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## The transmission of bank capital requirements and monetary policy to bank lending

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# **Non-technical summary**

## **Research Question**

After the global financial crisis, banking regulation in Europe underwent a comprehensive overhaul, in particular with respect to the increases in bank capital requirements. At the same time monetary policy – in the euro area as well as in other major economies – was characterized by an accommodative monetary policy stance. As the banking system is a major transmission channel for monetary policy and banking regulation alike, the implications of the two policies with respect to bank lending and interest rates deserve closer attention. This paper aims to contribute to the understanding of the short-term transmission of bank capital requirements as well as monetary policy, and the interaction between these two, on bank lending and bank interest rates in the German banking system.

## **Contribution**

This paper contributes to the existing literature by shedding light on the transmission of changes in capital requirements and monetary policy to banks' lending to corporates and the attendant lending rates, as well as the interaction between monetary policy and capital requirements. With respect to banks' capital requirements, we go beyond the usual investigation of implications of changes in regulatory requirements by accounting for bank idiosyncratic and time-specific "affectedness".

## **Results**

Our results show that for weakly capitalized banks increases in capital requirements are associated with a decrease in bank lending in the short-term. Furthermore, changes in the monetary policy stance are positively related to lending rates. Regarding the interaction effect of capital regulation and monetary policy, we observe that increases in capital requirements attenuate the general effects of monetary policy on interest rates. Overall, the transmission of an accommodating monetary policy to lending rates is attenuated by contemporaneous increases in bank capital requirements which additionally imply a transitory decrease of the loan growth of weakly capitalized banks.

# **Nichttechnische Zusammenfassung**

## **Fragestellung**

Nach der globalen Finanzkrise wurde die Bankenregulierung in Europa umfassend überarbeitet, insbesondere hinsichtlich der Kapitalanforderungen für Banken. Gleichzeitig war die Geldpolitik, in der Eurozone ebenso wie in anderen Volkswirtschaften, gekennzeichnet durch eine nie zuvor gewesene akkommodierende Ausrichtung. Da sowohl für Regulierungspolitik als auch für Geldpolitik das Bankensystem ein wichtiger Transmissionskanal ist, verdienen die Auswirkungen der beiden Politiken auf die Kreditvergabe von Banken nähere Aufmerksamkeit. Dieses Papier untersucht die Transmission von Kapitalanforderungen und Geldpolitik, sowie die Interaktion der beiden auf die Kreditvergabe und Kreditzinsen der Banken in Deutschland in der kurzen Frist.

## **Beitrag**

Dieses Papier leistet einen Beitrag zur bestehenden Literatur, indem es die Transmission der Änderung von Kapitalanforderungen und Geldpolitik auf die Kreditvergabe von Banken an nicht-finanzielle Unternehmen sowie die entsprechenden Kreditzinsen und die Interaktion der beiden Politiken untersucht. Hinsichtlich der Kapitalanforderungen für Banken gehen wir über die übliche Untersuchung von Änderungen der regulatorischen Anforderungen hinaus, indem wir berücksichtigen, in welchem Ausmaß die Banken von den Maßnahmen betroffen waren.

## **Ergebnisse**

Unsere Ergebnisse zeigen, dass Erhöhungen von Kapitalanforderungen bei Banken mit schwacher Kapitalausstattung nah am regulatorischen Minimum kurzfristig mit einer geringeren Kreditvergabe einhergehen. Zudem besteht ein positiver Zusammenhang zwischen Änderungen der geldpolitischen Ausrichtung und Kreditzinsen. Dieser Effekt ist jedoch gedämpft, wenn parallel zu geldpolitischen Änderungen sich die Kapitalanforderungen für Banken erhöhen. Insgesamt wird die Transmission akkommodierender Geldpolitik auf Kreditzinsen also durch höhere Kapitalanforderungen verringert, wobei die Kreditvergabe der weniger kapitalisierten Banken temporär sinkt.

# The transmission of bank capital requirements and monetary policy to bank lending

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## Abstract

We investigate the transmission of changes in bank capital requirements and supranational monetary policy, and their interaction effect, on euro area bank lending and lending rates. Our results show that - for weakly capitalized banks - increases in capital requirements are in the short-run associated with a decrease in the total of domestic and cross-border bank lending. In addition, we find that there is no similar effect of capital requirements for strongly capitalized banks. Furthermore, changes in the monetary policy stance are positively related to lending rates. Regarding the interacting effect of national capital requirements and supranational monetary policy, we observe that increases in capital requirements attenuate the general effects of monetary policy on interest rates. Overall, the transmission of an accommodating monetary policy to lending rates is attenuated by contemporaneous increases in bank capital requirements which additionally imply a transitory decrease of the loan growth of weakly capitalized banks.

**JEL classification:** E52, F30, G28.

**Keywords:** Bank Lending, Lending Rates, Capital Requirements, Monetary Policy, International Policy Interaction.

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## 1. Introduction

After the global financial crisis, banking regulation in Europe underwent a comprehensive overhaul, in particular with respect to bank capital. Microprudential capital requirements were tightened and complemented with several macroprudential measures to provide regulators with (further) tools which could now address systemic risks. At the same time monetary policy – in the euro area as well as in other major economies – was characterized by an accommodative monetary policy stance. As the banking system is a major transmission channel for monetary policy and capital regulation alike, the implications of the two policies with respect to bank lending and interest rates<sup>1</sup> deserve closer attention. This paper aims to contribute to the understanding of the transmission of bank capital requirements as well as supranational monetary policy, and the interaction between the two policies, on euro area bank lending and related bank interest rates. Consequently it sheds light into domestic as well as international implications of national and supranational policy interactions over the short term.

Both policies have been investigated separately in the empirical literature. The evidence on the effects of changes in bank capital requirements is mixed,<sup>2</sup> and implications hinge on the time horizon analyzed.<sup>3</sup> As to the impact of monetary policy, the results in the literature suggest that its effects on bank lending depend on banks' risk.<sup>4</sup> While the central bank policy rate has

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<sup>1</sup> In this paper the terms “bank interest rate”, “lending interest rate” and “interest rate” are used synonymously. All terms refer to the bank- and time-specific weighted interest rate for outstanding lending to corporates in the euro area and denominated in Euro.

<sup>2</sup> Aiyar et al. (2014) observe a decrease in lending in response to higher capital requirements, while a survey by the Basel Committee on Banking Supervision (BCBS) (1999) of more than 130 research papers on the effects of Basel I suggests that this is the case in economic troughs only. Other studies argue that the effects depend on the industry sector (Bridges et al., 2015), bank dependency (Gropp et al., 2018), banks' rating approach (Behn et al., 2016), or bank type (De Jonghe et al., 2016). Moreover, Jiménez et al. (2017) investigate a dynamic provisioning of capital requirements and find that it helps smooth the credit cycle. Francis and Osborne (2012) and Imbierowicz et al. (2018) show that banks tend to adjust the risk composition of their asset portfolio in response to an increase in capital requirements rather than the volume of loan portfolios.

<sup>3</sup> Some papers examining the long-term implications find transitory adverse implications (see e.g. Eickmeier et al. 2018) and in the long-run higher bank capital being associated with higher loan volumes (see e.g. Buch and Prieto (2014) for an analysis of the German banking system).

