# European Bank Capital Management in Response to Regulatory Requirements

## Master Thesis I:

Voluntary Capital Safety Buffers: How European Banks Behave in Response to Regulatory Requirements?

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# MASTER THESIS I

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# Voluntary Capital Safety Buffers: How European Banks Behave in Response to Regulatory Requirements?

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## Abstract

This thesis examines the association between regulatory capital requirements and the management buffers of European banks. The management buffers are the surplus capital buffers, which banks hold on top of the capital levels required by regulators. I examine unbalanced semi-annual multi-country panel data of 57 European banks during the period from 2016-2020. I collect public information on bank-specific capital requirements to assess their role in setting management buffers. I show that higher capital requirements are associated with lower management buffers, but the sensitivity is less than one to one. Moreover, the sensitivity is particularly low (yet significant) if fully loaded capital requirements are taken into consideration rather than the phase-in requirements. Overall, it appears that banks tend to adjust capital ratio levels in response to changes in applicable formal capital requirements, but only slightly reduce management buffers, thus keeping them relatively stable. However, banks tend to hold additional buffers to cover expected long-term requirements e.g., requirements applicable after phase-in periods.

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# 1. Introduction

This thesis is an empirical study on the determinants of European bank surplus capital buffers, also known as the management buffers, which banks hold top of the capital levels required by regulators. The conventional view would be that in the presence of government safety nets, e.g. deposit insurance schemes, profit-seeking banks would leverage as much as possible and operate close to the minimum required capital ratios (Flannery & Rangan, 2002). European banks have significantly raised their capital ratios since the global financial crisis and on average hold substantial surplus capital buffers of 5.3 pp above above the levels that trigger regulatory restrictions (Melis & Weissenberg, 2019). The observed surplus buffers are not formally required by the regulators, which raises the question of what explains the size and changes of these discretionary management buffers and are they indeed unrelated to capital requirements or expectations of future capital requirements. In this study, I focus on the role of the capital requirements themselves as determinants of the size of the management buffers after controlling for factors mentioned previously in the literature on bank capital. I provide empirical evidence that higher capital requirements are associated with lower management buffers, but the sensitivity is less than one-to-one. This result is in line with expectation assuming banks are constrained in ability to adjust their capital ratio, which is generally adjusted through new equity, reduction of risk exposures or through “on paper” discretionary regulatory capital calculation adjustments (Gropp et al., 2021). The result might also be driven by the fact that banks expect increases in capital requirements in advance thus, by definition, the surplus capital buffer decreases when requirements are formally adopted. In fact, the management buffers appear relatively insensitive after considering capital requirements on fully loaded basis, i.e. assuming banks do not use regulatory transition periods.

Understanding the drivers behind voluntary surplus buffers could shed a light on the effectiveness of the regulatory capital buffer policies such as the capital buffer requirement releases in periods of recession or uncertainty e.g. the Covid-19 crisis macro- and micro-prudential policy response. My results show that regulators should consider that banks will tend to keep management buffers relatively constant and consequently plan their lending activities accordingly. Drivers behind the discretionary buffers could complement the analysis on how regulatory reforms such as the finalization of the Basel

III affect bank capital ratios beyond the effects shown in the traditional capital shortfall impact studies. The distance to regulatory restrictions such as distribution restrictions also matter for the market participants as this is one of the key indicators that plays a role in the valuation of bank-issued equity and debt instruments.

This paper aims to contribute to the existing literature that aims to evaluate the effects of the new regulatory framework in the EU that was introduced after the global financial crisis. Specifically, I focus on bank management buffers rather than the levels of capital ratios. While there have been studies on the buffers before, they mostly cover pre-crisis period and focus on banks within the same jurisdiction (e.g. Ayuso et al., 2004; Lindquist, 2004; Pereira & Saito, 2011). I examine unbalanced semi-annual multi-country panel data of 57 banks during the period from 2016-2020. I collect public information on bank-specific capital requirements to assess their role in setting management buffers. I compliment the work of Lubberink (2020) by employing the partial adjustment framework and the generalized method of moments (GMM) to account for the potential endogeneity and simultaneity biases (Arellano & Bond, 1991; Blundell & Bond, 1998; Roodman, 2009). I test for the relevance of the Pillar 2 requirements and combined buffer requirement relevance for the management buffers of the banks. I also test if proxies for the bank's risk play a role in the management buffer size given that they should be covered by the capital requirements, while controlling for business cycle, market pressure and other factors.

My results show empirical evidence that higher capital requirement is associated with lower management buffers, but the sensitivity is less than one to one. A 1 percentage point increase in total capital requirement is linked to a lower management buffer by 14 basis points in the next six months and in a total of 45 basis points in the longer run. And on a flip side, I find evidence that capital ratios increase accordingly as a response to a capital requirement increase. However, the impact on the management buffer could be as low as 12 – 18 basis points as shown by a robustness check with a crude assumption that all banks planned their capital on a fully loaded capital requirement basis that was a feature peculiar to the sample period. The true effect is somewhere in between since not all banks planned capital on a fully loaded basis during the sample period. Overall, it appears that banks tend to hold management buffers relatively stable in response to additional capital requirements. This contrasts the findings by Lubberink (2020) who associates additional capital requirements to lower discretionary buffers. Other important determinants of management buffer are bank size, growth of loans and associated risks proxied by density and z-score. I also find that shocks to a management buffer seem to materialize faster in European banks compared to studies on previous periods and countries.

The reminder of the thesis is organised as follows: section 2 describes a brief background in the regulatory framework in the European banking sector and reviews the literature on optimal levels of capital, bank behaviour in response to capital requirements. The last part of the literature reviews focuses specifically on previous studies of management buffers. Section 3 is lays out the methodological framework, i.e., the partial adjustment model, and the main empirical model. Section 4 provides a high-level description of data collection and stylised facts regarding data. Section 5 is devoted to empirical results of the main model of the management buffers. It also looks at analogous model for capital ratio levels and alternative panel data models for robustness check purposes. Lastly, section 6 contains concluding remarks.

## 2. Literature review

Given the importance of banks in the functioning of the financial sector and the real economy, the intended and unintended consequences of the bank capital requirements have been high on the research agenda for many academics and institutions. Many researchers at central banks and other regulatory have been working on this topic due to their policy mandates and their exclusive access to non-public data sources. However, over the last decade, the culture of transparency in the EU has enabled the public to access elements of supervisory data in quite harmonised format that enables empirical research on comparable supervisory data. One example of such a shift to transparency is the EBA's EU-wide transparency exercise in which detailed bank-level supervisory data is published since 2015.

This section is devoted to the introduction of the bank capital framework in the EU that is followed by a discussion of the main contributions of studies in the bank regulatory capital policy and management area.

## 2.1. *Overview of the bank regulatory capital requirement framework in the EU*

The purpose of this section is not to describe the history of the Basel Accords for banking regulation, but provide some key information on the bank capital requirement framework in the EU, which helps to navigate through the rather complex and technical jargon.

The main legislative acts that set basis for the capital regulation in the EU are the Capital Requirements Regulation (CRR) and the Capital Requirements Directive (CRD), which are periodically updated, especially when new banking regulatory and supervisory standards are agreed by the Basel Committee of Banking Supervision (BCBS) and must be implemented in the EU. In fact, the proposal by the European Commission regarding the next major update is expected in 2021, which will set out rules that finalise the Basel III implementation in the European Union.

In 2014, the CRR/CRD IV came into force that among other things set out the timeline of new capital requirements stack that was gradually phased-in from 2016 to 2019 (Directive 2013/36; Regulation 575/2013). A stylised capital requirement stack is depicted in Figure 1. The main components of the total capital requirement (TCR) are the minimum requirement (i.e. the Pillar 1 requirement – P1R), combined buffer requirement and bank-specific capital measures (i.e. the Pillar 2 requirement – P2R). These requirements are typically expressed in percentage terms of the risk-weighted assets (RWA) of a bank even though some elements are calculated in nominal terms. Banks are expected to hold regulatory capital above the levels set by all the mentioned elements. However, the consequences of the breach vary. Breaches of some requirements lead to restrictions on distribution policies while others can lead to withdrawal of banking licence. The CRR also defines regulatory capital, which differs from the accounting definition used in financial statements: Common Equity Tier 1 (CET1), Additional Tier 1 (AT1) and Tier 2 (T2) capital. Some of the capital requirements do not necessarily have to bet with the core bank capital, i.e. CET1, thus there is flexibility for banks in terms of capital composition. Some capital requirement shortfalls can bet met with hybrid instruments that fall under the definitions of Additional Tier 1 and Tier 2 instruments.

The Pillar 1 requirement of 8% (Total capital/RWA) consist of minimum CET1 requirement (CET1/RWA) of 4.5%, AT1 capital requirement of additional 1.5% (Tier 1 capital/RWA must be at least 6%) and T2 capital requirement of additional 2%. Any AT1/T2 capital shortfall must be met with CET1 capital.

The combined buffer requirement consists of complex interaction of various buffer requirements — the countercyclical buffer (CCyB), the capital conservation buffer (CCB) and the maximum of the systemic risk buffer (SRB), the other systemically important institution (O-SII) buffer or the globally systemically important institution (G-SIB) buffer. Except for the CCB, the rest of the buffers cover different types of systemic risks. The CCyB that under normal circumstances can be from 0% to 2.5% is supposed to address the cyclical nature of banking business. The idea is that macroprudential authorities would set CCyB higher in "good times" to force banks to accumulate extra capital in the boom period of the financial cycle that can be used in recessions when authorities would set CCyB lower. The SRB, O-SII and G-SIB buffers that can be set 0-3%, 0-2% and 0-3.5% respectively are intended to address a structural systemic importance of an institution in the financial system. The CCB is 2.5% and meant to be as a safety buffer above the sum of minimum capital requirements, Pillar 1 and Pillar 2 requirements. All the buffer requirements had phase-in period from 2016 to 2019 and national macroprudential authorities have the discretion to set them to the levels they see fit.

Pillar 2 measures are to address bank-specific risks that are no covered by the P1R. The P2R (sometimes called as the SREP capital requirement, especially prior 2016) is communicated to the banks by the corresponding supervisor (the ECB for institutions under its direct supervision within the Single Supervisory Mechanism (SSM); and national competent authorities (NCAs) for other banks in the Banking Union and the EU). Before 2016 in some EU jurisdictions, the P2R was communicated not as a separate requirement but rather than the overall SREP capital requirement. Some banks have been reluctant to publicly disclose the P2R because of the perceived market sensitivity of such information (Magnus & De Biase, 2020). In 2016, the ECB, inspired by the regulatory approach in the United Kingdom, introduced Pillar 2 Guidance (P2G) that is a "soft requirement" on top of the total capital ratio and is based on bank-specific stress test results. It is considered as a soft requirement because it does not automatically lead to supervisory measures if breached by a bank and does not come into consideration in the calculation of the maximum distributable amount (MDA) restriction trigger level. The MDA is the amount a bank is legally allowed to distribute in dividends, share-buybacks, variable remuneration without supervisory action.

While the CRR2/CRDV changes some of the aspects in the capital requirement stack (Directive 2019/3878; Regulation 876/2019), for instance, additivity rule of the SRB and O-SII/G-SIB buffers, they have be adopted relatively recently and play a limited role in the 2020 capital requirement stack thus are not further discussed here. The bank management buffer can be defined as the capital in excess of the capital requirements, however, an operational definition for the purposes of this paper is introduced later in the paper.

While the overall capital regulation framework is the same in all the EU (the UK still effectively followed the same framework despite Brexit in the sample period of this study), there are various different competent authorities that are delegated with the responsibility of setting the capital requirements for banks. Broadly speaking, the mandates of the competent authorities differ by jurisdiction, the systemic significance of banks and the purpose of the capital requirement. For instance, the ECB is setting the P2R and P2G for all the significant institutions within the banking union that fall under the SSM, while the national competent authorities are responsible for the non-banking union banks as well as less systemically important institutions. The responsibility of setting systemic buffers falls under the remit of national macroprudential authorities. Therefore, the variation of capital requirements can come from country-specific effects and bank-specific effects. However, the overall CCyB requirement for a bank is the combination of its exposures that are subject to the CCyB requirement. E.g. even if a bank has a 0% capital requirement for domestic exposures that does not mean that its international exposure does not have such a requirement either. Since the capital regulations are phased-in over time, there is a common variation of capital requirements (e.g. so-called "Danish compromise").

### *2.2. Consequences of bank regulatory capital requirements*

A lot of the discussion in the literature is around the optimal levels of bank capital. Studies on the optimal level of capital ratios emerged especially after the 2008 global financial crisis when the calibration of the Basel III standard was high on policymaker agenda. Studies of optimal capital levels differ by the model assumptions but essentially follow the same idea that the long-term optimal level of bank capital should balance marginal macroeconomic costs and benefits. The range of the suggested optimal CET1 ratios in these studies is wide, between 10% to 25% (BCBS, 2019). The BCBS (2010) estimates that

10% - 15% is the optimal level that balances benefits such as reduced probability and severity of banking crisis and costs such as increased spreads on lending rates. Other studies (Barth & Miller, 2018; Brooke et al., 2015; Cline, 2017; FED Minneapolis, 2017; Fender & Lewrick, 2016; Firestone et al., 2017; Miles et al., 2013) build on this approach, for example, by changing assumptions regarding pass-through of funding costs on lending rates and estimating the Modigliani-Miller offset. The Modigliani-Miller offset accounts for the effect of higher capital level, thus a lower risk of bank failure, on bank funding costs. While some of the studies (Almenberg et al., 2017; Barth & Miller, 2018; Firestone et al., 2017) find upper estimates of the optimal capital range above 20%, the BCBS (2019) suggest that marginal benefits converge to zero when bank capital ratios reach the level around 12%. However, Admati et al. (2013) advocate for higher capital requirements, up to 20-30% on total assets rather than exposure amount, by challenging the assumptions in many of the previously mentioned optimal capital level studies. Their assumptions overstate the costs of additional bank equity capital and underestimate the benefits. For example, these studies often use the historical average for return on equity, which Admati et al. (2013) argue would decline as the underlying risk in the bank would decline with extra equity.

Begenau (2020) connects studies on macro-finance general equilibrium with studies on bank optimal capital regulation and challenges the idea that higher capital requirements necessarily lead to a decrease in bank lending activity. This is modelled through an endogenous response of equilibrium deposit rates to a change in the supply of deposits as a response to a capital requirement increase. If the overall effect reduces the cost of financing, then the general equilibrium could lead to even higher lending activity. Begenau & Landvoigt (2021) extends the idea further and find that higher capital requirements lead to a safer financial system through a competition effect i.e. a higher equity requirement reduces the value of implicit government subsidies to banks and benefits shadow banking sector – financial institutions apart from banks. Even though the shadow banking sector becomes larger in response to capital requirements, the overall competitive pressure does not create risk-taking incentives for shadow banks.

As already implied by the macro-level studies, more bank capital is not the panacea for all financial stability issues. While the benefits of the Basel III reform cannot be understated, some unintended externalities have been registered as well. For instance, funding costs of banks increase when CET1 ratios reach the level of around 11% due to a convex relationship between the two (Arnould et al., 2020). Dautović (2019) by employing a multi-treatment group difference-in-difference identification strategy estimates that an additional 1pp in capital requirement leads to a 13% increase in the CET1 capital and a 6.1 pp increase in the average risk weight of the bank asset portfolio. An increase in the CET1 capital is desirable as opposed to an improved CET1 ratio through deleveraging (i.e. a reduction of risk-weighted assets in the denominator of the capital ratio) from a macroeconomic perspective. However, the increase of risk-weighted assets suggests that extra capital might incentivise risk-taking by banks. Gropp et al. (2019) exploit a quasi-natural experiment of the 2011 EBA capital exercise to identify the effect of capital requirement increase on the credit supply and density (RWA/Total assets). They find a significant negative effect only to the former.

The inverse relationship between capital requirements and credit supply is not necessarily a negative externality. It is in fact one of the rationales behind the introduction of the CCyB that is intended to address the procyclical nature of the banking business. Several studies (e.g. Aiyar et al., 2014) focus on the macroprudential policy and capital requirement impact on bank balance sheets and lending behavior. However, also micro-prudential capital requirements such as the P2R have an economically meaningful impact on the credit supply (De Jonghe et al., 2020).

Finding difference-in-difference and regression discontinuity designs is not a trivial task. The partial adjustment framework is a common method used in bank decision modeling. De-Ramon et al. (2016) focus on capital ratio target levels and balance sheet adjustments with respect to capital requirements of UK banks. They find a positive relationship between higher capital requirements and capital ratios of banks. In addition, UK bank asset growth decreased by 14 bp in pre-crisis and by 20 bp in the post-crisis period in response to a 1pp increase in capital requirements. The annual risk-weighted asset growth and loan growth declined by 12 and 8 bp respectively. Bakkar et al. (2019) use a similar partial adjustment model of capital ratios to investigate the speed of balance sheet adjustment of sample banks from 28 OECD countries. They find evidence that the speed of adjustment is larger for systemically important institutions. De Jonghe & Öztekin (2015) also focus on the speed of adjustment and find that banks perform quicker capital adjustments in jurisdictions with stricter capital requirements, supervisory scrutiny and developed capital markets.

### *2.3. Bank capital management buffers*

Some of the capital requirement externalities are more noticeable for capital-constrained banks. De Marco & Wieladek (2015) find that small and medium-sized enterprise asset growth and investments decline by 3.5% - 6.9% and 12% in the first year respectively as a response to a 1% rise in capital requirements for UK banks. These effects are more pronounced for banks with tight discretionary capital buffers. Capital-constrained banking groups tend to tame their lending and risk-taking in their cross-border subsidiaries as a response to capital buffer increases (Cappelletti et al., 2020). Thus, it appears that the dynamics of bank excess capital play a role in the overall capital allocation.

Generally, banks in the EU hold buffers well beyond capital requirements and even Pillar 2 guidance levels in 2017 Q3 as reported in the EBA's staff paper. Only five countries had the average bank buffer lower than 3pp yet still positive and the overall average was 5.3pp above the MDA restriction trigger level (Melis & Weissenberg, 2019). This is in contrast to the conventional view that in the presence of government safety nets, for example, deposit insurance schemes, profit-seeking banks would leverage as much as possible and operate close to the minimum required capital ratios. Clearly, this expectation is not supported by neither by empirical evidence, nor by theoretical considerations. Banks in general have market incentives to keep safety buffers and leverage under control (Flannery & Rangan, 2002).

The discussion on bank management buffers and their usability is raised in the ECB's 2020 Macroprudential Bulletin that was issued around the time when the ECB and various national macroprudential authorities made extraordinary steps to lower regulatory capital buffers to support bank lending and loss absorption capacity. Andreeva et al. (2020) and Behn et al. (2020) find that the majority of the sample Euro Area banks did not lower their CET1 ratio targets after the Covid-19 capital relief measures. Authors note that there might be substantial financial market and regulatory pressures that undermine regulatory buffer release measures during a stress episode. Market-based factors are funding-related as the declining capital ratios might increase the perceived probability of default, funding costs and even trigger credit rating downgrades as capital ratios are an important input in the credit rating methodologies. Regulatory and prudential impediments are such as conflict with other binding regulatory requirements (e.g. the leverage ratio requirement), uncertainty about supervisory scrutiny after depleting capital ratios and avoidance of breaching maximum distributable amount (MDA) triggers that limit the flexibility of banks to meet its payout plans, including coupons on AT1 instruments. The ECB in its Financial stability review (ECB, 2021b) provides preliminary analysis that indeed banks with capital levels closer to capital requirements tended to deleverage more during the pandemic in 2020 compared to those banks that had more surplus capital, especially by reducing exposures in corporate segments.

There are some empirical studies on bank management buffers, but surprisingly few. Ayuso et al. (2004) investigate the procyclical nature of the capital buffers for Spanish banks during 1986-2000. Lindquist (2004) looks at capital buffers of Norwegian savings banks and commercial banks during 1995-2001. At the time, only Basel I was implemented. The paper finds that for the commercial banks the buffer capital serves as the safety buffer i.e. insurance against the bank's failure, and that the buffer tends to increase with supervisory intensity, however not with an increase in the credit risk. The study also shows a negative relationship between buffer capital and GDP growth and unspecified credit loss provisions. A similar study on Brazilian banks confirms that supervisory scrutiny increases the management buffers (Pereira & Saito, 2011). In addition, the findings suggest that recapitalization costs, profitability, and earnings volatility matter in the buffer size. Eckley et al., (2019) show that the regulatory uncertainty increases the discretionary capital surpluses as a bank precautionary measure to avoid the breach of capital requirements. A more recent study by Lubberink (2020) on European banks shows that the management buffers are negatively associated with bank risk, the yields on Additional Tier 1 instruments and CoCos are higher when the buffers are low. Also, the price drop during initial Covid-19 shock was larger for banks with low management buffers.

