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Banks' Capital Surplus and the Impact of Additional Capital Requirements

Simona Malovaná [*]

Abstract

Banks in the Czech Republic maintain their regulatory capital ratios well above the level required by their regulator. This paper discusses the main reasons for this capital surplus and analyses the impact of additional capital requirements stemming from capital buffers and Pillar 2 add-ons on the capital ratios of banks holding such extra capital. The results provide evidence that banks shrink their capital surplus in response to higher capital requirements. A substantial portion of this adjustment seems to be delivered through changes in average risk weights. For this and other reasons, it is desirable to regularly assess whether the evolution and current level of risk weights give rise to any risk of underestimating the necessary level of capital.

Abstrakt

České banky dlouhodobě dosahují vysokého kapitálového přebytku nad kapitálovými požadavky vyžadovanými regulátorem. Tento článek diskutuje hlavní motivy, které mohou banku vést k udržování kapitálových přebytků, a analyzuje vliv dodatečných kapitálových požadavků plynoucích z kapitálových rezerv a navýšení v rámci Pilíře 2 na kapitálové poměry bank udržujících kapitálové přebytky. Výsledky ukazují, že banky při navýšení kapitálových požadavků k jejich pokrytí snižují svůj kapitálový přebytek. Významná část tohoto přizpůsobení je zřejmě realizována prostřednictvím změn průměrných rizikových vah. Nejenom z tohoto důvodu je žádoucí pravidelně posuzovat, zda vývoj a současná úroveň rizikových vah nezakládá rizika podhodnocení potřebné výše kapitálu.

JEL Codes: G21, G28, G32.
Keywords: Banks, capital requirements, capital surplus, panel data, partial adjustment model.

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Nontechnical Summary

Banks in the Czech Republic have maintained their total regulatory capital ratios well in excess of the regulatory minima. The maintenance of capital surpluses and the underlying motives for this behaviour have important policy implications. In particular, an increase in the additional capital requirements might be expected to have a limited effect on banks' capitalization if banks have a high capital surplus, simply because they would use the extra capital and shrink the surplus. But if banks intentionally target higher capital ratios than the level required by their regulator and form an intentional capital surplus, additional capital requirements could actually lead them to increase their overall capitalization in an effort to preserve the existing surplus. It is therefore important to distinguish between intentionally and unintentionally formed capital surpluses and to analyse the effect of capital regulation on each of them separately.

The paper has two main objectives: (i) to estimate individual bank-specific capital targets and distinguish between intentionally and unintentionally formed capital surpluses, and (ii) to analyse the impact of additional capital requirements stemming from capital buffers and Pillar 2 add-ons on banks' intentional capital surplus and total regulatory capital ratio. The Czech National Bank currently applies three capital buffers – a conservation buffer (2.5% since July 2014), a systemic risk buffer (1%–3% for some banks since October 2014) and a countercyclical capital buffer (0.5% since January 2017). It has also set an additional Pillar 2 requirement since 2014 Q1 (1.6% on aggregate as of 2016 Q4). Pillar 2 add-ons have been set for banks for which supervisory colleges have been established. The analysis draws on quarterly bank-level data for 14 banks and bank groups between 2002 Q4 and 2016 Q4.

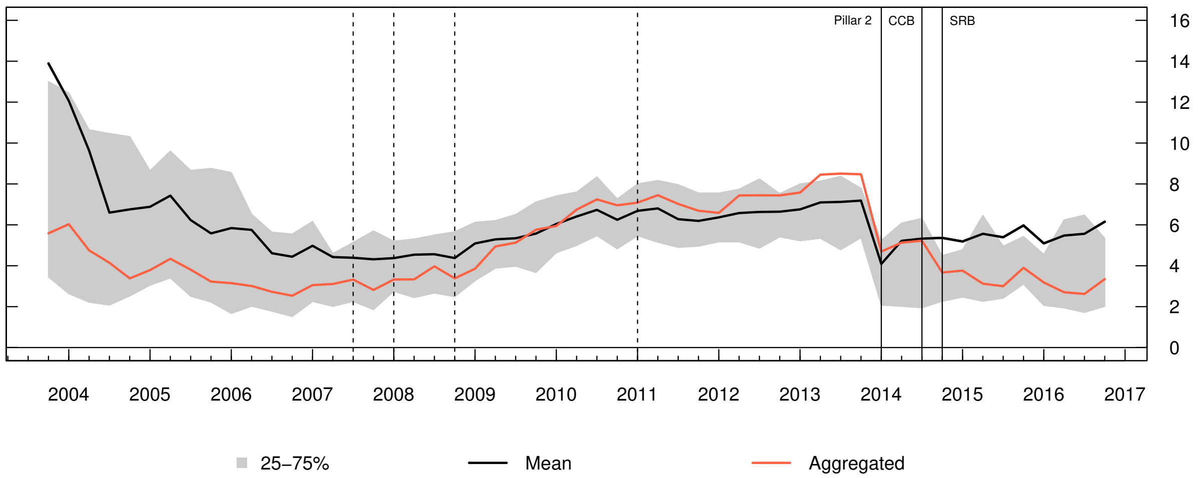
In the first step of the analysis, bank-specific target capital ratios are estimated using a standard partial adjustment model. The estimation results indicate that domestic banks cannot be regarded as either active or passive managers of their capital. While the overall speed of adjustment seems to be rather high and above the average values reported in the literature, the contribution of the adjustment in the level of capital is one-half, which is a below-average value. In other words, a substantial portion of this adjustment can be attributed to changes in risk-weighted exposures (through a combination of changes in portfolio size, structure and risk).

In the second step of the analysis, the impact of additional capital requirements stemming from capital buffers and Pillar 2 add-ons is analysed using a dynamic panel data model. The evidence implies that banks shrink their capital surplus in response to an increase in the additional capital requirements. Along with that, banks slightly revise both the target and the total regulatory capital ratio. Again, a substantial portion of the change seems to be delivered through changes in risk weights. For this and other reasons, it is desirable to regularly assess whether the evolution and current level of risk weights give rise to any risk of underestimating the necessary level of capital.

1. Introduction

For almost three decades, the Czech banking sector has been subject to prudential regulation. This has included formal capital requirements designed to maintain the resilience of the banking sector and its capacity to absorb financial and economic shocks.[1] Banks frequently argue that extra capital requirements reduce their ability to expand their business because equity is more expensive than debt. It would therefore be natural to expect banks to operate with their regulatory capital close to the minimum requirements. Nevertheless, banks in the Czech Republic have maintained their total regulatory capital ratios well in excess of the regulatory minima. The aggregated capital surplus of the domestic banking sector relative to the overall capital requirements[2] was CZK 80 billion (3.3% of risk-weighted exposures) as of 2016 Q4.[3] Most banks are compliant with these requirements by a sufficient margin on an individual basis as well (see Figure 1).

Figure 1: Total Capital Surplus (Total Regulatory Capital in Excess of Overall Capital Requirements; % of Risk-Weighted Exposures)



Note: The total capital surplus is calculated on a consolidated basis as total regulatory capital net of other regulatory capital requirements (Pillar 1 capital requirement + additional Pillar 2 capital requirement + combined buffer requirement) over risk-weighted exposures. Dashed vertical lines – switches to the internal ratings-based approach (five banks/bank groups in four waves); solid vertical lines – additional capital requirements stemming from capital buffers (capital conservation buffer, CCB, and systemic risk buffer, SRB) and Pillar 2 add-ons.

The maintenance of capital surpluses and the underlying motives for this behaviour have important policy implications. In particular, an increase in the additional capital requirements might be expected to have a limited effect on banks' capitalization if banks have a high capital surplus, simply because they would use the extra capital and shrink the surplus. But if banks intentionally target higher capital ratios than the level required by their regulator and form an intentional capital surplus, additional capital requirements could actually lead them to increase their overall capitalization in an

[1] The current rules can be found in the act implementing Basel III in Europe: the CRD IV/CRR regulatory framework. CRD IV – the Capital Requirements Directive – refers to Directive 2013/36/EU of the European Parliament and of the Council of 26 June 2013 on access to the activity of credit institutions and the prudential supervision of credit institutions and investment firms; CRR – the Capital Requirements Regulation – refers to Regulation (EU) No 575/2013 of the European Parliament and of the Council of 26 June 2013 on prudential requirements for credit institutions and investment firms.
[2] The overall capital requirements consist of the Pillar 1 capital requirement, additional Pillar 2 capital requirements and capital buffers (see subsection 2.2).
[3] The capital surplus is calculated on a consolidated basis.

effort to preserve the existing surplus. It is therefore important to distinguish between intentionally and unintentionally formed capital surpluses and to analyse the effect of capital regulation on each of them separately. The question is whether the pass-though is complete or incomplete and what portion of the change is delivered through a change in the capital level (the numerator) and what portion through a change in risk-weighted exposures (the denominator).

To the best of our knowledge, there is no other similar study estimating the impact of additional capital requirements for the Czech banking sector. This is not surprising given the recent advent of macroprudential policy and the short data history available. This paper is intended as the first attempt to find a reasonable methodological framework for this area and to test the sufficiency of the existing data. The paper has two main objectives: (i) to estimate individual bank-specific capital targets and distinguish between intentionally and unintentionally formed capital surpluses, and (ii) to analyse the impact of additional capital requirements stemming from capital buffers and Pillar 2 add-ons on banks' intentional capital surplus and total regulatory capital ratio. The Czech National Bank currently applies three capital buffers – a conservation buffer (2.5% since July 2014), a systemic risk buffer (1%–3% for some banks since October 2014) and a countercyclical capital buffer (0.5% since January 2017). It has also set an additional Pillar 2 requirement since 2014 Q1 (1.6% on aggregate as of 2016 Q4). Pillar 2 add-ons have been set for banks for which supervisory colleges have been established. The analysis draws on quarterly bank-level data for 14 banks and bank groups between 2002 Q4 and 2016 Q4.

In the first step of the analysis, bank-specific target capital ratios are estimated using a standard partial adjustment model. It is based on the simple idea that the costs of altering their capital prevent banks from moving it to the desired level immediately; instead, they close a constant proportion of the gap each period. This proportion can be interpreted as the speed of adjustment between the actual and the target capital ratios. The estimation results indicate that domestic banks cannot be regarded as either active or passive managers of their capital. While the overall speed of adjustment seems to be rather high and above the average values reported in the literature, the contribution of the adjustment in the level of capital is one-half, which is a below-average value. In other words, a substantial portion of this adjustment can be attributed to changes in risk-weighted exposures (through a combination of changes in portfolio size, structure and risk). This is not necessarily surprising given that asset risk and capital may be co-determined, as banks with more (less) capital may choose to take on more (less) portfolio risk (Flannery and Rangan, 2008).

In the second step of the analysis, the impact of additional capital requirements stemming from capital buffers and Pillar 2 add-ons is analysed using a dynamic panel data model. The evidence implies that a 1 percentage point (pp) increase in the overall capital requirements shrinks the intentional capital surplus (the difference between the target and the overall capital requirement) by 0.8 pp. Given that this response is less than one-to-one, the target capital ratio is actually revised upwards by 0.2 pp. This effect is caused partly by a change in the level of capital and partly by a change in average risk weights. Similarly, the total regulatory capital ratio increases by 0.1 pp in response to a 1 pp increase in the requirements; this is most likely the result of a very small estimated unintentional capital surplus (the difference between the total regulatory ratio and the desired target).

