and Pillar 2 add-ons. Specifications are estimated using the three-stage least squares estimator (3SLS). Using the bootstrap-based bias-corrected estimator (BBBC) or the least square dummy variable estimator (LSDV) with robust (clustered) standard errors yields quantitatively similar results. Standard errors are reported in parentheses

***, ** and * denote the 1%, 5% and 10% significance levels

growth decreases by around 1.5 pp (− 0.67 times 2.19), this time only for less-capitalised banks. Similarly to the direct effect, the response of credit growth is not statistically significant for well-capitalised banks, which is in line with what Goel et al. (2020) show theoretically in their model. Furthermore, the long-run indirect effect of a 1 pp increase in the capital requirements is an approximately 6.2 pp decrease in credit growth for less-capitalised banks.[18,19]

The effect via intentional and unintentional capital surplus. Higher capital requirements tend to reduce the intentional capital surplus (ICS) and have no statistically significant effect on the unintentional capital surplus (UCS). In particular, a 1 pp increase in the capital requirements leads to a 0.8 pp decrease in the ICS (see Table 11); this effect is similar to that estimated by Malovaná (2017). While the intentional capital surplus is formed deliberately with respect to asset structure and riskiness, the unintentional capital surplus is a result of temporary fluctuations in banks' profitability[20]; this is supported by the fact that UCS takes both positive and negative values and is much closer to zero (with a mean of 0.5, as compared to 5 for the ICS).

The results also show that the impact on bank credit growth differs for banks with relatively high and relatively low capital surplus. In particular, an increase in the capital requirements of 1 pp leads to a decrease in credit growth via the ICS of − 1.8 pp for banks with a low capital surplus (− 0.76 times 2.39; see Table 11); the effect is similar but slightly more negative than the effect estimated via the total capital surplus (− 1.5 pp; see Table 4). The effect via the UCS is not statistically significant, but the link between the UCS and bank credit growth is.

[18] We calculate the long-term impact in this system of equations assuming only first-round effects: $\beta_{CSEq} * \beta_{LoanEq}/(1\text{-}\alpha_{LoanEq})$.

[19] Estimation results with additional bank-specific and macrofinancial control variables are quantitatively and qualitatively similar (see Table 10 in the Appendix).

[20] The results show that the unintentional surplus is slightly higher with higher retained earnings and a higher ratio of interest income to assets, although the effect is not significantly different from zero. However, the UCS is significantly lower for IRB banks than for non-IRB banks.

Table 5 Selected estimation results—comparing short-term and long-term effects

Table	Specification	Estimation technique	ST effect	LT effect
	Direct effect			
2	All banks	BBBC	– 0.737**	– 4.980
2	Less-capitalised banks	BBBC	– 1.193*	– 4.889
2	Well-capitalised banks	BBBC	– 0.488	– 2.000
2	All banks	LSDV	– 1.027**	– 6.757
2	Less-capitalised banks	LSDV	– 1.751***	– 6.976
2	Well-capitalised banks	LSDV	– 0.606	– 2.414
	Indirect effect			
4	All banks	3SLS	– 0.138	– 1.450
4	Less-capitalised banks	3SLS	– 1.462***	– 6.220***
4	Well-capitalised banks	3SLS	0.168	– 1.055

The table summarizes the estimation results of 1pp increase in capital requirements on annual bank credit growth. The data sample covers 20 quarters from 2013 Q1 to 2017 Q4. Bank fixed effects are included. BBBC—bootstrap-based bias-corrected LSDV estimator with bootstrapped standard errors; LSDV—least squares dummy variable; 3SLS—three-stage least squares. ST (short-term) effect is the effect in time t for the direct specification and in time $t + 1$ for the indirect specification. LT (long-term) effect is calculated as $\beta/(1 - \alpha)$, where β is the short-term effect and α is the autocorrelation coefficient

***, ** and * denote the 1%, 5% and 10% significance levels

3.3 Discussion and sensitivity analysis

For ease of comparison, we provide a summary of selected estimation results in Table 5. The effect of higher capital requirements is negative across different model specifications. The differentiation of banks based on their overall capitalisation indicates that the negative relationship primarily applies to less-capitalised banks; the impact on well-capitalised banks remains negative but ceases to be statistically significant. Quantitatively, a 1 pp increase in the capital requirements dampens annual credit growth of less-capitalised banks by about 1.2–1.8 pp in the short run and by about 5–7 pp in the long run.[21] These numbers are very much in line with those estimated by other studies which rely on similar bank-level data samples (Aiyar et al. 2014; Bridges et al. 2015). Similarly to us, the authors of both papers explore the effect of higher *capital requirements* rather than higher *capital adequacy ratios*; they find the effect to be between – 1 and – 8 pp in the short run (depending on the type of loan) and between – 6 and – 8 pp in the long run. Studies analysing the effect of changes in capital rather than capital requirements usually report a weaker impact on bank provision of loans.

[21] The long-term relationship between higher capital requirements and the capital surplus or credit growth should be taken with caution due to the relatively short time span used in our estimation. The long-term relationship between the capital surplus and credit growth, however, is also estimated using a longer data sample, so these effects are more reliable.