<sup>4</sup> Examples are Bernanke and Blinder (1992), Kashyap et al. (1993), Kashyap and Stein (1994, 2000), Gambacorta and Mistrulli (2004), or Jiménez et al. (2012).

an effect on banks' risk-taking and leverage and therefore financial stability (for an overview, see e.g. Gambacorta, 2009), prudential capital requirements generally induce a change in banks' funding mix and accordingly their costs, and thereby affect their response to policy changes. Some more recent studies have also looked into the interaction between the two policies. Takáts and Temesváry (2019) find significant interactions between macroprudential policy in general and monetary policy associated with the currency of cross-border bank lending. Tighter macroprudential policy mitigates the lending impact of monetary policy, whereas an ease of macroprudential policy amplifies the lending impact of monetary policy. Some studies investigate the interaction between monetary policy and bank capital requirements. Aiyar et al. (2016) find in a study for the UK that a tightening of both capital requirements and monetary policy reduces bank lending. However, they find little evidence of an interaction between the two policy instruments. De Marco and Wieladek (2016) also study bank-specific capital requirements and monetary policy in the UK and the consequences for SMEs. They find that effects differ depending on the bank-firm relationship and firms' dependency on banks, as well as bank and firm characteristics. Empirical evidence presented by Budnik and Bochmann (2017) shows that the response of better capitalized banks' loan growth to changes in monetary policy is less severe. Relatedly, Gambacorta and Mistrulli (2004) and Maddaloni and Peydro (2013) illustrate that lending by poorly capitalized banks responds more strongly to changes in monetary policy rates. Eickmeier et al. (2018) show for the US that monetary policy cushions negative short-term effects of capital requirement tightenings. We are not aware of studies looking at the implications on lending rates.

In our paper, we examine the impact of changes in capital requirements and supranational monetary policy on the total of banks' domestic and cross-border lending to the non-financial corporate sector in the euro area and the interest rate charged for these loans. Our sample covers the period from 2008:Q1 to 2018:Q3 for a sample of German and international banks in the German banking system. We analyze the effects of the supranational monetary

policy stance accounting for the transmission of changes in bank capital requirements. As a measure for the monetary policy stance, we use the cumulative changes in the money market interest rate over one year. We measure a bank's capital requirement as the ratio of capital required by the regulator for the specific type of loans we investigate (i.e. corporate loans). It is calculated as the sum of the bank-specific risk-weighted capital requirement ratios multiplied by the average risk weight of the corporate loan portfolio (RWA density). It therefore includes more variation in the time dimension than regulatory changes alone.

In a first step, we investigate the effect of changes in banks' loan type-related capital requirements on euro area lending as well as on the related lending rates. We find that in the short term higher capital requirements are, on average, associated with a reduction in the total of domestic and cross-border lending. This effect stems from those banks with less capital beyond the regulatory required level. We do not observe an effect on lending rates. We then investigate whether the effect of changes in capital requirements on lending and lending rates depends on the level of a bank's capital. To do so, we calculate a bank's excess capital, that is, the difference between its regulatory capital requirement and its actual capital ratio. We observe that the decrease in lending in response to higher capital requirements derives from banks with lower levels of excess capital. Our analyses show that these are banks with a level of excess capitalization of less than 2.8%. A one-percentage-point increase in bank capital requirements implies a 1.5% lower loan growth for these banks. We acknowledge that dynamics might be different over longer time horizons as banks may target a bank- and time-specific optimal capital ratio (e.g. Gropp and Heider 2010). Furthermore, we cannot rule out substitution effects. Banks might decrease their lending to the corporate sector but increase lending to other sectors with for example lower risk weights (e.g. Imbierowicz et al. 2018).<sup>5</sup> Our finding complements well Buch and Prieto (2014) who also look at the German banking system. While they show

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<sup>5</sup> Mankart et al. (2018) show that tighter leverage requirements c.p. (ceteris paribus) increase lending to sectors with higher risk weights, while higher risk-weighted capital requirements c.p. reduce banks' loan supply.

that aggregate and long-term implications of higher bank capital for lending are positive, we add to this by exploring short-term effects and by pointing out that possible transitory adverse effects hinge on the excess capitalization of banks.

In a second step, we additionally analyze the effects of changes in the supranational monetary policy stance. We find that changes in the monetary policy stance, tightening as well as easing ones, are positively related to euro area lending rates but are not related to loan growth. However, the effect of a tightening of monetary policy on lending rates is stronger than for an easing. We observe that a decrease (increase) in the monetary policy rate of 1 percentage point implies a decrease of 0.038% (increase of 0.181%) of the change in lending rates, what translates to a transmission to corporate interest rate levels of about 75%.

In a last step, we explore the interaction of capital requirements and supranational monetary policy. Prudential regulation and monetary policy are likely to interact in their effects as for both types of policy the banking sector is a major transmission channel. Both types of policies might have an effect on bank refinancing costs which, in turn, might affect lending rates and volumes. Accordingly, the transmission of one policy may be affected by changes to the other. Interacting changes in regulatory capital requirements and monetary policy shows that changes in the monetary policy stance are associated with attenuating effects when capital requirements change in the opposite direction. This implies that a lower monetary policy rate translates into a smaller decrease in bank lending rates if capital requirements are tightened at the same time. Correspondingly, lower bank capital requirements might cushion the effects of policy rate hikes. However, we find our previous result of capital requirements being negatively related to the lending of weaker banks again confirmed. Higher capital requirements imply a decrease in the lending for weaker capitalized banks.

Our findings add to the still rather scarce empirical literature on the joint effects of capital regulation and monetary policy, and show that bank regulation and monetary policy should not only be considered individually as they also interact, and that real effects - which

appear domestically and cross-border - hinge crucially on bank capitalization. Yet, it is to be noted that our analysis contributes to an improved understanding of *short-term* implications of policy changes for different types of banks, which are shown to be different from positive *long-term* or more aggregate implications (see e.g. Buch and Prieto 2014, Eickmeier et al. 2018). Our results are important for policymakers as a thorough understanding of policy transmission and interactions is crucial for maintaining the stability of the domestic as well as other banking systems, and the resulting real implications. They might further be useful for ex-ante assessments of envisaged policy changes, in particular with respect to unintended externalities and the understanding of their transitory nature. Last but not least, our paper contributes to the at this point still scarce literature in which the intensity of prudential policy changes is mapped to outcome variables.<sup>6</sup>

The remainder of the paper is structured as follows. In Section 2 we provide a brief overview of bank capital regulation and monetary policy in Germany. Section 3 describes the data, and Section 4 presents our empirical work and the results. Section 5 concludes.

## **2. Capital requirements and monetary policy**

### **2.1 Bank capital requirements in Germany**

Our sample period starts in 2008:Q1 when Basel II was already in force. Accordingly, for determining risk weights, banks were able to choose between the standardized approach (SA) and the internal ratings-based approach (IRBA). In contrast to the SA, in which risk weights are assigned by predefined templates set by the regulator, the IRBA allows banks to determine risk weights based on their internal risk models, subject to approval by the regulator. In Germany, mainly large banks gradually shifted their loan portfolios from the SA to the IRBA upon the introduction of Basel II. This resulted in most cases in substantially lower risk weights

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<sup>6</sup> See Vandebussche et al. (2015) for a study of a comprehensive set of prudential policy measures. Other studies accounting for the intensity of policy changes focus on LTV changes only.

for most of these banks' assets as well as in differences in risk weights across banks.

