Bank Response to Policy Related Changes in Capital Requirements

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Abstract

We estimate how banks respond to regulatory capital requirements. We use a novel measure called capital surplus/shortfall, which we construct from notifications on regulatory capital requirements sent to Slovenian banks over the period 2009-2015. Capital surplus/shortfall is more relevant than capital adequacy ratio (CAR). It conveys more information about future lending because it is a forward-looking measure of bank capitalization. Our paper carries policy implications for supervisors in countries with a distressed banking sector. Using this measure we show that the same firm has on average a 3.54 p.p. lower loan growth when the loan is obtained through a bank with 1 p.p. higher capital shortfall. Finally, we show that in response to an increase in capital requirements banks engage in risk-taking behaviour.

JEL Classification Codes: G01, G21, G28

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1 Introduction

The recent financial crisis induced policymakers to introduce instruments that aim at preventing and mitigating the effects of systemic risks. These instruments are collectively called macro-prudential instruments. Of the macro-prudential instruments several are related to capital requirements[1]. However, it is not entirely clear how policy-related changes in capital requirements, whether they are micro- or macro-prudential, affect bank behaviour. We investigate how they affect banks by using a new and timely measure of policy-related changes in capital.

We show that the conventional variables used to estimate the effect of policy-related changes in capital on credit supply are flawed. The reason is twofold. First, the capital adequacy ratio (CAR) measures the ratio of a bank's capital to its risk-weighted assets. It contains policy and non-policy-induced changes in capital. The coefficient on the CAR will thus also reflect non-policy related changes[2]. By using it as a proxy for *policy*-related changes the estimated response of banks will be biased. Second, capital requirements are announced to the banks before they become binding. They can adapt to them before the final change in capital is recorded.

In this paper, we account for these two facts and provide a new estimate of how banks respond to policy-related changes in capital. With the help of the supervision department of the Bank of Slovenia, we collected notification letters. They inform banks on their future required CAR that is to be fulfilled in a year. We calculate the difference between a bank's current CAR and its future required ratio and call it $Surplus/Shortfall$. We use it to estimate the effects of policy-related changes in capital requirements on credit supply.

We consider the Slovenian banking system, which was among the most severely affected in the global financial crisis. Due to high credit risk, its share of non-performing loans (NPLs) reached 25% for the corporate sector in 2013. This triggered bank re-capitalizations that amounted to more than 20% of GDP (in 2014). It places Slovenia third according to recapitalization costs among European countries (see Hartmann et al. (2018)) and makes it particularly suitable for analysis of distressed banking systems.

The literature on the effects of policy-induced changes in capital on credit supply is scarce. Seminal papers investigate how (reduced) shocks to capital affect bank behaviour: Bernanke et al.

[1] E.g. counter-cyclical capital buffer, systemic risk buffer, capital conservation buffer and other. See Claessens (2015).

[2] For example, an increase in CAR due to recapitalization is likely to increase credit supply (see for example Beccalli et al. (2018) who show that bank recapitalizations lead to asset expansion). But an increase in capital, that is due to stricter policy requirements, is likely to decrease credit supply.

(1991), Hancock and Wilcox (1994) and Hancock et al. (1995)[3]. Bernanke et al. (1991) use bank capital to explain credit supply. Capital alone cannot be used as a proxy for policy-related changes in capital requirements because it is not a policy-induced target like $Surplus/Shortfall$. Hancock and Wilcox (1994) and Hancock et al. (1995) use the deviation of capital to assets ratio from an estimated target capital. Yet, target capital does not necessarily reflect policy decisions. Other approaches include Kishan and Opiela (2000) and Gambacorta and Mistrulli (2004). They use a variant of capital that could be a lagged or contaminated signal for the true notifications on capital requirements.

Some of the cited literature does not claim that they are investigating the effects of policy-induced changes in capital on credit supply, but they often draw policy conclusions. Other papers use the capital requirement ratio to draw them. See for example, Thakor (1996), Gambacorta and Mistrulli (2004), and Aiyar et al. (2016). These papers are closer to our approach. However, they do not take into account that requirements are disclosed to banks before they become legally binding. Bank's current CAR thus reflects past policy announcements. This timing mismatch could bias the coefficients and render policy implications incorrect. $Surplus/Shortfall$ does not suffer from a timing mismatch because it is a forward-looking measure of bank capitalization.

Based on a sample of Slovenian banks, for the period 2009-2015, we find that the same firm has on average a 3.5 p.p. lower loan growth in banks with 1 p.p. higher capital shortfall. We show that if the CAR is used as a proxy for policy-related changes, the estimated effect is only 0.8 p.p. When we use both measures in a single model, the coefficient on the CAR decreases and becomes insignificant. This implies that our measure of capital shortfall is a superior proxy for policy-related changes in capital. It delivers quantitatively and qualitatively different results when compared to the CAR. For this reason, policymakers and academics should strive to record or recover a series of notification dates. This will enable them to better assess their effect on bank behaviour.

We also show that banks with a capital shortfall tend to engage in risky behaviour. Compared to banks with a surplus they lend less to firms with the highest credit rating and provision less for NPLs.[4] By implication, policymakers should not only be concerned with a capital shortfall. They should closely supervise the risk-taking by banks after the capital requirement is announced.

We conclude the empirical part with a finding that firms cannot compensate for the decrease in lending by borrowing more from banks with a surplus. Increased capital requirements have a

[3]See also Berrospide and Edge (2010).

[4]These results are consistent with Brezigar-Masten et al. (2015). They show that in the crisis period Slovenian

negative effect on aggregate firm borrowing. This was expected since it is difficult for firms to switch to a different bank during a crisis period.

Note that the literature cited above suffers from an omitted variable bias. The variable that is omitted is loan demand[5]. The above-cited authors attempt to control for it by including macroeconomic variables. The problem, however, is that one can never be sure if this control is sufficient. Our results are free from this problem. We use the Khwaja and Mian (2008) difference-in-difference model on detailed data form credit registry. Our model controls for all effects that vary across firms and in time, including also the demand for loans. It is further explained in the Model section.