The presented findings have important policy implications. In particular, the pass-through from an increase in the additional capital requirements to the total regulatory and target capital ratios is incomplete. A substantial portion of the change seems to be delivered through changes in average risk weights. Banks may adjust risk weights through a combination of changes in asset structure and risk estimates (under the internal ratings-based approach). Each of the two options has a totally different interpretation and different implications for the prudential authority. The former would imply that the bank actually shifts the portfolio to less risky assets, i.e. it optimizes the portfolio risk with respect to its capital (Flannery and Rangan, 2008). The latter would imply that the bank starts to see the same asset as less risky immediately after the increase in the additional capital requirements. This could be attributed to strategic risk-modelling by banks (i.e. risk-weight manipulation; see Mariathasan and Merrouche, 2014). For this and other reasons, it is desirable to regularly assess whether the evolution and current level of risk weights give rise to any risk of underestimating the necessary level of capital. It is beyond the scope of this paper to distinguish between these two effects, but it is important to bear in mind these different possible transmission channels.

The remainder of this paper is organized as follows. Section 2 briefly discusses literature related to bank capital targets and higher capital requirements. Sections 3 and 4 present the econometric framework and describe the data. Section 5 reports the estimation results and provides a robustness analysis. Section 6 concludes.

2. Literature Review

2.1 The Bank Capital Surplus and the Capital Target

Maintaining capital in excess of the minimum regulatory requirements is not solely a phenomenon of the Czech banking sector, but has also been observed in other countries around the world (Berger et al., 2008; Brewer et al., 2008; Flannery and Rangan, 2008; Gropp and Heider, 2010; Berrospide and Edge, 2010). Banks may experience a capital surplus for various reasons. They can build up an intentional capital surplus to hedge against having to raise new equity at short notice, which might entail significant transaction costs or share price reductions (Ayuso et al., 2004; Peura and Keppo, 2006). Banks might be willing to hold more capital in order to match planned future asset expansions or changes in asset structure. They will tend to hold additional capital if they expect an increase in the additional capital requirements in the near future. More risk averse banks with volatile earnings are also more likely to build up additional surpluses than less risk averse banks with stable earnings streams (Gale and Ogur, 2005). In all these cases, the higher capital ratio would be set as an explicit bank-specific target. However, it is also relatively easy to maintain or increase capital when earnings are high. Since dividend payments tend to be sticky, capital ratios may rise almost automatically in a situation of high earnings. According to this view, today's high bank capital ratios were not explicitly targeted, but simply reflect a long run of high profits (Myers and Majluf, 1984; Berger et al., 2008). Combining the two views, the difference between the target capital ratio and the overall capital requirement can be regarded as an intentional capital surplus and the difference between the total regulatory capital ratio and the target capital ratio as an unintentional capital surplus. The sum of the two would then form the total capital surplus.

The estimation of individual bank-specific target capital ratios is the crucial aspect for distinguishing between intentionally and unintentionally built capital surpluses. One well-known approach in this area is the partial adjustment model introduced by Hancock and Wilcox (1994) and used by many others (see e.g. Berger et al., 2008; Flannery and Rangan, 2008; Francis and Osborne, 2009; Lemmon et al., 2008; Berrospide and Edge, 2010; Gropp and Heider, 2010). The model is based on the simple idea that the costs of altering their capital prevent banks from moving it to the desired target immediately. The main focus of this stream of literature is to estimate the speed of adjustment between the actual capital ratio and the desired target and to determine the differences in the adjustment process between different bank groups.

According to an alternative view, banks maintain excess capital as an outcome of pressures emanating from shareholders, debt holders and depositors, while regulatory interventions are of secondary importance (Morgan and Stiroh, 2001; Martinez Peria and Schmuckler, 2001; Calomiris and Wilson, 2004; Ashcraft, 2008). In these studies, banks simply optimize their capital structure much like non-financial corporations, in respect of which capital requirements are not necessarily binding (Flannery, 1994; Diamond and Rajan, 2000; Allen et al., 2009).

2.2 The Impact of Higher Additional Capital Requirements

The recent financial turmoil undoubtedly demonstrated that the existing capital regulation framework was not sufficient to prevent a panic in the financial sector. In response, the Basel Committee on Banking Supervision proposed new regulatory rules commonly known as the Basel III reforms, which introduce, among other things, more stringent capital requirements using a three-pillar system. Specifically, under Pillar 1 the common equity Tier 1 requirement increases from 2% to 4% and the Tier 1 requirement from 4% to 6% of risk-weighted exposures, while the total risk-adjusted capital requirement remains unchanged at 8%. In addition, banks must meet a combined buffer requirement consisting of requirements for the capital conservation buffer, the systemic risk buffer, the capital buffer for other systemically important institutions and the countercyclical capital buffer. On top of that, under Pillar 2 the supervisory authority may determine an additional capital requirement as a result of a supervisory review and evaluation process (SREP),[4] which should cover risks that are not covered by Pillar 1 or capital buffers. The sum of the Pillar 1 capital requirement, the additional Pillar 2 capital requirements and the capital buffers forms the overall capital requirement (sometimes also referred to as the other relevant capital requirement).[5]

The literature analysing the effect of changes in capital requirements is usually focused on their impact on lending (Ediz et al., 1998; Francis and Osborne, 2009; Bridges et al., 2014; Aiyar et al., 2012; Noss and Toffano, 2014); much less attention has been given to their impact on banks' capital ratios and capital targets. Moreover, many studies have focused on analysing the impact of changes in banks' *capitalization* rather than the *capital requirements* themselves (Bernanke and Lown, 1991; Jimenez et al., 2013; Albertazzi and Marchetti, 2010; Fonseca et al., 2010). This paper falls into the most recent branch of the literature, which links changes in capital requirements, capital targets, overall capital levels and risk-weighted exposures. This branch of literature has grown in prominence over the last ten years with the advent of macroprudential policy; the other branches, however, are also relevant and closely related to the entire issue.[6]

In general, banks may adjust the regulatory capital ratio through a combination of changes in the level of capital, asset structure and risk weights (under the internal ratings-based[7] approach; Cohen and Scatigna, 2014). One of the crucial factors influencing the particular way a bank chooses to adjust its capital ratio is the state of the economy and the prospects for the near future (Brei and

[4] Determination of additional capital requirements under Pillar 2 is elaborated in the Guidelines on common procedures and methodologies for the supervisory review and evaluation process.

[5] Rules for determining the Pillar 1 minimum capital requirements, additional Pillar 2 capital requirements and capital buffers are defined in the CRD IV/CRR regulatory framework.

[6] A different stream of literature explores the relationship between banks' capital, lending and risk-taking and monetary policy. This literature is even less closely related, so it is not reviewed here.

[7] The current CRD IV/CRR regulatory framework allows two approaches to be used to set risk weights: the standardized approach (STA) and the internal ratings-based approach (IRB). The STA approach takes into account the type of exposure, its external rating and the quality of collateral. The IRB approach is based on internal ratings set by individual banks, i.e. on their own assessment of the riskiness of the portfolio based on internal model-based estimates of the probability of default (PD) and the loss given default (LGD) and on determining the exposure at default (EAD).

Gambacorta, 2014). Under favourable economic conditions, banks may be more likely to increase their capital ratios through retained earnings or by issuing equity, while in worse economic conditions they may prefer to shift their asset structure towards less risky assets (such as government securities bearing low risk weights) or to reduce their total exposures (Dahl and Shrieves, 1990; Jackson, 1999; Heid et al., 2004; Brei and Gambacorta, 2014).

On top of that, there are other possible adjustments for banks reporting under the internal ratings-based (IRB) approach. A number of studies have shown that IRB risk weights are systematically lower than those of STA banks, while this does not necessarily reflect lower or better-managed credit risk. For instance, Behn et al. (2016a) find that the internal risk estimates of banks that have switched to IRB systematically underpredict the actual default rates. Mariathasan and Merrouche (2014) analyse a panel of 115 banks from 21 OECD countries and find that once regulatory approval for the IRB approach is granted the risk-weight density becomes lower, while *"this phenomenon cannot be explained by modelling choices, or improved risk-measurement alone"*. The authors attribute part of this decline to banks' strategic risk-modelling, i.e. risk-weight manipulation.

Another weakness of risk-sensitive capital regulation is its tendency to magnify the inherent procyclicality of banks' behaviour (see e.g. Borio et al., 2001; Rochet, 2008; Repullo et al., 2010; Cannata et al., 2011; Andersen, 2011; Saurina and Trucharte, 2007; Behn et al., 2016b). Risk estimates generally vary over time, being lower in booms and higher in busts. This may lead to underestimation of a portfolio's real loss potential. Thus, in good times, the IRB approach may not capture the level of exposure risk accurately. The Basel Committee on Banking Supervision addresses this issue in a consultation document (Bank for International Settlements, 2016). The last two issues mentioned above are important but beyond the scope of this paper. Nevertheless, it is important to be aware of these potential transmission channels.

3. The Econometric Framework

This section presents two empirical models. The first is designed to estimate individual bank-specific capital targets. The second aims to analyse the impact of additional capital requirements on banks' capital ratio, capital target, capital surplus and risk weights.

3.1 A Partial Adjustment Model of the Target Capital Ratio

As discussed in subsection 2.2, one of the well-known approaches to estimating bank-specific capital targets is the partial adjustment model as introduced by Hancock and Wilcox (1994). Following this framework, the target capital ratio $CAR^*_{i,t}$ is modelled as a linear function of bank-specific, institutional and aggregate variables $X_{i,t}$:

$$CAR^*_{i,t} = \theta X_{i,t} \tag{1}$$

In addition, it is assumed that bank cannot adjust its capital immediately to achieve the target due to adjustment costs; instead, the bank closes a constant proportion of the gap each period. Thus, the total capital ratio $CAR_{i,t}$ is assumed to follow a partial adjustment model of the form:

$$CAR_{i,t} - DNCAR_{i,t} = \lambda(CAR^*_{i,t} - DNCAR_{i,t}) + \varepsilon_{i,t} \tag{2}$$

where $DNCAR_{i,t} = (capital_{i,t-4} + NP_{i,t} - DIV_{i,t-4})/RWE_{i,t-4}$ is the "do-nothing" capital ratio and λ is the speed of adjustment; $capital_{i,t}$ is total regulatory capital, $NP_{i,t}$ is annual net profit, $DIV_{i,t}$ are average annual dividend payments and $RWE_{i,t}$ are risk-weighted exposures. In order to estimate the *annual* speed of adjustment, the regulatory capital, dividend payments and risk-weighted exposures are lagged by four quarters; in addition, net profit and dividend payments are annualized.

The idea of the "do-nothing" capital ratio was introduced by Berger et al. (2008) in order to separate banks' capital ratio into an active and a passive component. The left-hand side of equation (2) can be viewed as the actively managed annual change in the capital ratio, which can be undertaken through a combination of changes in equity, dividend payments and risk-weighted exposures. The right-hand side of the equation aims to capture the proportion of the distance between the passive "do-nothing" capital ratio and the target closed per year. A low estimated speed of adjustment λ would indicate that banks are passive managers of their capital ratio; this might be caused simply by passive accumulation of net profit $NP_{i,t}$ adjusted for dividend payments $DIV_{i,t}$. In contrast, a high estimated λ would indicate that banks are active managers keeping the actual capital ratio close to the desired level.