Table 6 What was the role of the capital surplus before the tightening of capital regulation

Estimation technique:	(1) BBBC	(2) LSDV
Credit growth ($t-1$)	0.798***	0.849***
	(0.036)	(0.036)
CS ($t-1$)*dPostCR*dLowCS	1.633**	1.483**
	(0.585)	(0.580)
CS ($t-1$)*dPostCR*(1-dLowCS)	− 0.073	− 0.060
	(0.174)	(0.143)
CS ($t-1$)*(1-dPostCR)*dLowCS	0.663***	0.565*
	(0.201)	(0.303)
CS ($t-1$)*(1-dPostCR)*(1-dLowCS)	− 0.003	− 0.018
	(0.177)	(0.124)
LLPA ($t-1$)	− 0.556	− 0.428
	(0.519)	(0.391)
Real GDP growth	0.412**	0.336***
	(0.144)	(0.117)
Lending rate ($t-1$)	0.647	0.478
	(0.389)	(0.305)
CA ($t-1$)	− 0.270	− 0.180
	(0.277)	(0.271)
Observations	630	630

The table presents estimation results of Eq. (4) enriched with dummy variable dPostCR which equals 1 for the period after 2013. The data sample covers 56 quarters from 2004 Q1 to 2017 Q4. Bank fixed effects are included. dLowCS—a dummy variable which equals 1 for the five banks with the lowest total capital surplus in the period after 2014, i.e. after the introduction of capital buffers and Pillar 2 add-ons; BBBC—bootstrap-based bias-corrected estimator; LSDV—least square dummy variable estimator with robust (clustered) standard errors. Standard errors are reported in parentheses

***, ** and * denote the 1%, 5% and 10% significance levels

The results using a longer sample are comparable in terms of direction and statistical significance but weaker, given that the true variation in the regulatory capital requirements takes place only since 2014 (see Tables 12, 13 in the Appendix). The relationship between the capital surplus and credit growth, however, remains positive and statistically significant before 2014, as indicated by the estimation results with an additional interaction dummy controlling for the pre- and post-2014 periods (see Table 6). In particular, a 1 pp increase in the capital surplus leads to about a 0.6–0.7 pp increase in the credit growth of banks with lower capital surplus before 2013. This suggests that the relationship between the capital surplus and credit growth plays an important role in banks' behaviour and does not serve only as an intermediate channel for the transmission of higher capital requirements.

4 Conclusions

We explore the effect of higher capital requirements on bank annual credit growth in the Czech Republic, drawing on a unique confidential supervisory panel data set. We emphasise a key role of the capital surplus in the transmission.

The differentiation of banks based on their overall capitalisation indicates that the negative relationship primarily applies to less-capitalised banks. Quantitatively, a 1 pp increase in the capital requirements depresses bank credit growth by about 1.2–1.8 pp. We find a similar effect if we first disentangle the effect of capital requirements on capital surplus—which is always negative—and then estimate the effect of capital surplus on bank credit growth, which is positive. Our results confirm the importance of the relationship between the capital surplus and credit growth. This relationship between capital surplus and credit growth is positive and statistically significant not only in the period of increasing capital requirements, but also in the period before such changes. The importance of the relationship is confirmed using different methodological approaches and time spans and can therefore be considered robust. Recognising the motives for maintaining capital surplus and its role in the transmission of higher capital requirements may have important implications for policy decision-making. Specifically, additional capital buffers may be tailored to individual banks' capital surplus to a greater extent. Furthermore, we believe that our findings may be applicable to similar countries in the region, given the size and nature of the Czech banking sector and the economy.

It is important to bear in mind that the sample period covers mostly a growing phase of the financial cycle and a build-up phase of capital requirements. Future research could focus on potential non-linearities in the estimated relationship during a less favourable phase of the financial cycle or in response to the release of capital buffers. The role of model-based capital regulation in the transmission would also be worth exploring, particularly the role of variability in risk weights under the IRB approach. Although we provide a somewhat simplified comparison of the short-term and long-term effects, it may be appropriate to re-estimate the relationship as a longer series of changes in capital requirements become available.

Appendix: Data and additional estimation results

See Tables 7, 8, 9, 10, 11, 12 and 13 and Fig. 5.

Table 7 Explained and explanatory variables—summary statistics

	Long sample					Short sample				
	Mean	SD	Min	Max	Median	Mean	SD	Min	Max	Median
EA	10.13	5.26	1.47	30.33	9.13	10.10	4.78	1.47	30.33	9.95
REA	3.85	4.93	− 4.26	24.03	2.37	3.50	4.65	− 4.26	24.03	2.70
CA	9.18	5.09	1.47	30.05	7.52	9.20	5.47	1.47	30.05	8.06
CS	5.61	4.57	− 1.47	28.03	4.39	5.56	5.38	− 1.47	28.03	3.81
ICS	5.38	4.20	− 3.15	19.17	4.77	4.96	4.50	− 3.15	19.12	3.87
UCS	0.28	2.64	− 8.68	15.51	0.17	0.57	2.28	− 4.94	9.22	0.27
RW	59.58	21.73	11.45	140.60	53.48	52.07	18.66	11.45	112.56	47.91
Credit growth	15.17	20.49	− 21.72	87.44	9.54	10.85	20.25	− 21.72	87.44	7.04
ORCR	9.49	2.49	8.00	17.01	8.00	11.46	2.74	8.00	17.01	10.50
ROA	1.07	1.15	− 4.40	10.86	0.95	0.80	1.01	− 4.40	3.39	0.80
LLP/A	1.87	2.00	0.00	10.75	1.32	1.67	1.84	0.08	10.75	1.23
Lending rate	5.00	2.09	− 0.20	13.96	4.69	4.18	2.18	0.56	12.23	3.63
Interbank loans/A	5.13	5.50	0.00	44.85	3.64	2.68	3.27	0.00	26.59	2.04
Loans to CB&CG/A	3.72	8.25	0.00	76.99	0.62	7.24	11.54	0.00	76.99	1.87
Loans to PS excl. IL/A	56.75	17.32	12.02	89.23	55.99	56.24	17.58	12.02	86.47	56.07
Bonds/A	16.25	11.55	0.00	52.12	15.83	16.74	11.21	0.01	49.44	14.96
IRB	0.29	0.46	0.00	1.00	0.00	0.36	0.48	0.00	1.00	0.00
Real GDP growth	2.75	3.18	− 5.58	7.34	2.85	2.95	2.16	− 1.75	5.80	3.40
PX growth	5.19	25.01	− 53.46	67.39	2.88	1.63	9.54	− 15.21	19.06	− 0.11
Spread	1.37	0.91	− 0.04	3.68	1.46	0.77	0.68	− 0.04	2.24	0.51
Observations	644	644	644	644	644	278	278	278	278	278