Most Basel III-related provisions have been applicable since January 2014 in the EU.<sup>7</sup> The requirements implied a gradual tightening of capital regulations – both in terms of capital definitions and quantity. Minimum capital requirements were complemented with additional capital buffers such as, for instance, the capital conservation buffer (CCoB) and the buffers for systemically important financial institutions (SIFI buffers). In addition, from 2015 onwards, bank-specific pillar 2 capital requirements (based on the Supervisory Review and Evaluation Process – SREP) have been determined annually by banking supervisors. Over our sample period from 2008:Q1 to 2018:Q3, only bank capital-related prudential regulatory action – possibly affecting lending to non-financial corporates – was implemented in Germany.<sup>8</sup>

## **2.2 Supranational monetary policy and monetary policy stance**

Monetary policy for Germany, as a member of the euro area, is conducted at the supranational level within the Eurosystem, which consists of the European Central Bank (ECB) and all euro-area national central banks. Since October 2008, in response to the crisis, the ECB has set a fixed main policy interest rate and provided liquidity according to banks' demand (full allotment).<sup>9</sup> It also extended the maturity of refinancing operations and the range of eligible assets that could be used as collateral for these operations. Prior to October 2008, the ECB offered liquidity such that banks were able to exactly fulfill their reserve requirements. Liquidity was issued by the ECB in a competitive tender procedure and thereafter distributed in the markets such that each bank was able to fulfill its requirement. Consequently, since October 2008 the ECB has been operating in an environment of surplus liquidity and the money

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<sup>7</sup> In the EU, Basel III has been implemented by the Capital Requirement Directive (CRD IV) and the Capital Requirement Regulation (CRR), which form the European legal framework. CRD IV provisions require implementation in the German Banking Act (Kreditwesengesetz - KWG).

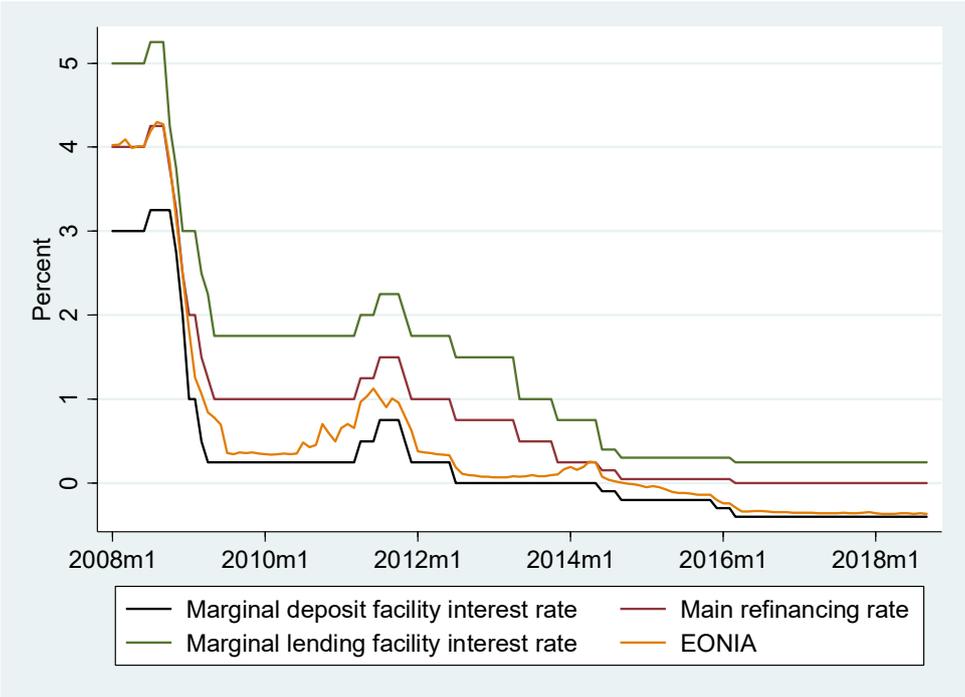
<sup>8</sup> See Budnik and Kleibl (2018) and the related MaPPED for details on all macroprudential policy actions in the EU between 1995 and 2014.

<sup>9</sup> For an extensive overview of euro-area monetary policy, see Hartmann and Smets (2018).

market rate has approached the lower bound of the corridor (ECB marginal deposit facility interest rate). Figure 1 depicts the key policy interest rates and the money market rate from 2008:Q1 to 2018:Q3.

**Figure 1: Monetary policy rates**

The figure shows key ECB policy interest rates and the EONIA interest rate from 2008:Q1 to 2018:Q3.



Prior to October 2008, the main refinancing rate and the overnight interbank money market rate (Euro Over Night Index Average, or EONIA) were close to each other. Since then, the EONIA interest rate has moved from being close to the main refinancing rate towards the lower bound of the interest rate corridor set by the ECB, that is, to the deposit facility interest rate. We therefore use the EONIA interest rate as our proxy for the ‘true’ supranational monetary policy rate. In our empirical analyses, we incorporate the cumulative changes in the short-term money market rate over the current and the three previous quarters as a measure of the monetary policy stance (in contrast to immediate shocks). In the literature, other measures have been used to explore the implications of monetary policy changes. These measures include

shadow rates (e.g. Krippner 2013, Wu and Xia 2016) or monetary policy surprises. However, we consider the EONIA rate to be the most relevant rate for our analysis, as it is most directly related to bank lending conditions and reflects the supranational monetary policy environment better than other variables.

### **3. Data and main variables**

For our analyses, we use quarterly data from 2008:Q1 to 2018:Q3 from the Bundesbank's MFI interest rate and balance sheet statistics.<sup>10</sup> The MFI interest rate statistics are based on the interest rates charged by monetary financial institutions (MFIs) in Germany and the corresponding volumes of euro-denominated loans extended to private sector borrowers in the euro area. Our variables of interest are the q-o-q change in outstanding loans to the non-financial corporate sector in the euro area, and the weighted average of the interest rates charged for these loans. The MFI interest rate statistics cover a representative sample of about 200 to 240 banks in the German banking system. This sample of banks captures about 70% of the total assets of the entire German banking market. Figure 2 shows the changes in corporate loan growth and interest rate and their distribution from 2008:Q1 to 2018:Q3. We observe that both variables depict sufficient variation for multivariate analyses. The median values show that lending to corporates grew in most time periods while corresponding interest rates decreased most of the time.

We are interested in how the growth in lending to the corporate sector as well as the average interest rate charged for these loans change in response to changes in capital requirements. We calculate our main measure of bank-specific capital requirements for corporate loans by multiplying a bank's risk-weighted capital requirement ratio by its average risk weight for corporate loans, that is, the risk-weighted assets (RWA) density.

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<sup>10</sup> For more detailed information see:  
<https://www.bundesbank.de/resource/blob/604796/d52dbf21479d4be76e0afd0d3d50e7bb/mL/research-data-micro-data-zista-2017-data-report-data.pdf>.

$$cap_{b,t} = \frac{regCR_{b,t}}{RWA_{b,t}} \cdot \frac{RWA_{b,t}^{corp}}{TA_{b,t}^{corp}} \quad (1)$$

The first term is a bank's total regulatory capital requirement ratio, i.e. the sum of minimum pillar 1 requirements, macroprudential capital add-ons including the buffer for SIFIs and the CCoB, and pillar 2 requirements divided by the bank's total risk weighted assets.<sup>11</sup> The second term – RWA density – is the risk-weighted exposure for the bank's corporate loans relative to the total unweighted exposure for corporate loans. It reflects the average risk weight of the bank's corporate loan portfolio. Hence, our variable  $cap_{b,t}$  captures a bank's total regulatory capital requirement related to corporate lending. We use this measure rather than the simple regulatory capital requirement ratio because banks with a lower RWA density are relatively less exposed to a change in capital requirements. Accordingly, our measure  $cap_{b,t}$  more precisely reflects banks' de facto capital requirements.