In its current form, equation (2) captures the adjustment of the capital ratio through both its numerator and its denominator. A slight modification of the "do-nothing" capital ratio could shed some light on their individual contributions. By replacing the *lagged* risk-weighted exposures with their *current* values, the coefficient λ will indicate what portion of the adjustment can be attributed only to changes in the numerator, i.e. it will express the speed of adjustment of capital given the current level of risk-weighted exposures. Such a sensitivity exercise is performed alongside the baseline regression in section 5.

Substituting in expression (2) for $CAR^*_{i,t}$, rearranging the terms and introducing bank-specific fixed effects v_i yields the following estimation equation:

$$CAR_{i,t} = (1-\lambda)DNCAR_{i,t} + \lambda\theta X_{i,t} + \varepsilon_{i,t} + v_i \tag{3}$$

The measure of capital $CAR_{i,t}$ used in estimating the targets is the Basel III total regulatory ratio, i.e. total regulatory capital divided by risk-weighted exposures. In general, the numerator – regulatory capital – is affected by bank size, earnings and risk (see e.g. Milne and Whalley, 2001; Ayuso et al., 2004; Gropp and Heider, 2010; Brei and Gambacorta, 2014)[8] and the denominator – risk-weighted exposures – by the regulatory approach, the bank business model and the business cycle (see e.g. Cannata et al., 2011; Mariathasan and Merrouche, 2014; Czech National Bank, 2015; Behn et al., 2016a).[9] Moreover, all these aspects are closely interlinked. With respect to this, the vector of control variables $X_{i,t}$ includes return on total assets, the ratio of loan loss provisions to total assets, the natural logarithm of total assets, various loan categories in relation to total assets (mortgage loans, other retail loans, corporate loans), real GDP growth and the VIX.[10]

Loan loss provisions serve as an indicator of the riskiness of banks' loan portfolios. Banks are expected to build up loan loss provisions in response to increased credit risk and higher future losses.

[8] These factors are supposed to capture the direct cost of remunerating capital and the risk profile of banks. They have been used in a number of studies explaining the determinants of bank capital and capital targets.

[9] For instance, Cannata et al. (2011) find pro-cyclicality of risk weights for credit risk under the IRB approach using supervisory data for Italian banks. Mariathasan and Merrouche (2014) analyse a panel of 115 banks from 21 OECD countries and find that once regulatory approval for the IRB approach is granted the risk-weight density becomes lower. Behn et al. (2016a) document that the internal risk estimates of banks which switched to IRB systematically underpredict the actual default rates. Czech National Bank (2015) discusses the impact of these three aspects in practice using data for the Czech banking sector.

[10] Calculated and published by the Chicago Board Options Exchange.

The relationship between provisions and the total regulatory capital ratio will depend on at least three effects working in different directions. First, if banks set their capital in line with the riskiness of their loan portfolios, the relationship will be positive (Milne and Whalley, 2001; Brei and Gambacorta, 2014). Second, provisions are deductions from bank revenues; a higher level of provisions may thus reduce banks' retained earnings and consequently their capital, assuming a fixed ratio of dividend payouts. In this case, the relationship will be negative. Third, higher expected credit risk and future losses will be reflected not only in higher provisions, but also in higher estimates of the risk parameters used to calculate regulatory capital and risk weighed exposures under the IRB approach; this will lead to a negative relationship. The overall relationship will then depend on the prevailing effect.

A proxy for profitability – return on total assets – is included to capture its effect on capital via retained earnings (Ayuso et al., 2004; Gropp and Heider, 2010; Brei and Gambacorta, 2014). A proxy for bank size – the natural logarithm of total assets – is intended to capture the fact that larger banks usually face lower risk and have better access to funding (and may thus require less capital; Berger et al., 2008; Flannery and Rangan, 2008; Brei and Gambacorta, 2014). Moreover, larger banks may tend to maintain lower capital surpluses if they believe that in the event of any difficulty they will receive support from the regulator or the government (the "too-big-to-fail" hypothesis). The loan categories are included to capture the different riskiness associated with different asset classes. Usually, higher risk weights should be assigned to riskier assets, and markets and regulators should require more capital to be held against riskier assets. All bank-specific control variables are included in lagged form to mitigate a possible endogeneity bias; endogeneity is discussed in more detail in subsection 3.3.

In addition, three dummy variables are considered – crisis, IRB and regulatory pressures. The crisis dummy takes the value of 1 in the period 2008–2012 (Borio et al., 2015; Brei and Gambacorta, 2014); the IRB dummy 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; the regulatory-pressures dummy takes the value of 1 if the bank's regulatory capital ratio is less than 1.5 pp above the minimum of 8% (Berrospide and Edge, 2010).

It is reasonable to assume that the speed of adjustment will depend on the actual capital position of the bank. Specifically, banks with capital ratios below their desired target may adjust more quickly than banks with capital ratios above the target. In addition, banks that are far below their targets and close to the regulatory requirements may be subject to extra pressure from regulators and investors to increase their capital even more rapidly. This hypothesis is not new and was earlier proved by Berger et al. (2008) for U.S. bank holding companies. To capture this non-linearity, the model was modified by including two interaction dummies controlling for bank capitalization:

$$CAR_{i,t} = \left[(1-\lambda_1)+(1-\lambda_2)dCAR25_{i,t}\right]DNCAR_{i,t} + \theta_1 X_{i,t} + \varepsilon_{1,i,t} + v_{1,i} \quad (4)$$
$$CAR_{i,t} = \left[(1-\lambda_3)+(1-\lambda_4)dCAR75_{i,t}\right]DNCAR_{i,t} + \theta_2 X_{i,t} + \varepsilon_{2,i,t} + v_{2,i} \quad (5)$$

where $dCAR25_{i,t}$ ($dCAR75_{i,t}$) is the dummy for the lower (upper) quartile of the total regulatory capital ratio.

3.2 Dynamic Panel Data Model of the Impact of Additional Capital Requirements

To capture the effect of additional capital requirements on a bank's total regulatory and target capital ratios, the following models are constructed:

$$ICS_{i,t} = \alpha_1 ICS_{i,t-1} + \beta_1 Reg_{i,t-1} + \theta_1 X_{i,t-1} + \varepsilon_{1,i,t} \quad (6)$$
$$CAR_{i,t} = \alpha_2 CAR_{i,t-1} + \beta_2 Reg_{i,t-1} + \theta_2 X_{i,t-1} + \varepsilon_{2,i,t} \quad (7)$$

where $ICS_{i,t}$ is the intentional capital surplus (the difference between the estimated target and the overall capital requirement) and $Reg_{i,t}$ is the overall capital requirement. The variation in $Reg_{i,t}$ stems from capital buffers and Pillar 2 add-ons. The dynamic structure of the model makes it possible to distinguish between the short-run dynamics, as captured by coefficients β, and the long-run (or equilibrium) relationship, as given by $\frac{\beta}{(1-\alpha)}$; $(1-\alpha)$ is the rate of convergence.

In order to distinguish between the contributions of changes in risk weights and the capital level, the baseline models are complemented with the following three:

$$ICSnrw_{i,t} = \alpha_3 ICSnrw_{i,t-1} + \beta_3 Reg_{i,t-1} + \omega_1 RW_{i,t} + \theta_3 X_{i,t-1} + \varepsilon_{3,i,t} \quad (8)$$
$$CA_{i,t} = \alpha_4 CA_{i,t-1} + \beta_4 Reg_{i,t-1} + \omega_2 RW_{i,t} + \theta_4 X_{i,t-1} + \varepsilon_{4,i,t} \quad (9)$$
$$RW_{i,t} = \alpha_5 RW_{i,t-1} + \beta_5 Reg_{i,t-1} + \omega_3 CA_{i,t} + \theta_5 X_{i,t-1} + \varepsilon_{5,i,t} \quad (10)$$

where $ICSnrw_{i,t}$ is a *non-risk-weighted* version of $ICS_{i,t}$, i.e. the non-risk-weighted capital surplus over total assets, $RW_{i,t}$ is the implicit risk weight, calculated as risk-weighted exposures over total assets, and $CA_{i,t}$ is total regulatory capital over total assets. In specifications with $ICSnrw_{i,t}$ and $CA_{i,t}$, the actual value of $RW_{i,t}$ (the effect of the denominator) is additionally controlled for, while in the specification with $RW_{i,t}$, the actual value of $CA_{i,t}$ (the effect of the numerator) is controlled for. The main reason for including additional controls is to capture purely the effect of higher capital requirements on the numerator and the denominator of the ratio, assuming the second is constant. By not including the controls we could potentially face omitted variable bias. The test for Granger causality between $CA_{i,t}$ and $RW_{i,t}$ at various orders indicates that the simultaneity problem should not be present.

3.3 Estimation Techniques

One of the possible identification problems in the context of dynamic panel data models with one-way fixed effects is endogeneity bias. Nickell (1981) shows that this bias is introduced by applying the within (demeaning) transformation in attempt to remove unobserved heterogeneity within 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.

There are a few possible estimation methods that can help to mitigate endogeneity bias. They can be divided into two main groups – GMM estimators and bias-corrected least square dummy variable (LSDV) estimators. GMM estimators are well established in similar areas of research, but they are only suitable for panels with very large N and small T. One particular weakness of GMM estimators (especially the System-GMM) is that when T is relatively large compared to N, the huge number of instruments produced may render the GMM estimator invalid even though the individual instruments may be valid (Roodman, 2009). Some studies also show that using the instrumental variables technique to avoid bias often leads to poor small-sample properties (Kiviet, 1995; Bun and Windmeijer, 2010). Motivated by these disadvantages, Kiviet (1995) pioneered a group of bias-corrected FE estimators. Soon after, a few modifications to the Kiviet (1995) estimator allowing for heteroscedasticity emerged (Bun, 2010; Bun and Carree, 2005; Everaert and Pozzi, 2007; De Vos et al., 2015). Bias-corrected LSDV estimators have been shown to have superior small sample properties to GMM estimators and to maintain relatively small coefficient uncertainty while removing most of the bias of the standard LSDV estimator.

Given that the panel for the Czech Republic has a relatively large number of time periods (T=57) compared to the number of individuals (N=14), the standard LSDV estimator and the bias-corrected LSDV estimator are suitable for the estimation. Specifically, the bootstrap-based bias-corrected LSDV estimator proposed by De Vos et al. (2015)[11] is used. The wild bootstrap as suggested by Liu (1988) and Mammen (1993) is used to deal with general heteroscedasticity[12] by implementing the *xtbcfe* Stata routine.[13] For each model, 300 iterations are produced and 250 enter the final inference. The two methods provide comparable results in terms of the coefficient and standard error estimates, suggesting that there is little or no endogeneity bias in the model; this is in line with the theory and simulations discussed above. We therefore report results for one estimation technique only; the other sets of results are available upon request.

The partial adjustment model of the target capital ratio described by equations (3)–(5) is estimated using the standard LSDV estimator, while the effect of additional capital requirements described by equations (6)–(10) is estimated using the bootstrap-based estimator. Given the comparability of the estimation results under the two techniques, the standard LSDV is preferred as more straightforward; the main reason for using the bootstrap-based estimator in the second part of the analysis is to address the generated regressor problem. It arises from the inclusion of the estimated target capital ratio from the first model in the second model. The literature suggests using bootstrapped standard errors as a possible solution (see e.g. Cameron and Trivedi, 2013; Ashenfelter and Card, 2010; Bernanke et al., 2005; Bellak et al., 2010; Agostino et al., 2009). The proposed estimator is therefore a suitable alternative for tackling this issue.