An important recent contribution, that conforms with our results, is provided by Gropp et al. (2019). They use the EBA 2011 capital exercise to investigate how banks responded to a one-time increase in capital requirements. Similar to us, they find that banks ration on credit to improve on their capital ratios. They show that increased capital requirements resulted in a reduction in firm investment, sales and growth. This is an important transmission channel of financial shocks to the real economy. We instead focus on risk and loan loss provisioning. This enables us to draw policy conclusions related to credit risk, the most important determinant of a sound financial sector. Gropp et al. (2019) data is, in a geographical sense, representative for the euro area whereas we use a single country data that focuses on a distressed banking system. They focus on a single time period whereas we study the response of banks over a period of seven years. Our sample, although more restricted in the geographic scope, includes all loans and not only syndicated loans. Syndicated loans are loans given by a syndicate of banks predominantly to large international corporations. Finally, we control for individual firm loan demand whereas Gropp et al. (2019) control for firm-cluster level demand. The two papers are complementary in their results.

Another recent working paper is provided by De Jonghe et al. (2016). They study how regulatory capital requirements affect Belgian banks' balance sheet composition and supply of loans to firms. They find that capital requirements have a small effect on bank lending. They do not take into account that only banks with a capital shortfall are required to adjust their capital adequacy. We find that the effect of capital surplus on lending is insignificant but the effect of capital shortfall is substantial and significant. We use growth of loans before and after a required CAR is announced. They use quarterly loan growth rate as a dependent variable. This could attenuate their coefficients since banks tend to adjust their assets around the time of the announcement.

banks underestimated credit risk, more so if they were weakly capitalized.

[5]Ciccarelli et al. (2015) control for it by including indicators of demand obtained from a bank lending survey. For

Three other papers that are close to ours are Jiménez et al. (2017), Mesonnier and Monks (2015) and Behn et al. (2016). Jiménez et al. (2017) use the same estimation strategy, the difference-in-difference model. They investigate how dynamic provisioning affects loan supply before the crisis. Dynamic provisioning can be interpreted as a form of capital requirement. We instead investigate the period after the financial crisis and use data on future capital requirements. Mesonnier and Monks (2015) study the impact of EBA's 2011/2012 capital exercise on lending. Like us, they use announced increases in capital requirements, that were largely unexpected. Their analysis is done at a bank level and can control for demand only at a country level. We control for it at a firm level. Behn et al. (2016) study the effect of model-based capital regulation on bank lending. Following an exogenous increase in credit risk in Germany, caused by the collapse of the Lehman Brothers in 2008, model-based capital requirements increased by 0.5 p.p. They that in response banks that used IRB regulatory approach contracted loan amount by 2.1 to 3.9 p.p. more than banks that used the standardized approach. They study the impact of increased capital requirements that are endogenous to the IRB regulatory approach. Our findings are based on policy-related increases in capital requirements.

The remainder of this paper is structured as follows: presenting our data on capital requirements, applying the model, demonstrating results and finishing with conclusions.

The rest of the paper is structured as follows. Section 2 presents data on capital requirements and notification letters. The model is described in Section 3. Section 4 contains the main empirical analysis and Section 5 concludes.

2 Capital Requirements

The Slovenian banking system is subject to the Basel II regulatory framework since 2007 and to the Basel III framework since 2013. Under Pillar II of the Basel II and III banks are required to fulfill minimum capital requirements, which are subject to supervisory review.

The supervisory review consists of two steps. The first step, called the Internal Capital Adequacy Assessment Process (ICAAP), requires banks to internally asses their capital adequacy. The second step, called the Supervisory Review and Evaluation Process (SREP), requires the supervisor to review the bank's self-assessment. The key output of the ICAAP-SREP process is summarized in the required CAR. Bank's CAR is the ratio between a bank's capital and its risk-weighted assets

a critique of this approach see Peydro (2010) .

(hereafter RWA). Bank's required CAR is the amount of capital, also expressed as a share of risk-weighted assets, that a bank is required to hold to be considered as adequately capitalized.

The SREP was conducted for the first time by the Bank of Slovenia in 2009. Each April the banks report their internal assessment of adequate capitalization (ICAAP). The Bank of Slovenia revises it and issues its own recommendation (SREP)[6], usually by August each year. Some banks are found to be undercapitalized and some overcapitalized. If the bank is undercapitalized, the supervision department of the Bank of Slovenia holds a meeting with it where they discuss necessary adjustments. The bank is given six months to submit a written action plan[7]. Except in 2013, banks have always restored the adequate capital ratio within a year.

A bank has a capital shortfall if its CAR is lower than the required one and is obligated to increase its capital share in RWA. If a bank has a capital surplus it is not required to adjust. In Table 1 we present summary statistics across surplus and shortfall banks. On average, there are 13 surplus banks per year with an average surplus of 2.8% of the RWA. There are fewer shortfall banks, 4.4 per year on average, and they hold an average shortfall of 3.3%. Besides total capital requirements, we also present information on Tier 1 capital requirements[8]. Average surplus/shortfall in Tier 1 capital requirements is similar to total capital requirements.

In the last four rows of Table 1 we characterize the surplus and shortfall banks according to their CAR, share of NPLs, asset size and the number of firms which they were lending to at the time of capital announcements. Banks with a shortfall are characterized by lower capital adequacy and a higher share of NPLs. Their total assets are of similar size compared to banks with a surplus. Banks with shortfall hold a lower average number of lending relations because there are fewer of them.

The bank needs to address its shortfall within a year. It can restore its capital adequacy by increasing capital (the numerator) or by decreasing the risk-weighted assets (the denominator).[9]

A bank can increase its capital either by raising new capital or by retaining profit. A bank can decrease its risk-weighted assets by decreasing risky assets (such as risky loans) or by restructuring its current assets[10]. In expansions, when profit is abundant, the banks often re-capitalize from

[6]The regulation on adequate bank capitalization includes capital provisions for different types of risk. The most important types of risk are credit risk, liquidity and operational risk. Further information can be found on the European Banking Association's web page.

[7]The banks are required to hand in a written action plan since 2013. It defines the steps that the bank will take to restore adequate capitalization.

[8]Tier 1 capital requirements are defined more narrowly compared to total capital requirements.

[9]The bank needs to increase its capital by more than its risk-weighted assets or decrease its risk-weighted assets by more than its capital.

[10]The bank can re-qualify existing loans into a higher quality brackets by obtaining proof that they are safe or by obtaining new guarantees related to the loan. Banks can also sell off a risky subordinated firm to increase its CAR.