Panel A of Figure 3 shows regulatory capital requirements from 2008:Q1 to 2018:Q3 for the banks in our sample. Panel B shows the RWA density for loans to non-financial corporates over time. Accordingly it measures the 'affectedness' of a bank following an increase in regulatory capital requirements. It depicts a substantial degree of heterogeneity across banks as well as over time. Panel C in Figure 3 shows the capital requirement for corporate loans (the product of the two prior measures) across banks over our sample period. Note that the increase in the average capital requirement from 2015 on is largely attributable to the SREP-related requirements that, along with the SIFI-related add-ons, create heterogeneity in regulatory requirement ratios across banks. It confirms the substantial variation beginning in 2016. It also depicts that the quarterly change in capital requirements varies sufficiently across banks to ensure an adequate degree of heterogeneity for multivariate analyses.

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<sup>11</sup> The necessary compliance with these requirements differs. While minimum capital requirements are hard requirements for which fulfillment is mandatory, a breach of the capital buffer would only trigger automatic restrictions on dividend and bonus payments a bank can make.

## Figure 2

### *Change in corporate loan growth and interest rates*

The figure shows the 25th, 50th and 75th percentile of the quarterly change in corporate loans issued by our sample banks (Panel A) and the interest rate charged for these loans (Panel B) from 2008:Q1 to 2018:Q3.

#### **Panel A: Change in corporate loans ( $\Delta$ lending)**



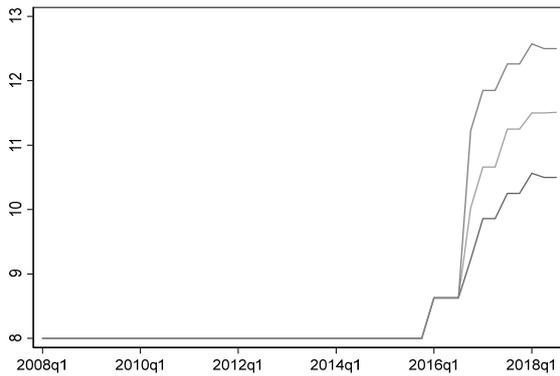
#### **Panel B: Change in corporate loan interest rates ( $\Delta$ interest rate)**



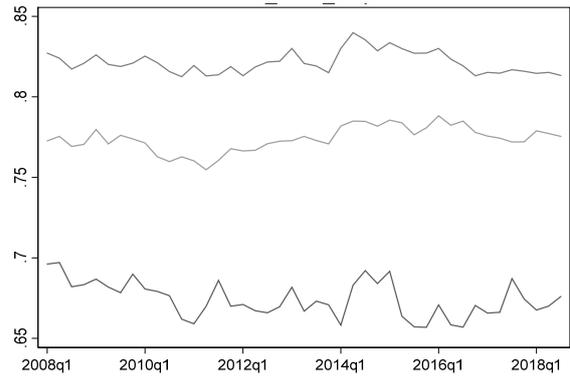
**Figure 3: Bank capital requirements**

The figure shows the 25th, 50th and 75th percentile of regulatory bank capital requirement (Panel A), the risk-weighted assets (RWA) density of corporate loans (Panel B), and bank-specific capital requirements for loans to the non-financial corporate sector (Panel C) from 2008:Q1 to 2018:Q3. It reflects the ingredients of  $cap_{b,t} = \frac{regCR_{b,t}}{RWA_{b,t}} \cdot \frac{RWA_{b,t}^{corp}}{TA_{b,t}^{corp}}$  where Panel A shows the first term, Panel B the second term, and Panel C the variable  $cap_{b,t}$ . The first term is a bank's total regulatory capital requirement ratio, i.e. the sum of minimum pillar 1, macroprudential capital buffers such as the O-SII buffer and the CCoB, and pillar 2 requirements divided by the bank's total risk-weighted assets. The second term, the RWA density, is the risk-weighted exposure for corporate loans of the bank relative to the total unweighted exposure for corporate loans.

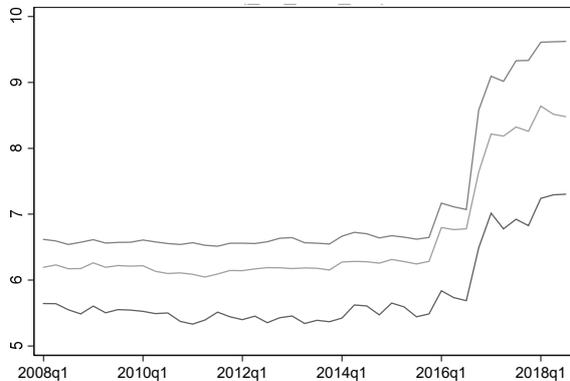
**Panel A: Regulatory bank capital requirements**



**Panel B: RWA density**



**Panel C: Bank-specific capital requirements**



Information on regulatory required capital ratios are publicly available (for minimum requirements, capital conservation and SIFI-related buffers), confidential information on SREP related add-ons are provided by banking supervisors. All other bank-level data is obtained from confidential Bundesbank balance sheet statistics. In our empirical analysis, we control for

different relevant bank characteristics and macroeconomic determinants. Bank-specific control variables include a bank's size (measured by the logarithm of its total real assets), the ratio of liquid assets to total assets, the ratio of its core deposits to total assets, and the return on assets, all described in more detail in Table 1. We also include a dummy variable for bank mergers which is one in the quarter when a bank merges with another bank and zero otherwise. Macroeconomic control variables are obtained from public sources. In Table 1, Panel A provides summary statistics and Panel B variable definitions.

Panel A of Table 1 shows that the loan growth to the non-financial corporate sector averages 0.83% each quarter, while the lending rate changes by -0.059%. The quarterly change in capital requirements is 0.049% and the level of excess capital is 2.762%, as a percentage of total assets. Our monetary policy stance variable, the one-year average quarterly change of the money market interest rate, averages -0.058% over our sample period. Note that this includes periods where it is both positive and negative. Banks hold, on average, 24% of their assets in liquid form and have core deposits of 36%, both in terms of total assets. The return on assets is on average 0.20% of total assets over our sample period, and we include 0.3% of bank quarters where two banks merge.

**Table 1: Descriptive statistics and variable definitions**

The table shows descriptive statistics using data from 2008:Q1 to 2018:Q3. Variables are defined in Panel B.