4. Data

At the end of 2016, the Czech banking sector consisted of 17 banks,[14] five building societies and 23 foreign bank branches. 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 larger domestic banks; together with individual banks the sector consists of 16 banks and bank groups on a consolidated basis. The Czech Export Bank and the Czech-Moravian Guarantee and Development Bank were excluded from the analysis because they are wholly owned by the Czech state (which provides implicit state guarantees for their liabilities) and have different business models and volatile credit portfolios. With respect to time span, the longest available period was used. The final sample thus covers 14 banks and 57 quarters from 2002 Q4 to 2016 Q4, giving an unbalanced panel of 664 observations in total.[15]

[11] De Vos et al. (2015) build on the model by Everaert and Pozzi (2007); instead of analytical expressions for the bias, usually derived under strict assumptions, they make use of numerical evaluation by bootstrap resampling. This procedure is far simpler and turns out to perform well.

[12] A likelihood-ratio test indicates that there is heteroscedasticity in our dataset.

[13] For more details on the implementation of this routine and a description of the methodology, see De Vos et al. (2015).

[14] ERB bank was excluded due to insolvency.

[15] Bank-level data are obtained from the CNB's internal database (FINREP and COREP reporting statements). The total regulatory capital 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 total regulatory capital 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. The influence of this adjustment is studied in a sensitivity analysis in subsection 5.3.

Consolidated bank statements are considered in the baseline empirical analysis. This is mainly because banks usually formulate their capital planning strategies at the whole-group level. In addition, the regulatory capital requirements in Pillar 2 are very often expressed primarily on a consolidated basis. The influence of consolidation is also studied in the sensitivity analysis in subsection 5.3.

Table 1 reports summary statistics for the regulatory capital ratio and its components by bank business model and regulatory approach. With respect to business model, the Czech banking sector can be divided into two broad groups – universal banks and investment banks. Within the group of universal banks we can further distinguish a sub-group of building societies and mortgage banks; most of these banks, however, are part of larger bank groups as described above. With respect to regulatory approach, the IRB approach was adopted in the five largest universal banks and the majority of their subsidiaries in four waves starting in 2007 Q3; their market share was about 82% as of 2016 Q4. All IRB banks use also the STA approach for a certain (usually very small) portion of their exposures.

Table 1: Regulatory Capital Ratio and its Components – Summary Statistics

	Market share†	Number of obs.	Number of banks	Variable	Mean	Difference in means	St. dev.	Min.	Max.
All banks	100%	664	14	CAR	15.38		7.17	8.12	92.10
				CA	8.93		4.58	1.50	27.46
				RW	59.33		21.51	7.26	140.60
Investment banks	8.1%	112	2	CAR	18.27	3.47***	13.75	10.20	92.10
				CA	10.35	1.71***	4.89	4.64	21.53
				RW	66.74	8.91***	32.34	7.26	140.60
Building societies and mortgage bank subsidiaries‡	13.5%	392	7	CAR	16.57	0.89*	8.56	8.16	56.38
				CA	5.68	-3.31***	3.07	2.22	17.58
				RW	35.99	-23.72***	14.94	12.00	88.40
IRB approach	81.6%	169	5	CAR	14.85	-0.71*	2.50	9.39	21.33
				CA	7.45	-2.00***	1.62	4.58	11.67
				RW	50.69	-11.59***	10.08	31.98	80.19
STA approach	18.4%	495	9	CAR	15.56	0.71*	8.18	8.12	92.10
				CA	9.44	2.00***	5.13	1.50	27.46
				RW	62.28	11.59***	23.50	7.26	140.60
STA approach (excl. inv. banks)	10.3%	383	7	CAR	14.77	-0.08	5.36	8.12	38.53
				CA	9.18	1.73***	5.17	1.50	27.46
				RW	60.98	10.29***	20.06	12.73	108.39

Note: Summary statistics are calculated on a consolidated basis unless otherwise indicated. ***, ** and * denote whether the t-test of the difference in the mean between a particular group of banks and the rest of the sample is significant at, respectively, the 1%, 5% and 10% levels. CAR – total regulatory capital ratio (regulatory capital over risk-weighted exposures); CA – regulatory capital over total assets; RW – implicit risk weights (risk-weighted exposures over total assets). "IRB approach" – banks using the IRB approach for at least some portion of their exposures in the given quarter; "STA approach" – banks using solely the STA approach in the given quarter. † Market share is expressed in % of the total assets of the whole banking sector as of 2016 Q4. ‡ Statistics for building societies and mortgage bank subsidiaries are calculated on a solo basis.

A few patterns emerge. First, the capital ratio of investment banks differs significantly from those of the rest of the domestic banks; this is due to their different business models and capital planning strategies. The mean values are not strikingly different, but the volatility is significant. The robustness of the baseline results is therefore tested with respect to the inclusion of these two banks in subsection 5.3.

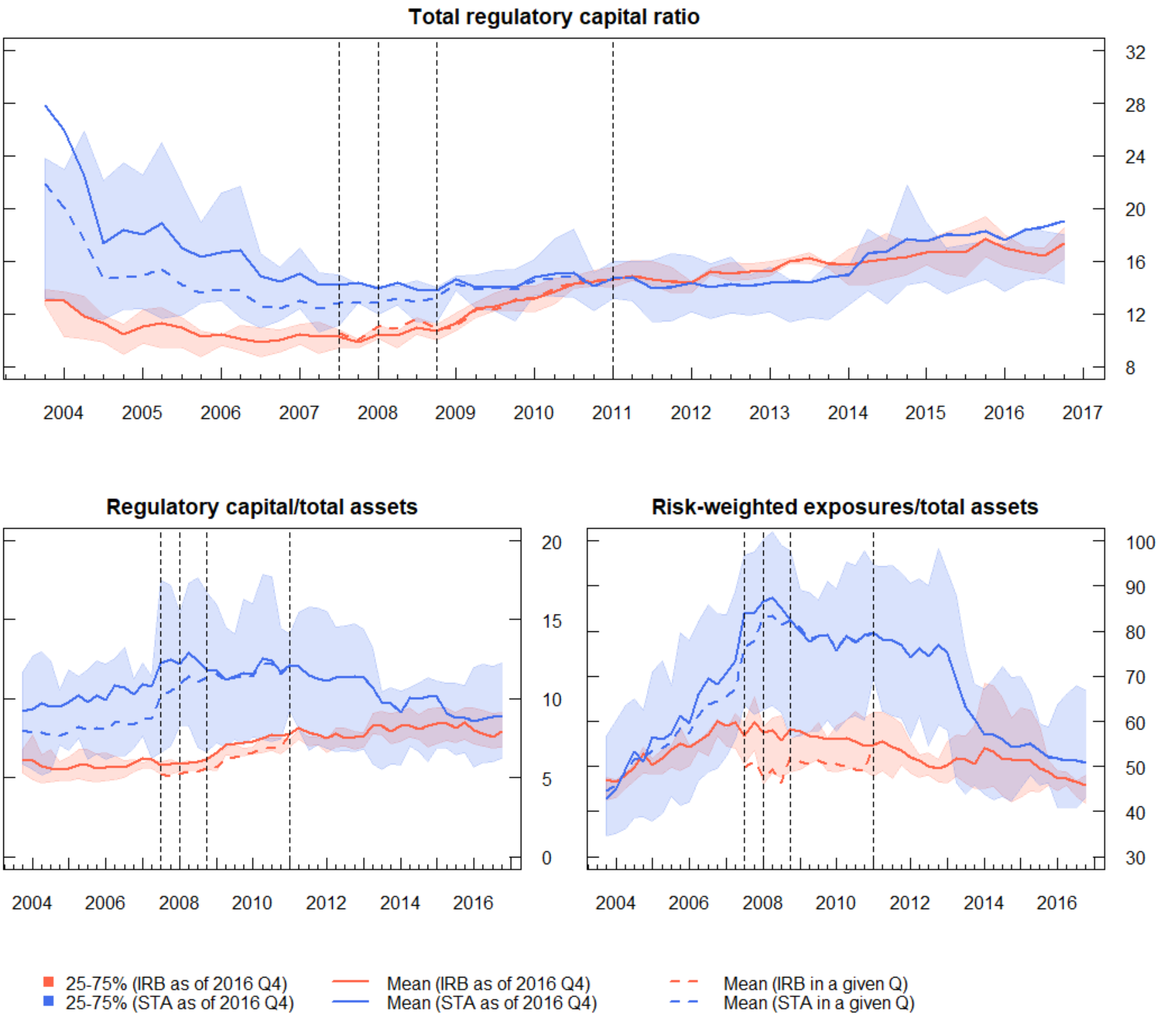
Second, the denominator and the numerator of the regulatory capital ratio are lower for banks using predominantly the IRB approach compared to banks using solely the STA approach. On average, the risk weights are 11.6 pp lower and capital over total assets is 2 pp lower. The results remain comparable even when investment banks are excluded.

Third, the risk weights and capital over total assets of building societies and mortgage bank subsidiaries (i.e. banks whose business model is focused almost exclusively on providing loans for house purchase) are, on average, significantly lower than those for the rest of the sample. Specifically, the risk weights are 23.7 pp lower and capital over total assets is 3.3 pp lower. This may be due partly to the fact that the largest building societies and one medium-sized building society and one medium-sized mortgage bank are IRB banks. Moreover, loans secured by residential property – which form a significant share of loans provided by building societies and the entire loan portfolio of mortgage banks – are in general less risky than other types of loans. Nevertheless, the risk may be undervalued in IRB building societies. The average risk weight of retail loans other than those secured by residential property is significantly lower for IRB building societies than for other IRB banks (about 28% versus 50%, calculated on a solo basis as of 2016 Q4). Moreover, the average risk weight of loans secured by residential property is also lower for IRB building societies than for other IRB banks (about 22% versus 27%, calculated on a solo basis as of 2016 Q4). For further discussion of this issue, see Czech National Bank (2017).

Figure 2 illustrates the evolution of the total regulatory capital ratio and its two components over time. To show the effect of the adoption of the IRB approach, it distinguishes between IRB banks as of 2016 Q4 (the solid red line) and IRB banks using the IRB approach in the given quarter (the dashed red line). Generally, the dynamics of the capital level are fairly stable, with a slightly positive trend, while most of the variation in the regulatory capital ratio is caused by changes in risk weights. This stable positive capital level is due to a combination of factors. First, the Czech banking sector has long been profitable (Czech National Bank, 2017), while banks follow a stable dividend policy. Second, the profit has remained largely in the domestic banking sector and has not been withdrawn by foreign parent companies. Third, banks have maintained higher capital in anticipation of higher capital requirements (especially before the introduction of capital buffers and Pillar 2 capital add-ons in 2014).

The group of banks using solely the STA approach for the entire period analysed displayed much larger regulatory capital ratios, especially until 2007, than the group of banks that adopted the IRB approach later on. This was due to significantly higher capital over total assets given a comparable level of risk weights. The risk weights of banks that adopted the IRB approach started falling simultaneously with this switch, while those of STA banks started to decrease slowly a few quarters later due to a change in their asset structure (an increasing share of less risky loan categories). As a result, the regulatory capital ratios of the two groups converged to a similar level. Despite constant gradual growth, the capital over total assets of IRB banks remains lower than that of STA banks over the entire sample period. The same applies to risk weights – even though the risk weights of STA banks drop significantly at the end of the sample, those of IRB banks remain lower. This visible trend – a decrease in the risk weights of both STA and IRB banks – is due to a combination of an increasing share of less risky loans secured by residential property in banks' loan portfolios and an increasing share of less risky sovereign exposures in their total balance sheets. Favourable economic conditions, however, certainly play a role too (for some literature on the pro-cyclicality of the IRB approach, see section 2).