The gap in the literature and my contribution relates to further investigation of capital requirement interaction with bank management buffer targets in the post-global financial crisis bank regulatory environment. Previous studies mainly focus on banks within one country and cover the period before the introduction of the Basel III framework. Cross-country panel provides additional validity to results. In addition, banks are in a quite different position than they were before the financial crisis in terms of levels of capital, regulatory environment and industry dynamics, all of which warrant investigation covering a more recent period. Most capital regulation studies cover periods before the Basel III framework or concentrate on systemic buffers due to their data accessibility, but neglect Pillar 2 capital requirement since that is not easily accessible public data. By employing the partial adjustment framework, I extend the work by Lubberink (2020) and look at how management buffers are affected by total capital requirements as well as individual components.

This study should shed some light on how banks react to capital requirement changes with respect to the size of management buffers. Some effects are mechanical, for example, an increase in capital requirements will immediately decrease the size of a management buffer, because the banks cannot easily adjust their capital ratio level and consequently excess capital levels. However, I expect that the relationship will not be one-to-one. I expect that a 1pp increase in capital requirement will decrease the management buffer by less than 1pp because banks will target a sufficiently high safety buffer from the breach of the requirements. In other words, banks will try to restore management buffers closer to the size before the additional capital requirement. The reasons might be various, including signals to funding markets, risk management policy considerations and other. In fact, some banks even publicly state that they target a specific distance to MDA trigger (Andreeva et al., 2020). On the other hand, banks might be focusing on capital ratio levels or constrained in other ways to adjust capital ratio levels, and thus increase in capital requirement would be fully compensated by a decrease in management buffer without significantly affecting capital levels.

# 3. Methodology

## *3.1. Main model*

My main model is based on the idea of the partial adjustment framework, which is well-established in bank capital structure studies (S. de-Ramon et al., 2016; Eckley et al., 2019; Francis & Osborne, 2010; Pereira & Saito, 2011). The key idea behind the model is that the bank adjusts its current management capital buffer, $MngmBuff_{it}$, to its unobservable target level, $MngmBuff_{it}^{*}$, as given the following equation:

$$MngmBuff_{it} - MngmBuff_{it-1} = \theta(MngmBuff_{it}^{*} - MngmBuff_{it-1}), \tag{1}$$

where $i$ and $t$ are bank and time indices respectively, $\theta$ is an adjustment parameter that reflects the speed of adjustment. If $\theta$ is equal to one, then the bank adjusts its capital buffer in one period. However, if $\theta$ equals zero, then the bank does not make the adjustment all. In this framework, researchers model the target variable as a vector of control variables:

$$MngmBuff_{it}^{*} = \sum_{n=1}^{N} \delta_n X_{n,i,t}, \tag{2}$$

where $X$ is a vector of $N$ explanatory variables and $\delta$ is a vector of parameters. The combination of equations (1) and (2) yields the model of a bank's choice of the management buffer:

$$MngmBuff_{it} = (1-\theta)MngmBuff_{it-1} + \sum_{n=1}^{N} \theta\delta_n X_{n,i,t}. \tag{3}$$

The equation (3) is the basis of my estimation and hypothesis tests.

### *3.2. Explanatory and control variables*

To account for possible factors affecting a bank's capital buffer decisions, I include some variables that have been found meaningful in previous studies. The first one was already introduced in the main model description, i.e. the coefficient $(1-\theta)$ on the lagged management buffer variable, which represents the adjustment cost. Since typically it is costly for banks to adjust their capital ratios quickly, then the sign is expected to be positive. The implied adjustment parameter $\theta$ is in turn expected to be between 0 and 1.

The cost of funding is proxied by return on equity (*ROE*). The expected sign on ROE is negative because a bank is unlikely to hold high levels of discretionary capital if the cost of capital is high (Ayuso et al., 2004). However, there is also an argument for the opposite case which relates to the pecking order theory and the fact that banks might be using earnings to build capital buffers (Pereira & Saito, 2011). Raising equity through public offering might be perceived as a negative signal to the market. Therefore, the discretionary capital buffer is likely to be built by retained earnings or by cutting lending. Thus, the coefficients are likely to be positive for retained earnings and negative for the loan growth variable - *LoanG* (Ayuso et al., 2004; Eckley et al., 2019).

Capital requirements might affect the management buffers as well as suggested by Lubberink (2020), therefore I include the P2R and the combined requirement (*CBR*) that excludes the Pillar 2 guidance component. I expect negative signs on the coefficients because due to the scarcity and the cost of bank capital banks are more likely to reduce the management buffer to meet extra capital requirements (Andreeva et al., 2020).

Cost of failure is proxied as a ratio of provisions to total assets (*ProvisionsTA*). The relationship here is ambiguous. On the one hand, a positive coefficient might imply a prudent bank that holds a management buffer to cover for potential losses. On the other hand, a negative sign could imply that riskier banks have better-calibrated models and risk management policies (Eckley et al., 2019; Francis & Osborne, 2010). *Density* is defined as risk-weighted assets over total assets and is used as a measure for risk (Bruno et al., 2015; Lubberink, 2020; Melis & Weissenberg, 2019). A non-performing loan ratio can be used as an alternative, but I use another risk measure, namely, Z-score which is defined as the sum of the leverage ratio and return of assets over the standard deviation of return on assets. A high z-score implies a lower probability of a bank failure. The simple measure essentially measures the number of standard deviations the return on assets has to drop for a bank's equity to be wiped (Hesse & Čihák, 2007). The coefficient is expected to be positive based on Lubberink, (2020).

A size factor is commonly added to control variables in similar studies (e.g. Ayuso et al., 2004; Lubberink, 2020; Pereira & Saito, 2011). Larger banks tend to have lower capital ratios, better access to capital markets, to be more diversified and to have more advanced risk management practices e.g. advanced internal rating-based risk models. I use log of assets (*lAssets*), the coefficient is expected to be negative.

Market discipline is proxied by the ratio of subordinated debt to total assets (*SUBORD*). Subordinated debt unlike deposits, which are covered by guarantee scheme, might have a disciplinary effect on a bank to deleverage and to hold higher capital surplus that reduces the distance to default and consequently funding costs (Eckley et al., 2019; Pereira & Saito, 2011). In other words, subordinated debt holders are the first in line to suffer losses in the event of a bank failure, thus they are incentivised to require a higher risk premium and to monitor banks.

GDP growth ($GDPG$) is included to control for the business cycle effect on the management buffer. The expected sign is negative due to the procyclicality of bank capital (Ayuso et al., 2004).

### *3.3. Empirical model and specifications*

The main model is specified as follows:

$$\begin{aligned} MngmBuff_{it} = {} & (1-\theta)MngmBuff_{it-1} + \beta_1 P2R_{i,t-1} + \beta_2 CBR_{i,t} + \beta_3 ROE_{i,t} \\ & + \beta_4 Density_{i,t-1} + \beta_5 Zscore_{i,t-1} + \beta_6 lAssets_{i,t-1} \\ & + \beta_7 SUBORD_{i,t-1} + \beta_8 ProvisionsTA_{i,t-1} + \beta_9 LoanG_{i,t-1} \\ & + \beta_{10} GDPG_{i,t-1} + \alpha_i + \lambda_t + \varepsilon_{i,t} \end{aligned} \tag{4}$$

for bank i at the time t, and where $\theta$ is an adjustment parameter that reflects the speed of adjustment, $\alpha_i, \lambda_t$are bank and time fixed effects, $\varepsilon$ is the error term, parameters, $\beta$, are the corresponding coefficients for the bank-specific Pillar 2 requirement ($P2R$), combined buffer requirement ($CBR$) containing the sum of phase-in capital conservation buffer, countercyclical capital buffer and the maximum of G-SIB,O-SII or systemic risk buffer. I do not lag capital requirement variables because of their forward-looking nature and the fact that they are communicated before banks are expected to comply with them. The control variables are return on equity ($ROE$), *Density* is risk-weighted assets to total assets, *Z-score* is another risk metric, *lAssets* is the natural logarithm of assets, *SUBORD* is the proportion of subordinated debt in total liabilities, *ProvisionsTA* is the ratio of provisions to total assets, *LoanG* is the gross loan growth, *GDPG* is the growth of GDP in the county bank is domiciled. The main coefficients of interest are $\beta_1, \beta_2,$ that relate to main hypothesis. Coefficients $\beta_1, \beta_2$are expected to be negative, because banks are likely to decrease their management buffers the higher the capital requirements are set by supervisors and regulators. The coefficients $\beta_3$ ,$\beta_4$, $\beta_6, \beta_9, \beta_{10}$ are expected to be negative, while $\beta_5$, $\beta_7, \beta_8$ are expected to be positive.

Equation (4) can be viewed as a short-run target management buffer model, where coefficients represent a single period i.e. short-run effect on the unobservable management buffer target level. Using the speed of adjustment parameter, $\theta$, which the model implicitly assumes is the same for all banks, one can derive the long-run impact of the management buffer determinant. For example, the long-run effect or pass-through rate for the Pillar 2 capital requirement, $\gamma_{P2R}$, would be calculated as:

$$\gamma_{P2R} = \frac{\beta_1}{\theta}. \tag{5}$$

The model is estimated by using the generalised method of moments (GMM) estimation approach. Specifically, the system GMM is used (Blundell & Bond, 1998; Roodman, 2009). The GMM is suited for such dynamic panel data studies as this one where the number of periods (T) is relatively small compared to the number of individuals (N). Such dynamic panel models are prone to biased coefficient estimates because of the correlation between the lagged dependent variable and the error term, thus simple ordinary least squares, fixed effects models etc. are not suitable for such a model. The GMM addresses the issue by introducing instruments in first differences and levels for the lagged dependent variable. The GMM is also useful for situations when the variables are not strictly exogenous, which is a common issue with bank capital decision studies e.g. omitted variable bias, reverse causality, etc. For instance, the *Density* variable in the model could imply both that riskier banks decide to hold lower or higher management buffers or that banks with low management buffers adjust their RWA in a certain way.

I largely follow the procedure described by Roodman (2009), which suggests transforming exogenous variables into first differences and be instrumented by themselves. Endogenous variables such as management buffer and density are however transformed in first differences and instrumented by their lagged levels. For endogenous variables, I use lags from 2 to 5 as instruments. As advised by previous bank capital management studies I collapse the instrument matrix to reduce the number of instruments in the estimation and employ system GMM. As a rule of thumb, the system GMM is more suitable since the difference GMM estimator potentially yield biased and inefficient estimates in small samples if dependent variable such as management buffers are persistent.

The coefficients can be considered efficient and consistent if the models are not serially correlated of order two and if the instruments are jointly valid e.g. according to Sargan's J test. The null hypothesis of Sargan's J test is that the over-identifying restrictions are valid. The statistic asymptotically follows the chi-square distribution with the degrees of freedom is the difference between the number of instruments and endogenous variables. However, the test is subject to weaknesses and should be interpreted with care

(Roodman, 2009). There is a risk of too many instruments, overfitting that artificially pushed the p-value to unreasonable levels of one. The goodness of fit measure for GMM can calculated as squared correlation between the predicted and actual variables of the model, which is equivalent to standard $R^2$ used in ordinary least squares regressions (Bloom et al., 2001).

While $R^2$ is not typically reported for the GMM outputs, I include it along with a squared correlation between the predicted and actual variables, which is an equivalent goodness of fit measure used for IV-type regressions.

# 4. Data

## *4.1. Sample and data collection*

This paper employs an unbalanced semi-annual cross-country bank-level panel data with 57 European banks over the period from 2016 H1 to 2020 H2, which is the period covered by the EBA's regular bank-level supervisory data transparency exercise. While the transparency exercise data is available also for 2015, the capital requirement data for that year is scarce and seems to be concentrated in Sweden, where the supervisor has a long tradition to publish all capital requirements for banks and where capital requirements are particularly high, especially for specialised banks. Thus, I excluded 2015 data and started the sample period from 2016 when the availability of disclosures of capital requirements is generally better. The sample period also corresponds to the period when the SSM was just established and the Basel III and the EU-specific capital buffers were gradually phased in.

The sample consists mainly of listed EU and UK banks that participate in the EBA's transparency exercise. The EBA's transparency exercise is a useful data source for somewhat consistent supervisory data that is based on the COREP and FINREP reporting templates. Around 130 banks participate in the EBA's transparency exercise representing major banking groups in each European country. Thus, the sample mostly represents larger institutions, however, it includes also relatively small institutions domiciled in countries with a small financial sector.

The sample in this paper does not include all 130 banks mostly due to the lack of Pillar 2 requirement disclosures by banks. In 2020, the ECB published the SREP capital decisions for each of its supervised banks, however the banks that have no prior disclosures for at least 3 years were not included in the sample of this paper. In addition, subsidiaries in Europe of foreign banking groups are excluded from the sample, because it is assumed that the capital allocation decisions are taken mainly at the group level. The data is collected on the highest level of consolidation to avoid issues with intra-group capital allocations that might distort the interpretation of capital ratio levels in certain parts of the banking group, for example, excess capital allocated to subsidiaries in tax-beneficial countries. I also exclude banks that are extreme outliers in terms of capital requirement and levels, for instance, *Kommuninvest* bank in Sweden has a P2R that reaches as high as 112% of RWA, while the mean is less than 3% of RWA. Relevant accounting data and ratios described in the methodology section are extracted from the S&P Capital IQ data base (variable descriptions can be seen in Table 1).

The sample consists of 57 banks from 21 European countries. The mean asset size is around 363 billion euros. The sample ranges from small banks with just 632 million euros in assets to global institutions with 2623 billion euros in assets (see Figure 2). Around two-thirds of banks are under SSM at the group level. The range of asset size and countries give some comfort that the sample is not biased to only large listed banks that can be expected to have more transparency in capital requirement disclosures due to greater market scrutiny and disclosure requirements.

### *4.2. Capital requirements and management buffers*

Public financial reports, investor presentations, Pillar 3 disclosure reports, the ECB's and the Swedish Financial Supervisory Authority's public reports are the main source of the capital requirement data. While capital requirements for the buffers are generally easy to retrieve, banks are not obligated to disclose individual SREP decisions, i.e. the Pillar 2 capital requirements. The Swedish Supervisory Authority has published capital requirements for all its supervised banks over the sample period, however the ECB published the Pillar 2 capital requirements in 2020 for the first time for all directly supervised significant institutions in the banking union. Generally, not all banks disclose Pillar 2 requirements due to the perceived market sensitivity of such information since a higher Pillar 2 requirement might imply that a bank is less financially stable in the view of the supervisor. However, the ECB in the supervisory letters to banks has encouraged banks to disclose Pillar 2 requirements for transparency purposes even before 2020. The disclosure has become more common over the years. The ECB introduced Pillar 2 guidance in 2017, which is not included in the analysis since too few institutions disclose it. The guidance is not considered as a requirement and is not included in the calculation of the MDA either. The average Pillar 2 guidance is around 1.1% for the institutions supervised by the ECB (ECB, 2021a).

I define management buffer as

$$MngmBuff_{it} = CET1\,ratio_{it} - CR_{it}^{CET1}\,, \tag{6}$$

where $i$ and $t$ are bank and time indices respectively, CET 1 ratio is the ratio between CET1 capital and risk-weighted assets and $CR^{CET1}$ is the CET1 capital requirement (i.e. does not include Tier 1 and Tier 2 components) as a share of risk-weighted assets. So, if CET 1 ratio is above the capital requirement, then a bank has a positive management buffer. The CET1 capital requirement is calculated as:

$$CR_{it}^{CET1} = P2R_{it} + CBR_{it} + 4.5\%\,, \tag{7}$$

where P2R is a bank-specific Pillar 2 CET1 capital requirement expressed as a share of risk-weighted assets, CBR is the combined buffer requirement and the 4.5% represents the minimum CET1 requirement stipulated in the CRR. Lastly, the (total) capital buffer requirement is defined as:

$$CBR_{it} = CCB_{it} + CCyB_{it} + Max\,\{SRB_{it}, OSIIB_{it}, GSIIB_{it}\}\,, \tag{8}$$

where CCB is the capital conservation buffer requirement, which is not simply set to 2.5% or risk-weighted assets because of the gradual phase-in period during the sample period. CCyB is counter-cyclical capital buffer requirement. The CCyB is effectively also bank-specific because it depends on a bank's individual exposure mix that is subject to the CCyB policy rate. SRB, OSIIB and GSIIB are systemic risk buffer, other systemically important institution, and globally systemically important institution buffer requirements respectively. Effectively the CRDV changes in the additivity rules were not in force during the sample period, thus the maximum of the three buffer requirements is considered as it was in the CRDIV.

### *4.3. Descriptive statistics*

The average management buffer size of the sample banks over the sample period is 5.2% of risk-weighted assets (see Figure 3 and Table 2), which is a similar average figure reported by Melis & Weissenberg (2019) for cross-sectional European bank data in 2017. Both the mean and the distribution of management buffer is relatively stable over years compared to distributions of the Pillar 2 CET1 capital requirement and the combined buffer requirement over time (see Figures 3, 4 and 5). The variation of the capital requirements over time can be explained by the phase-in period of components of the combined capital buffer as well as multiple changes in the SREP framework for SSM banks. Figure 6 depicts that the average combined buffer gradually increases over time from 2.1% in 2016 to 2.6% of risk-weighted assets in 2020 that is in line with the phase-in narrative. A slight decline in the combined buffer requirement can be observed in 2020 due to the Covid-19 policy response by macroprudential authorities e.g. release of the countercyclical buffer requirement to support bank lending and loss absorption capacity during the stress episode in the economy. Figures 6 and 7 illustrate that the average management buffers are relatively stable over time and between countries. However, the cross-country comparison should be analysed with care given that the sample size is small, and the results of some countries are driven by just a single institution. However, it can be observed that Nordic banks tend to have higher capital requirements and smaller management buffers.

The average Pillar 2 CET1 capital requirement has been gradually decreasing from 4.1% to 1.4% of risk-weighted assets from 2016 to 2020 (see Figures 4 and 6). The reasons behind the variation of the Pillar 2 CET1 capital requirement over time are less obvious compared to the combined buffer requirements. Some changes could be attributed to a decline in bank risk profile, however substantial drivers of the dynamics are the changes in the Pillar 2 framework itself. Since the sample is dominated by the SSM banks than also dynamics of the Pillar 2 requirement can be explained by decisions of the ECB. SREP 2015 was the first assessment cycle and the methodology might have been fine-tuned with more risk sensitivity in later years. The introduction of the Pillar 2 guidance in 2017 might have replaced part of the Pillar 2 requirement. Lastly, the ECB decided to frontload the CRDV and require only 56.25% of the Pillar 2 requirement to be met with CET1 capital in 2021 as a response to Covid-19 crisis. Thus, the overall Pillar 2 requirement remained the same, however the CET1 part of the Pillar 2 requirement was reduced (ECB, 2021a).

Table 3 shows that the mean CET1 capital ratio has been stable over years around 15.3% of risk-weighted assets over the sample period. The variation between banks is larger and has even some extreme values. Table 2 shows that the capital ratio can take the value as high as 32.2% for SBAB bank. The sample excludes the filtered case of *Kommuninvest* bank that had the capital ratio of over 200%. The minimum CET1 capital ratio observed in the sample is for *Banca Monte dei Paschi di Siena* in Q2 2017, when the banks regulatory reports to the supervisor showed that the ratio was just at 1.5% of risk-weighted assets, technically breaching the minimum requirement. While this bank's troubles are well known, it appears that according to data that was a temporary breach and the capital ratios were back to normal level already by the end of the year. Overall, while this stage it is not a formal test, it appears that on average sample banks hold CET1 capital ratio around 15.3% and any increases in capital requirements lead to an adjustment in discretionary buffer i.e. banks on average might have a target capital ratio rather than specific management buffer target size.

Tables 2 and 3 also show other bank-specific financial ratios. Profitability measure i.e. semi-annual ROE on average is 2.8%. The interquartile range is between 1.3% and 4.9%. Weak profitability has been an issue for European banks in the post-global financial crisis period. Clearly, the average ROE figures for 2020 are even lower since many banks are impacted by the Covid-19 pandemic-related issues. The average density i.e. the ratio of risk-weighted assets over total assets has been overall quite stable over time at around 39% yet declined to around 35% in 2020. The decline in density can be attributed to the increase in total assets of banks in 2020 that was largely driven by the increase in excess liquidity due to accommodative monetary policy. The average NPL ratio has declined over time from almost 10% to around 6% probably due to bank efforts to clean their balance sheets in recent years, while the gross loan growth gradually increased over the sample period. The subordinated debt share in total liabilities is on average 1.4% with the interquartile range between 0.8% and 1.8%, while the maximum was 11.8% in 2016 for *Credito Emiliano*.

Correlations between variables are reported in Figure 8, which shows that density and the leverage ratio have a correlation of 0.9. That can be explained by the fact that both ratios have a common denominator — total assets. Only one of the variables should be used in a regression to avoid multicollinearity issues. Also, NPL ratio and the provisions over assets ratio are somewhat positively correlated i.e. the Pearson correlation coefficient is 0.6. NPL ratio and ROE have the correlation coefficient of -0.6 i.e. banks with weaker balance sheets are associates with lower profitability. Pillar 2 requirement and combined buffer requirement are weakly correlated, which is in line with expectation given that they are used to address different risks, namely, banks-specific vs systemic risks.