<b>Panel A: Descriptive Statistics</b>		
Variable	Mean	Standard deviation
<b>(1) Dependent variables</b>		
Δ lending (q-o-q change)	0.826	3.910
Δ interest rate (q-o-q change)	-0.059	0.081
<b>(2) Independent variables</b>		
Capital requirements for lending to corporates (change)	0.049	0.440
Excess capital (% total assets)	2.762	1.564
Monetary policy stance (%)	-0.058	0.233
Bank size (ln real assets)	18.115	1.378
Liquid assets (% total assets)	24.083	12.765
Deposits share (% total assets)	35.732	18.899
RoA	0.197	0.285
Merger dummy	0.003	0.050
Uncertainty	137.662	54.331
Ifo business climate	97.462	5.280
Term spread (change)	-0.012	0.454
Credit-to-GDP gap	-7.241	2.730
GDP gap	0.263	1.570

<b>Panel B: Variable definitions</b>		
Variable	Definition	Data source
<b>(1) Dependent variables</b>		
Δ lending	Loans to non-financial corporations in the euro area; % change (q-o-q)	MFI interest rate statistics
Δ interest rate	Weighted interest rate for loans to non-financial corp. in the euro area; change (q-o-q)	
<b>(2) Independent variables</b>		
Capital requirements for lending to corporates (change)	Total capital requirements (minimum + combined buffer + pillar 2 requirements); % change (q-o-q)	COREP, Supervisory data
Excess capital (% total assets)	Minimum of CET1, T1 and T2 excess capital; % of total assets	
Monetary policy stance (%)	Cumulative change in the money market rate (EONIA) over four quarters	ECB
Bank size (ln real assets)	Log of total real assets	BISTA, FINREP, Solvency statistics
Liquid assets (% total assets)	Sum of cash, balances with the central bank, securities and shares; % of total assets	
Deposits share (% total assets)	Total deposits of the non-financial sector; % of total assets	
RoA	Annual net profit; % of total assets	
Merger dummy	Dummy equal to one in the quarter when a merger took place and zero otherwise	Supervisory data
Uncertainty	News based economic policy uncertainty index	Economic Policy Uncertainty (EPU)
Ifo business climate	ifo Business Climate index; 2015=100	ifo
Term-spread	Spread between 10-year government bond interest rate and money market rate	ECB
Credit-to-GDP gap	Deviation of credit to GDP from its long-term trend	Bundesbank
GDP gap	Deviation of actual GDP from potential output	Bundesbank

## 4. Results

### 4.1 Transmission of capital requirements

In a first step, we analyze the relationship between changes in banks' capital requirements and changes in banks' lending and interest rates. We estimate the following panel regression:

$$\Delta Y_{b,t} = \alpha_0 + \sum_{k=1}^K \alpha_{1,k} \Delta cap_{b,t-k} + \beta X_{b,t-1} + f_b + f_t + \epsilon_{b,t} \quad (2)$$

where  $\Delta Y_{b,t}$  is the change in the ln of outstanding loans to the non-financial corporate sector and the difference in the corresponding lending interest rate of bank  $b$  in quarter  $t$ . Note that we use a simultaneous equations approach to account for the possibility that changes in lending and lending rate might not be orthogonal to each other. This implies that we estimate a system of structural equations comparable with Imbierowicz et al. (2018). All dependent variables are explicitly taken to be endogenous to the system and are treated as correlated with the disturbances in the system's equations. For identification, we use the first lag of the dependent variables as instruments after having rejected a unit root for these in a Phillips-Perron test and autocorrelation in panel data by a Wooldridge test. This GMM estimator then calculates a weight matrix which is used in the second step of the estimation for the correlation structure of the equation disturbances. The change in a bank's capital requirement is represented by  $\Delta cap_{b,t-k}$ , with  $K=4$ . Accordingly, we measure changes in lending and changes in lending rates in response to the changes of a bank's capital requirement over the previous year.  $X_{b,t-1}$  is a vector of lagged bank specific control variables and also includes an indicator variable for bank mergers. All regressions include bank fixed effects and use standard errors clustered at the bank-quarter level. The results are shown in Table 2.

Columns (1) and (2) of Table 2 contain macroeconomic control variables and columns (3) and (4) quarter fixed effects to further account for unobserved factors varying at the time level. The results show that a change in a bank's capital requirement over the previous year is

negatively related to its corporate loan growth. This result is in line with the findings in, for example, Aiyar et al. (2014), Gropp et al. (2018), and De Jonghe et al. (2016). The coefficient indicates that a 1 percentage point increase in the bank loan type-specific capital requirements results in a 1% decrease in corporate lending. Note that our analysis focuses on corporate lending and the corresponding interest rates and hence we cannot rule out the possibility of a bank's lending shifting to other sectors with lower risk weights or lending in other currencies. Table 2 also shows that capital requirements are not (directly) related to changes in lending rates.

**Table 2:** *The effect of capital requirements on lending and interest rates*

The table shows the second step of two-step GMM regression results of a simultaneous equations estimation regressing the quarterly change in lending to the non-financial private sector and the quarterly change in the average interest rate charged for these loans on control variables. The data range from 2008:Q1 to 2018:Q3. All variables are used at the bank-quarter level and defined in Panel B of Table 1. For the two-step GMM estimator, the first step estimates each equation via 2SLS using the first lag of the dependent variables as instruments, where a Fisher type unit root test based on the Phillips-Perron test rejects a unit root and a Wooldridge test rejects autocorrelation in panel data in all cases. A weight matrix is then calculated which is used in the second step of GMM. The dependent variables are taken to be endogenous to the system and treated as correlated with the disturbances in the system's equations. *Capital requirement* is shown as the cumulative effect over the previous four quarters. Control variables are bank size, liquid assets, deposits share, RoA, included lagged by one quarter, and a dummy variable which is one in a quarter when a bank merges with another bank. In the table, columns (1) and (2) shows the results for the regression with macro controls, and columns (3) and (4) the results when using time fixed effects instead. Both regression specifications are estimated simultaneously. The statistical significance of results is indicated by \* = 10% level, \*\* = 5% level and \*\*\* = 1% level using standard errors clustered at the bank level. P-values are shown in parentheses below coefficient estimates.

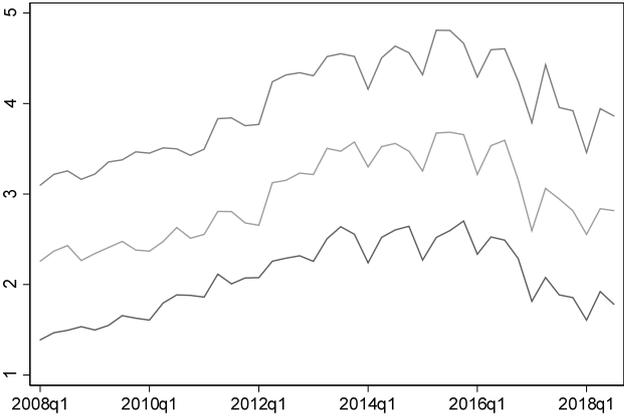
Dependent variable:	(1) Δ lending	(2) Δ interest rate	(3) Δ lending	(4) Δ interest rate
Capital requirement	-1.786*** (3.79E-04)	0.0105 (0.466)	-1.016*** (9.75E-04)	0.004 (0.612)
Bank control variables	yes	yes	yes	yes
Bank fixed effects	yes	yes	yes	yes
Macro control variables	yes	yes	no	no
Time fixed effects	no	no	yes	yes
Observations	5,051	5,051	5,123	5,123
Number of banks	170	170	170	170
R-squared	0.139	0.224	0.166	0.284

The implications of changes in capital requirements might depend on banks' characteristics. De Jonghe et al. (2016), for example, show that increasing capital requirements

imply the strongest decrease in bank lending for riskier banks. A bank’s reaction to an increase in regulatory capital requirements might depend on the amount of banks’ excess capital reduced by the new requirement, i.e. how much this bank is constrained through the regulatory change. Accordingly, the response to changes in bank capital requirements might vary between banks with low and high levels of excess capital, that is, capital above the required regulatory minimum. We calculate a bank’s excess level of capital using the regulatory definitions for CET1, T1 and T2 capital, in terms of total assets, and use the minimum out of these three. This ensures that we are conservative in our approach as banks have to adhere to all three requirements but their compliance with respect to each capital requirement might be heterogeneous. Figure 4 shows that banks’ excess capital increased until 2015 but decreased thereafter until the end of our sample period.