Figure 2: Total Regulatory Capital Ratio and its Components – IRB vs STA Banks (%)



Note: Vertical lines – switches to the IRB approach (five banks/bank groups in four waves). The red (blue) solid line refers to banks using the IRB approach for at least some portion of their exposures (solely the STA approach) as of 2016 Q4; dashed lines refer to the situation in the given quarter.

5. Results

5.1 The Bank-specific Target Capital Ratio

Table 2 shows the estimation results for equations (3)–(5). The coefficient on the "do-nothing" capital ratio indicates that banks close 67% of the gap between the ratio and the target each year, i.e. the estimated speed of adjustment is 67% per year (column 2). To the best of our knowledge, there is no similar analysis for the Czech banking sector suitable for comparison. Some earlier studies conducted for the U.S. banking sector provide estimates of between roughly 30% and 60% per year (Flannery and Rangan, 2008; Berrospide and Edge, 2010; Berger et al., 2008). Gropp and Heider (2010) estimate the combined speed of adjustment for U.S. and EU publicly traded banks; their estimate falls within the same range (about 47%).

Table 2: Estimation Results – Target Capital Ratio

Denominator of do-nothing CAR:	Lagged RWE				Current RWE		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Do-nothing CAR	0.340***	0.326***	0.307***	0.092**	0.667***	0.655***	0.398***
	(0.021)	(0.021)	(0.021)	(0.044)	(0.033)	(0.034)	(0.063
Do-nothing CAR*dCAR25			-0.279**			-0.479***	
			(0.139)			(0.137)	
Do-nothing CAR*dCAR75				0.216***			0.250***
				(0.049)			(0.078)
ROA (t-1)	0.608***	0.666***	0.577***	0.528***	0.363**	0.317*	0.315*
	(0.202)	(0.200)	(0.195)	(0.184)	(0.183)	(0.179)	(0.177)
Log(assets) (t-1)	-0.093	-0.707*	-0.935**	-0.465	-1.687***	-1.747***	-1.325***
	(0.364)	(0.395)	(0.385)	(0.364)	(0.344)	(0.337)	(0.340)
Loan loss provisions/assets (t-1)	-0.211	-0.155	-0.371*	-0.043	-0.758***	-0.888***	-0.583***
	(0.207)	(0.207)	(0.207)	(0.191)	(0.190)	(0.188)	(0.185)
Regulatory pressures	-2.178***	-2.155***	-1.683**	-2.010***	-1.379*	-1.396*	-1.543**
	(0.824)	(0.810)	(0.813)	(0.746)	(0.741)	(0.748)	(0.719)
Mortgage loans/assets (t-1)		0.139***	0.080**	0.082**	0.095***	0.051	0.078**
		(0.038)	(0.039)	(0.036)	(0.035)	(0.035)	(0.035)
Other retail loans/assets (t-1)		-0.304***	-0.232***	-0.241***	-0.223***	-0.150**	-0.204***
		(0.067)	(0.067)	(0.063)	(0.062)	(0.061)	(0.060)
Corporate loans/assets (t-1)		-0.039**	-0.031**	-0.030**	-0.014	-0.010	-0.015
		(0.016)	(0.016)	(0.015)	(0.015)	(0.014)	(0.014)
IRB	3.020***	2.597***	1.843***	2.241***	2.211***	1.665***	2.066***
	(0.601)	(0.638)	(0.633)	(0.586)	(0.582)	(0.575)	(0.562)
VIX	-0.058**	-0.046*	-0.038	-0.043**	-0.027	-0.020	-0.032
	(0.024)	(0.024)	(0.023)	(0.022)	(0.022)	(0.021)	(0.021)
Crisis	-1.816***	-1.416***	-1.302***	-0.753	-1.010**	-0.978**	-0.487
	(0.514)	(0.513)	(0.499)	(0.475)	(0.469)	(0.457)	(0.459)
Real GDP growth	-0.233***	-0.145*	-0.128	-0.149*	-0.088	-0.084	-0.106
	(0.086)	(0.086)	(0.084)	(0.079)	(0.079)	(0.077)	(0.076)
dCAR25			0.650			3.049**	
			(1.818)			(1.546)	
dCAR75				0.829			-0.986
				(0.945)			(1.301)
Observations	622	622	622	622	622	622	622
Adjusted R^2	0.396	0.420	0.454	0.513	0.518	0.543	0.553
F Statistics	47.706***	39.514***	38.829***	48.633***	57.697***	54.670***	56.736***

Note: This table presents the fixed-effect regression estimates of equations (3)–(5) for the determinants of banks' target capital ratios. The sample period is from 2002 Q4 to 2016 Q4. Standard errors are reported in parentheses; ***, ** and * denote the 1%, 5% and 10% significance levels. Fixed effects are not reported. CAR – total regulatory capital ratio, i.e. regulatory capital over risk-weighted exposures; dCAR25 – dummy for lower quartile of total regulatory capital ratio; dCAR75 – dummy for upper quartile of total regulatory capital ratio; RWE – risk-weighted exposures; IRB – banks using the IRB approach for at least some portion of their exposures as of 2016 Q4; STA – banks using solely the STA approach as of 2016 Q4.

Furthermore, the interaction dummies indicate that banks below the 25th percentile of the total regulatory capital ratio adjust 28 pp faster than better capitalized banks (column 3), while banks above the 75th percentile adjust 22 pp slower than their less capitalized peers (column 4). This result supports the initial hypothesis that less capitalized banks (which may find themselves below the desired target or close to the regulatory requirements) feel the need to adjust much faster than better capitalized banks.

As discussed earlier, a change in the capital ratio can be undertaken through a combination of changes in equity, dividend payments and risk-weighted exposures. In order to shed more light on the contribution of the denominator, the "do-nothing" capital ratio was slightly modified by replacing lagged risk-weighted exposures with their current value. As such, the estimated λ indicates what portion of the adjustment can be attributed only to changes in the numerator, i.e. it expresses the annual speed of adjustment of capital given the current level of risk-weighted exposures.

After this modification, the speed of adjustment decreases significantly from the initial 68% to 34% (column 5), indicating that half of the overall adjustment can be attributed to change in the level of capital (given the stable dividend policy of domestic banks) and the other half to change in risk-weighted exposures (through a combination of changes in portfolio size, structure and risk). This is not necessarily surprising given that asset risk and capital may be co-determined, as banks with more (less) capital may choose to take on more (less) portfolio risk (Flannery and Rangan, 2008). The difference in the speed of adjustment between less and more capitalized banks remains similar as in the baseline (columns 6 and 7).

Looking at the whole picture, domestic banks cannot be regarded as either active or passive managers of their capital ratios. While the speed of adjustment of the total regulatory capital ratio seems rather high and above the average values reported in the literature, the contribution of the numerator is one-half, which is a below-average value. Given the good capitalization of domestic banks overall and the very stable evolution of the level of capital, which is showing a slight positive trend, banks seem to have a rather lower tendency to quickly adjust their capital; they maintain a reasonable balance between changes in risk-weighted exposures and capital.

Most of the remaining coefficients have the expected sign. Loan loss provisions, which are supposed to control for bank credit risk, are associated with lower capital ratios, suggesting that banks hold less capital over risk-weighted exposures during times of worse loan quality. As discussed in section 3, this may be the result of three effects working in different directions and affecting both the numerator and the denominator of the ratio. To shed some light on these effects, the same model specification was estimated with the *non-risk-weighted* version of the regulatory capital ratio, i.e. regulatory capital over total assets (the results are not reported but are available upon request). Unlike in the baseline regression, the relationship between provisions and capital over total assets is positive, in line with other studies (see e.g. Milne and Whalley, 2001; Brei and Gambacorta, 2014). The results of this additional exercise suggest that banks set their capital in line with the riskiness of their loan portfolios; the negative relationship in the baseline regression is therefore most likely the result of higher risk weights reflecting higher credit risk.

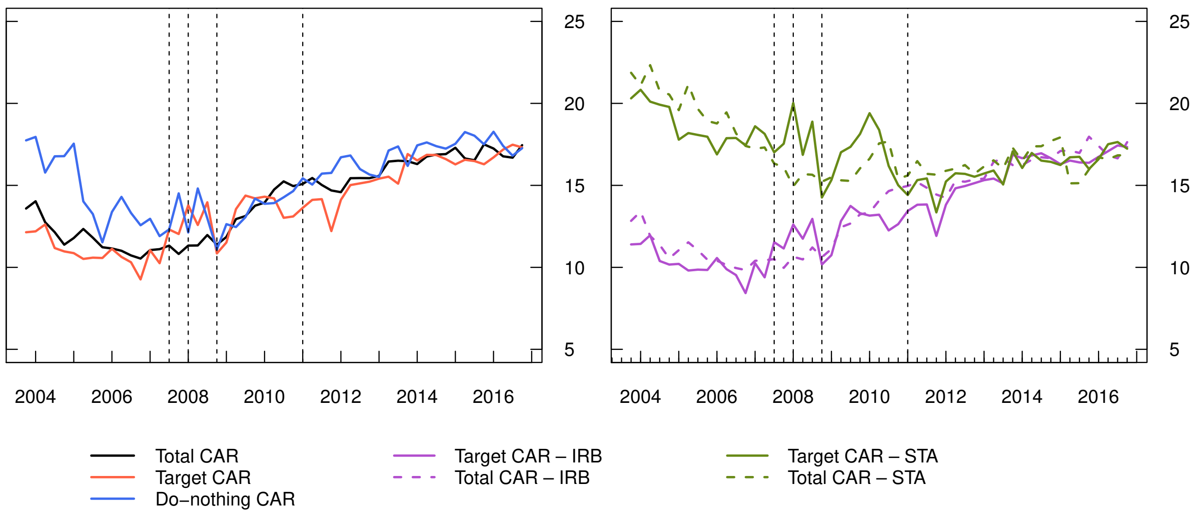
Size has a negative and significant coefficient, confirming the initial hypothesis that larger banks tend to hold lower capital ratios. Similar results are reported by, for example, Berger et al. (2008) and Flannery and Rangan (2008) for U.S. bank holding companies and Brei and Gambacorta (2014) for 109 major banks from the G10 countries, Austria, Australia and Spain. The relationship between bank profitability and the capital ratio is positive, indicating the existence of a channel via retained earnings.

With respect to asset structure, a higher share of less risky loans (mortgage loans secured by residential property) is positively associated with the regulatory capital ratio, while a higher share of more risky loans (other retail loans not secured by property and corporate loans) is negatively related to it. A possible explanation is the effect of change in asset structure on the average risk weights – a shift to a less risky asset structure reduces risk-weighted exposures and, all other things being equal, the capital ratio.

The coefficients on real GDP growth and the crisis dummy are both negatively associated with the regulatory capital ratio. Specifically, the capital ratio is about 1.6 pp lower during a contraction; in response to 1 pp higher real GDP growth, the capital ratio decreases by roughly 0.15 pp (column 2). The negative statistically significant coefficient on the dummy for regulatory pressures indicates that regulatory restrictions do seem to bind in a way that affects banks' capital ratios. The coefficient on the IRB dummy is significant and positive, suggesting that banks using the IRB approach hold a 3 pp higher regulatory capital ratio on average. This is due to a combination of lower average risk weights of IRB banks and a comparable level of capital; moreover, the total regulatory ratio is slightly higher on average in the second half of the sample, during which the IRB approach started to be used.