Another observation is that CET1 capital ratio correlates with the management buffer, but imperfectly. The Pearson's correlation coefficient is 0.6 between the two variables, which indicates that they tend to covary as expected. While CET1 capital ratio positively correlates with capital requirements, the opposite is the case for the management buffers, which indicates that banks could be partially increasing CET1 ratio and partially using management buffers to compensate for increased capital requirements.

## 5. Empirical results

This section reports and discusses the results of the analysis of the determinants of bank capital management buffers, particularly focusing on the path through of capital requirements in the short-run and the long-run management buffer targets. In addition, I present a complementary analysis on capital ratio levels as well as some robustness checks.

### *5.1. Determinants of management buffers*

Table 4 presents the estimation results of the regression described in equation (4) over a full-sample period i.e. 2016-2020. Variations of the same models are reported in Tables 5 and 6. The former excluded 2020 from the estimation and the latter introduces addition an additional lagged variable of the dependent variable to account for worrying autocorrelation signs in the baseline model. The dependent variable is the management capital buffer as defined in the previous section. The coefficients estimates can be viewed as short-term effects of changes in regressors on banks' target capital management buffer. The main regressors are bank-specific CET1 capital requirements. A lagged dependent variable (or two in Table 6) is included as discussed earlier. The control variables are profitability, Z-score, Density, size which proxied by the natural logarithm of assets, the share of subordinated debt, provisions as a share of total assets, growth of gross loans, retained profits as a share of total assets and the GDP growth of a country where a specific banking group is domiciled. All control variables are lagged by one period (by half a year) to better reflect the information that was available at the time when potentially capital planning decisions were made. I do not lag capital requirement variables because of their forward-looking nature and the fact that they are communicated before banks must comply with them. The model in the column (1) excludes all capital requirement variables; the column (2) includes total CET1 capital requirements specific to each bank. The column (3) breaks the total capital requirement into the Pillar 2 CET1 capital requirement and combined buffer requirement; and column (4) breaks the requirement even further by dividing combined buffer requirement into phase-in capital conservation buffer and systemic buffers, which I defined as combined buffer requirement excluding the capital conservation buffer.

Overall, the short-run coefficients across the model specification and sample periods are consistent (see Tables 4, 5, 6). After controlling for robust standard errors, the coefficients of several control variables become statistically indistinguishable from zero, however various specifications of capital requirements, density, z-score, size factor and loan growth are consistently significant at the conventional significance levels. In addition, I report the calculated long-run coefficients in Table 8.

The main interest in my analysis is the relationship between bank capital management buffers and capital requirements, which the results show is negative and statistically significant at the conventional significance levels in most specifications. Model 2 results show that the short-run and long-run coefficients of the total capital requirement on the management buffer is around -0.14 and -0.45 (= capital requirement elasticity ( $\beta_1$) over speed of adjustment (θ) as in eq. 5) respectively. In other words, a 1pp increase in total capital requirement is associated with a 14bp decline in management buffer in the next 6 months and a 45bp over a longer period, ceteris paribus. This is consistent with idea that bank facing additional capital requirements partially use their discretionary capital buffers to meet the new capital ratio levels expected by the supervisors rather than adjust the balance sheet in a way such that the management buffer remains the same. In other words, the result does not indicate that on average banks would target a constant management buffer when faced with additional capital requirements.

Model 3 shows that when the capital requirement is broken into the effect of Pillar 2 requirement and the combined buffer requirement component then the effect appears to be dominated by combined buffer requirement and the Pillar 2 requirement is not statistically significant. The estimated pass-through rate of the combined buffer requirement appears to be 30% in the short-run and close to 90% in the long run in negative terms. This is an unexpected result, because there was no expectation that the difference between elasticities of different capital requirements would be so notable. Especially, given that Lubberink (2020) in a different study design find a significant negative relationship between SREP requirement and management buffer. The only similarity is that the effect was also more pronounced for the combined buffer requirement and above 1.0 in some specifications.

The Model 4 shows that the Pillar 2 requirement component remains statistically insignificant, while the negative short-run pass-through rate for capital conservation buffer requirement varies between 60-83% and rate for the systemic buffer requirement — between 13% and 18% depending on specification of the model and sample. The long-run estimates are around 60% for systemic buffer impact and 250% for the capital conservation buffer impact. The pass-through rate for systemic buffers (including the countercyclical capital buffer requirement) implies that management buffers are partially used to meet macroprudential capital requirements. The size of the impact of the capital conservation buffer is sample-specific. The capital conservation buffer is 2.5% since 2019 and will remain there in the future but was phased in gradually during the period of 2015-2019.

The large estimated response coefficients for the capital conservation buffer could reflect that many banks chose to hold capital ratios and consequently extra discretionary capital in management buffers already on fully phased basis already before 2019. This would ultimately mechanically decrease management buffer over time as the phased-in capital requirement formally reached the 2.5% level. To test this explanation, I changed the definition of the management buffer by using the fully loaded capital conservation buffer in the calculation and re-estimated the main regression that kept the phase-in capital conservation buffer requirement as the explanatory variable (see Table 7). The coefficient of the capital conservation buffer becomes statistically insignificant, which indicates many banks held extra management buffer to cover capital conservation buffer requirement on a fully loaded basis (i.e. 2.5%) already before 2019. In other words, variability of the capital conservation buffer did not affect the management buffer because banks on average already held the extra capital. It was known well before 2016 that such requirement would be in force and banks possibly wanted to signal that they have no difficulties achieving the long-term capital level targets.

Regarding control variables, the size factor is among those control variables that remain statistically significant with robust standard errors and have a negative sign as expected. That is in line with previous empirical evidence that larger banks hold smaller discretionary capital surpluses as well as lower capital (Eckley et al., 2019; Lindquist, 2004; Lubberink, 2020; Pereira & Saito, 2011). The negative sign is consistent with idea that larger banks tend to be more diversified and have more access to capital markets to raise funds if necessary.

The coefficient on bank's gross loan growth is another negative and statistically significant one consistently across model specification except, for Models 1 and 2 with the AR(2) specification. The negative sign is in line with studies that find a negative association between lending and capital levels (Ayuso et al., 2004; De Marco & Wieladek, 2015; Eckley et al., 2019; Gropp et al., 2019; Lubberink, 2020).

The estimated coefficients for both risk measures – density and z-score – are statistically different from zero at the conventional significance levels consistently across almost all models. Both coefficients are negative. Density, i.e. a ratio between risk-weighted assets over total assets, is found to be negatively associated with discretionary buffers also by Lubberink, (2020). Banks in the danger zone, i.e. with lower capital surpluses, have been associated with risk-taking (Eckley et al., 2019). This means that riskier banks tend to have lower discretionary buffers. Endogeneity or reverse causality regarding density measure is a potential problem i.e. banks might as well be adjusting their risk-weighted assets if they have low management buffers. The coefficient for z-score is not as expected. It implies that banks with a higher multiple of absorbing return on asset variability i.e. safer have lower management buffers. This further illustrates that it is not easy to disentangle the endogeneity issues of risk-taking measures and discretionary capital buffers. Moreover, one could argue that the Pillar 2 requirement is also a bank-specific risk measure. The three variables are not highly correlated though. The results are not reported, but excluding one or two of coefficients do not alter the overall estimates regarding coefficients of density, z-score and Pillar 2 requirement.

Other control variables such as profitability, provisions, retained profits, GDP growth and market discipline (proxied by subordinated debt as a percent of total liabilities) do not appear statistically significant after the application of robust standard errors. The fact that the control variables are not statistically significant does not necessarily mean that the models is wrong, for instance, Eckley et al. (2019) do not find all the variables mentioned in the literature as statistically significant.

The average speed of adjustment of management buffers to the target level which is implied by the coefficients on the lagged management buffer range between 0.25 to 0.33 on a semi-annual basis. This indicates that the application of the partial adjustment model is reasonable. By multiplying the semi-annual speed of adjustment by 2, I get the annualized adjustment rate of around 0.50 to 0.66 per year depending on the model specification and the sample, which is consistent with the level estimated on UK bank data by Eckley et al. (2019). In fact, de-Ramon et al. (2016) estimated the speed of adjustment of 0.64 for UK capital ratio levels, which might might imply similarities of adjustment speeds for both the management buffers and the levels of capital ratios.

All models in the Table 4 are estimated by the two-way system GMM, endogenous variables are instrumented with two to five lags and these instruments are collapsed. All models contain time and bank fixed effects. Wald test results are not reported in the tables due to space limitations but are statistically significant from zero at the conventional significance levels in all models. Thus, the coefficients can be considered jointly different from zero. The p-values for Sargan overidentification test are larger than 10% for all models, which means that the null hypothesis of all instruments being valid cannot be rejected. The p-values for Sargan test are not close to 1, which provides additional assurance that overfitting is not an issue either (Roodman, 2009). The first order serial correlation in the idiosyncratic disturbance term is generally expected in the GMM models, however the second order auto-regressive process should not be present for model to be considered valid. Unfortunately all AR(2) test in statistically significant at the 5% significance level for all four models. However, I cross-check the overall stability of results by re-estimating the model on a reduced sample that excludes year 2020 (see Table 5) and by introducing additional lagged dependent as the independent one on a full sample (see Table 6). In both cases, the AR(2) test for all models lose their significance, while p-values for Sargan test remain within reasonable bounds. Higher order autocorrelation tests are not statistically significant from zero at the 5% level (including the model with two lagged dependent variables).

### *5.2. Consistency of results with the capital requirement impact on capital ratio levels*

In order to provide a better illustration of the interaction between capital requirement, management buffer and capital level, to check the consistency of analysis with pervious literature that mainly focuses on capital ratio levels and to complement the management buffer analysis, I provide equivalent analysis to the one discussed in the previous sub-section. The capital ratio level results should show consistent results with the previous one, for example, a 1pp increase in capital requirement that leads to 45bp decrease in the management buffer imply that the capital ratio level increases by 55bp. However, the certain capital requirement components (e.g. the phase-in capital conservation buffer) might not have an observable effect of capital ratio levels due to the bank behaviour described in the previous section i.e. banks tend to apply fully loaded capital requirement in their capital planning.

The model specified in equation (4) can be rewritten for CET1 capital ratio levels as well. The management buffer variable is replaced by CET1 capital ratio as follows:

$$\begin{aligned}&CET1\,ratio_{it} = (1-\theta)CET1\,ratio_{it-1} + \beta_1 P2R_{i,t-1} + \beta_2 CBR_{i,t} + \beta_3 ROE_{i,t} + \\ &\beta_4 Density_{i,t-1} + \beta_5 Zscore_{i,t-1} + \beta_6 lAssets_{i,t-1} + \beta_7 SUBORD_{i,t-1} + \\ &\beta_8 ProvisionsTA_{i,t-1} + \beta_9 LoanG_{i,t-1} + \beta_{10} GDPG_{i,t-1} + \alpha_i + \lambda_t + \varepsilon_{i,t}.\end{aligned} \tag{9}$$

Tables 9 and 10 present the estimation results and long-run coefficients of a similar regression model I used in the previous section, but the CET1 capital ratio is used as the dependent variable instead. The estimation is made on a full sample period i.e. 2016-2020. The capital requirement regressors and their breakdown, as well as control variables, are the same as for the management buffer regression. The capital ratio target models are also estimated by the two-way system GMM, endogenous variables are instrumented with two to five lags and these instruments are collapsed. All models contain time and bank fixed effects. Wald test results are not reported in the tables due to space limitations but are statistically significant from zero at the conventional significance levels in all models. Thus, the coefficients can be considered jointly different from zero. The p-values for Sargan overidentification test are larger than 10% for all models and yet not close one. The second order auto-correlation tests are not statistically significant from zero at the 5% level. Overall, the specification seems appropriate for the CET1 capital level model as well.

The key difference in results between the management buffer and the CET1 capital ratio model are the estimates for the capital requirement impact on the dependent variable both in the short-run and the long-run. Model 1 in Table 9 reports that the total capital requirement impact is in fact positive on capital ratios and statistically significant, which is in line with previous literature that overs UK banks data over a different sample period. My estimates of capital requirement pass-through rates are much lower, namely, 19.5% in the short-run and 49.2% in the long run, compared to the 30% and 90% estimated by de-Ramon et al. (2016) for UK banks over the period of 1989-2013. However, de-Ramon et al. (2016) registers a structural change in their paper that the sensitivity of bank capital levels to capital requirements has declined after the global financial crisis in 2007. My sample period does not overlap with the one used in that study; my estimates could be showing that the declining sensitivity might have continued beyond 2013. Combining my baseline model estimations for management buffers and capital ratio levels, a 1pp increase in total capital requirement is associated with a 45bp point decrease in management buffer and a 49.2bp increase in capital ratio levels. While there is some discrepancy, it appears that in the long run the capital requirement is equally split between the two components. These estimates, however, do not consider the fully loaded capital requirement bias associated with capital conservation buffer phase-in period. The real dive into management buffer, therefore, is probably closer to 20bp and the rest is an increase in capital ratio levels that can be achieved either by new capital, by reduction of risk-weighted assets or in some instances by regulatory capital calculation discretions (Gropp et al., 2021).

Models 3 and 4 in Tables 9 and 10 analogously to the previous specifications break the capital requirement in various components to test their associations to the levels of capital targets of a bank. Bank capital ratios are positively and statistically significantly associated with the Pillar 2 requirement. A 1pp increase in Pillar 2 requirement is associated with a CET1 capital ratio target increase of 35bp increase in the short-run and of 88.5bp in the long run. However, the results for combined capital buffer and its components do not show a statistically significant relationship with the CET1 capital ratio.

This contrasts with the results regarding management buffers, which showed that the Pillar 2 requirement had no significant impact, but the combined buffer had a significantly negative association. It appears that banks on average have different capital planning responses on different components of capital requirements. However, the lack of CET1 ratio sensitivity to capital conservation buffer requirement supports the assertion that many banks held extra capital to meet the fully loaded capital requirement before it was formally expected in 2019.

Table 9 also shows that the coefficient estimates for the control variables in CET1 ratio models are almost the same as in the discretionary buffer models. Size factor, growth of gross loans, and density are the same both in terms of significance levels and signs. However, Models 2, 3, 4 suggest that z-score in not a relevant factor for target CET1 capital ratio function unlike in the management buffer function. In specifications 3 and 4 also GDP growth appears statistically significant, but only at 10% significance level. The positive sign is counterintuitive since the negative relationship is well-documented in the literature (Andreeva et al., 2020; Ayuso et al., 2004). The unusual result might stem from the fact that the whole sample period is mostly in an upward economic cycle, except for 2020 and thus the model might not be able to capture the relationship throughout the cycle.

The average speed of adjustment of CET1 capital ratio target levels are reported in Table 10. Model 1 estimates a quite low speed of adjustment of 0.14, while model 2,3 and 4 consistently yields the estimate of around 0.4, which is high compared to previous studies. Annualised speed estimates on different time period US and UK bank data has been in the range of 28% to 64% (Berrospide & Edge, 2010; S. de-Ramon et al., 2016), while my annualised estimates range between 28% in Model 1 and 80%. In Models 2,3 and 4. However, the annualization is an approximation. The estimated semi-annual adjustment speeds are comparable i.e. 0.36 estimated by de-Ramon et al. (2016) which is comparable to my 0.4. In addition, there has been a structural break and increasing adjustment speed parameter after the global financial crisis. Thus, my estimate could just represent this observation.

### 5.3. *Robustness check*

To check the robustness of the results regarding determinants of the management buffer dynamics, I reran the system GMM with various combinations of the main variables and specifications of internally instrumented variables. However, as an additional way to look at the association between capital requirements and management buffers I rerun the main regression by employing standard panel data estimation methods rather than the partial adjustment model that was used so fat. Tables 11, 12 and 13 show results of panel regressions where dependent variable is management capital buffer and regressors are the same as before, except that the lagged term of dependent variable is not included. Pooled ordinary least squares, bank fixed effects, time fixed effects and bank and time fixed effects models are estimated for the same combinations of capital requirement variables and control variables as before. The significance levels and signs for control variables are generally consistent with the ones estimated by the system GMM. Under some specifications, the GDP growth and provision variables become significant as well.

Most importantly, the total requirement is negatively associated with the management buffer that confirms the finding of the GMM as well. Pooled OLS and time fixed effects model show the coefficient of around -0.4 that is consistent with the long-run effect estimated by the partial adjustment model. When bank fixed effects are included, then the estimate declines to around -0.2. Consistent results can be seen also for other capital requirement coefficient estimates. It appears that the effect of Pillar 2 requirement disappears when the model accounts for time fixed effects since the coefficient is negative and statistically significant in other specifications.

In addition, I added the IV-regression that tries to identify the effect of the density variable on management buffers by employing an instrumental variable as suggested by Lubberink (2020). The instrumental variable is the latitude of geographical coordinates of the location where banking groups' headquarters are located. As one can see in Figure 8, the latitude has a high negative correlation with density of 50%. However, there should be no reasonable expectation or reasons why the latitude should be directly affecting a bank's management buffers. Thus, the conditions for a valid instrumental variable seem to be achieved, but I remain cautious since latitude corelate with risk-taking and thus management buffers. Tables 11, 12 and 13 show that the instrumental variable regression results show significantly more negative coefficient for the density variable on the management capital buffer, namely it decreases from around -0.06 to -0.12 at least. This yields additional evidence that a 1pp increase of density is directly associated with a 13-20 bp decrease in the management buffer.

## 6. Conclusion

This thesis studies the impact of bank capital requirements on bank management buffers, the capital banks hold on top of minimum requirements, in Europe over 2016-2020. I find empirical evidence that higher capital requirement is associated with lower management buffers, but the sensitivity is less than one to one. A 1 percentage point increase in total capital requirement is linked to a lower management buffer by 14 basis points in the next six months and in a total of 45 basis points in the longer run. And on a flip side, I find evidence that capital ratios increase accordingly as a response to a capital requirement increase. However, the impact on the management buffer could be as low as 12 – 18 basis points as shown by a robustness check with a crude assumption that all banks planned their capital on a fully loaded capital requirement basis that was a feature peculiar to the sample period. The true effect is somewhere in between since not all banks planned capital on a fully loaded basis during the sample period. Overall, it appears that banks tend to hold management buffers relatively stable in response to additional capital requirements.

Analysis of the capital requirement components shows that changes in systemic buffers tend to dive into management buffers while Pillar 2 capital requirements not. A potential explanation could be that systemic buffers have a similar phase-in feature i.e. banks expect systemic buffers in advance and therefore hold additional management buffers before they formally apply. A limitation of the study is that I can observe only the formal date of application of the requirement, not the date when a bank learned about it and formed expectations.

Other important determinants of management buffer are bank size, growth of loans and associated risks proxied by density and z-score. I also find that shocks to a management buffer seem to materialize faster in European banks compared to studies on previous periods and countries.

My results are relevant in the buffer usability debate that emerged during the Covid-19 crisis response when policymakers released buffers in a hope to support lending.

Regulators should consider that banks will tend to keep management buffers relatively constant and thus plan their lending activities accordingly. Secondly, if banks form an expectation that capital requirements will be back at some level, then they will keep the additional management buffer accordingly.

I contribute to the literature linking capital requirements and bank behaviour in the post-global financial crisis bank regulatory environment. Cross-country panel provides additional validity to results. Future research could employ the same partial adjustment framework and link it to EBA stress test results that contribute to the formation of Pillar 2 guidance that is generally not publicly known but forms part of the management buffer.

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**Figure 1. A stylised bank regulatory capital requirement stack in the EU**

The figure provides intuition of the regulatory capital requirement stack in the EU, however various country, bank and time-specific features apply e.g. regulatory buffer requirements have phase-in transition periods, the capital composition requirements may vary by country (e.g. the ECB requires only 56.25% of P2R to be met with CET1 capital since 2020). The Prudential Regulatory Authority (PRA) in the UK refers to the P2R and the P2G as the P2A and the P2B respectively. The CRD V introduces changes with respect to SRB, G-SII/O-SII buffers with respect to additivity, but those changes do not de facto affect the capital requirement stack during the sample period in the analysis.