**Figure 4:** *Excess capital*

The figure shows the 25th, 50th and 75th percentile of banks’ excess capital from 2008:Q1 to 2018:Q3. Excess capital is the minimum of a bank’s capital above the regulatory requirement, using the definitions for CET1, T1 and T2. Regulatory capital requirements include the minimum pillar 1 requirements, the combined capital buffer (capital conservation buffer, countercyclical capital buffer and the buffer for systemically important banks) and pillar 2 requirements (SREP).



We again investigate the relationship between changes in banks' capital requirements and banks' lending and interest rates but now additionally condition on banks' excess capital. We hypothesize that those banks with lower capitalization levels react more strongly to changes in capital requirements. We investigate the effects of changes in capital requirements on loan growth and the change in interest rates by interacting the change in capital requirement with our continuous variable of banks' excess level of capital. We estimate the following regression model using, again, our simultaneous equations setup for both corporate loan growth and the change in the lending rate

$$\Delta Y_{b,t} = \alpha_0 + \sum_{k=1}^K \alpha_{1,k} \Delta cap_{b,t-k} + \sum_{k=1}^K \alpha_{2,k} \Delta cap_{b,t-k} * \widehat{cap}_{b,t-1-K} + \alpha_3 \widehat{cap}_{b,t-1-K} + \beta X_{b,t-1} + f_b + f_t + \epsilon_{b,t} \quad (3)$$

where  $\widehat{cap}_{b,t-K}$  is a banks' excess capital ratio. Additionally, we split banks by their level of excess capital and estimate the following regression model using simultaneous equations.

$$\Delta Y_{b,t} = \sum_{k=1}^K \alpha_{1,k} cap_{b,t-k}^{low} + \sum_{k=1}^K \alpha_{2,k} cap_{b,t-k}^{high} + \sum_{k=1}^K \alpha_{3,k} cap_{b,t-k} + \beta X_{b,t-1} + f_b + f_t + \epsilon_{b,t} \quad (4)$$

where  $cap_{b,t-k}^{low}$  is the change in capital requirements when a bank is in the lowest quartile of the distribution of excess capitalization and zero otherwise, and  $cap_{b,t-k}^{high}$  the change in capital requirements when a bank is in the highest quartile.  $K$  is again set to  $K=4$ . This allows us to test for the differential effects of changes in capital requirement between worse and better capitalized banks. Table 3 shows the results.

Panel A of Table 3 shows the results when we interact the changes in capital requirements with our continuous variable of a bank's level of excess capital. We observe that higher levels of excess capital attenuate the negative relationship between a change in a bank's capital requirement and its corporate loan growth. The coefficients indicate that the effect of changes in bank capital requirements is zero for banks with a level of excess capital to total

assets of about 6%. Panel B shows our results including the change in capital requirements separately for banks in the lowest and in the highest quartile of excess capital in a quarter.<sup>12</sup> We observe that changes in capital requirements are negatively related to only the loan growth of banks with the lowest capitalization levels. Accordingly, increasing capital requirements are related to decreasing loan growth for weaker banks. As we are estimating within effects and accordingly statistical significance stems from capitalization and lending dynamics for each bank (instead of across banks), we can rule out the possibility that our results regarding the relationship between capital requirements and lending are driven by factors such as bank size and business model. Rather for ensuing policy ex-ante analysis of the aggregate implications of changes in capital requirements the distribution of lending volumes across capitalization levels is crucial. In both Panel A and B we again do not observe a relationship between capital requirements and corporate lending rates. Our explanation for this is that an increase in lending rates in response to higher capital requirements would, in fact, constitute a competitive disadvantage that is too large for more constrained banks and therefore results rather in a better selection of borrowers by the less capital-constrained banks. To explore this further, loan level data would be needed.

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<sup>12</sup> All regressions in Panel B of Table 3 include the change in capital requirement as base effect which is not reported for brevity. The coefficients are statistically insignificant in all cases.

**Table 3: The effect of capital requirements and bank capitalization on lending and interest rates**

The table shows the second step of two-step GMM regression results of a simultaneous equations estimation regressing the quarterly change in lending to the non-financial private sector and the quarterly change in the average interest rate charged for these on control variables. The data range from 2008:Q1 to 2018:Q3. All variables are used at the bank-quarter level and defined in Panel B of Table 1. For the two-step GMM estimator, the first step estimates each equation via 2SLS using the first lag of the dependent variables as instruments, where a Fisher type unit root test based on the Phillips-Perron test rejects a unit root and a Wooldridge test rejects autocorrelation in panel data in all cases. A weight matrix is then calculated which is used in the second step of GMM. The dependent variables are taken to be endogenous to the system and treated as correlated with the disturbances in the system's equations. *Capital requirement* is shown as the cumulative effect over the previous four quarters. *Excess capital* is defined as a bank's capital holdings above its regulatory requirement, divided by the bank's total assets. In Panel A, *Excess capital* as base effect is included but omitted. In Panel B, the change in capital requirement is interacted with an indicator variable, *low excess capital*, which is one when a bank is in the lowest quartile of the distribution of excess capitalization in a quarter and zero otherwise, and with *high excess capital*, which is one when a bank is in the highest quartile of excess capital in a quarter and zero otherwise. In Panel B, the change in capital requirement as a base effect is included but omitted from the table. Control variables are bank size, liquid assets, deposits share, RoA, included lagged by one quarter, and a dummy variable which is one in a quarter in which a bank merges with another bank. In the table, columns (1) and (2), and columns (3) and (4) are estimated simultaneously. The statistical significance of results is indicated by \* = 10% level, \*\* = 5% level and \*\*\* = 1% level using standard errors clustered at the bank level. P-values are shown in parentheses below coefficient estimates.

Panel A: Interaction with excess capital

Dependent variable:	(1) Δ lending	(2) Δ interest rate	(3) Δ lending	(4) Δ interest rate
Capital requirement	-2.078*** (0.000)	0.012 (0.273)	-2.015*** (0.001)	0.010 (0.520)
Capital req. * excess capital	0.369** (0.007)	0.002 (0.427)	0.298** (0.035)	2.80E-04 (0.426)
Bank control variables	yes	yes	yes	yes
Bank fixed effects	yes	yes	yes	yes
Macro control variables	yes	yes	no	no
Time fixed effects	no	no	yes	yes
Observations	5,099	5,099	5,099	5,099
Number of banks	170	170	170	170
R-squared	0.134	0.229	0.163	0.286

Panel B: Banks broken down by excess capital

Dependent variable:	(1) Δ lending	(2) Δ interest rate	(3) Δ lending	(4) Δ interest rate
Capital requirement (low excess capital)	-1.251** (0.045)	0.003 (0.849)	-1.425** (0.023)	-0.005 (0.768)
Capital requirement (high excess capital)	0.189 (0.735)	0.002 (0.893)	0.122 (0.829)	-0.005 (0.759)
Bank control variables	yes	yes	yes	yes
Bank fixed effects	yes	yes	yes	yes
Macro control variables	yes	yes	no	no
Time fixed effects	no	no	yes	yes
Observations	5,051	5,051	5,051	5,051
Number of banks	170	170	170	170
R-squared	0.168	0.287	0.139	0.225