Table 1: Average values across surplus and shortfall banks

	Banks with Surplus	Banks with Shortfall	Total
Number of banks per year	13	4.4	17.4
Total Surplus/shortfall (% of RWA)	2.8	-3.3	1.2
Tier 1 Surplus/shortfall (% of RWA)	3.4	-3.4	1.7
Capital adequacy (% of RWA)	14.0	10.4	12.9
Share of NPLs (%)	8.9	15.5	10.5
Total assets (EUR bln)	2.6	2.5	2.6
Number of firm-bank relations per year	38614	11726	50340

Source: Bank of Slovenia, own calculations.
Notes: The table reports the average values in periods when SREP letter was sent to the banks. Total (Tier 1) Surplus/Shortfall is surplus/shortfall in total (Tier 1) capital requirements. Share of NPLs is defined as share of loans classified in C, D or E rating class.

retained earnings. In contractions, it is harder for them to do so. In contractions, it is more likely that banks will utilize a decrease in loans in order to restore their capital adequacy.

Our policy variable (bank surplus/shortfall) is expressed in terms of the two CARs:

$$Surplus/Shortfall_{it} = CAR_{it} - RCAR_{it} \tag{1}$$

where CAR_{it} represents bank i's CAR in period t and $RCAR_{it}$ represents the required CAR. t relates to the period when a bank received the letter of notification[11] on its adequate CAR and up to the period when a new letter on a new required CAR ($RCAR_{it+1}$) is received. The capital surplus/shortfall is forward-looking because banks have up to a year to adjust their CAR (CAR_{it}) towards the required ratio ($RCAR_{it}$). E.g.: a bank with a 2 p.p. shortfall needs to increase its CAR by 2 p.p. in a year's time following the notification. A bank with a surplus is not required to adjust its capital. However, higher capital, holding everything else constant, will render a bank less profitable per capital unit. Therefore, the bank has an incentive to increase its risk-weighted assets (e.g., by increasing loans).

Furthermore, it is reasonable to expect that the effect of the capital shortfall and surplus is asymmetric for lending. Given that only banks with a shortfall are required to adjust their capital, we expect them to react stronger than banks with a surplus. To account for asymmetric effects we introduce an interaction variable $Surplus/Shortfall \times D_{Shortfall}$:

$$Surplus/Shortfall_{it} \times D_{Shortfall_{it}} = \Big[CAR_{it} - RCAR_{it}\Big] \times I(CAR_{it} < RCAR_{it}) \tag{2}$$

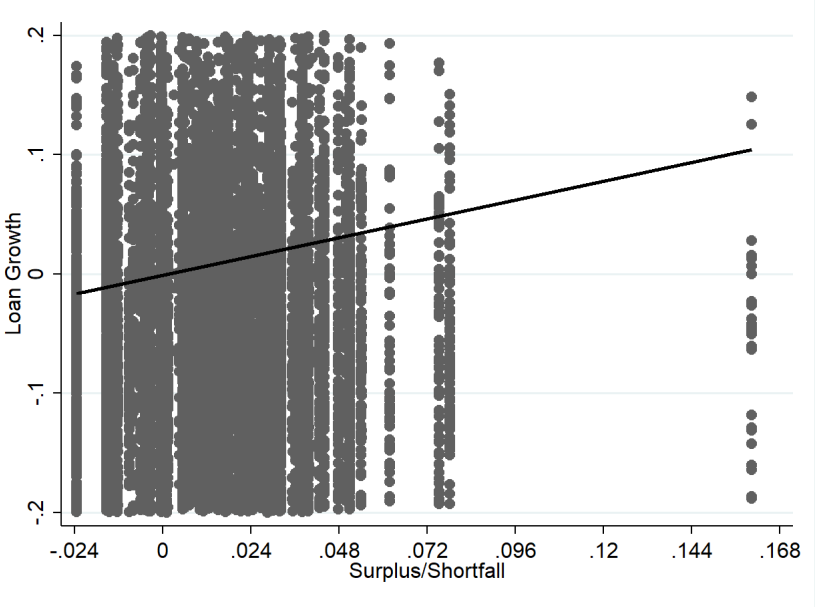
[11]Note that in some cases two notification letters were sent to an individual bank within a single SREP process. In such cases we disregard the second letter and only take into account the first letter. After the first letter has been received, the bank is already informed on policy maker's view of its adequacy and the second letter can no longer be

where $I(.)$ is an indicator function that takes value *1* when the condition in the brackets is met and *0* otherwise. This is the same variable as $Surplus/Shortfall$ except that it has zeros when a bank has capital surplus.

We expect a positive coefficient on the interaction variable. The higher the $Shortfall_{it}$ (the more negative the variable is), the larger is the expected decrease in loan growth, since it restores capital adequacy. We later show that $Surplus/Shortfall$ is a superior measure in terms of explaining credit growth when compared to the CAR (CAR_{it}).

In Figure 1 we present a zoomed-in scatter plot between loan growth at the firm-level (y-axis) and $Surplus/Shortfall$ (x-axis). The scatter plot is zoomed in because firm-level loan changes are very dispersed. This obstructs visual representation of results. [12] Gray points are individual loans, and the black line is the fit between them and capital $Surplus/Shortfall$. An increase in $Surplus/Shortfall$ is associated with an increase in loan growth.

Figure 1: Micro loan growth (y axis) and $Surplus/Shortfall$ (x axis)



Source: Bank of Slovenia, own calculations.
In this Figure we present a zoomed-in scatter plot between (micro) loan growth rates and $Surplus/Shortfall$, which is defined in Eq. (1). The black line represents a linear fit.

We expect most of the adjustment in credit to occur within a year after the bank was found to have a shortfall (or a surplus) because they are required to restore their capital adequacy in that period. Besides, banks might decide to restore it (and thereby adjust credit) even sooner out of

treated as unexpected.

[12] In the empirical application we exclude all the observations at 1^s and 100^{th} percentile of loan growth distribution.

prudential concerns.

We now show that firm-specific loan growth depends on the origin of the loan. Loans originating from surplus banks are expected to grow faster or to decrease by less, compared to loans originating from the shortfall banks. The difference is expressed for firms that hold loans with at least two banks, and where out of the two (or more banks) at least one had a capital shortfall and at least one had a surplus.

We report the Welch (1947) test for equality of means in Table 2. The null hypothesis states that there is no statistically significant difference between average loan growth rates of firms financed by banks with a shortfall or with a surplus. Because our data is dispersed and winsorized we also perform Mann and Whitney (1947) test for equality of medians[13].