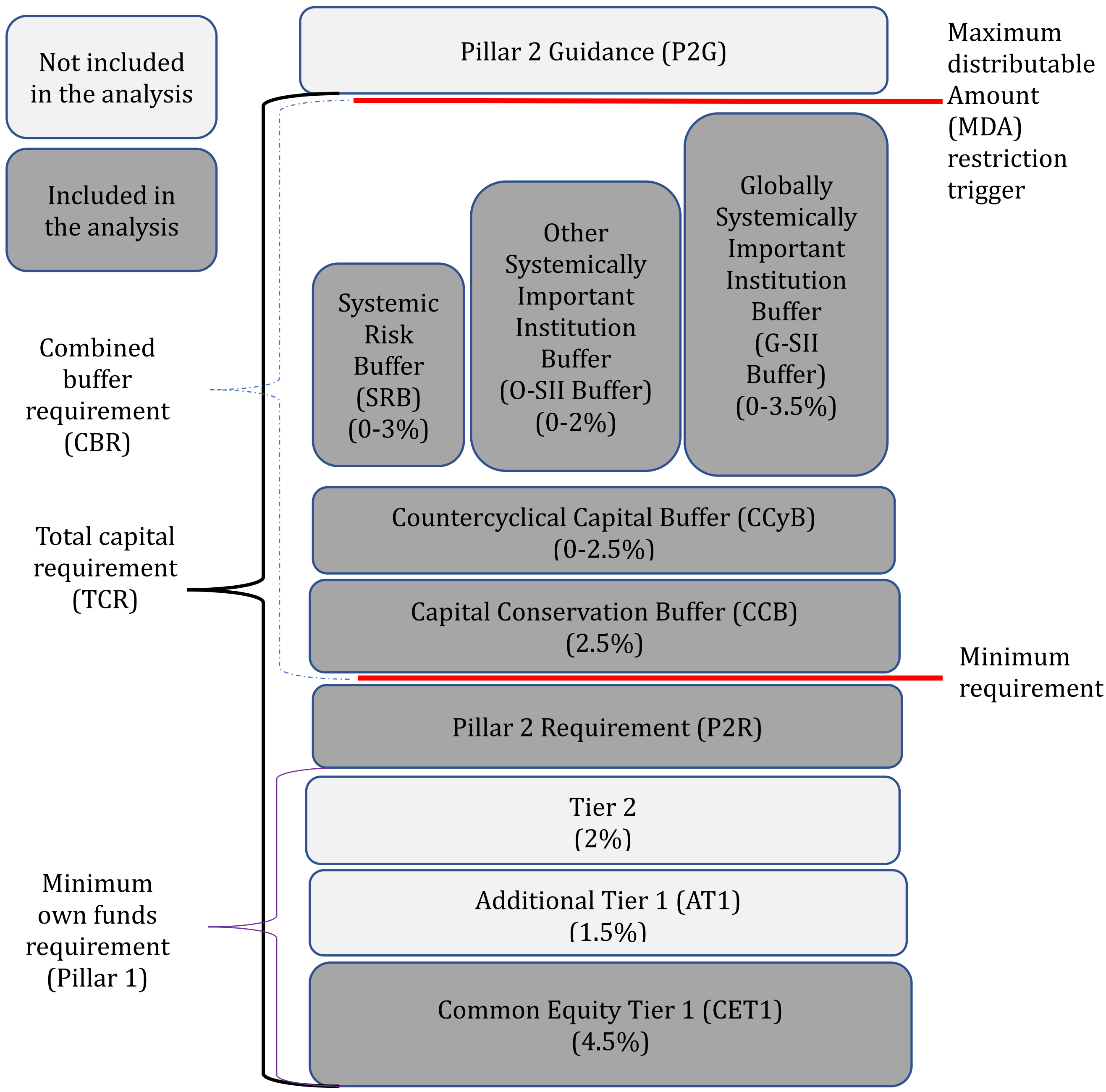


**Figure 2. The asset size of sample banks by country**

The figure plots the median, maximum, minimum, and interquartile range of asset size for 57 sample banking groups that are categorised by 21 European countries where their headquarters are located. Some countries have very few or even one observation.

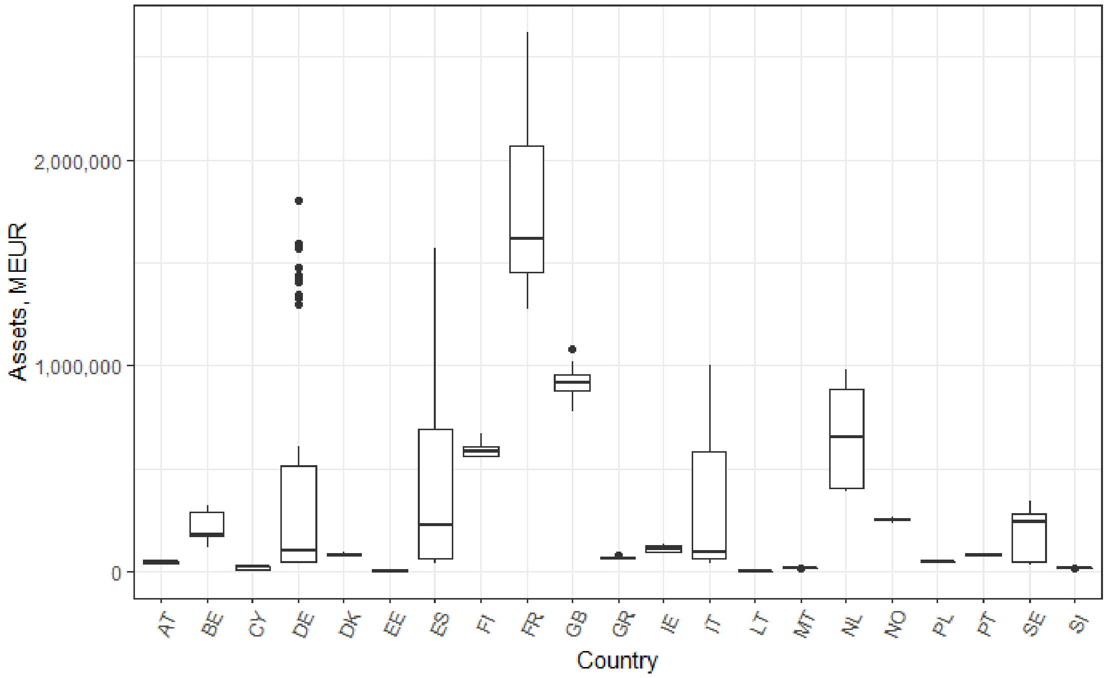



**Figure 3. Bank CET1 management buffer size density plots**

The figure plots densities of bank CET1 capital management buffer sizes expressed in percent of risk-weighted assets by year.

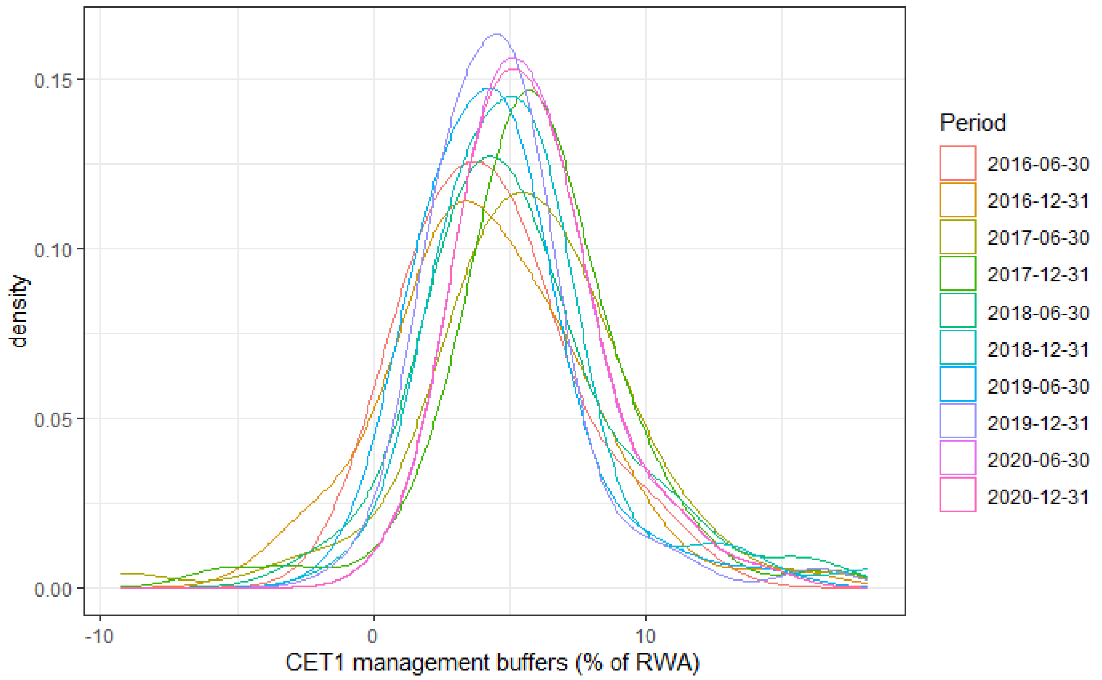


**Figure 4. Pillar 2 CET1 requirement density plots**

The figure plots densities of bank specific Pillar 2 CET1 capital expressed in percent of risk-weighted assets by year. The requirement was reduced for SSM banks in 2020.

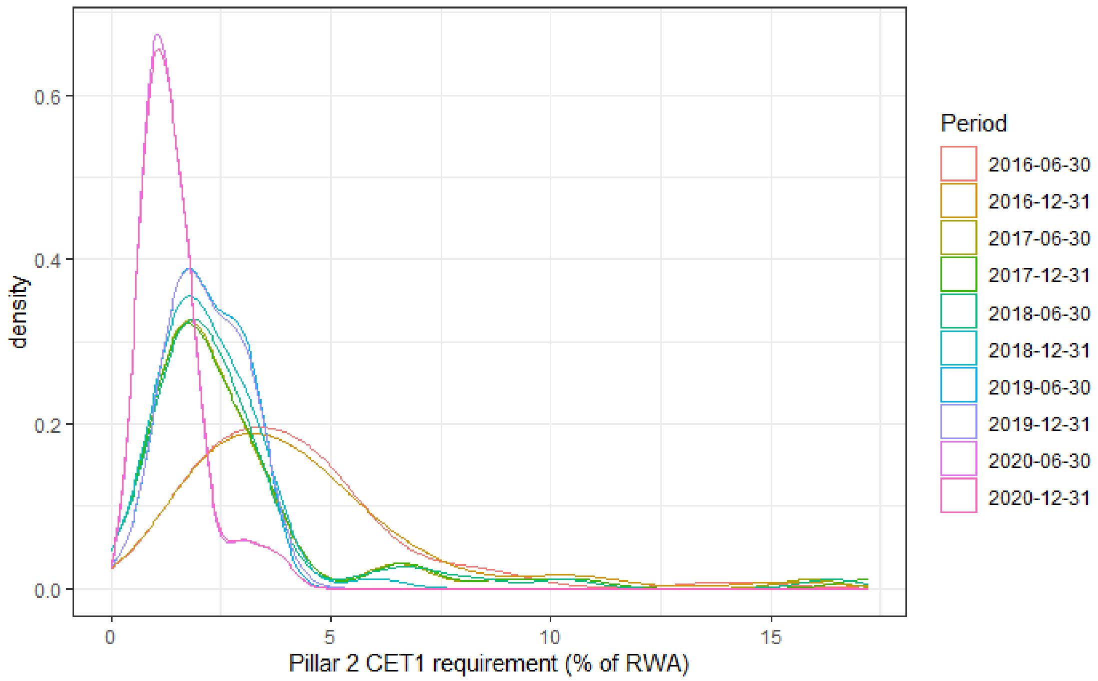



**Figure 5. Combined CET1 buffer requirement density plots**

The figure plots densities of bank specific combined CET1 buffer requirement expressed in percent of risk-weighted assets by year.

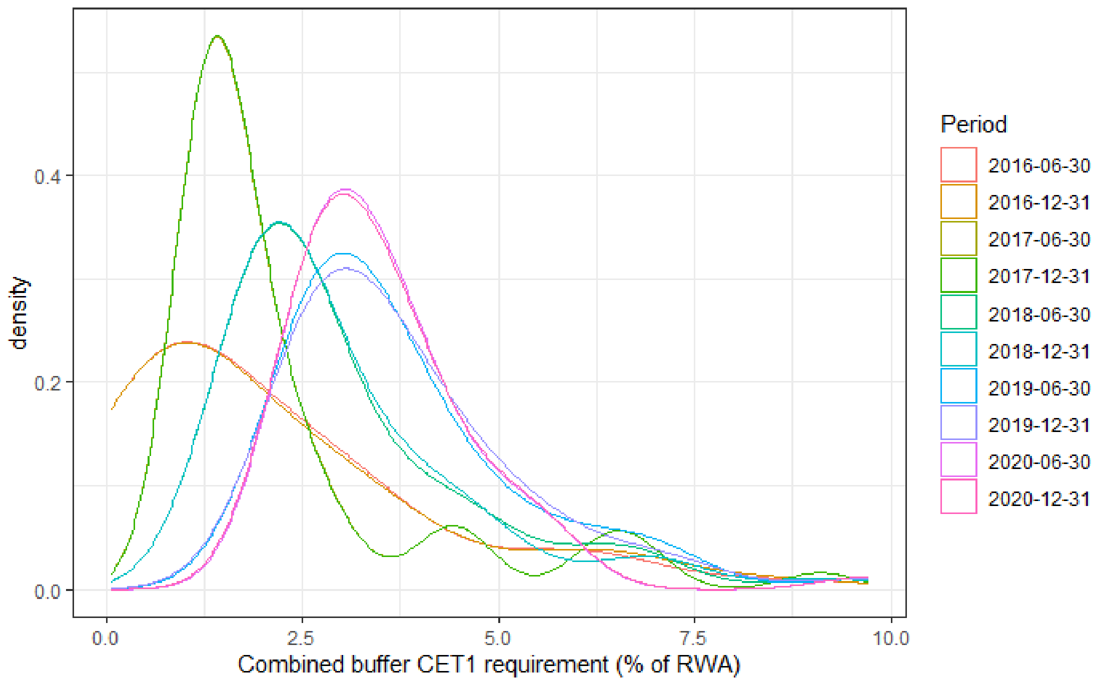


**Figure 6. Dynamics of average CET1 capital ratio by components (% RWA)**

The figure shows dynamics of sample bank unweighted average CET1 capital ratios by components.

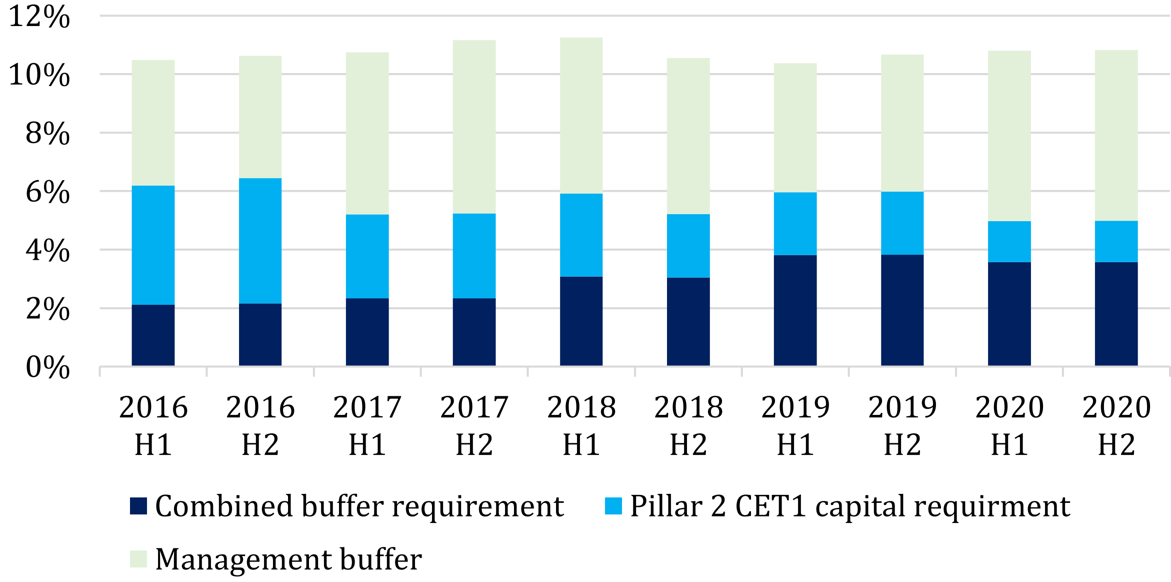



**Figure 7. Average CET1 capital ratio by components and by country (% RWA)**

The figure shows sample bank unweighted average CET1 capital ratios by country.

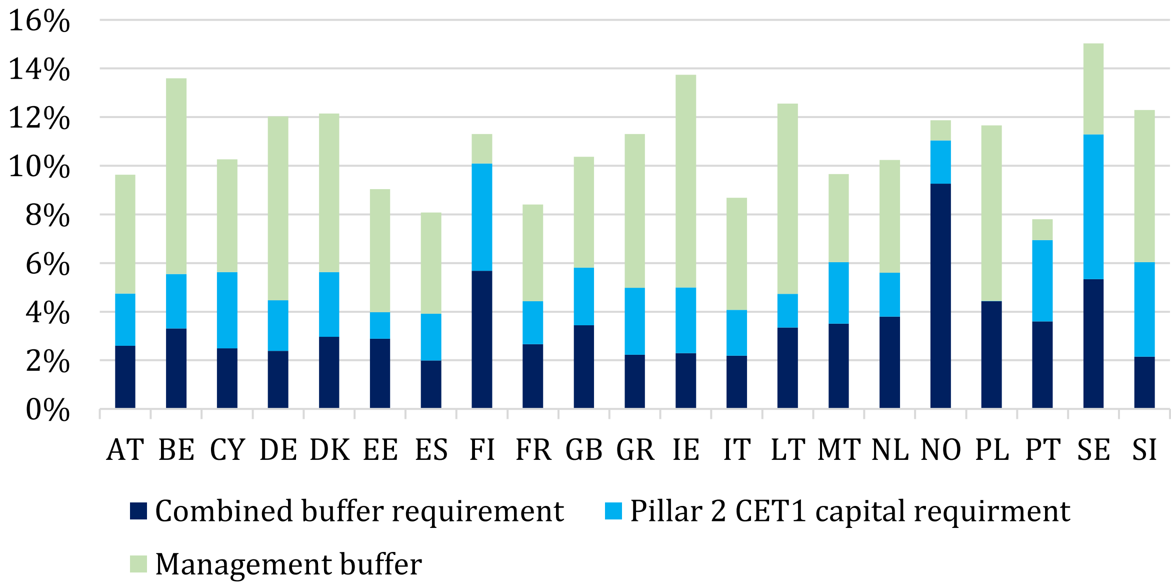
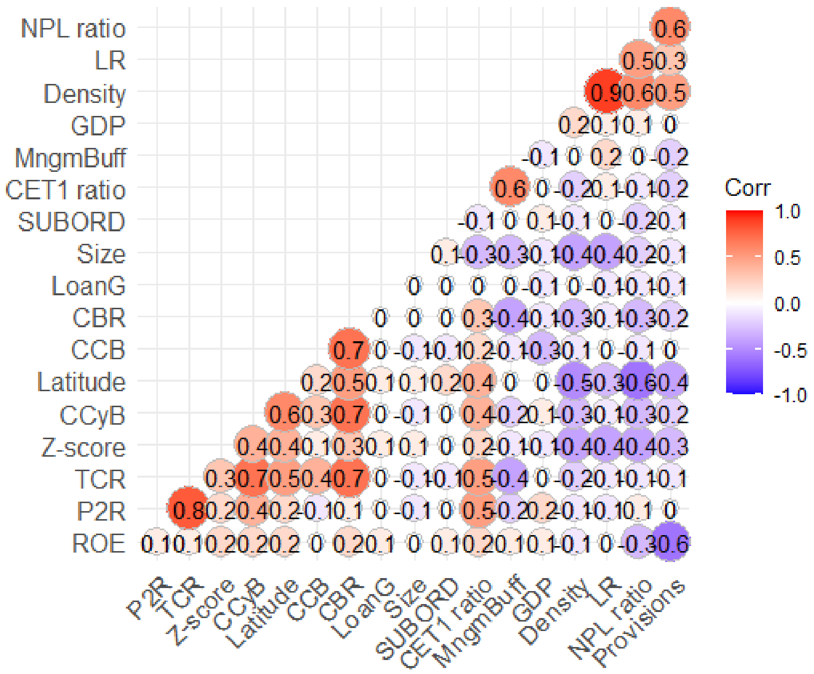


**Figure 8. Pearson correlations of main variables**

The figure depicts correlations between variables that are used and discussed in the paper. Size and colour indicate the magnitude and direction of Pearson correlations.