## 4.2 Transmission of capital requirements and monetary policy

In this section, we additionally investigate the effect of supranational monetary policy on corporate loan growth and lending rates. In our sample period, monetary policy was largely accommodative. The bank lending channel was the target of several monetary policy measures and accordingly we hypothesize that monetary policy is also transmitted to bank lending. In addition to the change in capital requirements we incorporate the monetary policy stance which is measured by the cumulative change in the money market rate over the previous three quarters and the current quarter.<sup>13</sup> That is, we estimate the following regression model using again our simultaneous equations setup for both corporate loan growth and the change in the lending rate

$$\Delta Y_{b,t} = \alpha_0 + \sum_{k=1}^K \alpha_{1,k} \Delta cap_{b,t-k} + \alpha_2 \sum_{l=0}^L \Delta MP_{t-l} + \beta X_{b,t-1} + \gamma M_t + f_b + \epsilon_{b,t} \quad (5)$$

with  $\Delta MP_{t-l}$  indicating the change in our monetary policy variable and  $L=3$ . Note that we are not able to include quarter time fixed effects in these regressions as they would absorb our monetary policy variable, which is the same for each bank in a quarter, but include our set of macro control variables  $M_t$  instead. We additionally account for our finding from the previous section and split banks into those in the lowest and those in the highest quartile in terms of their level of excess capital in each quarter. We are interested whether our result – that changes in capital requirements are related only to the lending of weaker banks – continues to hold, and whether differential effects exist with respect to monetary policy between weaker and stronger banks as well. Panel A of Table 4 shows the results.

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<sup>13</sup> We rerun all our analyses using the lending rate spread over the money market rate instead of the lending rate. The results are qualitatively the same.

**Table 4: The effect of capital requirements and monetary policy on lending and interest rates**

The table shows the second step of two-step GMM regression results of a simultaneous equations estimation regressing the quarterly change in lending to the non-financial private sector and the quarterly change in the average interest rate charged for these on control variables. The data range from 2008:Q1 to 2018:Q3. All variables are used at the bank-quarter level and defined in Panel B of Table 1. For the two-step GMM estimator, the first step estimates each equation via 2SLS using the first lag of the dependent variables as instruments, where a Fisher type unit root test based on the Phillips-Perron test rejects a unit root and a Wooldridge test rejects autocorrelation in panel data in all cases. A weight matrix is then calculated which is used in the second step of GMM. The dependent variables are taken to be endogenous to the system and treated as correlated with the disturbances in the system's equations. *Capital requirement* is shown as the cumulative effect over the previous four quarters. *Monetary policy* is the level of the money market interest rate which is shown as the joint average effect over the current and the previous three four quarters. In Panel B, *Monetary Policy* is interacted with indicator variables which are one when the money market interest rate declines (*Monetary Policy [loose]*) and when it increases (*Monetary Policy [tight]*) from month<sub>t-3</sub> to month<sub>t</sub>. Control variables are bank size, liquid assets, deposits share, RoA, included lagged by one quarter, and a dummy variable which is one in a quarter when a bank merges with another bank. In the table, columns (1) and (2), columns (3) and (4), and columns (5) and (6) are estimated simultaneously. The statistical significance of results is indicated by \* = 10% level, \*\* = 5% level and \*\*\* = 1% level using standard errors clustered at the bank level. P-values are shown in parentheses below coefficient estimates.

Panel A: Bank capital requirements and monetary policy						
Dependent variable	All banks		Low excess capital banks		High excess capital banks	
	(1) Δ lending	(2) Δ interest rate	(3) Δ lending	(4) Δ interest rate	(5) Δ lending	(6) Δ interest rate
Capital requirement	-0.870*** (0.002)	0.014* (0.081)	-1.627*** (0.005)	0.023 (0.171)	0.431 (0.476)	0.017 (0.343)
Monetary policy	-0.868 (0.123)	0.136*** (0.000)	-0.608 (0.622)	0.116*** (0.001)	-1.948* (0.081)	0.084** (0.010)
Bank control variables	yes	yes	yes	yes	yes	yes
Bank fixed effects	yes	yes	yes	yes	yes	yes
Macro control variables	yes	yes	yes	yes	yes	yes
Observations	5,123	5,123	1,168	1,168	1,344	1,344
Number of banks	170	170	92	92	80	80
R-squared	0.138	0.234	0.213	0.286	0.135	0.204

Panel B: Bank capital requirements and loose and tight monetary policy						
Dependent variable:	All banks		Low excess capital banks		High excess capital banks	
	(1) Δ lending	(2) Δ interest rate	(3) Δ lending	(4) Δ interest rate	(5) Δ lending	(6) Δ interest rate
Capital requirement	-0.912*** (0.002)	0.00622 (0.442)	-1.64*** (0.004)	0.021 (0.210)	0.39 (0.520)	0.39 (0.520)
Monetary policy [loose]	-0.736 (0.194)	0.154*** (0.000)	-0.532 (0.667)	0.137*** (0.000)	-1.984* (0.077)	0.110*** (0.001)
Monetary policy [tight]	2.130 (0.223)	0.723*** (0.000)	2.106 (0.587)	0.776*** (0.000)	0.174 (0.960)	0.663*** (0.000)
Bank control variables	yes	yes	yes	yes	yes	yes
Bank fixed effects	yes	yes	yes	yes	yes	yes
Macro control variables	yes	yes	yes	yes	yes	yes
Observations	5,123	5,123	1,168	1,168	1,344	1,344
Number of banks	170	170	92	92	80	80
R-squared	0.139	0.257	0.214	0.308	0.135	0.223

Panel A confirms our previous finding. We observe that changes in capital requirements are negatively related to banks' corporate loan growth which is driven by banks with low levels of excess capital. The table also shows that the central bank's monetary policy stance is related to bank lending. Panel A of Table 4 shows that the supranational monetary policy is transmitted to changes in corporate lending rates with a positive relationship. The coefficients in Panel A imply that a one percentage point decrease in the money market rate reduces the change in interest rates by about 0.14 percentage points. We observe neither a relationship of monetary policy to loan growth nor differences of the effects of monetary policy by banks' excess capital.<sup>14</sup>

As mentioned earlier, monetary policy was largely accommodative in our sample period. However, we observe several periods where the average change in the money market rate was also increasing, indicating a monetary policy tightening.<sup>15</sup> To explore whether the effect is symmetric in episodes with a tightening and with an easing monetary policy stance, we split our monetary policy variable into two variables. *Monetary policy [loose]* is the cumulative change in the money market rate when it is negative and zero otherwise. *Monetary policy [tight]* is the cumulative change when it is zero or positive and zero otherwise. We again estimate equation (5) but replace  $\Delta MP_{t-l}$  with these two variables. Panel B of Table 4 shows the results.

We find our previous results confirmed for both the tightening and the easing of supranational monetary policy. Changes in the policy rate are positively related to changes in corporate lending rates. This implies that a looser monetary policy stance translates into lower corporate lending rates while stricter monetary policy implies higher corporate lending rates. Note that the coefficients between our monetary policy variables are not directly comparable in

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<sup>14</sup> We also re-rerun all regressions excluding the changes in capital requirements. All results continue to hold.

<sup>15</sup> As an example, the ECB increased its main refinancing rate from 100bps to 125 bps on April 13, 2011 and further to 150bps on July 13, 2011.

their relation to lending rates as the average decrease in the money market rate, as well as its standard deviation, are much larger than its average increase and deviation in our sample period. Accounting for the average change and standard deviation in the money market rate, the sensitivity with respect to corporate lending rates is rather comparable. Interestingly, column (5) in Panel B shows that banks with high levels of excess capital seem to increase their lending when the money market rate decreases. This may indicate that better capitalized banks are better transmitters of accommodative monetary policy. However, we refrain from interpreting this result in more detail as the coefficient is only marginally significant.