The variables are ordered based on their order of appearance in the text. The dependent variables are located in the upper part of the summary table. Different statistics are provide for the long and short samples. The long data sample covers 56 quarters from 2004 Q1 to 2017 Q4; the short data sample covers 20 quarters from 2013 Q1 to 2017 Q4. Credit growth is winsorised at the 2nd and 98th percentiles

Table 8 The effect of higher capital requirements on credit growth—additional control variables

	(1) BBBC	(2) BBBC	(3) BBBC	(4) BBBC	(5) BBBC	(6) BBBC	(7) LSDV	(8) LSDV	(9) LSDV	(10) LSDV	(11) LSDV	(12) LSDV
Credit growth ($r-1$)	0.848***	0.844***	0.836***	0.842***	0.835***	0.841***	0.750***	0.744***	0.732***	0.731***	0.731***	0.729***
	(0.058)	(0.061)	(0.065)	(0.065)	(0.066)	(0.066)	(0.041)	(0.050)	(0.029)	(0.033)	(0.030)	(0.034)
ORCR	− 0.712*		− 0.635*		− 0.490		− 0.959**		− 0.765*		− 0.569	
	(0.386)		(0.353)		(0.403)		(0.387)		(0.364)		(0.329)	
ORCR*dLowCS		− 1.148*		− 0.898		− 0.764		− 1.674***		− 1.323**		− 1.128*
		(0.694)		(0.718)		(0.753)		(0.506)		(0.586)		(0.541)
ORCR*(1-dLowCS)		− 0.466		− 0.489		− 0.346		− 0.556		− 0.543		− 0.343
		(0.371)		(0.322)		(0.369)		(0.437)		(0.337)		(0.309)
LLPA ($t-1$)	0.438	0.491	0.393	0.472	0.325	0.405	− 0.041	0.144	0.102	0.198	0.012	0.107
	(0.581)	(0.540)	(0.503)	(0.504)	(0.499)	(0.499)	(0.266)	(0.243)	(0.242)	(0.251)	(0.284)	(0.291)
CA ($t-1$)	1.640***	1.507***	1.006*	1.056*	1.036*	1.087*	2.026**	1.883**	1.094	1.209	1.139	1.255
	(0.517)	(0.540)	(0.528)	(0.551)	(0.530)	(0.552)	(0.745)	(0.695)	(0.807)	(0.827)	(0.827)	(0.850)
Lending rate ($t-1$)	− 1.259*	− 1.206*	− 1.893**	− 1.706**	− 2.066***	− 1.877**	− 1.473**	− 1.461**	− 2.304***	− 2.088***	− 2.492***	− 2.277***
	(0.667)	(0.663)	(0.750)	(0.755)	(0.791)	(0.800)	(0.569)	(0.495)	(0.662)	(0.652)	(0.703)	(0.686)
ROA ($t-1$)			1.080	0.812	1.271	1.000			1.082	0.637	1.209	0.764
			(1.205)	(1.241)	(1.259)	(1.295)			(1.594)	(1.407)	(1.530)	(1.344)
LogAssets ($t-1$)			− 6.061	− 4.604	− 5.549	− 4.093			− 9.539*	− 7.190	− 8.858	− 6.485
			(4.025)	(4.190)	(3.975)	(4.138)			(5.247)	(5.949)	(5.464)	(6.268)
Real GDP growth	− 0.149	− 0.122	− 0.062	− 0.069	− 0.046	− 0.055	− 0.075	− 0.045	− 0.020	− 0.016	0.035	0.039
	(0.370)	(0.381)	(0.358)	(0.362)	(0.363)	(0.366)	(0.374)	(0.400)	(0.302)	(0.311)	(0.333)	(0.344)
Spread	0.024	0.112					0.686	0.596				
	(1.352)	(1.369)					(2.141)	(2.114)				
PX growth	0.034	0.033					0.036	0.031				
	(0.069)	(0.073)					(0.065)	(0.068)				
Nominal wage growth					− 0.395	− 0.390					− 0.439	− 0.445
					(0.414)	(0.416)					(0.348)	(0.369)

Table 8 (continued)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	BBBC	BBBC	BBBC	BBBC	BBBC	BBBC	LSDV	LSDV	LSDV	LSDV	LSDV	LSDV
Observations	276	276	276	276	276	276	276	276	276	276	276	276

The table presents estimation results of Eqs. (1) and (4), including additional control variables. The data sample covers 20 quarters from 2013 Q1 to 2017 Q4. Bank fixed effects are included. dLowCS—a dummy variable which equals 1 for the five banks with the lowest total capital surplus in the period after 2014, i.e. after the introduction of capital buffers and Pillar 2 add-ons; BBBC—bootstrap-based bias-corrected estimator; LSDV—least square dummy variable estimator with robust (clustered) standard errors. Standard errors are reported in parentheses

***, ** and * denote the 1%, 5% and 10% significance levels

Table 9 How the effect changes with different lags and leads—full regression results