## Table 1. Variable descriptions and sources

The table summarizes the definitions and sources of the key variables that are used in the paper.

| Variable | Description | Source |
|---|---|---|
| $MngmBuff_{it}$ | CET1 ratio – Total CET1 capital requirement | S&P Capital IQ, EBA Transparency exercise, Pillar 3 and other public disclosures |
| $ROE_{i,t}$ | Earnings for the half a year/ Average common equity | S&P Capital IQ |
| $P2R_{i,t}$ | Pillar 2 requirement as a % of RWA. Implied P2R for years when only overall SREP requirement disclosed. | Various public sources (mainly Pillar 3 reports) |
| $CBR_{i,t}$ | CCB+CCyB +max(SRB,O-SII,G-SIB) as a % of RWA | Various public sources (mainly Pillar 3 reports) |
| $TCR_{i,t}$ | Total capital requirement= P2R+CBR+4.5 | Various public sources (mainly Pillar 3 reports) |
| $Density_{i,t}$ | RWA/Total Assets | S&P Capital IQ, EBA Transparency exercise |
| $lAssets_{i,t}$ | Natural logarithm of a bank's assets | S&P Capital IQ |
| $Size_{i,t}$ | Bank's total assets | S&P Capital IQ |
| $SUBORD_{i,t}$ | Subordinated debt outstanding/Total liabilities | S&P Capital IQ |
| $Provisions_{i,t}$ | Provisions/Total Assets | S&P Capital IQ |
| $NPL\ ratio_{i,t}$ | Non-performing loans/Total Gross Loans | S&P Capital IQ |
| $LoanG_{i,t}$ | Gross loan growth over the half a year | S&P Capital IQ |
| $GDPG_{i,t}$ | Quarterly GDP growth for the quarter in the country where the bank is domiciled | Eurostat |
| $LR_{i,t}$ | Leverage ratio calculated on accounting data (not regulatory) | S&P Capital IQ |
| $Z-score_{i,t}$ | $Z-score_{it} = \frac{LR_{i,t}+ROA_{i,t}}{\sigma_{ROA}}$, annual z-score calculated based on 6 year a simple volatility estimation window | S&P Capital IQ |
| $Latitude$ | IV for Table 11&12 | S&P Capital IQ, Google maps and spreadsheet features |

## Table 2. Sample descriptive statistics

The table reports descriptive statistics of variables for the unbalanced semi-annual bank panel data containing 57 EU banks over the period of 2016 H1-2020H2. All variables are expressed in percentage terms except for the size factor that is expressed in millions of euros and z-score ratio.

| Statistic | N | Mean | St. Dev. | Min | Pctl(25) | Pctl(75) | Max |
|---|---|---|---|---|---|---|---|
| **Size** | 519 | 364,732 | 503,604 | 823 | 47,765 | 454,699 | 2,622,988 |
| **CCB** | 519 | 2.004 | 0.659 | 0.062 | 1.250 | 2.500 | 2.500 |
| **CCyB** | 519 | 0.224 | 0.496 | 0 | 0 | 0.1 | 2.5 |
| **CBR** | 519 | 3.028 | 1.741 | 0.063 | 1.875 | 3.693 | 9.700 |
| **CET1 ratio** | 519 | 15.271 | 3.396 | 1.505 | 12.972 | 16.611 | 32.240 |
| **Density** | 503 | 38.899 | 15.517 | 9.842 | 26.682 | 47.219 | 85.086 |
| **MngmBuff** | 519 | 5.175 | 3.152 | -9.245 | 3.172 | 6.557 | 18.115 |
| **GDP** | 517 | -0.383 | 3.287 | -18.800 | 0.100 | 0.700 | 14.500 |
| **LoanG** | 519 | 1.672 | 11.683 | -52.596 | -2.205 | 4.147 | 108.417 |
| **NPL ratio** | 470 | 8.110 | 12.028 | 0.045 | 1.811 | 7.049 | 58.743 |
| **P2R** | 519 | 2.556 | 2.098 | 0.000 | 1.500 | 3.000 | 17.200 |
| **Provisions** | 519 | 0.181 | 0.351 | -0.217 | 0.018 | 0.216 | 3.400 |
| **ROE** | 519 | 2.753 | 5.883 | -68.461 | 1.322 | 4.934 | 42.096 |
| **SUBORD** | 519 | 1.424 | 1.144 | 0.000 | 0.773 | 1.820 | 11.846 |
| **LR** | 519 | 6.877 | 2.628 | 2.881 | 5.179 | 7.504 | 15.002 |
| **TCR** | 519 | 10.257 | 2.896 | 6.260 | 8.750 | 10.700 | 26.200 |
| **Z-score** | 519 | 53.336 | 47.667 | 2.933 | 21.448 | 68.568 | 250.102 |

**Table 3. Sample descriptive statistics: means by period**

The table reports the evolution of means of variables for the unbalanced semi-annual bank panel data containing 57 EU banks over the period of 2016 H1-2020H2. All variables are expressed in percentage terms except for the size factor that is expressed in millions of euros and z-score ratio.

| **Means** | **2016 H1** | **2016 H2** | **2017 H1** | **2017 H2** | **2018 H1** | **2018 H2** | **2019 H1** | **2019 H2** | **2020 H1** | **2020 H2** |
|---|---|---|---|---|---|---|---|---|---|---|
| **Size** | 419,613 | 397,028 | 354,824 | 342,856 | 349,305 | 339,059 | 352,068 | 347,171 | 385,246 | 377,507 |
| **CCB** | 1.35 | 1.35 | 1.51 | 1.51 | 2.00 | 2.00 | 2.50 | 2.50 | 2.50 | 2.50 |
| **CCyB** | 0.13 | 0.18 | 0.21 | 0.22 | 0.25 | 0.28 | 0.37 | 0.42 | 0.08 | 0.08 |
| **CBR** | 2.11 | 2.16 | 2.34 | 2.34 | 3.08 | 3.05 | 3.81 | 3.82 | 3.57 | 3.57 |
| **CET1 ratio** | 14.98 | 15.12 | 15.25 | 15.67 | 15.76 | 15.05 | 14.91 | 15.26 | 15.31 | 15.33 |
| **Density** | 39.26 | 39.88 | 40.56 | 40.14 | 38.95 | 40.55 | 39.11 | 39.12 | 36.16 | 35.07 |
| **MngmBuff** | 4.29 | 4.18 | 5.55 | 5.92 | 5.34 | 5.33 | 4.41 | 4.69 | 5.83 | 5.84 |
| **GDP** | 0.31 | 1.03 | 0.86 | 0.81 | 0.64 | 0.58 | 0.42 | 0.33 | (5.99) | (2.32) |
| **LoanG** | 1.19 | 0.32 | 1.51 | 0.08 | 2.86 | 0.53 | 5.40 | 0.21 | 2.83 | 1.32 |
| **NPL ratio** | 9.50 | 8.86 | 9.73 | 10.13 | 10.17 | 7.17 | 7.41 | 6.96 | 6.27 | 5.73 |
| **P2R** | 4.08 | 4.29 | 2.86 | 2.90 | 2.84 | 2.17 | 2.15 | 2.16 | 1.40 | 1.41 |
| **Provisions** | 0.16 | 0.23 | 0.27 | 0.17 | 0.12 | 0.16 | 0.11 | 0.12 | 0.31 | 0.17 |
| **ROE** | 4.06 | 1.63 | 2.59 | 2.75 | 3.77 | 3.38 | 4.34 | 3.10 | (0.00) | 1.97 |
| **SUBORD** | 2.10 | 1.75 | 1.47 | 1.50 | 1.39 | 1.38 | 1.29 | 1.33 | 1.15 | 1.10 |
| **LR** | 6.39 | 6.54 | 6.92 | 7.14 | 6.92 | 7.16 | 6.96 | 7.11 | 6.68 | 6.79 |
| **TCR** | 10.69 | 10.94 | 9.70 | 9.74 | 10.42 | 9.72 | 10.50 | 10.57 | 10.24 | 10.25 |
| **Z-score** | 54.52 | 57.15 | 51.62 | 54.25 | 51.68 | 53.89 | 52.20 | 54.52 | 51.20 | 53.37 |

**Table 4. Results of the main regression (2016-2020)**

The dependent variable is a bank's capital management buffer. The regression is estimated by two-way system GMM; endogenous variables are instrumented with two to five lags and the instruments are collapsed. Time and individual fixed effects are included, but the coefficients are suppressed. Indexes *,**,*** represent robust significance levels of 10%, 5% and 1%, respectively, and robust standard errors are reported in parenthesis. P-values are reported for the Sargan test, which refers to the test for over-identification restrictions, and AR(1) and AR(2) tests, which refer to autocorrelation tests. While $R^2$ is not typically reported for the GMM outputs, I include it along with a squared correlation between the predicted and actual variables, which is an equivalent goodness of fit measure used for IV-type regressions.

| | *Dependent variable:* | | | |
|---|---|---|---|---|
| | Management Buffer$_{i,t}$ | | | |
| | (1) | (2) | (3) | (4) |
| MngmBuff$_{t-1}$ | 0.702$^{***}$ | 0.696$^{***}$ | 0.688$^{***}$ | 0.707$^{***}$ |
| | (0.068) | (0.069) | (0.060) | (0.052) |
| Total requirement$_{t}$ | | -0.137$^{***}$ | | |
| | | (0.046) | | |
| P2R$_{t}$ | | | -0.051 | -0.024 |
| | | | (0.053) | (0.051) |
| Combined buffer$_{t}$ | | | -0.286$^{***}$ | |
| | | | (0.061) | |
| Combined buffer (excl. CCB)$_{t}$ | | | | -0.184$^{***}$ |
| | | | | (0.069) |
| CCB$_{t}$ | | | | -0.747$^{***}$ |
| | | | | (0.200) |
| ROE$_{t-1}$ | -0.012 | -0.007 | -0.005 | -0.011 |
| | (0.012) | (0.012) | (0.012) | (0.016) |
| Density$_{t-1}$ | -0.037$^{***}$ | -0.036$^{***}$ | -0.035$^{***}$ | -0.040$^{***}$ |
| | (0.013) | (0.013) | (0.010) | (0.012) |
| Z-score$_{t-1}$ | -0.006$^{***}$ | -0.004$^{***}$ | -0.003$^{**}$ | -0.004$^{**}$ |
| | (0.002) | (0.001) | (0.001) | (0.002) |
| lAssets$_{t-1}$ | -0.342$^{***}$ | -0.343$^{***}$ | -0.297$^{***}$ | -0.343$^{***}$ |
| | (0.115) | (0.122) | (0.101) | (0.121) |
| Subord$_{t-1}$ | 0.001 | -0.010 | 0.020 | 0.005 |
| | (0.064) | (0.058) | (0.048) | (0.059) |
| Provisions$_{t-1}$ | 0.088 | 0.132 | 0.072 | 0.102 |
| | (0.200) | (0.205) | (0.163) | (0.226) |
| LoanG$_{t-1}$ | -0.004$^{**}$ | -0.005$^{*}$ | -0.007$^{***}$ | -0.006$^{***}$ |
| | (0.002) | (0.003) | (0.002) | (0.002) |

**Table 4 (continued). Results of the main regression (2016-2020)**

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| Retained Profits$_{t-1}$ | 2.087 | 1.894 | 2.589 | 1.955 |
| | (3.095) | (2.754) | (2.365) | (2.571) |
| GDP$_{t-1}$ | 0.017 | 0.019 | 0.022 | 0.023 |
| | (0.020) | (0.019) | (0.019) | (0.020) |
| Observations | 519 | 519 | 519 | 519 |
| Sargan test | 0.55 | 0.73 | 0.8 | 0.68 |
| AR (1) | 0.01 | 0.01 | 0.02 | 0.02 |
| AR (2) | 0.03 | 0.03 | 0.05 | 0.05 |
| Goodness of fit | 0.78 | 0.79 | 0.79 | 0.79 |
| $R^2$ | 0.74 | 0.75 | 0.76 | 0.76 |

**Table 5. Results of the main regression (2016-2019; excluding Covid-19)**

The dependent variable is a bank's capital management buffer. The regression is estimated by two-way system GMM; endogenous variables are instrumented with two to five lags and the instruments are collapsed. Time and individual fixed effects are included, but the coefficients are suppressed. Indexes *,**,*** represent robust significance levels of 10%, 5% and 1%, respectively, and robust standard errors are reported in parenthesis. P-values are reported for the Sargan test, which refers to the test for over-identification restrictions, and AR(1) and AR(2) tests, which refer to autocorrelation tests. While $R^2$ is not typically reported for the GMM outputs, I include it along with a squared correlation between the predicted and actual variables, which is an equivalent goodness of fit measure used for IV-type regressions.

| | *Dependent variable:* | | | |
|---|---|---|---|---|
| | Management $Buffer_{i,t}$ | | | |
| | (1) | (2) | (3) | (4) |
| $MngmBuff_{t-1}$ | 0.705*** | 0.724*** | 0.663*** | 0.705*** |
| | (0.075) | (0.083) | (0.076) | (0.065) |
| Total $requirement_t$ | | -0.138** | | |
| | | (0.057) | | |
| $P2R_t$ | | | -0.084 | -0.048 |
| | | | (0.076) | (0.065) |
| Combined $buffer_t$ | | | -0.293** | |
| | | | (0.114) | |
| Combined buffer (excl. $CCB)_t$ | | | | -0.132 |
| | | | | (0.115) |
| $CCB_t$ | | | | -0.829*** |
| | | | | (0.271) |
| $ROE_{t-1}$ | -0.018 | -0.015 | -0.011 | -0.018 |
| | (0.017) | (0.020) | (0.017) | (0.021) |
| $Density_{t-1}$ | -0.054*** | -0.042*** | -0.044*** | -0.046*** |
| | (0.014) | (0.014) | (0.012) | (0.013) |
| $Z\text{-}score_{t-1}$ | -0.009*** | -0.005*** | -0.003** | -0.004** |
| | (0.002) | (0.002) | (0.001) | (0.002) |
| $lAssets_{t-1}$ | -0.412*** | -0.343*** | -0.348*** | -0.373*** |
| | (0.125) | (0.118) | (0.097) | (0.122) |
| $Subord_{t-1}$ | -0.027 | -0.036 | -0.026 | -0.056 |
| | (0.080) | (0.065) | (0.059) | (0.076) |
| $Provisions_{t-1}$ | 0.313 | 0.356 | 0.241 | 0.285 |
| | (0.349) | (0.461) | (0.271) | (0.412) |
| $LoanG_{t-1}$ | -0.009** | -0.011*** | -0.013*** | -0.011*** |
| | (0.004) | (0.004) | (0.004) | (0.004) |

**Table 5 (continued). Results of the main regression (2016-2019; excluding Covid-19)**

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| Retained Profits$_{t-1}$ | 1.966 | 1.355 | 1.622 | 0.476 |
| | (3.084) | (2.358) | (2.218) | (2.745) |
| GDP$_{t-1}$ | 0.095 | 0.077 | 0.102 | 0.082 |
| | (0.080) | (0.090) | (0.086) | (0.095) |
| Observations | 410 | 410 | 410 | 410 |
| Sargan test | 0.72 | 0.63 | 0.68 | 0.43 |
| AR (1) | 0.02 | 0.03 | 0.04 | 0.04 |
| AR (2) | 0.07 | 0.09 | 0.11 | 0.11 |
| Goodness of fit | 0.75 | 0.76 | 0.76 | 0.76 |
| $R^2$ | 0.70 | 0.72 | 0.71 | 0.72 |

**Table 6. Results of the main regression with AR (2)**

The dependent variable is a bank's capital management buffer. The regression is estimated by two-way system GMM; endogenous variables are instrumented with two to five lags and the instruments are collapsed. Time and individual fixed effects are included, but the coefficients are suppressed. Indexes *,**,*** represent robust significance levels of 10%, 5% and 1%, respectively, and robust standard errors are reported in parenthesis. P-values are reported for the Sargan test, which refers to the test for over-identification restrictions, and AR(1) and AR(2) tests, which refer to autocorrelation tests. While $R^2$ is not typically reported for the GMM outputs, I include it along with a squared correlation between the predicted and actual variables, which is an equivalent goodness of fit measure used for IV-type regressions.

| | *Dependent variable:* | | | |
|---|---|---|---|---|
| | Management Buffer$_{i,t}$ | | | |
| | (1) | (2) | (3) | (4) |
| MngmBuff$_{t-1}$ | 0.688*** | 0.663*** | 0.657*** | 0.664*** |
| | (0.050) | (0.050) | (0.048) | (0.050) |
| MngmBuff$_{t-2}$ | 0.057 | 0.066 | 0.069* | 0.089* |
| | (0.054) | (0.043) | (0.039) | (0.048) |
| Total requirement$_t$ | | -0.125*** | | |
| | | (0.033) | | |
| P2R$_t$ | | | -0.047 | -0.035 |
| | | | (0.038) | (0.045) |
| Combined buffer$_t$ | | | -0.230*** | |
| | | | (0.061) | |
| Combined buffer (excl. CCB)$_t$ | | | | -0.140*** |
| | | | | (0.053) |
| CCB$_t$ | | | | -0.592* |
| | | | | (0.335) |
| ROE$_{t-1}$ | -0.018 | -0.007 | -0.004 | -0.011 |
| | (0.015) | (0.015) | (0.014) | (0.016) |
| Density$_{t-1}$ | -0.029** | -0.029*** | -0.027*** | -0.026* |
| | (0.012) | (0.011) | (0.010) | (0.014) |
| Z-score$_{t-1}$ | -0.005** | -0.003** | -0.003* | -0.003 |
| | (0.002) | (0.001) | (0.001) | (0.002) |
| lAssets$_{t-1}$ | -0.285*** | -0.297*** | -0.248*** | -0.261** |
| | (0.095) | (0.086) | (0.076) | (0.113) |
| Subord$_{t-1}$ | -0.033 | -0.007 | 0.028 | 0.024 |
| | (0.081) | (0.068) | (0.063) | (0.074) |
| Provisions$_{t-1}$ | 0.106 | 0.163 | 0.103 | 0.017 |
| | (0.186) | (0.185) | (0.168) | (0.195) |

**Table 6 (continued). Results of the main regression with AR (2)**

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| $LoanG_{t-1}$ | -0.003 | -0.003 | -0.004* | -0.004* |
| | (0.002) | (0.003) | (0.002) | (0.002) |
| Retained $Profits_{t-1}$ | 2.773 | 2.096 | 2.569 | 2.796 |
| | (2.465) | (2.095) | (1.817) | (2.043) |
| $GDP_{t-1}$ | 0.031* | 0.025 | 0.026 | 0.030* |
| | (0.017) | (0.018) | (0.017) | (0.017) |
| Observations | 519 | 519 | 519 | 519 |
| Sargan test | 0.68 | 0.76 | 0.81 | 0.65 |
| AR (1) | 0.01 | 0.01 | 0.01 | 0.01 |
| AR (2) | 0.12 | 0.07 | 0.15 | 0.25 |
| Goodness of fit | 0.80 | 0.80 | 0.80 | 0.81 |
| $R^2$ | 0.77 | 0.77 | 0.78 | 0.78 |

**Table 7. Results of the main regression with adjusted definition of the management buffer (2016-2020)**

A fully-loaded CCB is considered in management buffer definition. The regression is estimated by two-way system GMM; endogenous variables are instrumented with two to five lags and the instruments are collapsed. Time and individual fixed effects are included, but the coefficients are suppressed. Indexes *,**,*** represent robust significance levels of 10%, 5% and 1%, respectively, and robust standard errors are reported in parenthesis. P-values are reported for the Sargan test, which refers to the test for over-identification restrictions, and AR(1) and AR(2) tests, which refer to autocorrelation tests. While $R^2$ is not typically reported for the GMM outputs, I include it along with a squared correlation between the predicted and actual variables, which is an equivalent goodness of fit measure used for IV-type regressions.

| | *Dependent variable:* | | | |
|---|---|---|---|---|
| | Management Buffer (fully loaded CCB)$_{i,t}$ | | | |
| | (1) | (2) | (3) | (4) |
| MngmBuff (fully loaded CCB)$_{t-1}$ | 0.728*** | 0.690*** | 0.712*** | 0.696*** |
| | (0.069) | (0.081) | (0.062) | (0.053) |
| Total requirement$_t$ | | -0.124** | | |
| | | (0.048) | | |
| P2R$_t$ | | | -0.010 | -0.024 |
| | | | (0.053) | (0.056) |
| Combined buffer$_t$ | | | -0.256*** | |
| | | | (0.056) | |
| Combined buffer (excl. CCB)$_t$ | | | | -0.263*** |
| | | | | (0.071) |
| CCB$_t$ | | | | -0.207 |
| | | | | (0.257) |
| ROE$_{t-1}$ | -0.012 | -0.006 | -0.003 | -0.0002 |
| | (0.013) | (0.015) | (0.013) | (0.013) |
| Density$_{t-1}$ | -0.038*** | -0.039** | -0.032*** | -0.032*** |
| | (0.013) | (0.016) | (0.012) | (0.012) |
| Z-score$_{t-1}$ | -0.006*** | -0.005** | -0.004** | -0.004** |
| | (0.002) | (0.002) | (0.002) | (0.002) |
| lAssets$_{t-1}$ | -0.328** | -0.365** | -0.271** | -0.273** |
| | (0.129) | (0.152) | (0.122) | (0.109) |
| Subord$_{t-1}$ | -0.015 | -0.027 | -0.006 | -0.014 |
| | (0.074) | (0.074) | (0.057) | (0.060) |
| Provisions$_{t-1}$ | 0.162 | 0.207 | 0.144 | 0.171 |
| | (0.198) | (0.244) | (0.181) | (0.205) |

**Table 7 (continued). Results of the main regression with adjusted definition of the management buffer (2016-2020)**

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| $LoanG_{t-1}$ | -0.004** | -0.005* | -0.005*** | -0.006*** |
| | (0.002) | (0.003) | (0.002) | (0.002) |
| Retained $Profits_{t-1}$ | 2.885 | 2.893 | 3.809 | 3.560 |
| | (4.245) | (4.073) | (3.083) | (3.100) |
| $GDP_{t-1}$ | 0.023 | 0.023 | 0.031 | 0.026 |
| | (0.021) | (0.022) | (0.019) | (0.020) |
| Observations | 519 | 519 | 519 | 519 |
| Sargan test | 0.61 | 0.59 | 0.82 | 0.80 |
| AR (1) | 0.01 | 0.01 | 0.02 | 0.03 |
| AR (2) | 0.04 | 0.05 | 0.07 | 0.08 |
| Goodness of fit | 0.99 | 0.99 | 0.99 | 0.99 |
| $R^2$ | 0.99 | 0.99 | 0.99 | 0.99 |