Table 2: Average credit growth across surplus and shortfall banks

	1q		2q		3q average	
	N	Mean	N	Mean	N	Mean
	Total capital requirements					
Surplus banks	19703	-0.003	19165	0.004	21941	0.021
Shortfall banks	13568	-0.037	13131	-0.038	15023	-0.024
Welch p-value		0.000		0.000		0.000
Mann-Whitney p-value		0.000		0.000		0.000
	Tier 1 capital requirements					
Surplus banks	30454	0.005	29682	0.016	33617	0.036
Shortfall banks	20826	-0.012	20157	-0.005	23252	0.004
Welch p-value		0.000		0.000		0.000
Mann-Whitney p-value		0.000		0.000		0.000

Source: Bank of Slovenia, own calculations.
Notes: In this table we report and test the difference in average loan growth at the firm level between banks in a capital surplus and shortfall position. The statistics are calculated for the same firms borrowing from at least two banks, where at least one had a capital shortfall and at least one had a surplus. Statistics are reported across three different periods and for total and Tier 1 capital requirements. Sample is 2009Q3-2015Q3. Capital shortfall is defined in Eq. (2).

The table contains six columns, separated into three double columns. Each double column contains the number of loan relations with banks in a shortfall or surplus position (N) and average loan growth by type of a bank (*Mean*). $1q$ stands for average loan growth between 1 quarter before and after the notification (similar for $2q$). $3q$ *average* stands growth of the average loan amount in the 3 quarters after the notification compared to the 3 quarters before it.

Note that loan amount enters loan growth and CAR. This could cause reverse causality bias. Yet, each firm's specific loan is small compared to the bank's total stock of loans, and is thus unlikely

[13]We thank the anonymous referee for suggesting it.

to be causal. Besides, loans that enter CAR pre-date the loans included in the loan growth reported above. It takes time for the supervisor to analyze the data and draft a decision. Finally, we ensure that there is no overlap in the credit growth between two consecutive SREP processes.

The table also contains two separate blocks of rows. The first block reports loan growth for the Total capital requirements and the second for the Tier I capital requirements. The mean tests are performed over both types of capital because it's possible that one type of capital is better in explaining loan growth than the other. It would then be important to use the type of capital that is more likely to be causal for loan growth.

Finally, in the last two rows, we test for differences in mean and median with Welch's and Mann-Whitney's test, respectively. The average growth rate of loans is statistically different in shortfall banks compared to surplus banks, regardless of the type of capital, horizon and type of test.

Note also that loan demand is implicitly controlled for in Table 2. The table includes only firms that have loan relations with surplus and shortfall banks. If the firm's loan demand changes, the change should affect surplus and shortfall banks simultaneously and with the same magnitude[14]. However, the difference in average growth rates could be driven by third factors, which we control for in a regression model.

3 Model

In this section, we describe the identification strategy employed in the loan-level model. The key advantage of the loan-level model is that it controls for loan demand and thereby yields unbiased and consistent estimates of the coefficients. The methodology described in this section was put forward by Khwaja and Mian (2008) and further adopted by Jiménez et al. (2012) and others.

Khwaja and Mian (2008) use a clever estimation technique that controls for loan demand, which is unobserved[15]. This implies that any model explaining credit growth is missing a key control variable. If omitted control variable is correlated with regressors the coefficients are biased and inconsistent. The extent of bias depends on the strength of correlation. One can still use the model by introducing reasonable proxies for loan demand, such as the real GDP or investment, but he will remain uninformed on the extent of bias left.

[14]We are making an assumption that loan demand is independent of a bank. This is a common assumption in the difference-in-difference models. If loan demand is instead bank-specific, it can be controlled for with loan application data. Loan application data are unfortunately rare. We further discuss this assumption later in the text.

[15]Data on loan applications, which are a good proxy for loan demand, are rare. See for example Jiménez et al. (2012).

Khwaja and Mian (2008) bypass this issue by exploiting the data at loan level. Their data consists of borrowers who have at least two banking relations. The idea is intuitive. If the borrower's loan demand is constant between the two banks in a given time period, we can introduce a borrower-specific dummy that controls for loan demand in that time period. An analogous approach is used in a fixed effects model by means of transforming the data over the time dimension[16]. However, the variable that we need to control for (the loan demand) is not fixed over time. It is instead fixed over a borrower within each single time period. If we then have more than one observation per borrower, for each single time period, we can control for loan demand. The next few paragraphs present a simplified example that explains the idea originally presented in Khwaja and Mian (2008). The example presented in Khwaja and Mian (2008) is for a cross section (e.g., y_{ijt} is not time indexed). They do mention that the model can be applied to a time series setting.

Suppose we have N borrowers with at least two banking relations[17]:

$$y_{ijt} = \beta X_{ijt} + \eta_i + \nu_{it} + \epsilon_{ijt} \tag{3}$$

Where y_{ijt} stands for borrower i's loan (where $i = 1...N$) borrowed from bank j (where $j = 1...M$) in time t (where $t = 1...T$). X_{ijt} represents a $K \times 1$ vector of policy and control variables that we do not specify at this point. η_i represents the conventional fixed effects. They control for borrower characteristics that do not change over time. Suppose we now add to Eq. (3) a dummy variable that takes the value of 1 for individual i and zero elsewhere[18]. Because η_i is time invariant it will be absorbed by the dummy variable:

$$y_{ijt} = \beta X_{ijt} + \gamma D_i + \nu_{it} + \epsilon_{ijt} \tag{4}$$

This would be the conventional fixed effects model where D_i controls for η_i. However, the borrower's loan demand (ν_{it}) is time-variant. Because it is time-variant, it cannot be absorbed by the time-invariant dummy D_i. If we then estimate equation 4 as it is, ν_{it} will be absorbed into the error term. If the error term is correlated with the regressors in X_{ijt}, β will be biased and

[16]Note the subtle difference between the fixed effects estimator and the Khwaja and Mian (2008) difference-in-difference estimator. The fixed effects estimator exploits the fact that the fixed effects are constant over time. With at least two time periods they can be controlled for using a dummy for each borrower or by means of data transformation. But, loan demand changes over time so one cannot control for it using a time constant dummy for each borrower.

[17]This is a reduced form model. Khwaja and Mian (2008) derive it from a simplified theoretical model.