Estimation technique:	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
	LSDV	LSDV	LSDV	LSDV	LSDV	LSDV	LSDV	LSDV	BBBC	BBBC	BBBC	BBBC	BBBC	BBBC	BBBC	BBBC
Credit growth ($t-1$)	0.740***	0.736***	0.738***	0.747***	0.760***	0.755***	0.747***	0.734***	0.842***	0.841***	0.846***	0.854***	0.871***	0.872***	0.864***	0.864***
	(0.0528)	(0.0575)	(0.0553)	(0.0523)	(0.0437)	(0.0427)	(0.0446)	(0.0495)	(0.0438)	(0.0437)	(0.0419)	(0.0420)	(0.0444)	(0.0445)	(0.0463)	(0.0525)
ORCR ($t-1$)*dLowCS	− 1.611**								− 1.053*							
	(0.710)								(0.539)							
ORCR ($t-1$)*(1-dLowCS)	− 0.184								− 0.146							
	(0.320)								(0.422)							
ORCR ($t-2$)*dLowCS		− 1.367**								− 0.830						
		(0.631)								(0.520)						
ORCR ($t-2$)*(1-dLowCS)		0.0274								0.0513						
		(0.226)								(0.429)						
ORCR ($t-3$)*dLowCS			− 1.097*								− 0.563					
			(0.591)								(0.509)					
ORCR ($t-3$)*(1-dLowCS)			0.139								0.187					
			(0.204)								(0.430)					
ORCR ($t-4$)*dLowCS				− 0.726								− 0.290				
				(0.518)								(0.504)				
ORCR ($t-4$)*(1-dLowCS)				0.274								0.308				
				(0.162)								(0.435)				
ORCR ($t+1$)*dLowCS					− 1.071*								− 0.528			
					(0.522)								(0.572)			
ORCR ($t+1$)*(1-dLowCS)					− 0.266								− 0.123			
					(0.336)								(0.448)			
ORCR ($t+2$)*dLowCS						− 0.819								− 0.255		
						(0.483)								(0.596)		

Table 9 (continued)

Estimation technique:	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
	LSDV	LSDV	LSDV	LSDV	LSDV	LSDV	LSDV	LSDV	BBBC	BBBC	BBBC	BBBC	BBBC	BBBC	BBBC	BBBC
ORCR ($t+2$)*(1-dLowCS)						− 0.323								− 0.141		
						(0.348)								(0.457)		
ORCR ($t+3$)*dLowCS							− 0.536								− 0.0829	
							(0.722)								(0.729)	
ORCR ($t+3$)*(1-dLowCS)							− 0.0981								0.0426	
							(0.365)								(0.524)	
ORCR ($t+4$)*dLowCS								− 0.717								0.0697
								(0.862)								(0.825)
ORCR ($t+4$)*(1-dLowCS)								0.411								0.468
								(0.416)								(0.709)
LLPA ($t-1$)	0.199	0.180	0.181	0.153	0.536*	0.649*	1.033*	1.330**	0.403	0.392	0.554	0.559	0.922	1.011	1.314	1.652
	(0.237)	(0.238)	(0.231)	(0.232)	(0.286)	(0.365)	(0.510)	(0.607)	(0.746)	(0.750)	(0.787)	(0.801)	(0.887)	(0.982)	(1.189)	(1.135)
Real GDP growth	− 0.270	− 0.452	− 0.596**	− 0.702**	− 0.392	− 0.502	− 0.687*	− 0.764**	− 0.267	− 0.420	− 0.495*	− 0.553*	− 0.332	− 0.462	− 0.598*	− 0.670*
	(0.293)	(0.262)	(0.258)	(0.250)	(0.254)	(0.295)	(0.340)	(0.279)	(0.378)	(0.371)	(0.299)	(0.284)	(0.361)	(0.335)	(0.356)	(0.356)
Lending rate ($t-1$)	− 1.225**	− 1.068**	− 0.979*	− 0.782*	− 1.474**	− 1.311**	− 1.017	− 0.853	− 0.943	− 0.794	− 0.724	− 0.572	− 1.063	− 0.959	− 0.855	− 0.529
	(0.444)	(0.407)	(0.468)	(0.427)	(0.520)	(0.593)	(0.768)	(0.714)	(0.628)	(0.637)	(0.673)	(0.651)	(0.837)	(0.852)	(0.859)	(1.017)
CA ($t-1$)	1.757**	1.786**	1.848**	1.866**	1.923***	2.077***	2.221***	2.171***	1.404***	1.424***	1.450***	1.461***	1.552***	1.661***	1.800***	1.732**
	(0.669)	(0.656)	(0.669)	(0.668)	(0.633)	(0.652)	(0.661)	(0.615)	(0.509)	(0.508)	(0.521)	(0.524)	(0.528)	(0.569)	(0.584)	(0.683)
Observations	276	276	276	276	262	248	234	220	276	276	276	276	262	248	234	220

The table presents estimation results of Eqs. (4), including additional lags and leads. The data sample covers 20 quarters from 2013 Q1 to 2017 Q4. Bank fixed effects are included. dLowCS—a dummy variable which equals 1 for the five banks with the lowest total capital surplus in the period after 2014, i.e. after the introduction of capital buffers and Pillar 2 add-ons; BBBC—bootstrap-based bias-corrected estimator; LSDV—least square dummy variable estimator with robust (clustered) standard errors. Standard errors are reported in parentheses

***, ** and * denote the 1%, 5% and 10% significance levels

Table 10 How important is the capital surplus in transmission—system of two equations—additional control variables