Overall, our results in this section show that changes in capital requirements are negatively related to the loan growth of weaker banks, while changes in supranational monetary policy are positively related to corporate interest rates charged by banks irrespective of their capitalization.

#### **4.3 Transmission of capital requirements, monetary policy, and their interaction**

In this section, we are interested in whether changes in capital requirements and the monetary policy stance are related to bank lending only individually, or also mutually affect their transmission and effectiveness. To explore this, we additionally explore the interaction between changes in the two policies. We estimate our regression model from Panel B of Table 4 again but additionally interact the change in capital requirements with our variables *Monetary policy [loose]* and *Monetary policy [tight]*. We again investigate the results for the total sample as well as separately for the two subsamples of banks with low and high levels of excess capital. The results are shown in Table 5.

**Table 5: The effect of capital requirements and monetary policy stance conditional on bank capitalization on lending and interest rates**

The table shows the second step of two-step GMM regression results of a simultaneous equations estimation regressing the quarterly change in lending to the non-financial private sector and the quarterly change in the average interest rate charged for these on control variables. The data range from 2008:Q1 to 2018:Q3. All variables are used at the bank-quarter level and defined in Panel B of Table 1. For the two-step GMM estimator, the first step estimates each equation via 2SLS using the first lag of the dependent variables as instruments, where a Fisher type unit root test based on the Phillips-Perron test rejects a unit root and a Wooldridge test rejects autocorrelation in panel data in all cases. A weight matrix is then calculated which is used in the second step of GMM. The dependent variables are taken to be endogenous to the system and treated as correlated with the disturbances in the system's equations. *Capital requirement* is shown as the cumulative average effect over the previous four quarters. *Monetary policy* is the level of the money market interest rate which is shown as the joint average effect over the current and the previous three four quarters and interacted with indicators variables which are one when the money market interest rate declines (*Monetary Policy [loose]*) and when it increases (*Monetary Policy [tight]*) from month<sub>t-3</sub> to month<sub>t</sub>. Control variables are bank size, liquid assets, deposits share, RoA, included lagged by one quarter, and a dummy variable which is one in a quarter when a bank merges with another bank. In the table, columns (1) and (2), columns (3) and (4), and columns (5) and (6) are estimated simultaneously. The statistical significance of results is indicated by \* = 10% level, \*\* = 5% level and \*\*\* = 1% level using standard errors clustered at the bank level. P-values are shown in parentheses below coefficient estimates.

Dependent variable	All banks		Low excess capital banks		High excess capital banks	
	(1) Δ lending	(2) Δ interest rate	(3) Δ lending	(4) Δ interest rate	(5) Δ lending	(6) Δ interest rate
Capital requirement	-0.615* (0.056)	0.003 (0.765)	-1.340** (0.044)	0.002 (0.915)	0.297 (0.648)	0.004 (0.822)
Monetary policy [loose]	-0.885 (0.119)	0.171*** (0.000)	-0.552 (0.655)	0.137*** (0.000)	-2.710** (0.015)	0.122*** (0.000)
Monetary policy [tight]	1.441 (0.417)	0.745*** (0.000)	1.836 (0.649)	0.753*** (0.000)	-0.334 (0.925)	0.625*** (0.000)
Capital requirement * MP [loose]	2.677 (0.105)	-0.086* (0.058)	0.760 (0.763)	-0.154** (0.036)	-7.177 (0.207)	-0.328** (0.045)
Capital requirement * MP [tight]	-10.08 (0.285)	-0.546** (0.039)	-12.61 (0.531)	-0.597 (0.307)	-1.133 (0.953)	-1.146** (0.040)
Bank control variables	yes	yes	yes	yes	yes	yes
Bank fixed effects	yes	yes	yes	yes	yes	yes
Macro control variables	yes	yes	yes	yes	yes	yes
Observations	5,123	5,123	1,168	1,168	1,344	1,344
Number of banks	170	170	92	92	80	80
R-squared	0.140	0.263	0.218	0.322	0.157	0.238

Table 5 confirms our previous findings on the transmission of policy changes. Changes in capital requirements are negatively related to the loan growth of banks with lower levels of excess capital, and supranational monetary policy changes are positively related to corporate lending rates. As to the interaction between changes in capital requirements and monetary policy, we observe that an increase in capital requirements has countervailing effects to the transmission of monetary policy changes on lending rates. Both coefficients for our interaction terms are opposite to the positive association of monetary policy to banks' interest rates (column 2). This implies that a decreasing (increasing) policy rate is associated with lower (higher) corporate lending rates; however, when capital requirements simultaneously increase (decrease) this relationship is attenuated. This result is largely confirmed, including where we split banks into those with high and with low levels of excess capital, with the exception of the coefficient of the interaction term between changes in capital requirement and loose monetary policy for banks with low excess capital. It is negative but not statistically significant.

In sum, changes in the supranational monetary policy stance are related to changes in corporate lending rates in the same direction, irrespective of bank health. However, simultaneous but opposite changes in capital requirements might attenuate this transmission. While this might be desirable from a policy perspective when monetary policy is tightened, it might also counteract monetary policy intentions when the policy is accommodative. Importantly, changes in capital requirements are additionally related to the loan growth of weaker banks. This suggests that over the period after the financial crisis, when monetary policy was largely accommodative and bank capital requirements simultaneously were increased, banks' lending interest rates might have decreased to a smaller extent than intended by policymakers, and the loan growth of weaker banks may have actually decreased.

## 5 Conclusion

This paper explores the transmission of bank capital requirements and supranational monetary policy and their joint effect on banks' lending to the non-financial corporate sector in the euro area and corresponding lending rates in the short-term. Our results suggest that for weakly capitalized banks in the short-term increases in capital requirements are negatively associated with changes in loan growth but not with lending rates. The relationship is economically significant as an increase in the regulatory capital requirement of 1 percentage point is associated with a 1.7 percent decrease in euro area bank lending of weaker banks. This effect is only observable for banks operating close to the regulatory required level of capital, and it disappears for excess capital to total assets ratios of around 6 percent. Our results do not show a relationship between capital requirements and corporate lending rates. These findings suggest that externalities of changes in capital requirements in the short-term hinge on the level and the distribution of excess bank capitalization in a banking system.

Our sample period of 2008 to 2018 is predominantly characterized by increases in capital requirements. At the same time, the euro area monetary policy stance was mostly accommodative. When examining the interaction between the two policies, we observe that increases in capital requirements attenuate the general effects of monetary policy on interest rates. Accordingly, our results suggest that the bank lending channel was exposed to these two forces in the opposite direction, potentially implying reduced effectiveness. This finding suggests that a careful and elaborate mutual consideration of monetary policy and bank capital regulation is crucial for ensuring the policies' efficacy.

Overall, our results further may help policymakers to gauge ex ante the domestic as well as international implications of policy actions as well as to identify and gauge possible undesired short-term externalities. Besides, the results show the need for monitoring not only the policy actions of international financially integrated countries, but also certain features of the respective foreign banking systems and its main lenders. Last but not least, this study

provides crucial insights for analyses of the aggregate effects of policy changes (which are beyond the scope of our analysis). Future work exploring aggregate policy effects should account for how determining features, such as banks' excess capitalization, and their distribution is related to the distribution of, for instance, lending volumes.

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