**Table 8. Long-run coefficient estimates of determinants of capital management buffer**

The table reports the long-run coefficients for the determinants of bank capital management buffers. Calculations are based on the GMM regression results reported in Tables 4, 5, 6. The adjustment speed per period, $\Theta$, is calculated as the difference between 1 and the autoregressive coefficients. The long-run coefficients are calculated as the short-term coefficient over $\Theta$.

| | *Management buffer* | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Main Model 2016-2020 Table 4 | | | | Main Model 2016-2019 Table 5 | | | | Main Model 2016-2020 AR(2) Table 6 | | | |
| Long-run coefficients | (1) | (2) | (3) | (4) | (1) | (2) | (3) | (4) | (1) | (2) | (3) | (4) |
| Adj. speed, $\Theta$ | 0.298 | 0.304 | 0.312 | 0.293 | 0.295 | 0.276 | 0.337 | 0.295 | 0.255 | 0.271 | 0.274 | 0.247 |
| Total requirement$_t$ | | -0.45 | | | | -0.5 | | | | -0.46 | | |
| P2R$_t$ | | | -0.16 | -0.08 | | | -0.25 | -0.16 | | | -0.17 | -0.14 |
| Combined buffer$_t$ | | | -0.92 | | | | -0.87 | | | | -0.84 | |
| Combined buffer (excl. CCB)$_t$ | | | | -0.63 | | | | -0.45 | | | | -0.57 |
| CCB$_t$ | | | | -2.55 | | | | -2.81 | | | | -2.40 |
| ROE$_{t-1}$ | -0.04 | -0.02 | -0.02 | -0.04 | -0.06 | -0.06 | -0.03 | -0.06 | -0.07 | -0.03 | -0.02 | -0.05 |
| Density$_{t-1}$ | -0.12 | -0.12 | -0.11 | -0.14 | -0.18 | -0.15 | -0.13 | -0.16 | -0.11 | -0.11 | -0.1 | -0.1 |
| Z-score$_{t-1}$ | -0.02 | -0.01 | -0.01 | -0.01 | -0.03 | -0.02 | -0.01 | -0.01 | -0.02 | -0.01 | -0.01 | -0.01 |
| lAssets$_{t-1}$ | -1.15 | -1.13 | -0.95 | -1.17 | -1.4 | -1.24 | -1.04 | -1.26 | -1.12 | -1.1 | -0.91 | -1.06 |
| Subord$_{t-1}$ | 0.003 | -0.03 | 0.063 | 0.018 | -0.09 | -0.13 | -0.08 | -0.19 | -0.13 | -0.03 | 0.102 | 0.097 |
| Provisions$_{t-1}$ | 0.294 | 0.433 | 0.231 | 0.347 | 1.06 | 1.291 | 0.717 | 0.966 | 0.415 | 0.602 | 0.375 | 0.071 |
| LoanG$_{t-1}$ | -0.01 | -0.02 | -0.02 | -0.02 | -0.03 | -0.04 | -0.04 | -0.04 | -0.01 | -0.01 | -0.01 | -0.02 |
| Retained Profits$_{t-1}$ | 7.014 | 6.235 | 8.293 | 6.675 | 6.667 | 4.915 | 4.816 | 1.61 | 10.87 | 7.74 | 9.363 | 11.33 |
| GDP$_{t-1}$ | 0.059 | 0.063 | 0.07 | 0.08 | 0.321 | 0.28 | 0.304 | 0.278 | 0.121 | 0.092 | 0.096 | 0.120 |

**Table 9. Results of the capital ratio levels regression**

The dependent variable is a bank's CET1 capital ratio. The regression is estimated by two-way system GMM; endogenous variables are instrumented with two to five lags and the instruments are collapsed. Time and individual fixed effects are included, but the coefficients are suppressed. Indexes *,**,*** represent robust significance levels of 10%, 5% and 1%, respectively, and robust standard errors are reported in parenthesis. P-values are reported for the Sargan test, which refers to the test for over-identification restrictions, and AR(1) and AR(2) tests, which refer to autocorrelation tests. While $R^2$ is not typically reported for the GMM outputs, I include it along with a squared correlation between the predicted and actual variables, which is an equivalent goodness of fit measure used for IV-type regressions.

| | *Dependent variable:* | | | |
|---|---|---|---|---|
| | CET1 $ratio_{i,t}$ | | | |
| | (1) | (2) | (3) | (4) |
| CET1 $ratio_{t-1}$ | 0.858*** | 0.605*** | 0.588*** | 0.599*** |
| | (0.059) | (0.103) | (0.118) | (0.110) |
| Total $requirement_t$ | | 0.195** | | |
| | | (0.087) | | |
| $P2R_t$ | | | 0.351** | 0.355** |
| | | | (0.147) | (0.145) |
| Combined $buffer_t$ | | | 0.022 | |
| | | | (0.115) | |
| Combined buffer (excl. CCB) $_t$ | | | | 0.054 |
| | | | | (0.131) |
| $CCB_t$ | | | | -0.193 |
| | | | | (0.307) |
| $ROE_{t-1}$ | -0.007 | -0.013 | -0.009 | -0.010 |
| | (0.017) | (0.019) | (0.020) | (0.019) |
| $Density_{t-1}$ | -0.037*** | -0.038** | -0.041** | -0.040** |
| | (0.009) | (0.018) | (0.020) | (0.019) |
| Z-$score_{t-1}$ | -0.005** | -0.003 | -0.004 | -0.004 |
| | (0.002) | (0.003) | (0.003) | (0.003) |
| $lAssets_{t-1}$ | -0.179** | -0.353** | -0.358** | -0.363** |
| | (0.079) | (0.174) | (0.180) | (0.179) |
| $Subord_{t-1}$ | -0.002 | -0.037 | -0.023 | -0.029 |
| | (0.048) | (0.091) | (0.094) | (0.102) |
| $Provisions_{t-1}$ | 0.445* | 0.128 | 0.012 | 0.046 |
| | (0.239) | (0.214) | (0.316) | (0.293) |
| $LoanG_{t-1}$ | -0.008** | -0.009*** | -0.008*** | -0.008*** |
| | (0.004) | (0.003) | (0.003) | (0.003) |

**Table 9 (continued). Results of the capital ratio levels regression**

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| Retained Profits$_{t-1}$ | 2.514 | 2.532 | 2.559 | 2.749 |
| | (2.413) | (3.664) | (3.590) | (3.852) |
| GDP$_{t-1}$ | 0.023 | 0.024 | 0.032$^{*}$ | 0.033$^{*}$ |
| | (0.020) | (0.018) | (0.019) | (0.019 |
| Observations | 519 | 519 | 519 | 519 |
| Sargan test | 0.28 | 0.65 | 0.58 | 0.58 |
| AR (1) | 0.01 | 0.00 | 0.00 | 0.01 |
| AR (2) | 0.25 | 0.12 | 0.12 | 0.14 |
| Goodness of fit | 0.95 | 0.96 | 0.96 | 0.96 |
| $R^2$ | 0.94 | 0.95 | 0.96 | 0.96 |

**Table 10. Long-run coefficient estimates of determinants of CET1 capital levels**

The table reports the long-run coefficients for the determinants of bank capital ratio levels. Calculations are based on the GMM regression results reported in Table 9. The adjustment speed per period, *Θ*, is calculated as the difference between 1 and the autoregressive coefficient. The long-run coefficients are calculated as the short-term coefficient over *Θ.*

| | *CET 1 ratio* | | | |
|---|---|---|---|---|
| | Model (Table 9) | | | |
| Long-run coefficients | 1 | 2 | 3 | 4 |
| *Adj. speed, Θ* | 0.142 | 0.395 | 0.412 | 0.401 |
| Total requirement$_t$ | | 0.492 | | |
| P2R$_t$ | | | 0.852 | 0.885 |
| Combined buffer$_t$ | | | 0.054 | |
| Combined buffer (excl. CCB)$_t$ | | | | 0.135 |
| CCB$_t$ | | | | -0.48 |
| ROE$_{t-1}$ | -0.05 | -0.03 | -0.02 | -0.03 |
| Density$_{t-1}$ | -0.26 | -0.1 | -0.1 | -0.1 |
| Z-score$_{t-1}$ | -0.04 | -0.01 | -0.01 | -0.01 |
| lAssets$_{t-1}$ | -1.26 | -0.89 | -0.87 | -0.9 |
| Subord$_{t-1}$ | -0.02 | -0.1 | -0.06 | -0.07 |
| Provisions$_{t-1}$ | 3.136 | 0.324 | 0.03 | 0.116 |
| LoanG$_{t-1}$ | -0.06 | -0.02 | -0.02 | -0.02 |
| Retained Profits$_{t-1}$ | 17.72 | 6.405 | 6.212 | 6.852 |
| GDP$_{t-1}$ | 0.166 | 0.062 | 0.077 | 0.082 |

**Table 11. Robustness check model for total capital requirement variable**

The table reports the coefficients for the determinants of bank capital management buffers. Indexes *,**,*** represent robust significance levels of 10%, 5% and 1%, respectively, and robust standard errors are reported in parenthesis. The IV regression uses banking group headquarters' location latitude as an instrumental variable for the density variable. FE stands for various fixed-effect specifications.

| | *Dependent variable:* | | | | |
|---|---|---|---|---|---|
| | Management Buffer$_{i,t}$ | | | | |
| | Pooled OLS | Bank&Time FE | Bank FE | Time FE | IV-regression |
| | (1) | (2) | (3) | (4) | (5) |
| Total requirement$_t$ | -0.414*** | -0.197*** | -0.242*** | -0.401*** | -0.468*** |
| | (0.044) | (0.045) | (0.046) | (0.044) | (0.049) |
| ROE$_{t-1}$ | -0.035 | 0.024 | 0.015 | -0.032 | 0.054 |
| | (0.027) | (0.020) | (0.021) | (0.027) | (0.037) |
| Density$_{t-1}$ | -0.058*** | -0.053*** | -0.057*** | -0.055*** | -0.129*** |
| | (0.011) | (0.021) | (0.021) | (0.011) | (0.041) |
| Z-score$_{t-1}$ | -0.003 | -0.032 | -0.031 | -0.003 | -0.008* |
| | (0.003) | (0.022) | (0.021) | (0.003) | (0.005) |
| lAssets$_{t-1}$ | -0.898*** | -2.736*** | -2.491*** | -0.891*** | -1.149*** |
| | (0.090) | (0.831) | (0.841) | (0.089) | (0.162) |
| Subord$_{t-1}$ | -0.219** | -0.124 | -0.166 | -0.183* | -0.243** |
| | (0.105) | (0.106) | (0.108) | (0.107) | (0.107) |
| Provisions$_{t-1}$ | -1.307** | -0.682* | -0.571 | -1.511*** | 0.179 |
| | (0.508) | (0.370) | (0.379) | (0.510) | (0.955) |
| LoanG$_{t-1}$ | -0.023** | -0.003 | -0.004 | -0.022** | -0.035*** |
| | (0.010) | (0.006) | (0.007) | (0.010) | (0.011) |
| Retained Profits$_{t-1}$ | 1.633 | 9.770 | 9.773 | 0.737 | -0.271 |
| | (3.179) | (6.275) | (6.485) | (3.173) | (3.185) |
| GDP$_{t-1}$ | -0.006 | -0.078** | -0.094*** | 0.073 | -0.015 |
| | (0.040) | (0.036) | (0.027) | (0.054) | (0.042) |
| Constant | 23.160*** | | | | 29.243*** |
| | (1.426) | | | | (3.676) |
| Observations | 456 | 456 | 456 | 456 | 501 |
| $R^2$ | 0.332 | 0.804 | 0.778 | 0.358 | 0.285 |
| Adjusted $R^2$ | 0.317 | 0.766 | 0.741 | 0.332 | 0.270 |

**Table 12. Robustness check model for two capital requirement components**

The table reports the coefficients for the determinants of bank capital management buffers. Main variables of interest are P2R and the combined buffer requirement. Indexes *,**,*** represent robust significance levels of 10%, 5% and 1%, respectively, and robust standard errors are reported in parenthesis. The IV regression uses banking group headquarters' location latitude as an instrumental variable for the density variable. FE stands for various fixed-effect specifications.

| | *Dependent variable:* | | | | |
|---|---|---|---|---|---|
| | Management $Buffer_{i,t}$ | | | | |
| | Pooled OLS | Bank&Time FE | Bank FE | Time FE | IV-regression |
| | (1) | (2) | (3) | (4) | (5) |
| $P2R_t$ | $-0.223^{***}$ | 0.017 | $-0.127^{**}$ | -0.092 | $-0.340^{***}$ |
| | (0.060) | (0.056) | (0.050) | (0.068) | (0.068) |
| Combined $buffer_t$ | $-0.720^{***}$ | $-0.801^{***}$ | $-0.637^{***}$ | $-0.828^{***}$ | $-0.731^{***}$ |
| | (0.075) | (0.113) | (0.086) | (0.083) | (0.079) |
| $ROE_{t-1}$ | -0.027 | 0.018 | 0.005 | -0.020 | $0.093^{**}$ |
| | (0.026) | (0.019) | (0.020) | (0.026) | (0.037) |
| $Density_{t-1}$ | $-0.056^{***}$ | $-0.052^{***}$ | $-0.063^{***}$ | $-0.052^{***}$ | $-0.176^{***}$ |
| | (0.011) | (0.020) | (0.021) | (0.011) | (0.039) |
| $Z\text{-}score_{t-1}$ | -0.002 | -0.029 | -0.005 | -0.001 | $-0.012^{**}$ |
| | (0.003) | (0.021) | (0.021) | (0.003) | (0.005) |
| $lAssets_{t-1}$ | $-0.816^{***}$ | $-2.565^{***}$ | $-1.941^{**}$ | $-0.769^{***}$ | $-1.250^{***}$ |
| | (0.088) | (0.797) | (0.819) | (0.088) | (0.161) |
| $Subord_{t-1}$ | $-0.223^{**}$ | -0.076 | $-0.213^{**}$ | -0.122 | $-0.245^{**}$ |
| | (0.102) | (0.102) | (0.104) | (0.103) | (0.112) |
| $Provisions_{t-1}$ | $-1.397^{***}$ | $-0.760^{**}$ | $-0.814^{**}$ | $-1.566^{***}$ | 1.106 |
| | (0.494) | (0.355) | (0.369) | (0.490) | (0.926) |
| $LoanG_{t-1}$ | $-0.021^{**}$ | -0.002 | -0.002 | $-0.020^{**}$ | $-0.039^{***}$ |
| | (0.010) | (0.006) | (0.006) | (0.010) | (0.012) |
| Retained $Profits_{t-1}$ | 2.925 | 9.910 | $13.195^{**}$ | 2.482 | 0.570 |
| | (3.099) | (6.021) | (6.298) | (3.063) | (3.374) |
| $GDP_{t-1}$ | -0.017 | $-0.067^{*}$ | $-0.101^{***}$ | 0.075 | 0.002 |
| | (0.039) | (0.035) | (0.027) | (0.052) | (0.045) |
| Constant | $20.566^{***}$ | | | | $30.448^{***}$ |
| | (1.341) | | | | (3.413) |
| Observations | 456 | 456 | 456 | 456 | 501 |
| $R^2$ | 0.372 | 0.820 | 0.794 | 0.408 | 0.209 |
| Adjusted $R^2$ | 0.357 | 0.785 | 0.760 | 0.382 | 0.191 |

**Table 13. Robustness check model for three capital requirement components**

The table reports the coefficients for the determinants of bank capital management buffers. Main variables of interest are P2R and two combined buffer requirement components. Indexes *,**,*** represent robust significance levels of 10%, 5% and 1%, respectively, and robust standard errors are reported in parenthesis. The IV regression uses banking group headquarters' location latitude as an instrumental variable for the density variable. FE stands for various fixed-effect specifications.

| | Management Buffer$_{i,t}$ | | | | |
|---|---|---|---|---|---|
| | Pooled OLS | Bank&Time FE | Bank FE | Time FE | IV-regression |
| | (1) | (2) | (3) | (4) | (5) |
| P2R$_t$ | -0.210*** | 0.022 | -0.124** | -0.080 | -0.331*** |
| | (0.061) | (0.056) | (0.051) | (0.070) | (0.071) |
| Combined buffer (excl. CCB)$_t$ | -0.804*** | -0.667*** | -0.681*** | -0.784*** | -0.867*** |
| | (0.101) | (0.152) | (0.159) | (0.100) | (0.113) |
| CCB$_t$ | -0.451** | -1.082*** | -0.589*** | -1.100*** | -0.380* |
| | (0.227) | (0.242) | (0.168) | (0.356) | (0.230) |
| ROE$_{t-1}$ | -0.022 | 0.017 | 0.006 | -0.023 | 0.108*** |
| | (0.027) | (0.019) | (0.020) | (0.026) | (0.037) |
| Density$_{t-1}$ | -0.056*** | -0.051*** | -0.062*** | -0.052*** | -0.190*** |
| | (0.011) | (0.020) | (0.021) | (0.011) | (0.038) |
| Z-score$_{t-1}$ | -0.002 | -0.030 | -0.006 | -0.001 | -0.013*** |
| | (0.003) | (0.021) | (0.022) | (0.003) | (0.005) |
| lAssets$_{t-1}$ | -0.794*** | -2.471*** | -1.984** | -0.780*** | -1.268*** |
| | (0.090) | (0.799) | (0.830) | (0.089) | (0.162) |
| Subord$_{t-1}$ | -0.204** | -0.079 | -0.209** | -0.123 | -0.226* |
| | (0.103) | (0.102) | (0.105) | (0.103) | (0.116) |
| Provisions$_{t-1}$ | -1.379*** | -0.754** | -0.810** | -1.562*** | 1.405 |
| | (0.494) | (0.355) | (0.370) | (0.491) | (0.920) |
| LoanG$_{t-1}$ | -0.022** | -0.002 | -0.002 | -0.020** | -0.041*** |
| | (0.010) | (0.006) | (0.006) | (0.010) | (0.012) |
| Retained Profits$_{t-1}$ | 3.065 | 9.441 | 13.176** | 2.441 | 0.710 |
| | (3.099) | (6.025) | (6.306) | (3.065) | (3.459) |
| GDP$_{t-1}$ | -0.008 | -0.065* | -0.100*** | 0.074 | 0.026 |
| | (0.040) | (0.035) | (0.027) | (0.052) | (0.046) |
| Constant | 19.730*** | | | | 30.582*** |
| | (1.497) | | | | (3.475) |
| Observations | 456 | 456 | 456 | 456 | 501 |
| $R^2$ | 0.375 | 0.821 | 0.795 | 0.408 | 0.172 |
| Adjusted $R^2$ | 0.358 | 0.785 | 0.759 | 0.381 | 0.151 |

**END OF MASTER THESIS I**

# MASTER THESIS II

Stockholm School of Economics
Department of Finance
Master's Thesis (M.Sc. Finance)
Fall 2021

# European Bank Capital Requirements and Balance Sheet Adjustments

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## Abstract

This thesis focuses on the association between bank regulatory capital requirements and the balance sheet adjustment of European banks. Specifically, I test if additional bank-specific capital requirements tend to affect the growth of risk-weighted assets, regulatory capital assets, and gross loans. The data set covers 57 European banks in the period of 2016-2020 and includes publicly available information on bank-specific capital requirements. While additional capital requirements appear to have a direct negative effect on the growth of risk-weighted assets and the growth of regulatory capital, the analysis does not show evidence for a similar impact on the growth of total assets and gross loans. However, if banks are assumed to hold the voluntary capital buffers constant then the negative effect on the growth of risk-weighted assets is even larger, while the overall effect on the growth of regulatory capital is zero.

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# 1. Introduction

The capital requirements and ratios of European banks have been increased substantially since the global financial crisis in 2008. This is a result from structural changes in bank risks management practices and the regulatory framework that puts much more attention to the quality and amount of bank capital. This thesis is an empirical study on European bank balance sheet adjustments in response to capital requirements during the 2016-2020 period when the Basel III capital buffer framework was gradually implemented in Europe. Particularly, I focus on the growth of risk-weighted assets, regulatory capital as well as assets and gross loan amount in response to changes in capital requirements. Balance sheet and risk-weighted asset dynamics are relevant for policymakers as changes in the bank balance sheets and risk-taking have broader macroeconomic consequences. Banks generally can adjust capital ratio through alteration of equity, risk exposures or through "on paper" regulatory capital calculation adjustments or a mix of all these strategies (Gropp et al., 2021). Policymakers typically want to limit excessive deleveraging effect i.e., a reduction of bank assets in response to additional capital requirements that could cause credit supply shock. On the other hand, policymakers want to limit excessive risk-taking to ensure long term financial stability of the overall financial system.