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Estimation technique:	LSDV	LSDV	LSDV	LSDV	BBBC	BBBC	BBBC	BBBC	3SLS	3SLS	3SLS	3SLS
Dependent variable:	CS	Credit growth	CS	Credit growth	CS	Credit growth	CS	Credit growth	CS	Credit growth	CS	Credit growth
Dependent variable ($t-1$)	0.517***	0.752***	0.519***	0.753***	0.516***	0.738***	0.519***	0.735***	0.518***	0.735***	0.521***	0.731***
	(0.0397)	(0.0344)	(0.0397)	(0.0329)	(0.0396)	(0.0358)	(0.0397)	(0.0345)	(0.0397)	(0.0357)	(0.0397)	(0.0342)
ORCR ($t-1$)	− 0.704***				− 0.705***				− 0.699***			
	(0.0629)				(0.0628)				(0.0629)			
CS ($t-1$)		0.0735				0.0675				0.00223		
		(0.256)				(0.245)				(0.246)		
ORCR ($t-1$)*dLowCS			− 0.670***				− 0.667***				− 0.661***	
			(0.0842)				(0.0840)				(0.0842)	
ORCR ($t-1$)*(1-dLowCS)			− 0.712***				− 0.716***				− 0.709***	
			(0.0655)				(0.0654)				(0.0655)	
CS ($t-1$)*dLowCS				2.026***				1.893***				1.899***
				(0.459)				(0.447)				(0.442)
CS ($t-1$)*(1-dLowCS)				− 0.305				− 0.308				− 0.410
				(0.258)				(0.249)				(0.251)
ROA ($t-1$)	− 0.0369		− 0.0377		− 0.0403	1.399	− 0.0324	0.701	− 0.0399	1.489	− 0.0322	0.779
	(0.170)		(0.172)		(0.171)	(1.140)	(0.172)	(1.104)	(0.171)	(1.133)	(0.172)	(1.092)
LLPA ($t-1$)	− 0.528***	0.120	− 0.531***	− 0.216	− 0.531***	0.373	− 0.535***	− 0.0253	− 0.526***	0.124	− 0.529***	− 0.361
	(0.106)	(0.669)	(0.106)	(0.643)	(0.106)	(0.640)	(0.106)	(0.620)	(0.106)	(0.651)	(0.106)	(0.629)
Interbank loans/A ($t-1$)1	0.00137		0.00910		− 0.00443		0.00571		− 0.00415		0.00608	
	(0.0357)		(0.0371)		(0.0356)		(0.0370)		(0.0356)		(0.0371)	
Loans to CB&CG/A ($t-1$)	− 0.00811		− 0.00784		− 0.00875		− 0.00852		− 0.00861		− 0.00830	
	(0.0107)		(0.0109)		(0.0107)		(0.0109)		(0.0107)		(0.0109)	
Loans to PS excl. IL/A ($t-1$)	− 0.0642***		− 0.0617***		− 0.0658***		− 0.0629***		− 0.0656***		− 0.0625***	
	(0.0185)		(0.0186)		(0.0185)		(0.0186)		(0.0185)		(0.0186)	

Table 10 (continued)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Estimation technique:	LSDV	LSDV	LSDV	LSDV	BBBC	BBBC	BBBC	BBBC	3SLS	3SLS	3SLS	3SLS
Dependent variable:	CS	Credit growth	CS	Credit growth	CS	Credit growth	CS	Credit growth	CS	Credit growth	CS	Credit growth
Bonds/A ($t-1$)	0.0151		0.0162		0.0123		0.0141		0.0130		0.0150	
	(0.0169)		(0.0170)		(0.0169)		(0.0170)		(0.0169)		(0.0170)	
Lending rate ($t-1$)		− 1.032*		− 1.102**		− 2.074***		− 1.927***		− 2.453***		− 2.399***
		(0.547)		(0.524)		(0.605)		(0.582)		(0.639)		(0.612)
CA ($t-1$)		2.158***		1.846***		1.020*		0.992*		1.196**		1.216**
		(0.512)		(0.493)		(0.548)		(0.527)		(0.556)		(0.532)
LogAssets ($t-1$)						− 12.23***		− 9.889***		− 10.51***		− 7.584**
						(3.215)		(3.129)		(3.323)		(3.230)
Real GDP growth	0.0941*	− 0.320	0.0919	− 0.150	0.0998*	− 0.391	0.0952*	− 0.175	0.0952*	− 0.182	0.0902	0.0994
	(0.0562)	(0.346)	(0.0562)	(0.333)	(0.0560)	(0.269)	(0.0561)	(0.262)	(0.0560)	(0.291)	(0.0561)	(0.284)
PX growth	0.0283***	− 0.0112	0.0287***	− 0.0155	0.0277***		0.0283***		0.0281***		0.0287***	
	(0.0108)	(0.0651)	(0.0109)	(0.0623)	(0.0107)		(0.0108)		(0.0107)		(0.0108)	
Spread	− 1.095***	2.240*	− 1.098***	1.519	− 1.051***		− 1.073***		− 1.057***		− 1.079***	
	(0.213)	(1.228)	(0.213)	(1.183)	(0.211)		(0.212)		(0.211)		(0.212)	
Nominal wage growth										− 0.631*		− 0.801**
										(0.351)		(0.337)
IRV dummy	− 0.894		− 1.367		− 0.886		− 1.435		− 0.896		− 1.437	
	(0.556)		(1.008)		(0.555)		(1.007)		(0.556)		(1.008)	
Observations	276		276		276		276		276		276	

The table presents estimation results of the system of two Eqs. (2)–(3) and (5)–(6), including additional control variables. The data sample covers 20 quarters from 2013 Q1 to 2017 Q4. Bank fixed effects are included. dLowCS—a dummy variable which equals 1 for the five banks with the lowest total capital surplus in the period after 2014, i.e. after the introduction of capital buffers and Pillar 2 add-ons; SLS—three-stage least squares estimator; BBBC—bootstrap-based bias-corrected estimator; LSDV—least square dummy variable estimator with robust (clustered) standard errors. Standard errors are reported in parentheses

***, ** and * denote the 1%, 5% and 10% significance levels

Table 11 How important is the intentional and unintentional capital surplus in transmission—system of two equations