[18]The estimator of this kind of model is called the least squares dummy variable estimator. If the number of borrower's (N) is large we cancel out the fixed effects by transforming the data. We can, for example, use first differences: $\Delta_t y_{ijt} = \beta \Delta_t X_{ijt} + \Delta_t \nu_{it} + \Delta_t \epsilon_{ijt}$, where Δ_t represents differencing over time.

inconsistent. Jiménez et al. (2012) instead control for loan demand by introducing a dummy variable that takes the value of 1 for borrower i, over all banks j ($j = 1...M$) in time period t[19]:

$$y_{ijt} = \beta X_{ijt} + \gamma D_{it} + \epsilon_{ijt} \tag{5}$$

Borrower-specific time dummy (D_{it}) will absorb the loan demand (ν_{it}), rendering the estimates of β unbiased and consistent. Note also that the conventional fixed effects (D_i) are now excluded from the model because they are controlled for by D_{it} (they are perfectly collinear). By the same argument, the firm-time specific dummy absorbs time fixed effects (should they be included in X_{ijt}).

The model in Eq. (5) is general. In the next section, we specify X_{ijt} and present the results.

4 Results

Results include three tables with multiple regressions and a figure. They highlight different relations between a capital shortfall or surplus and bank behaviour. The first table shows that banks with a capital shortfall tend to decrease loan supply. We also show that restructuring of distressed banks expands bank lending. Next, we show that when surplus/shortfall is controlled for, the CAR (which is often used in empirical literature to identify the effects of capital requirements on loan supply) becomes insignificant. Finally, when we control for firm riskiness we find that banks with a shortfall decrease lending to prime-rated firms by more than banks with a surplus. This shifts their credit portfolio towards riskier clients. They also decrease provisioning for NPLs. We conclude that an increase in capital requirements is contractionary and could increase a bank's credit risk. Policy implications are discussed in the conclusion.

Main results are in Table 3. It shows that banks with a shortfall decrease loans to the same firm by more than banks with a surplus. Relative to surplus banks they tend to decrease lending to firms with highest credit rating.

Loan Growth is bank-firm specific and the sample period is 2009-2015. The model includes firm-time fixed effects (see Eq. (5) in the Model section) and bank-specific variables[20]. The choice of control variables was guided by theory and related research (see for example Khwaja and Mian

[19]To avoid introducing a large number of dummies we can difference the data for each individual i, in each time period t, over the two banks: $\Delta_{j=1,2}\Delta_t y_{ijt} = \beta\Delta_{j=1,2}\Delta_t X_{ijt} + \Delta_{j=1,2}\Delta_t \epsilon_{ijt}$, where $\Delta_{j=1,2}$ is the difference related to banks 1 and 2. Note that variables that are fixed across the banks for a given borrower i in a given time period t will be excluded from the model.

[20]The reader will note that other variables that do not change for firm i, between banks j in time t, are controlled for with firm-time fixed effects. Such variables could include real business cycle, borrowers financial soundness, firm

Table 3: The effect of capital surplus/shortfall on bank lending

	(1)	(2)	(3)	(4)	(5)
	All firms	Performing firms			
Surplus/Shortfall	0.61	0.91*		0.37	-0.38
Surplus/Shortfall $\times D_{trans}$	-3.81***	-4.79***		-6.79***	-6.72***
Capital adequacy	0.01	0.14	0.78**	0.10	0.39
Capital adequacy $\times D_{trans}$			1.11***		
Surplus/Shortfall $\times D_{shortfall}$				3.17*	3.74**
Rating					-0.05***
$D_{RatingA} \times D_{Shortfall}$					-0.05**
$D_{RatingBCDE} \times D_{Shortfall}$					0.01
NPL ratio	-0.01***	-0.01***	-0.01***	-0.01***	-0.01***
Total assets	0.00	0.00	-0.00	0.00	0.00
Constant	0.05	0.04	-0.02	0.06	0.07
Firm-time FE	Yes	Yes	Yes	Yes	Yes
No. of observations	36964	31477	31477	31442	31442

Source: Bank of Slovenia, own calculations.
Notes: In the table we report the effect of a capital surplus/shortfall on loan growth for firms borrowing from at least two banks that differ in the size of surplus/shortfall. The dependent variable is credit growth between the average loan amount in 3 quarters after the SREP letter was sent relative to 3 quarters average before the letter. Shortfall and Surplus are defined in equations (1) and (2). D_{trans} is a dummy variable that takes value *1* if a bank was subjected to a transfer of NPLs to a Bank Asset Management Company. All the models include firm-time fixed effects, which control for firm characteristics. We use robust standard errors. Significance: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

(2008), Jiménez et al. (2017) and Bonaccorsi di Patti and Sette (2016)). *Surplus/Shortfall* is described in the section on Capital Requirements (see Eq. (1)). *Capital adequacy* stands for CAR and controls for capitalization of the bank, *NPL ratio* for share of NPLs[21] (controls for bank's risk preferences) and *Total assets* control for bank size.

Surplus/Shortfall$\times D_{trans}$ is a control variable that interacts *Surplus/Shortfall* with a dummy variable D_{trans}. D_{trans} takes a value of *1* if bank j was in year t subjected to a transfer of NPLs to a Bank Asset Management Company (BAMC) and recapitalized by the government. In 2013, Slovenian authorities collaborated with the ECB and the European Commission in a comprehensive review. It included asset quality review and stress tests (for details, see Bank of Slovenia (2013)). Following the review, several banks were found distressed or insolvent. The distressed banks were capitalized by the government and a portion of their bad assets was transferred to the BAMC. In exchange they received safe bonds[22].

We excluded credit data for firms whose debt was transferred to the BAMC. Even so, it is still

size, etc.
[21]NPLs are defined as the share of borrowers classified in rating classes C, D or E. Rating scale is from A to E.
[22]Further information can be found in Bank of Slovenia (2015) and on the BAMC web-page.

important to control for this effect as distressed banks had a large capital shortfall (see Bank of Slovenia (2013)). We would expect them to contract lending extensively to meet capital requirements. These cases are however different. It was known in advance that the government plans to capitalize them. Therefore they were not constrained by capital shortfall even though it was high. Also, not only was the capital shortfall not binding for them, they received an extensive capital injection. We expect them to lend more, not less. The interaction variable *Surplus/Shortfall*$\times D_{trans}$ controls for these unique events.

Table 3 includes five columns. In the first column, we present results for the full sample. In the second column, we present them for the sample of firms that are performing[23] over the whole sample period. We focus on this sample because the sample of all firms is prone to bias. Due to accounting rules, the non-paid interest of defaulted firms is added to the outstanding amount of loan. This could be falsely interpreted as an increase in loan amount.

In column (3,) we present results for a regression that excludes capital Surplus/Shortfall. In column (4), we distinguish between responses to capital shortfall and capital surplus. Finally, in column (5), we present evidence that banks with a capital shortfall shift their credit portfolio towards riskier clients.