This thesis aims to contribute to the existing literature on the capital requirement interaction with the recently adopted bank regulatory framework in Europe. While there is substantial literature on the subject, most of it focuses on banks within single jurisdiction and time periods around the global financial crisis period. I extend the study of de-Ramon et al. (2021) that focuses on UK banks around the crisis period by examining unbalanced semi-annual multi-country panel data of 57 banks during the period from 2016-2020. The data set used in this paper is the same one used by Puharts (2021) that contains hand-collected capital requirement data from public sources such as Pillar 3 reports, public financial statements and investor presentations. Even though the sample is small, a major advantage of this data set is the availability of Pillar 2 requirement that is generally known only to banks and supervisors and not disclosed in a single information source. This allows to investigate overall capital requirement impact. In addition, I compliment Puharts (2021) by investigating what balance sheet adjustments are done by banks if one assumes that management buffers are kept constant or completely changed as a reaction to capital requirements. In both scenarios, I find evidence of substantial reduction of growth of risk-weighted assets, but no evidence of an effect on assets or loans. Mixed evidence is when it comes to the growth of regulatory capital. If one assumes constant management buffers, then it appears that banks do not significantly alter the growth of regulatory capital when new capital requirements are introduced.

The remainder of the thesis is organised in the following way: section 2 describes a brief background in the regulatory framework in the European banking sector and reviews the literature on optimal levels of capital, bank behaviour in response to capital requirements. Section 3 lays out the empirical strategy. Section 4 provides a description of data collection considerations and some stylised facts. Section 5 is devoted to empirical results and, lastly, section 6 is dedicated to conclusions.

## 2. Background and literature review

After the global financial crisis, the Basel Committee of Banking Supervision (BCBS) agreed on a new package of bank regulatory and supervisory standards and recommendations, known as Basel III. A major part of the new package introduced a new capital requirement framework for banks by introducing various new capital buffers, by redefining regulatory capital. The Capital Requirements Regulation (CRR) and the Capital Requirements Directive (CRD) lays out the rules for Basel III framework implementation in the European Union (Directive 2013/36; Regulation 575/2013). The provisions with respect to the capital requirement framework were gradually phased in from 2016 to 2019. In principle, the regulatory capital ratio is simply regulatory capital, which does not correspond to the accounting definition of the equity, divided by risk-weighted assets (RWA), which can be thought of as assets weighted by risk coefficients to reflect different levels of risk for different asset classes. However, the capital requirement framework is complex and full of jargon which I try to summarise over the next few paragraphs and in Figure 1 .

Regulatory capital consists of Common Equity Tier 1 (CET1), Additional Tier 1 (AT1) and Tier 2 (T2) capital. CET1 capital, which mostly consists of ordinary common equity, is the core capital that ensures the going concern of a bank. However, Basel III rules do not require to meet capital requirements entirely with CET1 capital, but it is up to banks as long as they meet the minimum standards of regulatory capital quality. Shortfalls up to pre-defined minimum levels in total capital requirement can be met with a mix of hybrid instruments that fall under the definitions of Additional Tier 1 and Tier 2 instruments. For instance, one of the components in total capital requirement is the Pillar 1 requirement (P1R) that stipulates that bank regulatory capital shall be 8% of risk-weighted assets consisting of minimum CET1 requirement of 4.5%, AT1 capital requirement of 1.5% and T2 capital requirement of 2%. AT1/T2 capital shortfalls must be met with higher quality capital e.g., CET1 capital. In addition to P1R, bank supervisors set a bank-specific capital requirement, so-called Pillar 2 requirement (P2R). The last component of the overall capital requirement the combined buffer requirement (CBR). Specifics regarding the Pillar 2 requirement and the combined buffer requirement are explained in the next few paragraphs.

Pillar 2 capital requirements (also known as SREP capital requirements) warrant a special mention since they are a major source of data issues in this paper. P2R is set by bank supervisors. In the case of significantly important institutions in the Banking Union, the P2R is set by the supervisory leg of the European Central Bank. National competent authorities are responsible for setting P2R for less significant institutions in the Banking Union as well as for all institutions that are based in the European Union but are not part of the Banking Union. The issue with the P2R is that historically banks have been reluctant to disclose their requirements due to the perceived market sensitivity of such information (Magnus & De Biase, 2020). Disclosure has been encouraged but not always done partially because banks feared the signalling effect of higher bank-specific requirements compared to peers. This is the reason why the sample size of this study is somewhat limited. Fortunately, the transparency has improved over the years. It's worth mentioning that in addition to P2R there is Pillar 2 Guidance (P2G) which is a bank-specific "soft requirement" based on stress test results. While a breach of P2G does not lead to restrictions (i.e., the maximum distributable amount (MDA) trigger level does not include P2G), it can lead to increased supervisory measures. Bank-level P2G data is particularly rarely disclosed, thus not included in the analysis.

The capital conservation buffer (CCB), the countercyclical buffer (CCyB) and the maximum of the systemic risk buffer (SRB), the other systemically important institution (O-SII) buffer or the globally systemically important institution (G-SIB) buffer together make the combined buffer requirement. All components of the combined buffer requirement had a phase-in period from 2016 to 2019 and national macroprudential authorities have the discretion to set all but the capital conservation buffer to the levels they see fit within certain ranges.

The aforementioned components of the capital requirements each serve a different purpose and address a different financial risk or externality. While banks are expected to hold regulatory capital above the total requirement, the consequences of a breach vary depending on which requirement is breached. Some breaches lead to just increased supervisory scrutiny and capital distribution restrictions, while other breaches of capital requirements could lead to a loss of licence or a bank resolution. In addition, the period covered in this paper is mostly a phase-in period when all the requirements were gradually increased over time (i.e., so-called "Danish compromise").

In this paper, I narrow the scope and focus on the total CET1 capital requirement and how it affects the balance sheet of banks. In other words, I do not separately look at the impact of Tier 1 or total capital requirement. The issue of balance sheet adjustments has always been high on the agenda of the financial regulators due to wider implications to the economy. Typically, regulators prefer additional capital requirements to be met with additional equity (the numerator of the capital ratio), for instance, through retained earnings or new equity issuances. That's because alternatives are either contraction in credit supply that can affect economy or migration to the shadow banking system which not necessarily is safer from the overall financial stability point of view. For substantial changes in regulatory requirement phase-in periods are used partially because of the costs associated with raising new capital (Kashyap et al., 2010). Banks can also adjust the denominator of the regulatory capital ratio – risk-weighted assets. A sharp reduction in risk-weighted assets can imply deleveraging or on paper" regulatory capital calculation adjustments or a mix of all these strategies (Gropp et al., 2021).

Positive relationship between the growth of risk-weighted assets and the capital requirement increase might imply incentives for risk-taking. Gropp et al. (2019) use a quasi-natural experiment around the 2011 EBA capital exercise event to identify the relationship between capital requirements and credit supply and density (risk-weighted assets as a share of total assets). They identify a significant negative effect with respect to the former. Other studies also find a relationship with respect to risk-weighted assets e.g., Dautović (2019) finds that additional capital requirements lead to an increase in the average risk weight of the bank asset portfolio.

De Marco & Wieladek (2015) find evidence of contraction in small and medium-sized enterprise asset portfolios in the first year respectively as a response to a 1% rise in capital requirements for UK banks. Capital-constrained banks tend to have more pronounced balance sheet adjustments. Cappelletti et al. (2020) find that banking groups with tight capital reserves curb their lending and risk-taking in their cross-border subsidiaries. Bridges et al. (2014) find that capital requirements have a heterogeneous effect on lending to different sectors. They also note that their evidence is based on the transition period just before and three years after the crisis when banks started adjusting to the new regulatory framework.

An alternative view is proposed by Begenau (2020) who challenges the idea that capital requirements necessarily reduce lending by incorporating macro-finance type of general equilibrium ideas in optimal bank capital level capital framework. The main argument is that under certain conditions overall effect can be positive on the cost of financing and even boost bank lending in general equilibrium. In fact, Admati et al. (2013) advocate capital requirements as high as 30% on total assets rather than risk-weighted assets by arguing that the marginal benefits would far exceed costs. Interestingly, the countercyclical capital buffer regime relies on the idea that banks behave in a procyclical manner and additional requirements would tame the lending activity. Several studies show that both countercyclical capital requirements, as well as other requirement components, affect credit supply in the economy (Aiyar et al., 2014; De Jonghe et al., 2020).

Recent papers focus on bank responses to the Covid-19 crisis. For instance, the loan growth decline has been more prominent in countries with greater intensity of the Covid-19 health crisis (Çolak & Öztekin, 2021). There is empirical evidence that European banks with low capital had relatively more loans issued during the Covid-19 crisis, which is in line with the zombie lending hypothesis (Dursun-de Neef & Schandlbauer, 2021).

In this thesis, I extend the work by Puharts (2021) by using the same dataset, but focusing on the balance sheet adjustments of European banks in response to higher capital requirements. In other words, rather than exploring factors affecting management buffers and capital ratio levels, I focus on finding evidence for strategies banks have used to achieve their capital ratio levels. The empirical strategy is similar to the one employed by de-Ramon et al. (2021) to investigate the capital requirement effect on UK bank balance sheets.

## 3. Methodology

I follow the methodology that is used by de-Ramon et al. (2021) to test the relationship between capital requirements and balance sheet changes. Specifically, I test the impact of changes in capital requirements to change in assets, risk-weighted assets, CET 1 capital and loan book. I regress the changes in these balance sheet items on the lagged values of capital requirements, capital ratios, bank-specific and macroeconomic control variables as well as firm fixed effects. The model is specified as follows:

$$\Delta lnBS_{jit} = \beta_1 CR_{i,t-1} + \beta_2 CET1_{i,t-1} + \beta_3 \Delta GDPG_{i,t-1} + \beta_4 \Delta Provisions_{i,t-1} + \alpha_i + \varepsilon_{i,t}, \tag{1}$$

where $\Delta lnBS_{jit}$ reflects the change in one of the balance sheet dimensions (i.e., change in assets, risk-weighted assets, CET 1 capital or loan book) for a bank *i* and at time *t*. The parameter $\alpha_i$ is bank fixed effects, $\varepsilon$ is the error term, parameters, $\beta$, are the corresponding coefficients for the explanatory variables. The main explanatory variables are CET 1 capital requirement, $CR$, and CET 1 capital ratio, CET1. To account for bank-specific credit conditions and macroeconomic environment, I add xxx. *GDPG* is the growth of GDP in the county, where the banking group is domiciled.

There are several hypotheses relevant to the research question. First two hypotheses relate to whether $\beta_1$and $\beta_2$are equal to zero. In other words, if balance sheet adjustments are directly associated with changes in capital requirements or CET1 capital ratio levels. The coefficient $\beta_1$reflects the impact of one percentage point change in capital requirement on the growth of a balance sheet dimension all other things constant. Analogously, $\beta_2$captures the effect of an additional percentage point in capital ratio level, holding everything else constant. It should be noted that, if a capital ratio of a bank is higher than the capital requirements, then there might not be a direct effect coming from the change in capital requirement since it is not a binding requirement.

The direct effects, however, assume that banks do not hold voluntary management buffers. In truth, banks often hold management buffers on top of requirements (de-Ramon et al., 2021; Puharts, 2021). For instance, if a bank targets a specific management buffer then an increase in capital requirement would coincide with an equivalent increase in capital ratio. Thus, the third hypothesis follows the approach of de-Ramon et al. (2021) and tests if $\beta_1 + \beta_2 = 0$. This tests whether the impact of changes in capital requirements are statistically significant, assuming that banks hold constant management buffers. In the case the sum of coefficients would not be statistically significant in combination that coefficient on the actual ratio is significantly different from zero, the evidence would be consistent with indirect effect channel i.e., balance sheet adjustment through voluntary buffer channel.

## 4. Data

I use the same data set as Puharts (2021), namely, an unbalanced semi-annual bank-level panel data covering 57 European banking groups from 21 European countries in the period of 2016 till the end of 2020. The sample in the data set is mostly constrained by the disclosures of Pillar 2 requirement data. Most of the sample banks are publicly listed and supervised by the ECB, and all participate in the EBA's transparency exercise, which is the main data source together with Capital IQ. The size of the assets is on average around 363 billion euros, ranging from 632 million to 2623 billion euros in assets.

The data is collected on the highest level of consolidation of the banking groups. Foreign banking groups that have subsidiaries in Europe are excluded from the sample, because capital allocation decisions are assumed to most likely be taken at the group level outside Europe. Therefore, it is not meaningful to interpret empirical data on local subsidiaries. Some extreme outlier banks with high capital requirements levels are excluded from the sample. For instance, while the average Pillar 2 requirement is around 3%, one Swedish bank has a Pillar 2 requirement of 112% of risk-weighted assets.

Data sources and variable descriptions are shown in Table 1. The sources of capital requirement data are financial statements, Pillar 3 disclosures, investor presentations and supervisory authority websites. The capital requirement, CR, is calculated as follows:

$$CR_{it} = P2R_{it} + CBR_{it} + 4.5\% , \tag{2}$$

where i an t are bank and time indices, P2R is a bank-specific Pillar 2 capital requirement, and the 4.5% is the minimum CET1 requirement, according to the CRR. CBR is the combined buffer requirement and is calculated as follows:

$$CBR_{it} = CCB_{it} + CCyB_{it} + Max\,\{SRB_{it}, OSIIB_{it}, GSIIB_{it}\}\,, \qquad (3)$$

where CCB is the capital conservation buffer requirement, the CCyB is the countercyclical capital buffer. SRB, OSIIB and GSIIB are systemic risk buffer, other systemically important institution and globally systemically important institution buffer requirements respectively. Figure 2 depicts density plots of the CET1 capital requirements by year. One can observe that the means have gradually increased to around 10% over the years and the distribution has become more concentrated. The gradual increase can be partially explained by phase-in periods in the capital requirements framework during the 2016 – 2019 period. 2020 figures are slightly different since supervisory authorities introduced CET1 requirement relief measures in response to the Covid-19 crisis. Some released just the CCyB buffers while the ECB went further by frontloading the CRDV (the directive that updates the CRDIV) by requiring only 56.25% instead of 100% of the Pillar 2 requirement to be met with CET1 capital (ECB, 2021a).

Figure 3 shows that the distribution of the capital ratio levels has been relatively stable over the years. As argued by Puharts (2021), the capital ratios might be more stable than the capital requirements because banks frontloaded and planned additional capital for some of the phased-in requirements already before the beginning of the sample period in 2016, for instance, the capital conservation buffer that was gradually increased from 0% in 2014 to 2.5% in 2019.

The correlation matrix of the relevant variables is depicted in Figure 4. Generally, the correlations are less than 0.32 in absolute terms with one exception – the correlation between the capital requirements and the capital ratios of 0.5. So, banks with higher capital requirements tend to have higher capital ratios. Tables 2 and 3 show summary statistics of the variables.

## 5. Empirical results

Table 4 reports the results of the estimated model that is specified in equation (1). The four columns in the table 4 represent results for four dependent variables, i.e., the growth of risk-weighted assets, growth of assets, growth of CET1 capital and growth of gross loans. The estimation period cover years 2016-2020, thus including the Covid-19 crisis. While not reported, the results are similar to the ones if the model is re-estimated by excluding 2020 from the data set.

The first observation is that the capital requirements affect both the numerator and denominator of the regulatory capital ratio. So, the growth of both the risk-weighted assets and CET1 capital has a statistically significant relationship with the capital requirements. In other words, I reject the hypothesis that $\beta_1 = 0$ in both the model for the growth of risk-weighted assets and the growth of CET1 capital. The results is consistent with previous literature. The sign in both cases is negative, therefore additional capital requirement reduces the growth of risk-weighted assets and regulatory capital, holding everything else constant (including the capital ratio level, thus effectively changing management buffer size). The negative relationship between capital requirements and the growth of risk-weighted assets is consistent with a reduced risk-taking and deleveraging behaviour of banks in response to capital requirements. This contrasts, for example, Dautović (2019) that finds evidence for banks engaging in more risk-taking after an increase in capital requirements. So, an additional percentage point in capital requirements leads to an almost 1 pp reduction in the risk-weighted asset growth and 3.6 pp in the CET1 capital growth. The large impact on the CET1 capital growth is largely driven by an outlier bank - *Banca Monte dei Paschi di Siena S.p.A.* If the bank is excluded from the sample, the size of the coefficient changes from -3.6 to -1.6. While the signs of the effect on the risk weighted-assets are consistent with one found in a similar study on UK banks (de-Ramon et al., 2021), the magnitude is larger. The negative impact on the growth of capital is somewhat surprising. One would expect that banks would rather keep the capital growth close to zero (i.e., reduce risk-weighted assets) or increase the regulatory capital. This would warrant further examination.

The second observation is that the empirical evidence does not suggest an association between capital requirements or capital ratios and asset or loan growth. This is somewhat surprising since previous studies find such a relationship (Berrospide & Edge, 2010; de-Ramon et al., 2021). Cohen (2013), however, presents findings that banks after crisis mostly adjust to capital requirements by accumulating retained earnings rather than by reduction of asset and lending growth. All in all, my finding is not necessarily inconsistent with the results I get for the growth of risk-weighted assets. Banks might use strategies to optimise risk-weighted assets while keeping asset and loan growth relatively stable.

The null hypothesis for the coefficient for capital ratio, $\beta_2 = 0$, is rejected only in the risk-weighted asset and capital equations. While the CET1 capital ratio is negatively associated with risk-weighted asset growth, it is positively associated with CET1 capital growth ceteris paribus. This implies, that $\beta_1$and $\beta_2$have opposite signs and possible moderating effects. To examine this closer I test the joint hypothesis that $\beta_1 + \beta_2 = 0$. Such a test provides a better view of what is the effect if both the capital ratio and the capital requirement increase by 1 percentage point at the same time (thus, the assumption is that the capital buffer remains the same). The joint test shows that only risk-weighted asset growth is affected negatively i.e., if we assume constant management buffers then the effect on risk-weighted assets is even larger than the direct effect described previously. In other cases, I could not reject the hypothesis that a joint equal increase in capital requirements and ratios does not affect the growth of CET1 capital, assets and loans. The fact that the sum of the two coefficients is insignificant in the case of CET1 capital together with the significant coefficient for the CET1 capital ratio variable is consistent with capital requirements affecting bank balance sheet through capital buffer channel. For example, if the capital ratio of a bank increases by 1pp, the capital growth increases by 4.36 pp, however, if this is a response to capital requirements and banks hold constant management buffers then the total effect is zero. Since there is evidence that banks hold substantial management buffers (Andreeva et al., 2020; Lubberink, 2020; Melis & Weissenberg, 2019; Puharts, 2021), then I interpret that overall the sample banks reduce the growth rate of their risk-weighted assets by 2.2 percentage points in response to an additional 1 percentage point capital requirement, while the capital remains relatively stable.

In Table 5, I report results for a similar model that includes intersection terms with a dummy variable if a bank is a capital-constrained bank. I assume that a bank is capital constrained if the capital ratio is below the sample median. The results are largely consistent with the previous model but indicate that the negative effect on the regulatory capital is driven by the capital constrained-banks. Thus, the counterintuitive result is largely driven by banks with lower capital ratios.

When it comes to the limitations of the study, there are some study design issues that are challenging to overcome. One can argue about endogeneity issues in such panel data analysis on banks, e.g., what if loan growth affects the capital requirements, however, I assume that bank supervisors decide exogenously. I use a partial equilibrium framework, and therefore no feedback loops between the economy and banks are considered. Another issue is the capital requirement timing and bank expectations. I assume that banks react to the capital requirement applicable in the previous period, i.e., 6 months before. However, in some instances banks build expectations and capital in advance, maybe even years in advance. As an example, if banks expect Basel IV requirements to be fully in force in 2028, they might be adjusting their balance sheet and keeping surplus buffers already now to provide confidence to financial markets. Also, my control variable for macroeconomic conditions is a simplified proxy. I use the GDP growth for a country where bank has headquarters, however more precise measure would be GDP growth weighted by exposures to different countries. Lastly, the data set mostly covers large publicly listed banks that historically have chosen to disclose their capital requirements. Even though the range of size and complexity of banks in the sample is, there might be inherent selection bias. For instance, large, transparent and publicly listed banks might have market pressure to behave in a certain way in response to capital requirements. In addition, larger banks have different capital requirements due to systemic importance. In future research, the cross-sectional sample can be improved since the ECB started to publish the Pillar 2 requirement data for all its supervised banks. Las

## 6. Conclusion

This thesis empirically examines the association between European bank-specific regulatory capital requirements and growth in risk-weighted assets, regulatory capital, assets and loans during the period 2016-2020. The data set covers 57 European banks and includes publicly available information on bank-specific capital requirements. The methodological framework reviews two scenarios – how banks react to capital requirement increase if they adjust management buffer size, i.e., the difference between required and actual capital ratio, and if they keep the buffer constant. In either scenario, I do not find empirical evidence that the growth of assets or loans are affected. However, evidence shows that banks tend to reduce the growth of risk-weighted assets in both scenarios. However, the banks appear not to change the growth of the regulatory capital if we assume constant management buffers.

There are several limitations to the methodological framework, for instance, timing issue of capital requirement announcement and expectation, potential endogeneity and feedback effects. However, policymakers should be aware of the indications that banks tend to reduce risk-weighted assets in response to additional capital requirements. While prudential supervisors might view this as a good sign, financial stability and potentially monetary policy authorities might be concerned about broader implications.