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Estimation technique:	3SLS	3SLS	3SLS	3SLS	3SLS	3SLS	BBBC	BBBC	BBBC	BBBC	BBBC	BBBC
Dependent variable:	ICS	UCS	Credit growth	ICS	UCS	Credit growth	ICS	UCS	Credit growth	ICS	UCS	Credit growth
Dependent variable ($t-1$)	0.313***	0.627***	0.749***	0.314***	0.630***	0.740***	0.357***	0.799***	0.870***	0.357***	0.803***	0.824***
	(0.028)	(0.047)	(0.034)	(0.028)	(0.047)	(0.033)	(0.034)	(0.073)	(0.065)	(0.034)	(0.074)	(0.057)
ORCR (t)	− 0.795***	0.036					− 0.756***	0.026				
	(0.036)	(0.038)					(0.037)	(0.046)				
ICS ($t-1$)			0.383						0.092			
			(0.290)						(0.300)			
UCS ($t-1$)			0.077						0.080			
			(0.370)						(0.437)			
ORCR*dLowCS				− 0.757***	0.053					− 0.732***	0.026	
				(0.046)	(0.059)					(0.044)	(0.065)	
ORCR*(1-dLowCS)				− 0.804***	0.029					− 0.764***	0.026	
				(0.037)	(0.048)					(0.039)	(0.058)	
ICS ($t-1$)*dLowCS						2.390***						1.682**
						(0.506)						(0.802)
ICS ($t-1$)*(1-dLowCS)						0.0266						− 0.129
						(0.299)						(0.253)
UCS ($t-1$)*dLowCS						2.546***						2.082**
						(0.589)						(1.019)
UCS ($t-1$)*(1-dLowCS)						− 0.648*						− 0.614*
						(0.391)						(0.357)
ROA ($t-1$)	0.185*			0.194**			0.370***			0.375***		
	(0.0987)			(0.0984)			(0.106)			(0.105)		

Table 11 (continued)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Estimation technique:	3SLS	3SLS	3SLS	3SLS	3SLS	3SLS	BBBC	BBBC	BBBC	BBBC	BBBC	BBBC
Dependent variable:	ICS	UCS	Credit growth	ICS	UCS	Credit growth	ICS	UCS	Credit growth	ICS	UCS	Credit growth
LLPA ($t-1$)	− 0.897***	0.096	0.418	− 0.905***	0.097	− 0.080	− 0.858***	0.132	0.573	− 0.865***	0.130	− 0.013
	(0.057)	(0.119)	(0.661)	(0.057)	(0.125)	(0.629)	(0.061)	(0.197)	(0.640)	(0.062)	(0.201)	(0.505)
Interbank loans/A ($t-1$)	− 0.038**			− 0.031			− 0.038**			− 0.034**		
	(0.019)			(0.019)			(0.017)			(0.018)		
Loans to CB&CG/A ($t-1$)	0.003			0.002			0.005			0.005		
	(0.006)			(0.006)			(0.006)			(0.006)		
Loans to PS excl. IL/A ($t-1$)	− 0.010			− 0.009			− 0.000			0.000		
	(0.009)			(0.009)			(0.010)			(0.010)		
Bonds/A ($t-1$)	− 0.019**			− 0.017**			− 0.021**			− 0.020**		
	(0.009)			(0.009)			(0.010)			(0.010)		
Lending rate ($t-1$)			− 0.788			− 0.931*			− 0.680			− 0.900
			(0.545)			(0.517)			(0.647)			(0.603)
CA ($t-1$)			1.826***			1.562***			1.381**			1.419**
			(0.526)			(0.498)			(0.639)			(0.568)
Real GDP growth	0.188***		− 0.532**	0.185***		− 0.186	0.191***		− 0.506	0.190***		− 0.262
	(0.029)		(0.268)	(0.029)		(0.261)	(0.030)		(0.350)	(0.030)		(0.286)
PX growth	− 0.003			− 0.002			− 0.004			− 0.003		
	(0.006)			(0.006)			(0.006)			(0.006)		
Spread	− 0.192**			− 0.205***			− 0.207*			− 0.210*		
	(0.111)			(0.111)			(0.117)			(0.117)		

Table 11 (continued)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Estimation technique:	3SLS	3SLS	3SLS	3SLS	3SLS	3SLS	BBBC	BBBC	BBBC	BBBC	BBBC	BBBC
Dependent variable:	ICS	UCS	Credit growth	ICS	UCS	Credit growth	ICS	UCS	Credit growth	ICS	UCS	Credit growth
IRB dummy	1.811***	− 0.479**		1.858***	− 0.476**			− 0.479**				
	(0.207)	(0.223)		(0.208)	(0.224)			(0.223)				
Int. income/A ($t-1$)		− 0.006			0.007			0.027			0.027	
		(0.165)			(0.165)			(0.208)			(0.210)	
Ret. earnings/A		0.039			0.033			− 0.015			− 0.015	
		(0.050)			(0.054)			(0.071)			(0.077)	
Observations	276	276	276	276	276	276	276	276	276	276	276	276

The table presents estimation results of the system of three Eqs. (7)–(9). The data sample covers 20 quarters from 2013 Q1 to 2017 Q4. Bank fixed effects are included. dLowCS—a dummy variable which equals 1 for the five banks with the lowest total capital surplus in the period after 2014, i.e. after the introduction of capital buffers and Pillar 2 add-ons; 3SLS—three-stage least squares estimator; BBBC—bootstrap-based bias-corrected estimator. Standard errors are reported in parentheses