The coefficient estimates of model (2) from Table 2 are used to calculate bank-specific capital targets. Figure 3 compares these targets with the actual and "do-nothing" capital ratios: the left panel illustrates the distance between the three ratios over time, while the right panel shows the difference between IRB and STA banks. Comparing the two sub-charts reveals that the path is determined predominantly by IRB banks (84% of the total assets of the whole banking sector as of 2016 Q4). The estimated target ratio reflects the switch of some banks to the IRB approach between 2007 Q3 and 2008 Q4: the decline in risk weights following this switch pushed the target temporarily above the actual ratio, but it returned below it very quickly.

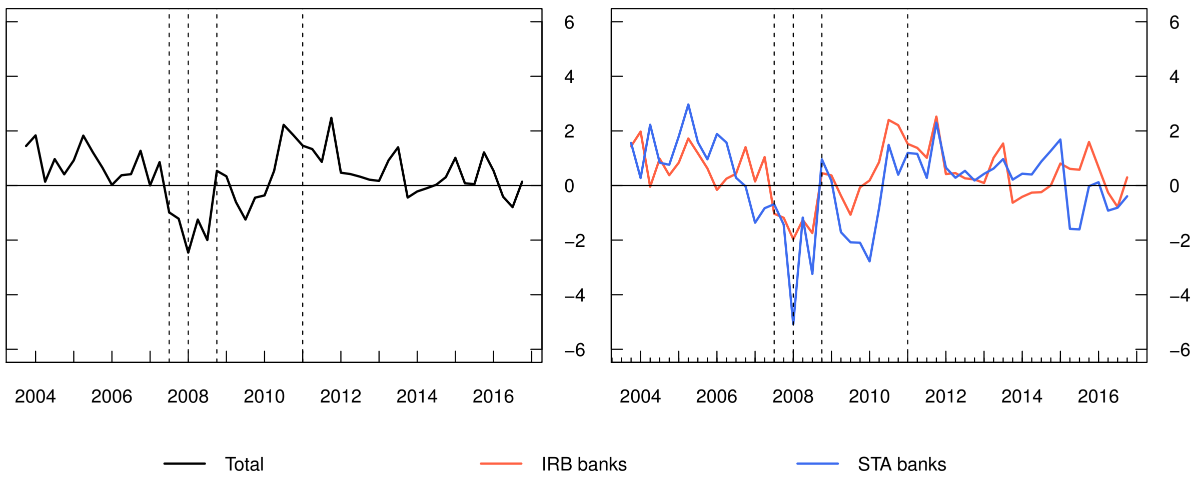
Figure 3: Total Regulatory and Target Capital Ratios (%)



Note: The target capital ratio is calculated using the coefficient estimates of model (2) from Table 2. Vertical lines – switches to the internal ratings-based approach (five banks/bank groups in four waves). "IRB banks" – banks using the IRB approach for at least some portion of their exposures as of 2016 Q4; "STA banks" – banks using solely the STA approach as of 2016 Q4.

Relatively fast adjustment if the target is above the actual ratio (and rather slower adjustment if it is below it) is consistent with the coefficient estimates in Table 2. This effect can also be seen in Figure 4, which shows the aggregated difference between the total regulatory and target capital ratios (i.e. the unintentional capital surplus). On average, banks operate very close to the target, displaying a positive difference over most of the period analysed. STA banks started to experience a shortfall rather earlier than IRB banks – at the end of 2006. This seems largely to reflect a relatively rapid balance sheet expansion and a rise in the ratio of loans to total assets, which caused a gradual increase in risk weights and led to a fall in the total regulatory capital ratio (see Figure 2).

Figure 4: Aggregated Difference between Total Regulatory and Target Capital Ratios ("Unintentional Capital Surplus"; %)



Note: Vertical lines – switches to the internal ratings-based approach (five banks/bank groups in four waves). "IRB banks" – banks using the IRB approach for at least some portion of their exposures as of 2016 Q4; "STA banks" – banks using solely the STA approach as of 2016 Q4.

5.2 Impact of Higher Additional Capital Requirements

Table 3 shows the estimation results of equations (6)–(10) for banks with the variation in the overall capital requirements stemming from capital buffers and Pillar 2 capital add-ons (seven banks, 77% of the Czech banking sector's total assets as of 2016 Q4).[16] The main effect of interest is captured by the estimates of the coefficient on the overall capital requirements; the remaining coefficients are in line with the theory and intuition presented and discussed in sections 3 and 5.1 and thus will not be discussed again in this section.

The impact of an increase in the additional capital requirements on the intentional capital surplus is negative and statistically significant, indicating that banks use part of their capital surplus to cover the increase in the regulatory requirements. Specifically, a 1 pp increase in the overall capital requirements shrinks the surplus by 0.8 pp; the short-run and long-run effects are similar, with a low and statistically insignificant estimated autocorrelation coefficient.[17] Since the response is less

[16] The overall capital requirements consist of the Pillar 1 capital requirement, additional Pillar 2 capital requirements and capital buffers. For more details on capital buffers in the Czech Republic, see the introduction to this paper and Czech National Bank (2017).
[17] The long-run effect is calculated as $\beta/(1-\alpha)$, where β is the coefficient on the overall capital requirements (the short-term response) and α is the autoregressive coefficient.

than one-to-one, the capital target is revised upwards by 0.2 pp on average (column 2). Similarly, the actual regulatory capital ratio increases by 0.1 pp (column 1), presumably due to the small gap between the ratio and the desired target (see Figure 3); given a small unintentional capital surplus (an excess of capital above the target), banks also have to shift the total regulatory capital ratio upwards when they revise the target itself. The long-run response of the total capital ratio is significantly higher – 0.6 pp – reflecting the high autocorrelation coefficient.

Table 3: Estimation Results – Impact of Additional Higher Capital Requirements

Dependent variable:	CAR (1)	ICS (2)	CA (3)	ICSnrw (4)	RW (5)
Dependent variable (t-1)	0.839***	0.061	0.682***	0.044	0.603***
	(0.035)	(0.057)	(0.066)	(0.062)	(0.088)
Overall capital requirements (t-1)	0.096***	-0.762***	0.079***	-0.394***	-0.550**
	(0.025)	(0.063)	(0.022)	(0.065)	(0.219)
ROA (t-1)	0.132	1.052***	-0.0751	1.170***	-0.277
	(0.188)	(0.264)	(0.116)	(0.209)	(0.600)
Log(assets) (t-1)	0.154	-0.997**	-0.102	-0.614	-2.005
	(0.343)	(0.412)	(0.197)	(0.423)	(2.958)
Loan loss provisions/assets (t-1)	0.104	-0.152	0.336**	-0.052	-3.249**
	(0.187)	(0.313)	(0.136)	(0.212)	(1.349)
Mortgage loans/assets (t-1)	0.017	0.168***	0.014	0.062	0.064
	(0.031)	(0.044)	(0.029)	(0.045)	(0.157)
Other retail loans/assets (t-1)	-0.078**	-0.256***	-0.119*	-0.107	0.685**
	(0.038)	(0.082)	(0.067)	(0.065)	(0.285)
Corporate loans/assets (t-1)	0.016	-0.029	-0.028	-0.005	0.126
	(0.024)	(0.024)	(0.030)	(0.023)	(0.108)
IRB	0.370	3.453***	0.489	2.130***	-2.657*
	(0.253)	(0.340)	(0.376)	(0.432)	(1.530)
VIX	0.000	-0.071***	-0.005	-0.047***	0.000
	(0.009)	(0.007)	(0.005)	(0.009)	(0.040)
Crisis	0.175	-1.185***	0.180	-0.782***	-1.587
	(0.259)	(0.191)	(0.256)	(0.193)	(1.845)
Real GDP growth	-0.014	-0.214***	-0.011	-0.140***	0.036
	(0.024)	(0.024)	(0.030)	(0.027)	(0.165)
CA					1.737***
					(0.541)
RW			0.071***	0.037*	
			0.021)	(0.019)	
Observations	363	363	363	363	363

Note: This table presents the bootstrap corrected dynamic fixed-effect regression (De Vos et al., 2015) estimates of equations (6)–(10). The wild bootstrap suggested by Liu (1988) and Mammen (1993) is used to deal with general heteroscedasticity using the *xtbcfe* Stata routine. For each model, 300 iterations are produced and 250 are used for the final inference. The sample period is from 2002 Q4 to 2016 Q4 and covers seven banks, with some variation in the overall capital requirements stemming from Pillar 2 add-ons and capital buffers. Bootstrapped standard errors are reported in parentheses; ***, ** and * denote the 1%, 5% and 10% significance levels. Fixed effects are not reported. CAR – total regulatory capital ratio, i.e. regulatory capital over risk-weighted exposures; ICS – intentional capital surplus/shortfall calculated as difference between target capital ratio and overall capital requirement; CA – regulatory capital over total assets; ICSnrw – non-risk-weighted intentional capital surplus/shortfall, i.e. intentional capital surplus/shortfall over total assets; CA – regulatory capital over total assets; RW – implicit risk weights calculated as risk-weighted exposures over total assets.

To give some guide to the contribution of changes in risk weights and capital, the model is re-estimated separately with the numerator and the denominator of the dependent variables, each of them as a share of total assets (columns 3–5). It is apparent that higher additional capital requirements have a strong negative and significant effect on banks' risk weights: a 1 pp increase translates on average to a 0.6 pp short-run decrease and a 1.4 pp long-run decrease in risk weights. The impact on the *non-risk-weighted* capital surplus is of the same direction as the impact on its risk-weighted peer, but the strength shrinks to roughly 50%. Specifically, 1 pp higher overall capital requirements lead to a 0.4 pp decrease in the non-risk-weighted intentional capital surplus (compared to a 0.8 pp decrease in the baseline). Similarly, the long-run response of the total *non-risk-weighted* capital ratio shrinks to less than a half of its original strength – from 0.6 pp to 0.25 pp.