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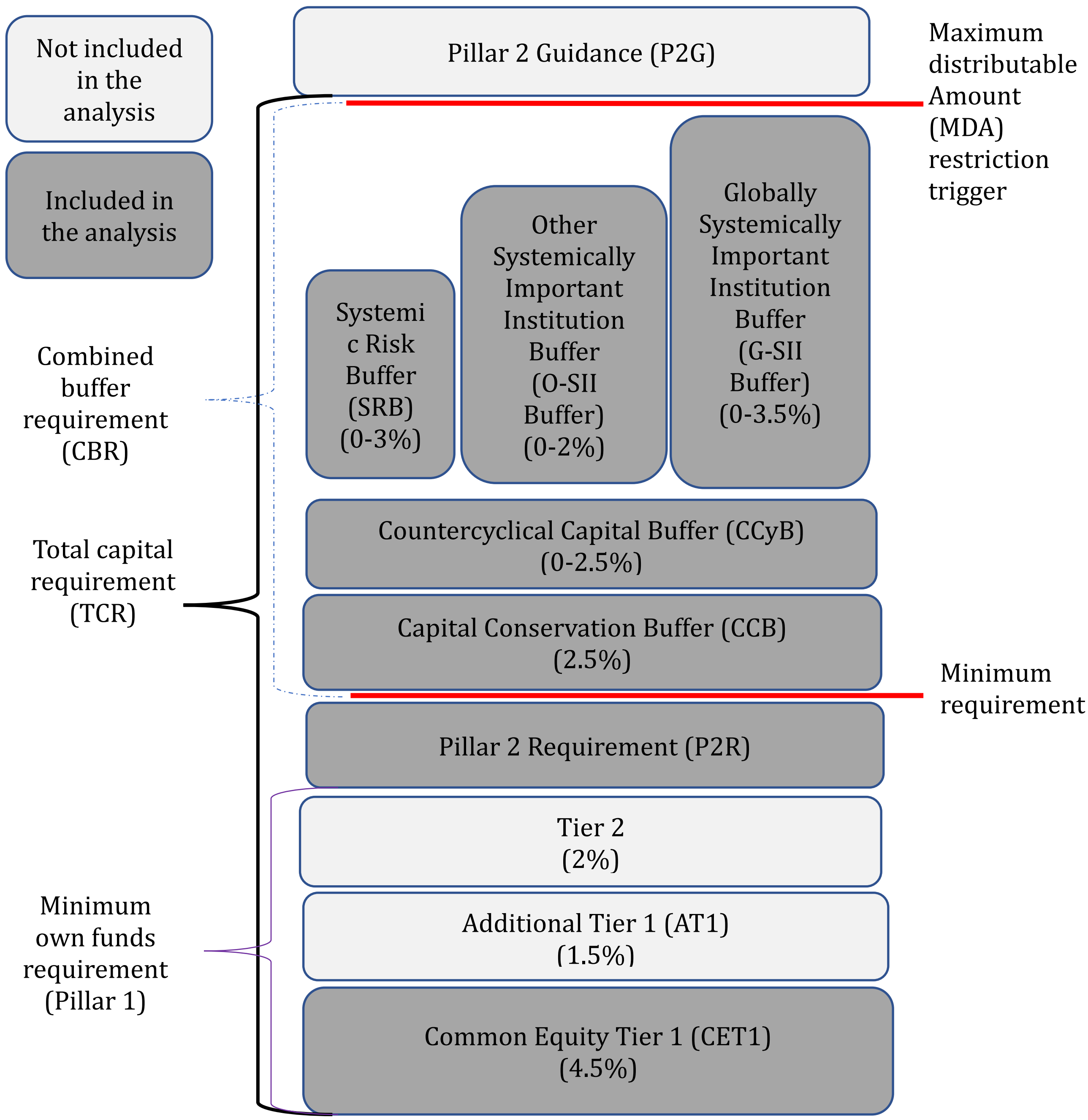
**Figure 1. A stylised bank regulatory capital requirement stack in the EU**

The figure provides intuition of the regulatory capital requirement stack in the EU, however various country, bank and time-specific features apply e.g., regulatory buffer requirements have phase-in transition periods, the capital composition requirements may vary by country (e.g. the ECB requires only 56.25% of P2R to be met with CET1 capital since 2020). The Prudential Regulatory Authority (PRA) in the UK refers to the P2R and the P2G as the P2A and the P2B respectively. The CRD V introduces changes with respect to SRB, G-SII/O-SII buffers with respect to additivity, but those changes do not de facto affect the capital requirement stack during the sample period in the analysis.




Source: Puharts (2021)

**Figure 2. Bank CET1 capital requirement density plots**

The figure plots densities of bank CET1 capital requirement expressed in percent of risk-weighted assets by year.

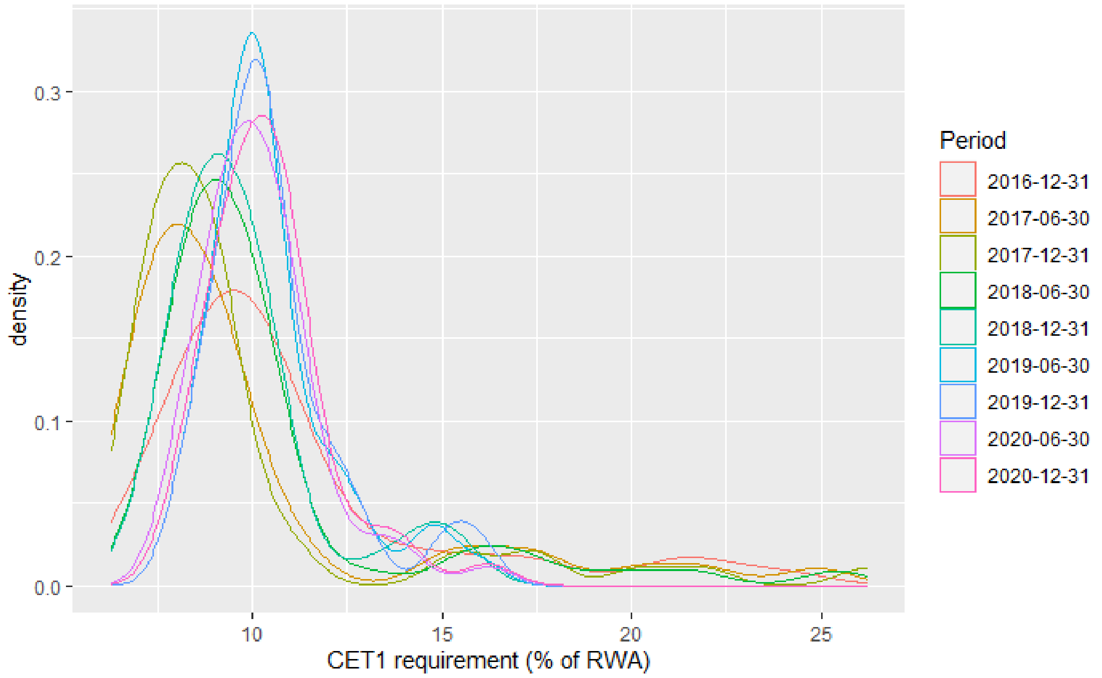



**Figure 3. Bank CET1 capital ratio density plots**

The figure plots densities of bank CET1 capital ratios expressed in percent of risk-weighted assets by year.

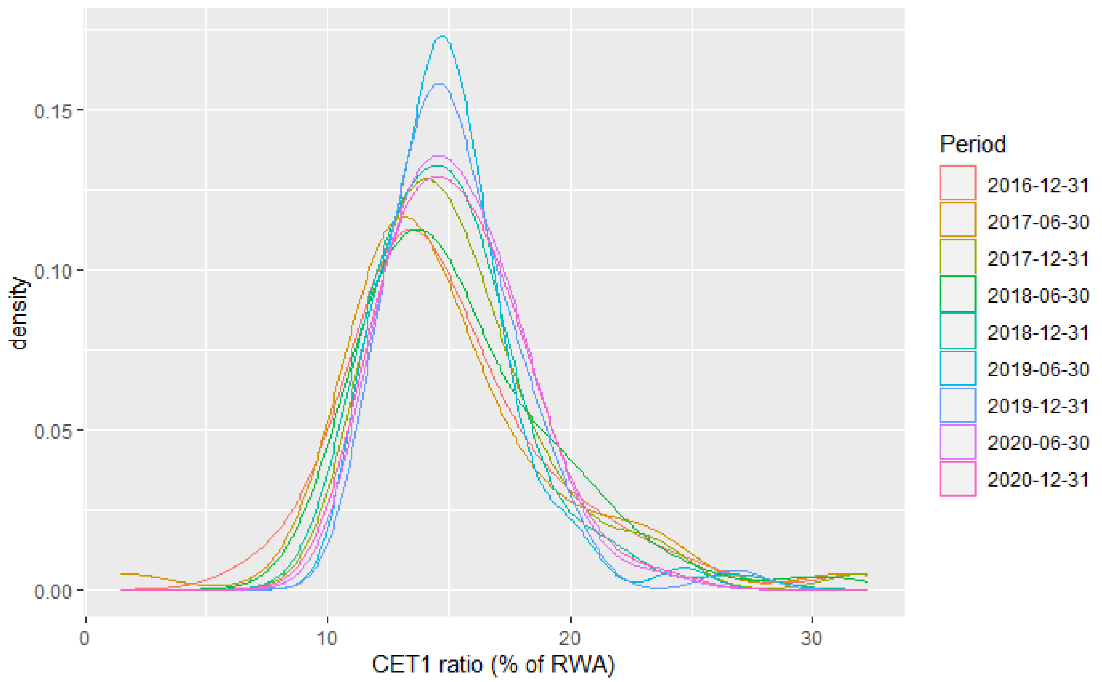
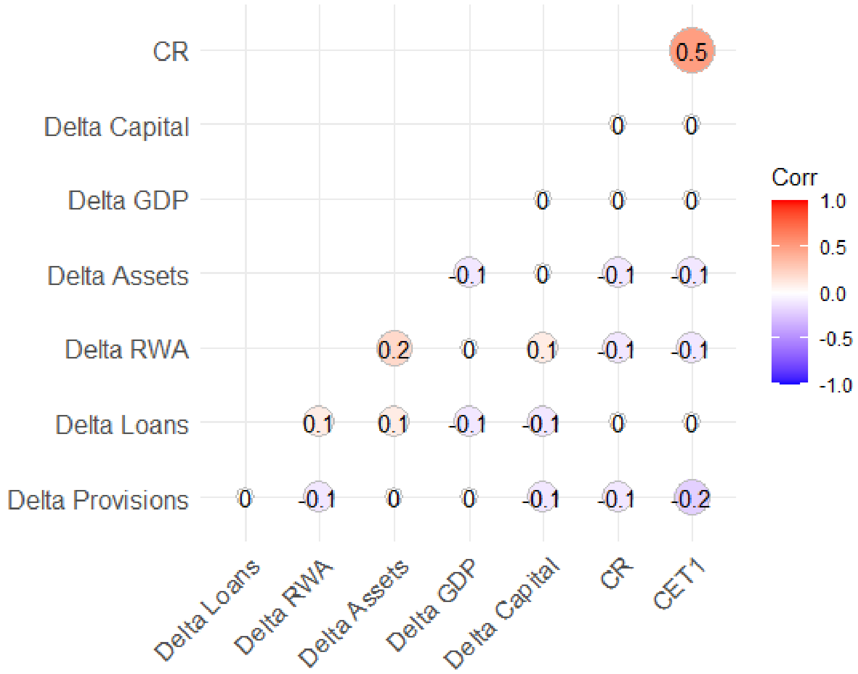


**Figure 4. Bank CET1 capital ratio density plots**

The figure depicts correlations between variables that are used and discussed in the paper. Size of the circles and colours indicate the magnitude and direction of Pearson correlations.



## Table 1. Variable descriptions and sources

The table summarizes the definitions and sources of the key variables that are used in the paper.

| Variable | Description | Source |
|---|---|---|
| $CR_{i,t}$ | Total capital requirement= P2R+CBR+4.5 | Various public sources (mainly Pillar 3 reports) |
| $P2R_{i,t}$ | Pillar 2 (SREP) requirement as a % of | Various public sources (mainly Pillar 3 reports) |
| $CBR_{i,t}$ | CCB+CCyB +max(SRB,O-SII,G-SIB) as a % of RWA | Various public sources (mainly Pillar 3 reports) |
| $CET1$ ratio | CET1 capital ratio | EBA transparency exercise |
| $\boldsymbol{\Delta} Provisions_{i,t}$ | Percentage change in provisions/total assets | S&P Capital IQ |
| $GDPG_{i,t}$ | Quarterly GDP growth for the quarter in the country where the bank is domiciled | Eurostat |
| $\Delta Loans$ | Percentage change in gross loan amount | S&P Capital IQ |
| $\Delta RWA$ | Percentage change in risk-weighted assets | S&P Capital IQ, EBA transparency exercise |
| $\Delta Assets$ | Percentage chnag in assets | S&P Capital IQ |
| $\Delta CET1$ | Percentage change in CET1 capital | S&P Capital IQ, EBA transparency exercise |

**Table 2. Sample descriptive statistics**

The table reports descriptive statistics of variables for the unbalanced semi-annual bank panel data containing 57 EU banks over the period of 2016 H2-2020H2.

| Statistic | N | Mean | St. Dev. | Min | Pctl(25) | Pctl(75) | Max |
|---|---|---|---|---|---|---|---|
| **ΔRWA** | 443 | 0.796 | 10.984 | -77.512 | -2.391 | 2.796 | 156.564 |
| **ΔAssets** | 463 | 1.988 | 9.295 | -15.509 | -2.351 | 5.038 | 134.067 |
| **ΔCET1 capital** | 443 | 2.669 | 42.694 | -82.845 | -2.259 | 3.255 | 874.694 |
| **ΔLoans** | 519 | 1.672 | 11.683 | -52.596 | -2.205 | 4.147 | 108.417 |
| **CR** | 519 | 10.257 | 2.896 | 6.260 | 8.750 | 10.700 | 26.200 |
| **CET1 ratio** | 519 | 15.271 | 3.396 | 1.505 | 12.972 | 16.611 | 32.240 |
| **ΔProvisions** | 519 | 0.181 | 0.351 | -0.217 | 0.018 | 0.216 | 3.400 |
| **ΔGDP** | 517 | -0.383 | 3.287 | -18.800 | 0.100 | 0.700 | 14.500 |

**Table 3. Sample descriptive statistics: means by period**

The table reports the evolution of means of variables for the unbalanced semi-annual bank panel data containing 57 EU banks over the period of 2016 H2-2020H2.

| Means | 2016 H2 | 2017 H1 | 2017 H2 | 2018 H1 | 2018 H2 | 2019 H1 | 2019 H2 | 2020 H1 | 2020 H2 |
|---|---|---|---|---|---|---|---|---|---|
| **ΔRWA** | -1.15 | 0.06 | -2.87 | 0.03 | 6.38 | 2.37 | 1.56 | 0.16 | -0.41 |
| **ΔAssets** | -2.08 | 2.39 | -0.48 | 1.45 | -1.20 | 6.72 | 1.00 | 6.72 | 2.59 |
| **ΔCET1 capital** | 0.40 | -1.16 | 15.94 | -0.84 | 2.16 | 2.31 | 3.89 | 0.26 | -0.41 |
| **ΔLoans** | 0.32 | 1.51 | 0.08 | 2.86 | 0.53 | 5.40 | 0.21 | 2.83 | 1.32 |
| **CR** | 10.94 | 9.70 | 9.74 | 10.42 | 9.72 | 10.50 | 10.57 | 10.24 | 10.25 |
| **CET1 ratio** | 15.12 | 15.25 | 15.67 | 15.76 | 15.05 | 14.91 | 15.26 | 15.31 | 15.33 |
| **ΔProvisions** | 0.23 | 0.27 | 0.17 | 0.12 | 0.16 | 0.11 | 0.12 | 0.31 | 0.17 |
| **ΔGDP** | 1.03 | 0.86 | 0.81 | 0.64 | 0.58 | 0.42 | 0.33 | -5.99 | -2.32 |

**Table 4. Results of the main model**

The table reports the coefficients for the determinants of changes in balance sheet dimensions. The specification is as follows:

$\Delta lnBS_{jit} = \beta_1 CR_{i,t-1} + \beta_2 CET1_{i,t-1} + \beta_4 \Delta GDPG_{i,t-1} + \beta_3 \Delta Provisions_{i,t-1} + \alpha_i + \varepsilon_{i,t}$,

Indexes *,**,*** represent robust significance levels of 10%, 5% and 1%, respectively, and robust standard errors are reported in parenthesis. All regressions include bank fixed effects but they are not reported. The results from the test of a constant voluntary capital buffer effect, i.e., if the impact of a joint change in capital requirement and actual capital ratio has a significant impact on dependent variables. This implies testing hypothesis that $\beta_1 + \beta_2 = 0$.

| | *Dependent variable:* | | | |
|---|---|---|---|---|
| | ΔRWA | ΔAssets | ΔCET1 capital | ΔLoans |
| | (1) | (2) | (3) | (4) |
| $CR_{t-1}$ | -0.977** | 0.168 | -3.593** | 0.231 |
| | (0.396) | (0.325) | (1.666) | (0.435) |
| $CET1_{t-1}$ | -1.242*** | -0.049 | 4.398*** | -0.009 |
| | (0.333) | (0.272) | (1.397) | (0.365) |
| $\Delta GDP_{t-1}$ | 0.048 | -0.384*** | 0.391 | -0.187 |
| | (0.155) | (0.127) | (0.650) | (0.170) |
| **Δ**$Provisions_{t-1}$ | -0.001* | 0.0002 | -0.001 | 0.0002 |
| | (0.0005) | (0.0004) | (0.002) | (0.0005) |
| $\beta_1 + \beta_2$ | -2.219 | 0.119 | 0.805 | 0.222 |
| $H_0: \beta_1 + \beta_2 = 0$ $(p\text{-}value)$ | 0.000 | 0.652 | 0.556 | 0.529 |
| Observations | 441 | 461 | 441 | 461 |
| $R^2$ | 0.230 | 0.216 | 0.101 | 0.130 |
| Adjusted $R^2$ | 0.113 | 0.101 | -0.036 | 0.001 |
| Residual Std. Error | 10.368 (df = 382) | 8.832 (df = 401) | 43.553 (df = 382) | 11.839 (df = 401) |
| *Note:* | *p<0.1; **p<0.05; ***p<0.01 | | | |

**Table 5. Results of model with capital constrained bank dummies**

The table reports the coefficients for the determinants of changes in balance sheet dimensions. The specification is as follows:

$$\Delta lnBS_{jit} = \beta_1 CR_{i,t-1} + \beta_2 CR_{i,t-1} * dummy + \beta_3 CET1_{i,t-1} + \beta_4 CET1_{i,t-1} * dummy + \beta_5 \Delta GDPG_{i,t-1} + \beta_6 \Delta Provisions_{i,t-1} + \alpha_i + \varepsilon_{i,t},$$

Dummy variable takes value of 1 if bank is capital constrained, which I assume is when the capital ratio is below the sample median. Indexes *,**,*** represent robust significance levels of 10%, 5% and 1%, respectively, and robust standard errors are reported in parenthesis. All regressions include bank fixed effects but they are not reported.

| | *Dependent variable:* | | | |
|---|---|---|---|---|
| | ΔRWA | ΔAssets | ΔCET1 capital | ΔLoans |
| | (1) | (2) | (3) | (4) |
| $CR_{t-1}$ | -1.110** | 0.328 | -0.453 | 0.207 |
| | (0.494) | (0.404) | (2.060) | (0.539) |
| dummy*$CR_{t-1}$ | 0.421 | -0.326 | -7.325** | 0.259 |
| | (0.727) | (0.602) | (3.030) | (0.804) |
| $CET1_{t-1}$ | -1.258*** | -0.312 | 0.441 | -0.234 |
| | (0.470) | (0.383) | (1.957) | (0.511) |
| dummy*$CET1_{t-1}$ | -0.479 | 0.069 | 3.633* | -0.508 |
| | (0.482) | (0.400) | (2.008) | (0.534) |
| $\Delta GDP_{t-1}$ | 0.060 | -0.384*** | 0.284 | -0.173 |
| | (0.155) | (0.127) | (0.646) | (0.170) |
| $\Delta Provisions_{t-1}$ | -0.001* | 0.0002 | -0.001 | 0.0002 |
| | (0.0005) | (0.0004) | (0.002) | (0.0005) |
| Observations | 441 | 461 | 441 | 461 |
| $R^2$ | 0.234 | 0.219 | 0.120 | 0.139 |
| Adjusted $R^2$ | 0.114 | 0.100 | -0.019 | 0.008 |
| Residual Std. Error | 10.362 (df = 380) | 8.837 (df = 399) | 43.190 (df = 380) | 11.801 (df = 399) |
| *Note:* | *p<0.1; **p<0.05; ***p<0.01 | | | |

**END OF MASTER THESIS II**