***, ** and * denote the 1%, 5% and 10% significance levels

Table 12 How important is the capital surplus in transmission—system of two equations (longer data sample)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Estimation technique:	LSDV	LSDV	LSDV	LSDV	BBBC	BBBC	BBBC	BBBC	3SLS	3SLS	3SLS	3SLS
Dependent var.:	CS	Credit growth	CS	Credit growth	CS	Credit growth	CS	Credit growth	CS	Credit growth	CS	Credit growth
Dependent var. ($t-1$)	0.841***	0.804***	0.835***	0.794***	0.904***	0.852***	0.896***	0.844***	0.841***	0.803***	0.835***	0.793***
	(0.0325)	(0.0369)	(0.0300)	(0.0392)	(0.0277)	(0.0370)	(0.0297)	(0.0372)	(0.0203)	(0.022)	(0.0210)	(0.023)
ORCR ($t-1$)	− 0.181***				− 0.164***				− 0.182***			
	(0.0323)				(0.0463)				(0.037)			
CS ($t-1$)		0.237				0.195				0.231		
		(0.187)				(0.158)				(0.164)		
ORCR*dLowCS			− 0.227***				− 0.193***				− 0.228***	
			(0.0512)				(0.0642)				(0.055)	
ORCR*(1-dLowCS)			− 0.166***				− 0.152***				− 0.167***	
			(0.0319)				(0.0518)				(0.040)	
CS ($t-1$)*dLowCS				0.713**				0.583*				0.704***
				(0.264)				(0.313)				(0.236)
CS ($t-1$)*(1-dLowCS)				− 0.0536				− 0.0461				− 0.056
				(0.180)				(0.135)				(0.193)
ROA ($t-1$)	0.0554		0.0468		0.046		0.0435		0.053		0.045	
	(0.0615)		(0.0630)		(0.107)		(0.106)		(0.076)		(0.076)	
LLPA ($t-1$)	− 0.025	− 0.261	− 0.0235	− 0.468	− 0.0279	− 0.174	− 0.0131	− 0.357	− 0.026	− 0.266	− 0.024	− 0.470
	(0.0419)	(0.511)	(0.0431)	(0.461)	(0.108)	(0.405)	(0.108)	(0.385)	(0.0733)	(0.477)	(0.073)	(0.480)
CA ($t-1$)		− 0.339*		− 0.353		− 0.247		− 0.25		− 0.324		− 0.342
		(0.189)		(0.291)		(0.248)		(0.243)		(0.254)		(0.252)
Lending rate ($t-1$)		0.693		0.519		0.522*		0.36		0.695**		0.522*
		(0.431)		(0.422)		(0.314)		(0.303)		(0.274)		(0.279)

Table 12 (continued)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Estimation technique:	LSDV	LSDV	LSDV	LSDV	BBBC	BBBC	BBBC	BBBC	3SLS	3SLS	3SLS	3SLS
Dependent var.:	CS	Credit growth	CS	Credit growth	CS	Credit growth	CS	Credit growth	CS	Credit growth	CS	Credit growth
Interbank loans/A ($t-1$)	− 0.0137		− 0.0174		− 0.0119		− 0.0148		− 0.014		− 0.018	
	(0.0288)		(0.0305)		(0.0181)		(0.0174)		(0.016)		(0.017)	
Loans to CB	0.00879		0.0105		0.00797		0.00968		0.009		0.01	
	(0.0137)		(0.0141)		(0.0122)		(0.0113)		(0.010)		(0.010)	
Loans to PS excl. IL/A ($t-1$)	0.00535		0.00289		0.00408		0.00248		0.005		0.003	
	(0.0102)		(0.0107)		(0.0117)		(0.0116)		(0.010)		(0.010)	
Bonds/A ($t-1$)	0.00522		0.00558		0.00415		0.0054		0.005		0.005	
	(0.00845)		(0.00834)		(0.0110)		(0.0115)		(0.010)		(0.010)	
Real GDP growth	− 0.0362*	0.376***	− 0.0363**	0.380**	− 0.0337	0.310**	− 0.0366	0.318***	− 0.036	0.378***	− 0.037	0.381***
	(0.0168)	(0.121)	(0.0167)	(0.137)	(0.0330)	(0.123)	(0.0337)	(0.118)	(0.028)	(0.129)	(0.028)	(0.128)
PX growth	0.00301		0.00287		0.00266		0.00271		0.003		0.003	
	(0.00226)		(0.00229)		(0.00311)		(0.00317)		(0.003)		(0.003)	
Spread	− 0.227*		− 0.230*		− 0.224**		− − 0.224*		− 0.228**		− 0.231**	
	(0.117)		(0.118)		(0.110)		(0.115)		(0.0987)		(0.0987)	
IRB dummy	0.586**		0.610***		0.39		0.423		0.589**		0.612**	
	(0.206)		(0.191)		(0.315)		(0.360)		(0.263)		(0.264)	
Observations	630	630	630	630	630	630	630	630	630	630	630	630

The table presents estimation results of the system of two Eqs. (2)–(3) and (5)–(6). The data sample covers 56 quarters from 2004 Q1 to 2017 Q4. Bank fixed effects are included. dLowCS—a dummy variable which equals 1 for the five banks with the lowest total capital surplus in the period after 2014, i.e. after the introduction of capital buffers and Pillar 2 add-ons; SLS—three-stage least squares estimator; BBBC—bootstrap-based bias-corrected estimator; LSDV—least square dummy variable estimator with robust (clustered) standard errors. Standard errors are reported in parentheses