All significant control variables have expected signs. Banks with a higher share of NPLs decrease their credit supply by more than banks that have a lower share of NPLs. The effect is significant but rather small. Bank size, measured with total assets, is statistically and economically insignificant.

Regression (2) shows that if the same firm borrows from a bank with a 1 p.p. lower Surplus/Shortfall, it is expected to have a 0.91 p.p. lower loan growth (or 0.61 p.p. when the sample of all firms is used, see regression (1))[24]. The result is significant at the 10% level. This is likely because banks with a shortfall tend to decreases their lending to improve their capital ratios, but banks with a surplus increase it to improve their profitability per-unit of capital.

The coefficient on Surplus/Shortfall for distressed banks, subject to a transfer of assets to the BAMC (Surplus/Shortfall$\times D_{trans}$), is negative and significant at 1%. We estimate that an additional 1 p.p. increase in the shortfall is expected to increase loan growth to the same firm (at the time of the transfers) by 3.88 p.p. $(= -1 \times (-4.79 + 0.91))$. The coefficient is capturing the effects of government-led bank (re)capitalization. We conclude that bank-restructuring process had strong

[23]Firms with less than 90 days overdue in loan repayment.

[24]Surplus/Shortfall and loan growth enter the model as a number and not as a percentage. To calculate the effect of a 1 p.p. increase in Surplus/Shortfall the coefficient is multiplied by 0.01, giving the results $0.91 \times 0.01 = 0.0091 = 0.91 p.p.$

and positive effects on lending.

In regression (3) we omit capital Surplus/Shortfall. Due to its omission, the coefficient on CAR becomes positive and statistically significant (the exact level of significance is 1.7%). The effect of a 1 p.p. increase in CAR is estimated to be similar (0.78) to a 1 p.p. increase in Surplus/Shortfall (0.91). We have argued that transfers of distressed assets to the BAMC are important for a response of bank lending to capital. Thus the regression includes an interaction term that controls for transfers (Capital adequacy $\times D_{trans}$)[25]. As in regression (3), we find a positive and significant effect on loan growth[26].

The coefficient on CAR becomes statistically insignificant when we add capital Surplus/Shortfall (compare regression (3) with regression (2)). The reason is that Surplus/Shortfall, by construction, conveys more information on future loan growth. Banks will have to adjust their lending (and other balance sheet items) to restore their capital ratios in a period of one year. It is a forward-looking measure of bank capitalization.

We assumed that the response to a 1 p.p. decrease in Surplus/Shortfall is the same for all banks (0.91 p.p. in regression (2)). However, banks with a shortfall are required to restore their CAR, whereas banks with a surplus are not required to act. Therefore, it could be that the response is asymmetric across the two types. In regression (4), we test for asymmetric effects. We take regression (2) and add to it an interaction term between *Surplus/Shortfall* and a dummy variable $D_{Shortfall}$. $D_{Shortfall}$ takes the value 1 if bank had a shortfall (see Eq. (2)) in section on Capital Requirements). The coefficient on the interaction term is significant at 10%. It tells us that the same firm is expected to have a 3.54 p.p. $(= 0.37 + 3.17)$ lower loan growth when borrowing from a bank with a 1 p.p. higher capital shortfall. The effect is substantial and likely occurs because shortfall banks decrease loans to improve their CAR.

We next investigate if policy-induced changes in bank capital affect banks risk-taking. Banks can decrease their risk-weighted assets (and increase the CAR) by reducing lending to riskier borrowers. This is especially holds for the internal rating based (IRB) regulatory approach[27]. Under the IRB approach risk weight is a function of a borrower's probability of default. All Slovenian banks, except one, use the standardized approach to calculate capital requirements for their corporate portfolio.

[25]If the interaction term is omitted from the regression, the coefficient on CAR becomes insignificant with the exact level of significance at 14.4%. At the suggestion of a referee, we also verified the robustness of regressions (4) and (5) to the inclusion of the interaction term. The interaction term is insignificant and does not change the conclusions.

[26]CAR is taken from a period just before the notification letter was sent to the bank. This implies that its value is lower compared to its value after recapitalization took place.

[27]The Internal rating based (IRB) regulatory approach is an approach to portfolio and credit risk evaluation under

Under the standardized approach banks use external credit ratings to determine risk weights[28]. However, these are available only for a small fraction of Slovenian firms. As a result, banks must apply a common risk weight of 100% for all performing firms, except those for which external credit ratings are available[29]. Since firms are assigned the same risk weight banks lack incentive to decrease loans to risky borrowers. Banks with a shortfall have an incentive to lend more to them because this could increase capital through higher profit and prevent risky borrowers from being classified as non-performing.

We now investigate how firm risk affects banks (regression (5)). Banks classify firms into risk brackets that range from A (best) to E (worst). We quantify them by assigning them values from 0 (A) to 4 (E) and label this variable *Rating*. We find that a downgrade by one risk bracket is expected to decrease loan growth by 5 p.p..

The regression also includes an interaction between a dummy variable for banks with a capital shortfall ($D_{Shortfall}$) and two dummy variables for firm risk. The first is for A-rated firms ($D_{RatingA}$) and the second for firms with credit ratings B, C, D and E ($D_{RatingBCDE}$). The distribution of firms is skewed towards A-rated firms. We also exclude the non-performing firms so the number of firms with credit rating D and E is small. To ensure a sufficient number of observations per a dummy variable we join B, C, D and E rated firms in one group.

We find that banks with a capital shortfall decrease lending to best-rated firms by 5 p.p. more compared to banks with a capital surplus. The result is significant at the conventional level. The coefficient on $D_{RatingBCDE} \times D_{Shortfall}$ tells us that banks with a shortfall increase lending to riskier firms by 1 p.p. more compared to banks with a surplus, however, it is not statistically significant[30].

The results imply that regulatory capital requirements can have and adverse effects on bank risk-taking. After an increase in capital requirements banks with a shortfall increase the share of risky firms in their portfolio. Thus, the supervisor should limit their options in adjusting assets in a way that would prohibit them from further risk-taking.

The results presented so far depend on a specific time window that is used for the calculation of credit growth. We compare the average loan amount in the three quarters after the notification is

which banks estimate credit risk themselves.

[28]For details see Capital requirements regulation (CRR) or Basel II.

[29]Note that in line with CRR a risk weight for defaulted firms can also be 150%. In our sample we exclude defaulted firms and this does not apply.