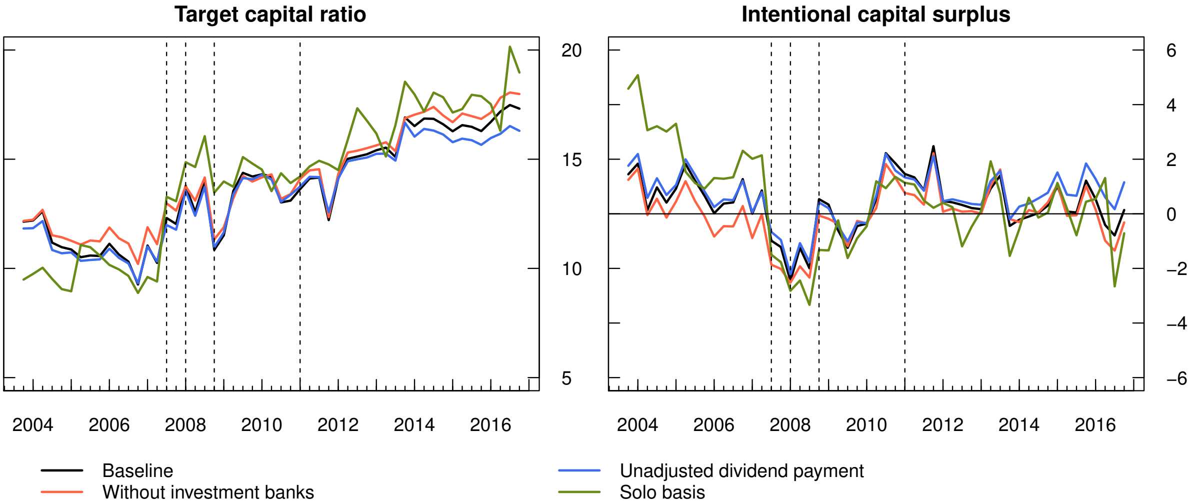
The presented findings have important implications for bank capital regulation. When setting additional capital requirements, it is important to bear in mind that the pass-through to the total regulatory capital ratio may be incomplete and that some portion of the change may be delivered through changes in average risk weights. Banks may adjust risk weights through a combination of changes in asset structure and risk estimates (under the IRB approach). Each of the two options has a totally different interpretation and different implications for the prudential authority. The former would imply that the bank actually shifts the portfolio to less risky assets, i.e. it optimizes the portfolio risk with respect to its capital (Flannery and Rangan, 2008). The latter would imply that the bank starts to see the same asset as less risky immediately after the increase in the additional capital requirements. This could be attributed to strategic risk-modelling by banks (Mariathasan and Merrouche, 2014, see section 4). For this and other reasons, it is desirable to regularly assess whether the evolution and current level of risk weights give rise to any risk of underestimating the necessary level of capital. Nevertheless, the former option seems to have been more prominent in recent years, as many international banks seem to have increased their regulatory capital ratios by reducing their risk-weighted exposures in response to the post-crisis regulatory pressures, i.e. they have shifted from assets with higher risk weights (for example, loans) to assets with lower risk weights (for example, government securities). It is beyond the scope of this paper to distinguish between these two effects, but it is important to bear in mind these different possible transmission channels.

5.3 Robustness Analysis

This section presents a robustness analysis of the baseline results with respect to the inclusion of investment banks, adjustment of dividend payments and consolidation; the underlying reasons for the proposed baseline specification and the need to test it against these alternatives are discussed in section 4. Figure 5 shows the capital targets estimated under the different specifications. The general dynamics remain very similar under all the alternatives; the most noticeable difference stems from the use of data on a solo basis. Even in this case, the trend (the estimated target rising over time) and the general patterns (periods of negative and positive intentional capital surpluses) remain very similar.

Table 4 compares the impact of additional capital requirements under different model specifications. For the sake of brevity, only the effect of interest is reported (i.e. the estimated coefficients on the regulatory requirement variable); the entire estimation results are presented in the appendix. Again, the results remain robust and comparable with the baseline. The only noticeable difference is a weaker negative impact of an increase in the additional capital requirements on risk weights using the sample excluding investment banks (column 5, row 2).

Figure 5: Target Capital Ratio – Robustness Analysis (%)



Note: See the note under Figure 3.

Table 4: Impact of Additional Capital Requirements – Robustness Analysis

Dependent variable:	CAR	ICS	CA	ICSnrw	RW
	(1)	(2)	(3)	(4)	(5)
Baseline	0.096***	-0.762***	0.079***	-0.394***	-0.550**
	(0.025)	(0.063)	(0.022)	(0.065)	(0.219)
Without investment banks	0.099***	-0.709***	0.058***	-0.313***	-0.266*
	(0.032)	(0.072)	(0.016)	(0.047)	(0.140)
Unadjusted dividend payment	0.096***	-0.783***	0.079***	-0.398***	-0.550**
	(0.025)	(0.053)	(0.022)	(0.071)	(0.219)
Solo basis	0.125***	-0.863***	0.104***	-0.451***	-0.545**
	(0.034)	(0.039)	(0.030)	(0.078)	(0.235)

Note: See the note under Table 3.

6. Conclusions

This paper documents the evolution of the total regulatory capital ratio of banks relative to the overall capital requirements in the Czech banking sector and discusses the importance of maintaining a capital surplus for the transmission of capital regulation. Banks may build up a capital surplus intentionally, for example in order to match a planned future asset expansion or change in asset structure or an expected increase in the additional capital requirements, or they may simply accumulate high earnings and achieve excess capital unintentionally. The paper has two main objectives: (i) to estimate individual bank-specific capital targets and distinguish between intentionally and unintentionally formed capital surpluses, and (ii) to analyse the impact of additional capital requirements stemming from capital buffers and Pillar 2 add-ons on banks' intentional capital surplus and total regulatory capital ratio.

The results from the first part of the analysis indicate that domestic banks cannot be regarded as either active or passive managers of their capital. While the overall speed of adjustment seems to be rather high and above the average values reported in the literature, the contribution of the adjustment in the level of capital is one-half, which is a below-average value. In other words, a substantial portion of this adjustment can be attributed to changes in risk-weighted exposures. The second part of the analysis provides evidence that banks shrink their capital surplus in response to an increase in the additional capital requirements. Along with that, banks slightly revise both the target and the total regulatory capital ratio. A substantial portion of the change seems to be delivered through changes in risk weights.

The presented exercise shows that the maintenance of capital surpluses and the underlying motives for this behaviour have important implications for prudential policy based on setting additional capital requirements. Without understanding the evolution and structure of banks' capital relative to the capital requirements, it is not possible to credibly predict the effect of regulatory changes.

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Appendix

Figure A1: Variables (1)

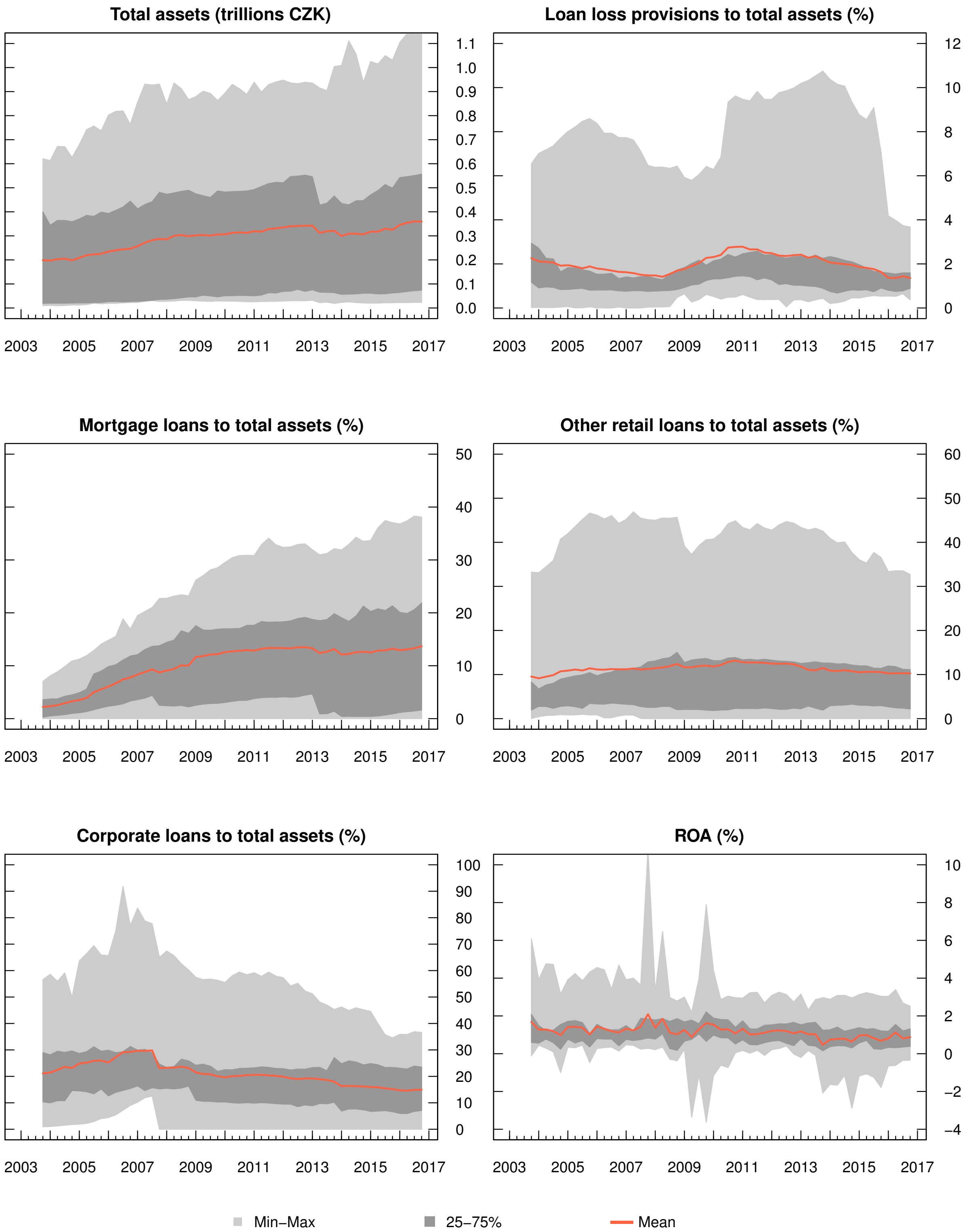

Figure A2: Variables (2)

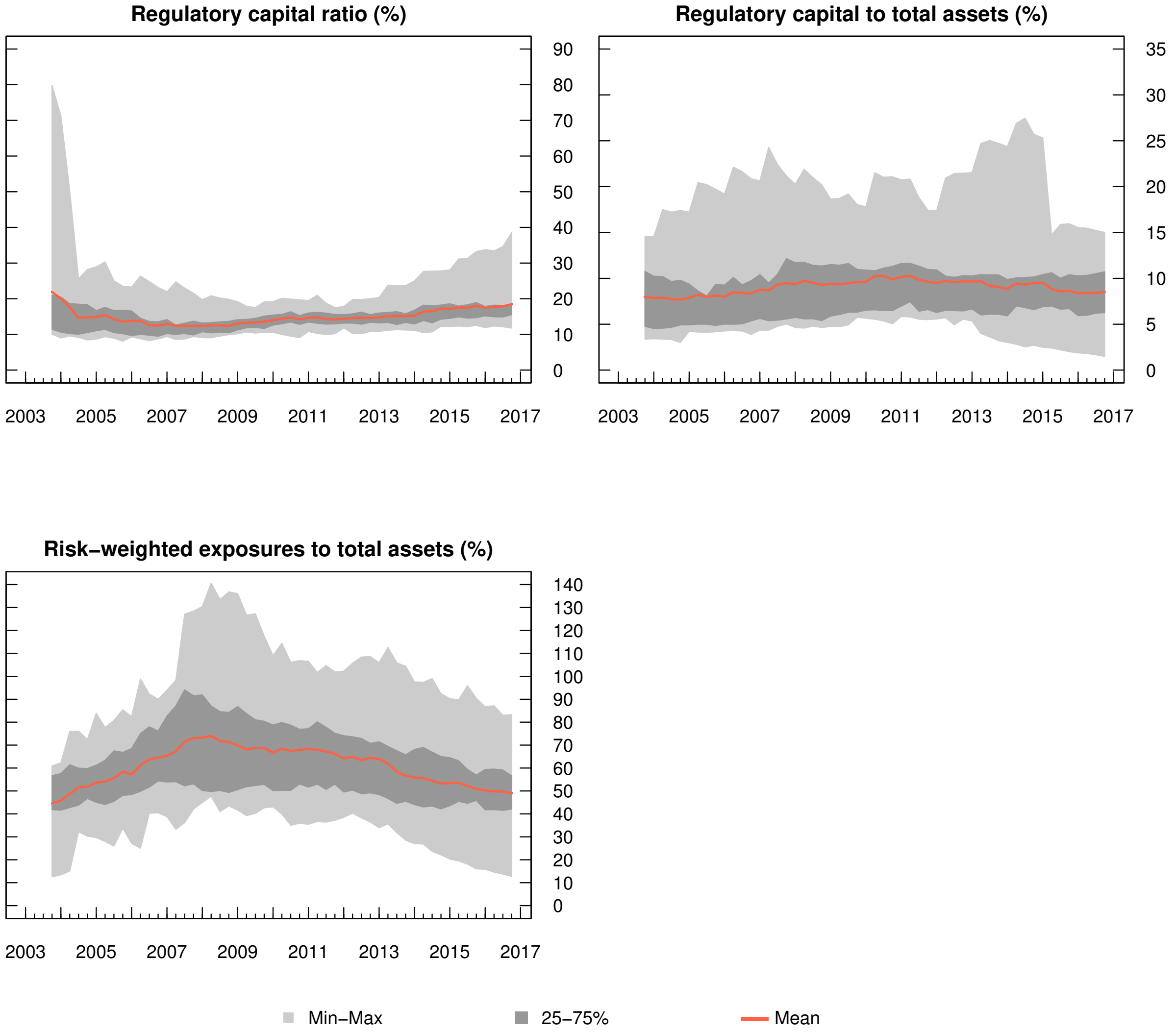

Table A1: Impact of Additional Capital Requirements – Robustness Analysis Without Investment Banks