***, ** and * denote the 1%, 5% and 10% significance levels

Table 13 How important is the intentional and unintentional capital surplus in transmission—system of two equations (longer data sample)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Estimation technique:	3SLS	3SLS	3SLS	3SLS	3SLS	3SLS	BBBC	BBBC	BBBC	BBBC	BBBC	BBBC
Dependent variable:	ICS	UCS	Credit growth	ICS	UCS	Credit growth	ICS	UCS	Credit growth	ICS	UCS	Credit growth
Dependent variable ($t-1$)	0.634***	0.808***	0.797***	0.628***	0.805***	0.769***	0.610***	0.827***	0.855***	0.605***	0.828***	0.827***
	(0.023)	(0.022)	(0.023)	(0.023)	(0.022)	(0.023)	(0.027)	(0.039)	(0.036)	(0.027)	(0.039)	(0.038)
ORCR ($t-1$)	− 0.327***	0.029					− 0.332***	0.055**				
	(0.030)	(0.030)					(0.030)	(0.025)				
ICS ($t-1$)			0.166						0.119			
			(0.193)						(0.179)			
UCS ($t-1$)			0.175						0.168			
			(0.208)						(0.226)			
ORCR*dLowCS				− 0.371***	0.016					− 0.379***	0.046	
				(0.043)	(0.044)					(0.035)	(0.038)	
ORCR*(1-dLowCS)				− 0.314***	0.040					− 0.317***	0.062*	
				(0.032)	(0.036)					(0.032)	(0.032)	
ICS ($t-1$)*dLowCS						1.642***						1.315**
						(0.388)						(0.553)
ICS ($t-1$)*(1-dLowCS)						− 0.309						− 0.247
						(0.218)						(0.159)
UCS ($t-1$)*dLowCS						0.443*						0.394
						(0.258)						(0.344)
UCS ($t-1$)*(1-dLowCS)						− 0.018						0.031
						(0.260)						(0.197)
ROA ($t-1$)	0.334***			0.329***			0.518***			0.509***		
	(0.055)			(0.055)			(0.055)			(0.054)		
LLPA ($t-1$)	− 0.435***	0.186**	− 0.312	− 0.435***	0.193**	− 0.615	− 0.444***	0.129	− 0.150	− 0.442***	0.131	− 0.406
	(0.060)	(0.075)	(0.482)	(0.060)	(0.075)	(0.480)	(0.066)	(0.117)	(0.428)	(0.065)	(0.117)	(0.418)

Table 13 (continued)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Estimation technique:	3SLS	3SLS	3SLS	3SLS	3SLS	3SLS	BBBC	BBBC	BBBC	BBBC	BBBC	BBBC
Dependent variable:	ICS	UCS	Credit growth	ICS	UCS	Credit growth	ICS	UCS	Credit growth	ICS	UCS	Credit growth
Interbank loans/A ($t-1$)	− 0.037***			− 0.040***			− 0.039***			− 0.042***		
	(0.011)			(0.011)			(0.010)			(0.009)		
Loans to CB&CG/A ($t-1$)	0.005			0.007			0.007			0.009		
	(0.007)			(0.007)			(0.008)			(0.008)		
Loans to PS excl. IL/A ($t-1$)	0.000			− 0.002			0.001			− 0.001		
	(0.007)			(0.007)			(0.008)			(0.008)		
Bonds/A ($t-1$)	0.004			0.005			0.008			0.008		
	(0.007)			(0.007)			(0.007)			(0.007)		
Lending rate ($t-1$)			0.738***			0.463*			0.535*			0.298
			(0.276)			(0.279)			(0.313)			(0.303)
CA ($t-1$)			− 0.292			− 0.382			− 0.243			− 0.325
			(0.266)			(0.266)			(0.292)			(0.292)
Real GDP growth	0.001		0.395***	0.001		0.381***	0.008		0.322**	0.007		0.325***
	(0.019)		(0.132)	(0.019)		(0.131)	(0.018)		(0.130)	(0.018)		(0.121)
PX growth	0.005**			0.005**			0.006***			0.006***		
	(0.002)			(0.002)			(0.002)			(0.002)		
Spread	− 0.225***			− 0.231***			− 0.234***			− 0.241***		
	(0.070)			(0.070)			(0.073)			(0.072)		
IRB dummy	1.811***	− 0.479**		1.858***	− 0.476**		2.172***	− 0.347*		2.197***	− 0.347*	
	(0.207)	(0.223)		(0.208)	(0.224)		(0.195)	(0.178)		(0.194)	(0.180)	

Table 13 (continued)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Estimation technique:	3SLS	3SLS	3SLS	3SLS	3SLS	3SLS	BBBC	BBBC	BBBC	BBBC	BBBC	BBBC
Dependent variable:	ICS	UCS	Credit growth	ICS	UCS	Credit growth	ICS	UCS	Credit growth	ICS	UCS	Credit growth
Int. income/A ($t-1$)		− 0.034			− 0.029			0.147			0.146	
		(0.158)			(0.159)			(0.103)			(0.103)	
Ret. earnings/A		0.036*			0.030			0.041*			0.039	
		(0.022)			(0.023)			(0.024)			(0.025)	
Observations	630	630	630	630	630	630	630	630	630	630	630	630

The table presents estimation results of the system of three Eqs. (7)–(9). The data sample covers 56 quarters from 2004 Q1 to 2017 Q4. Bank fixed effects are included. dLowCS—a dummy variable which equals 1 for the five banks with the lowest total capital surplus in the period after 2014, i.e. after the introduction of capital buffers and Pillar 2 add-ons; 3SLS—three-stage least squares estimator; BBBC—bootstrap-based bias-corrected estimator. Standard errors are reported in parentheses

***, ** and * denote the 1%, 5% and 10% significance levels

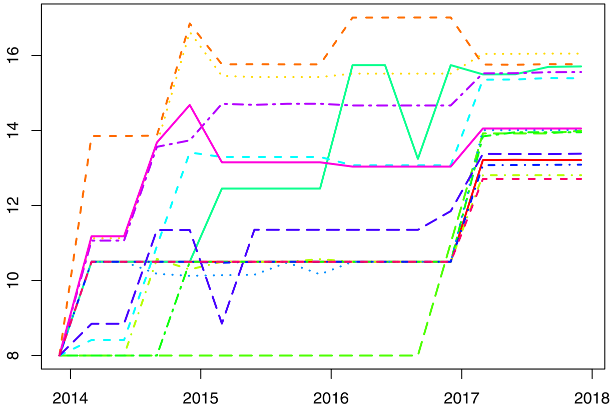

Fig. 5 Bank-level regulatory capital requirements (in % of RWE)

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