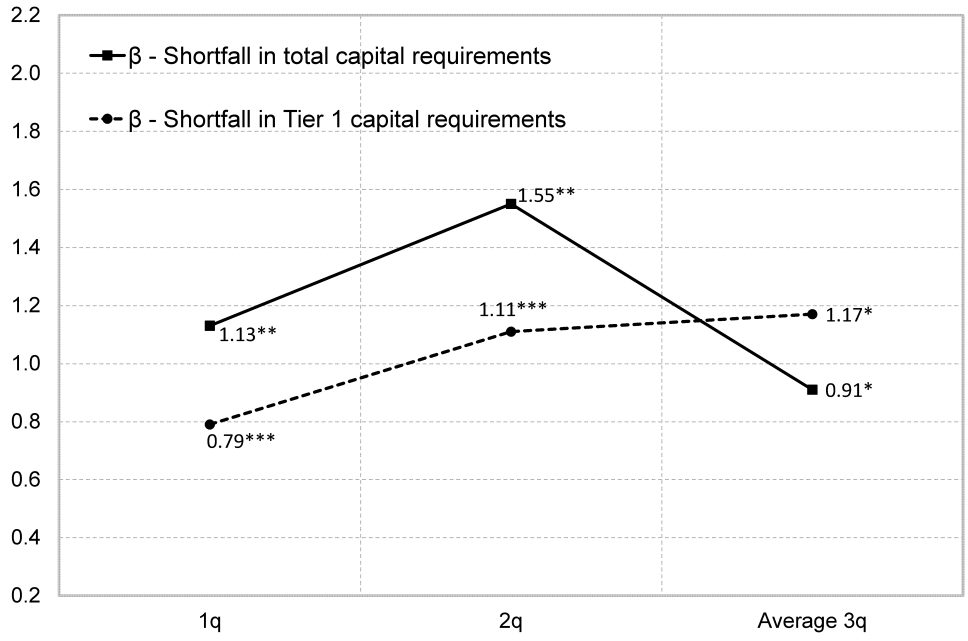
[30]As a robustness check we interacted individual rating classes (from A to E) with a dummy variable for shortfall. The coefficient on the interaction with rating class E is positive and statistically significant. This tells us that banks with a shortfall tend to increase lending to worst-rated firms. However, the sample of E-rated firms is small, which makes the result less reliable.

received by the bank with the average loan amount in the three quarters before. The results could depend on the chosen time window.

We now present the results with alternative time windows. We estimate regression from column (2) (Table 3) using two additional windows that were introduced in Section 2. We also present the estimates that use Tier 1 capital to derive Surplus/Shortfall (see Section 2).

We summarize the results in Figure 2. The two lines show the estimated coefficients on capital shortfall. The solid line refers to $Surplus/Shortfall$ defined from total and the dashed line from Tier 1 capital requirements. They show that the effect of $Surplus/Shortfall$ on lending is positive for both definitions of shortfall and across all horizons. Using robust standard errors, all the estimated effects are significant at the 10% level. The results are robust with respect to the time window used in the calculation of credit growth as well as to two different measures of shortfall.

Figure 2: Coefficient for Loan growth across three different horizons



Source: Bank of Slovenia, own calculations.
Significance: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

We found that banks that received notification for an increase in capital requirements, decrease loan growth by more than banks with a capital surplus. This was anticipated by the discussion in Section 2. They decrease lending, which decreases risk-weighted assets and improves CAR.

We now investigate how capital requirements affect bank loan loss provisioning. The dependent

[31] It is calculated as $\Delta CR_{ijt} = \frac{Provisions_{ij,t+1}}{Loans_{ij,t+1}} - \frac{Provisions_{ij,t-1}}{Loans_{ij,t-1}}$, where t refers to the date of SREP letter was sent. Provisions and loans in $t-1$ and $t+1$ are calculated as a three-quarter averages before and after the letter.

variable in Table 4 is the change in the coverage ratio for firm i in bank j in the period when the SREP letter was sent.[31] We present results for four sub-samples. In column (1), we show the results for the full sample of firms. In columns (2) to (4), we show them for samples of firms with different loan payment deferments. In Column (2), we use firms that have loans with repayment overdue by at least one day. In column (3), we firms that have loans overdue 90 days or more. In column (4), we use firms that have loans overdue 90 days or more and have defaulted after the bank has received the notification letter on the capital requirement. The last three samples contain borrowers for which banks should be setting the highest provisioning rates.

Table 4: The effect of increased capital requirements on bank loan loss provisioning

	(1)	(2)	(3)	(4)
	All firms	Overdue > 0	Overdue > 90	$\text{Overdue}_{\text{before}} \leq 90$, $\text{Overdue}_{\text{after}} > 90$
Surplus/Shortfall	0.263**	0.958**	1.117**	3.372**
Surplus/Shortfall $\times D_{trans}$	-1.715***	-3.476***	-3.481***	-3.468
Capital adequacy	-0.002*	-0.010**	-0.010*	-0.026
NPL ratio	0.001*	0.001	0.002	0.0001
Total assets	0.000	0.000	-0.000	0.000
Overdue				0.0002
Constant	0.066***	0.200***	0.240***	0.469**
Firm-time FE	Yes	Yes	Yes	Yes
No. of observations	25204	10660	6463	1892

Source: Bank of Slovenia, own calculations.
Notes: In the table we report the effect of a capital surplus/shortfall on the change in the coverage ratio of the same firms, borrowing from at least two banks, that differ in the size of surplus/shortfall. The results are reported across 4 sub-samples: (1) all firms, (2) and (3) includes firms that had overdue higher than 0 and 90 days, respectively, whereas (4) includes firms that become more than 90 days overdue after the SREP letter was sent. The results are reported using robust standard errors. Significance: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

The results are intuitive. They show that banks with a higher Surplus/Shortfall tend to provision more. Using the full sample of firms, we find that the coverage ratio of the same firm increases by 0.263 p.p. more in banks with a 1 p.p. higher Surplus/Shortfall. This is also confirmed by the other three samples where the effect is even stronger.

We now focus on the sample of firms that are more than 90 days overdue in loan repayment (see column (3)). This criterion is used to classify loans as non-performing. We find that the coverage ratio of the same firm increases on average by 1.12 p.p. more in banks with a 1 p.p. higher Surplus/Shortfall. Thus, the higher the capital shortfall the less banks provision for bad loans. Furthermore, in column (4) we focus on firms that defaulted after a SREP letter was received by a bank. For these firms, banks are required to create new provisions at the exact moment when

they are pressed by new capital requirements. The interaction between capital requirements and provisions is the strongest in this sample of firms, setting an upper bound to our estimates. We conclude that capital requirements decrease provisioning rates for defaulted borrowers (or increase them by less), which is not an outcome that policymaker desires.