Dependent variable:	CAR (1)	ICS (2)	CA (3)	ICSnrw (4)	RW (5)
Dependent variable (t-1)	0.834*** (0.046)	0.098 (0.078)	0.794*** (0.056)	0.224*** (0.067)	0.710*** (0.093)
Overall capital requirements (t-1)	0.099*** (0.032)	-0.709*** (0.072)	0.058*** (0.016)	-0.313*** (0.047)	-0.266* (0.140)
ROA (t-1)	0.352 (0.236)	1.343*** (0.176)	0.084 (0.140)	0.619*** (0.113)	-0.425 (1.163)
Log(assets) (t-1)	-0.178 (0.535)	1.273** (0.636)	-0.240 (0.311)	0.984** (0.488)	1.347 (3.473)
Loan loss provisions/assets (t-1)	0.269 (0.205)	-0.131 (0.364)	0.262** (0.125)	-0.116 (0.255)	-1.712** (0.691)
Mortgage loans/assets (t-1)	0.024 (0.044)	0.053 (0.046)	0.009 (0.024)	-0.001 (0.045)	-0.038 (0.154)
Other retail loans/assets (t-1)	-0.057 (0.044)	-0.125 (0.092)	-0.053* (0.028)	-0.033 (0.083)	0.302 (0.211)
Corporate loans/assets (t-1)	0.008 (0.025)	-0.007 (0.029)	-0.012 (0.022)	0.035 (0.034)	0.161 (0.133)
IRB	0.298 (0.293)	2.826*** (0.281)	0.217 (0.156)	1.304*** (0.370)	-2.137 (1.577)
VIX	0.002 (0.010)	-0.076*** (0.008)	-0.002 (0.005)	-0.044*** (0.008)	-0.022 (0.044)
Crisis	-0.044 (0.267)	-0.795*** (0.233)	0.006 (0.164)	-0.365*** (0.112)	0.364 (0.375)
Real GDP growth	-0.042*** (0.013)	-0.157*** (0.028)	-0.030*** (0.009)	-0.071*** (0.016)	0.149*** (0.052)
CA					0.718*** (0.269)
RW			0.041*** (0.010)	0.008 (0.019)	
Observations	311	311	311	311	311

Note: This table presents the bootstrap corrected dynamic fixed-effect regression (De Vos et al., 2015) estimates of equations (6)–(10). The wild bootstrap suggested by Liu (1988) and Mammen (1993) is used to deal with general heteroscedasticity using the *xtbcfe* Stata routine. For each model, 300 iterations are produced and 250 are used for the final inference. The sample period is from 2002 Q4 to 2016 Q4 and covers seven banks, with some variation in the overall capital requirements stemming from Pillar 2 add-ons and capital buffers. Bootstrapped standard errors reported in parentheses; ***, ** and * denote the 1%, 5% and 10% significance levels. Fixed effects are not reported. CAR – total regulatory capital ratio, i.e. regulatory capital over risk-weighted exposures; ICS – intentional capital surplus/shortfall calculated as difference between target capital ratio and overall capital requirement; CA – regulatory capital over total assets; ICSnrw – non-risk-weighted intentional capital surplus/shortfall, i.e. intentional capital surplus/shortfall over total assets; CA – regulatory capital over total assets; RW – implicit risk weights calculated as risk-weighted exposures over total assets.

Table A2: Impact of Additional Capital Requirements – Robustness Analysis With Unadjusted Dividend Payment

Dependent variable:	CAR (1)	ICS (2)	CA (3)	ICSnrw (4)	RW (5)
Dependent variable (t-1)	0.839*** (0.035)	0.041 (0.052)	0.682*** (0.066)	0.014 (0.070)	0.603*** (0.088)
Overall capital requirements (t-1)	0.096*** (0.025)	-0.783*** (0.053)	0.079*** (0.022)	-0.398*** (0.071)	-0.550** (0.219)
ROA (t-1)	0.132 (0.188)	1.250*** (0.222)	-0.0751 (0.116)	1.384*** (0.291)	-0.277 (0.600)
Log(assets) (t-1)	0.154 (0.343)	-1.186*** (0.352)	-0.102 (0.197)	-0.854* (0.442)	-2.005 (2.958)
Loan loss provisions/assets (t-1)	0.104 (0.187)	0.379 (0.276)	0.336** (0.136)	0.319* (0.192)	-3.249** (1.349)
Mortgage loans/assets (t-1)	0.017 (0.031)	0.186*** (0.037)	0.014 (0.029)	0.077* (0.045)	0.064 (0.157)
Other retail loans/assets (t-1)	-0.078** (0.038)	-0.097 (0.072)	-0.119* (0.067)	-0.010 (0.061)	0.685** (0.285)
Corporate loans/assets (t-1)	0.016 (0.024)	-0.041** (0.019)	-0.028 (0.030)	-0.014 (0.024)	0.126 (0.108)
IRB	0.370 (0.253)	2.764*** (0.335)	0.489 (0.376)	1.686*** (0.422)	-2.657* (1.530)
VIX	0.000 (0.009)	-0.059*** (0.005)	-0.005 (0.005)	-0.038*** (0.008)	0.001 (0.040)
Crisis	0.175 (0.259)	-1.080*** (0.168)	0.180 (0.256)	-0.750*** (0.222)	-1.587 (1.845)
Real GDP growth	-0.014 (0.024)	-0.202*** (0.020)	-0.011 (0.030)	-0.135*** (0.027)	0.036 (0.165)
CA					1.737*** (0.541)
RW			0.071*** (0.021)	0.039** (0.019)	
Observations	363	363	363	363	363

Note: This table presents the bootstrap corrected dynamic fixed-effect regression (De Vos et al., 2015) estimates of equations (6)–(10). The wild bootstrap suggested by Liu (1988) and Mammen (1993) is used to deal with general heteroscedasticity using the *xtbcfe* Stata routine. For each model, 300 iterations are produced and 250 are used for the final inference. The sample period is from 2002 Q4 to 2016 Q4 and covers seven banks, with some variation in the overall capital requirements stemming from Pillar 2 add-ons and capital buffers. Bootstrapped standard errors reported in parentheses; ***, ** and * denote the 1%, 5% and 10% significance levels. Fixed effects are not reported. CAR – total regulatory capital ratio, i.e. regulatory capital over risk-weighted exposures; ICS – intentional capital surplus/shortfall calculated as difference between target capital ratio and overall capital requirement; CA – regulatory capital over total assets; ICSnrw – non-risk-weighted intentional capital surplus/shortfall, i.e. intentional capital surplus/shortfall over total assets; CA – regulatory capital over total assets; RW – implicit risk weights calculated as risk-weighted exposures over total assets.

Table A3: Impact of Additional Capital Requirements – Robustness Analysis Using Data on Solo Basis

Dependent variable:	CAR	ICS	CA	ICSnrw	RW
	(1)	(2)	(3)	(4)	(5)
Dependent variable (t-1)	0.839***	0.033	0.771***	0.125***	0.728***
	(0.052)	(0.027)	(0.057)	(0.044)	(0.114)
Overall capital requirements (t-1)	0.125***	-0.863***	0.104***	-0.451***	-0.545**
	(0.034)	(0.039)	(0.030)	(0.078)	(0.235)
ROA (t-1)	0.250	4.873***	0.161**	2.864***	-0.190
	(0.189)	(0.126)	(0.0670)	(0.329)	(0.882)
Log(assets) (t-1)	0.739	1.689***	0.353	0.942	-3.355
	(0.456)	(0.411)	(0.237)	(0.611)	(3.431)
Loan loss provisions/assets (t-1)	0.285*	0.375***	0.332***	0.354**	-2.663**
	(0.166)	(0.132)	(0.103)	(0.141)	(1.171)
Mortgage loans/assets (t-1)	-0.030	-0.038	-0.022	-0.015	0.079
	(0.033)	(0.033)	(0.019)	(0.042)	(0.151)
Other retail loans/assets (t-1)	-0.020	-0.051	-0.060*	-0.146*	0.453
	(0.048)	(0.077)	(0.036)	(0.078)	(0.302)
Corporate loans/assets (t-1)	0.023	-0.062***	-0.009	-0.043	-0.047
	(0.016)	(0.017)	(0.031)	(0.026)	(0.156)
IRB	0.351	6.476***	0.261	3.740***	-2.310
	(0.331)	(0.273)	(0.217)	(0.561)	(1.626)
VIX	-0.003	0.005	-0.005	0.004	0.022
	(0.008)	(0.004)	(0.004)	(0.004)	(0.046)
Crisis	-0.235	-2.452***	-0.118	-1.418***	0.854
	(0.187)	(0.121)	(0.141)	(0.113)	(0.704)
Real GDP growth	-0.045***	-0.248***	-0.041**	-0.133***	0.169*
	(0.014)	(0.009)	(0.016)	(0.012)	(0.096)
CA					1.437**
					(0.567)
RW			0.039***	0.029***	
			(0.012)	(0.011)	
Observations	364	364	364	364	364

Note: This table presents the bootstrap corrected dynamic fixed-effect regression (De Vos et al., 2015) estimates of equations (6)–(10). The wild bootstrap suggested by Liu (1988) and Mammen (1993) is used to deal with general heteroscedasticity using the *xtbcfe* Stata routine. For each model, 300 iterations are produced and 250 are used for the final inference. The sample period goes from 2002 Q4 to 2016 Q4 and covers seven banks, with some variation in the overall capital requirements stemming from Pillar 2 add-ons and capital buffers. Bootstrapped standard errors reported in parentheses; ***, ** and * denote the 1%, 5% and 10% significance levels. Fixed effects are not reported. CAR – total regulatory capital ratio, i.e. regulatory capital over risk-weighted exposures; ICS – intentional capital surplus/shortfall calculated as difference between target capital ratio and overall capital requirement; CA – regulatory capital over total assets; ICSnrw – non-risk-weighted intentional capital surplus/shortfall, i.e. intentional capital surplus/shortfall over total assets; CA – regulatory capital over total assets; RW – implicit risk weights calculated as risk-weighted exposures over total assets.

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