Again we find the opposite effect for banks that are subject to the transfer of bad assets to the BAMC. Across all sub-samples, these banks provisioned more despite having a high capital shortfall. Large state-led recapitalization enabled them to act so.

The results presented in the previous paragraphs could be sensitive to the lack of two control variables, the time period a firm is in default and the collateral.

The first omitted control variable, the time period in default, is not the same across all banks. So, we control it by using the exact number of days overdue in each bank. We use the number of days overdue only for the sample of firms presented in column (4). In that sample, the difference in the number of days overdue could be important because it includes new defaulters. However, it is statistically insignificant.

The second omitted control variable, the collateral, is to some degree controlled for with fixed effects. They capture the total available collateral of a firm. Banks, however, differ in their strategy and ability to engage firm collateral. Unfortunately, we cannot control for the exact amount of the collateral pledged by firm i in bank j because these data are not available. However, we can assess the direction of bias, under the assumption that the collateral affects loan loss provisioning. Our estimates are expected to be downward biased. Had we been able to control for the effect of the collateral the surplus/shortfall coefficient would have been more positive. Why? The direction of bias is determined by the correlation between provisioning, collateral and shortfall. First, we expect that the surplus/shortfall and collateral are positively correlated. The reason is that one of the inputs in the determination of a bank's capital requirements is the size and quality of the bank's collateral. The smaller the size and the lower the quality of the bank's collateral, the higher the capital requirement and its shortfall will be. Next, we know that the collateral and loan loss provisions are negatively correlated. This follows the regulatory accounting rules. There would be no provisioning for loan losses had the loans been fully collateralized. We conclude that our omitted variable (collateral) is positively correlated with our target variable (surplus/shortfall) and negatively with our dependent variable (loan loss provisions). Therefore, if a surplus/shortfall really acts as a proxy for collateral, it will be downward biased. Because the coefficient on the surplus/shortfall is

positive but downward biased the estimate represents its lower boundary.

We conclude that banks with a shortfall tend to provision less than banks with a surplus. Banks adapt to increased regulatory capital requirements by engaging in risky behavior. Supervisors should devise mechanisms that would prevent or prohibit them from further increasing risk in the banking sector.

4.1 Can firms substitute for a capital shortfall shock?

So far we have shown that banks with a capital shortfall reduce lending (to the same firm) by more than banks with a surplus. But, the aggregate effect remains unclear. Firms could compensate for a decrease in lending from a shortfall bank by borrowing more from a surplus bank. In this section, we show that firms cannot fully compensate for a decrease in lending from a shortfall bank. Therefore, the total effect should be negative. However, these results should be interpreted with caution. To estimate the aggregate effect, we need to use a model that does not fully control for loan demand.

We now explain how we construct the dependent and the policy variable. The dependent variable is a sum over firm i's loans across all banks. We then calculate credit growth by using our benchmark time window: 3 quarters before and after the letter was received by the bank. Our policy variable is the share of firm i's loans borrowed from banks with a capital shortfall. It is calculated for the time period when the banks received the notification letter.

If firms can compensate for the decrease in lending from shortfall banks, by borrowing from surplus banks, the coefficient on the share of loans borrowed from shortfall banks will be insignificant. On the other hand, if the coefficient is significant and negative, capital shortfall decreases aggregate firm borrowing.

We include several firm-specific financial ratios to control for loan demand. We use credit rating and fixed effects at firm and time level. This identification strategy is weaker compared to the difference-in-difference estimates. Results presented in this section should thus be interpreted with caution.

Table 5 shows three sets of results that differ in control variables. We use the full sample of firms since we are no longer constrained with including only firms indebted to at least two banks. The coefficient on the share of shortfall is negative and statistically significant in all regressions. We judge that the most realistic estimate is in column (3). That regression includes the full set of controls: firm financial ratios, average credit rating (for firm riskiness), firm fixed effects and time

fixed effects. A firm that borrows from banks with a shortfall is expected to have (on average) a 3 p.p. lower credit growth compared to a firm that borrows from surplus banks. This implies that firms cannot compensate for a decrease in lending from shortfall banks by borrowing more from surplus banks. This result was expected. Changing banks in a crisis period is extremely difficult since sources are limited and banks are cautious.

Table 5: The effect of capital shortfall on aggregate firm borrowing

	(1)	(2)	(3)
Shortfall share	-0.158***	-0.029**	-0.030**
Quick ratio	-0.000	-0.000	-0.000
Debt-to-asset ratio	-0.006**	-0.006**	-0.004**
Asset turnover ratio	0.062***	0.047***	0.045***
Return on assets	-0.043	-0.067**	-0.062**
Rating			-0.097***
Constant	0.001	0.168***	0.210***
Firm FE	Yes	Yes	Yes
Time FE	No	Yes	Yes
No. of observations	83245	83245	83135

Source: Bank of Slovenia, own calculations.
Notes: The table reports the effect of capital shortfall on aggregate firm borrowing. Shortfall share is the share of total loans borrowed from banks with a capital shortfall. We also control for firm liquidity (Quick ratio), indebtedness (Debt-to-asset ratio), efficiency (Asset turnover ratio), profitability (Return on assets) and riskiness (average credit rating assigned by banks). The results are reported using robust standard errors. Significance: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

5 Conclusions

We estimate how banks respond to policy-induced changes in capital. We provide two contributions to the literature.

First, we show that conventional variables, that are used to estimate the effect of policy-related changes in capital on the supply of credit, are flawed. Capital ratios contain non-policy-induced changes in capital and reflect past policy requirements. Banks must respond to capital requirements before they become binding. We instead collect notification letters sent to Slovenian banks over the period 2009-2015. They inform them of their future required CAR that is to be fulfilled in a year. We use them to construct a forward-looking measure of bank capital surplus/shortfall. When we include it in regression the coefficient on the CAR becomes insignificant. Also, the magnitudes of the two coefficients are very different.

A forward-looking measure of capital requirements crucial to asses the effects of capital policy on banks.

Second, banks with a capital shortfall engage in a risky behaviour in response to increased capital requirements. Compared to banks with a surplus they lend less to firms with the highest credit rating and provision less for NPLs.

This result carries implications. After a CAR announcement, policymakers should not only be concerned with a capital shortfall. They should closely supervise the risk-taking by banks and devise mechanism that prohibit it.

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