Bank Response to Policy Related Changes in Capital Requirements

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Abstract

This paper uncovers current, and estimates future, responses by banks which are under notification of increased capital requirements. We collect notifications on regulatory capital requirements sent to Slovenian banks in the period 2009-2015 and construct a forward-looking measure of capital surplus/shortfall. Using a differences-in-differences model 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. Once the capital surplus/shortfall is included in the regression model, the coefficient on the capital adequacy ratio, often used as the main policy variable in empirical literature, becomes insignificant. It is insignificant because surplus/shortfall is a forward-looking measure of bank capitalization and conveys more information about future lending. Finally, we show that in response to an increase in capital requirements banks engage in more risk-taking behaviour. Our paper carries policy implications for regulators in countries with distressed banking sector.

JEL Classification Codes: G01, G21, G28

Keywords: capital requirement, credit, regulation, risk taking, policy

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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 inadequate. The reason is twofold. First, conventional capital measures, such as the capital adequacy ratio, contain policy and non-policy induced changes in capital. The estimated coefficient on the capital adequacy ratio will therefore also reflect non-policy related changes. Non-policy related changes in capital can have a different effect on credit supply[2]. By using capital adequacy as a proxy for *policy* related changes in capital the estimated response of banks will be biased. Second, capital requirements are announced to the banks before they become binding. Banks 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.

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 behavior: Bernanke et al. (1991), Hancock and Wilcox (1994) and Hancock et al. (1995)[3]. They often draw policy conclusions. Note that in Bernanke et al. (1991) bank capital is used to explain credit supply. In the preceding paragraph we argued why capital cannot be used as a proxy for policy related changes in capital requirements. Hancock and Wilcox (1994) and Hancock et al. (1995) use the deviation of capital to assets ratio from an estimated target capital. Although the approach is slightly different it still suffers from the same weakness. Other approaches include Kishan and Opiela (2000) and Gambacorta and Mistrulli (2004). They use a variant of capital that could potentially be a lagged and contaminated signal on the true notifications on capital requirements.

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

[2] For example, an increase in capital adequacy ratio due to recapitalization is likely to increase credit supply. On the other hand, an increase in capital that is due to stricter policy requirements is likely to decrease credit supply.

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

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 estimate the effect of policy related changes in capital on credit supply. 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 the capital requirement ratios are disclosed to banks before they become legally binding. The time mismatch could bias the coefficients and render policy implications incorrect.

We use a different approach. With the help of the supervision department of the Bank of Slovenia we collected notification letters. Notification letters are letters that inform banks on their (future) capital requirement that is to be fulfilled in a year[4]. We use the letters to construct a variable that represents forward-looking capital requirements. We call it capital $Surplus/Shortfall$ and use it to estimate the effects of policy-related changes in capital requirements on credit supply.

Based on a sample of Slovenian banks, for the period 2009-2015, we find that the same firm has on average a 3.54 p.p. lower loan growth in banks with 1 p.p. higher capital shortfall. We show that if the capital adequacy ratio is used alternatively as a proxy for policy-related changes, the estimated effect is 1.89 p.p. When we use both measures in a single model, the coefficient on the capital adequacy ratio decreases to zero and becomes insignificant. This implies that our measure of capital shortfall is a superior proxy for policy related changes in capital and delivers quantitatively and qualitatively different results when compared to the capital adequacy ratio. 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.

Further we show that banks characterized by a capital shortfall tend to engage in more risky behaviour. Banks with a capital shortfall are more inclined to finance firms with lower credit ratings. The negative effect of credit rating on loan growth is reduced if a bank has capital shortfall. A potential explanation might be that banks with a shortfall extend credit to riskier firms in a hope to delay or prevent creation of new non-performing loans. In addition, our results also reveal that the higher the capital shortfall the less banks provision for defaulted borrowers. The implication is that policymakers should not only be concerned with capital shortfall but should closely supervise the risk-taking by banks after the capital requirement has been announced.

We conclude the empirical part with a finding that firms cannot compensate for the decrease in

[4]Unless a new letter is issued before the year expires.

lending by banks with a capital shortfall by borrowing more from banks with a surplus. Increased capital requirements have a 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. We are, however, cautious in interpreting this result since in these regressions the loan demand cannot be properly controlled for and could be subject to omitted variable bias.

Note that the literature cited so far potentially suffers from an omitted variable bias. The variable that is omitted is credit demand[5]. The above cited authors attempt to control for loan demand by including macroeconomic variables which have the potential to be correlated with loan demand. The problem, however, is that one can never be sure if the loan demand is sufficiently controlled for. Our results are free from this problem. By having access to detailed firm-bank level data from credit registry, we utilize the Khwaja and Mian (2008) difference-in-difference model. This model eliminates all the effects that vary across firms and in time, including also the demand for loans. The model is further explained in the Model section.

An important recent contribution, that conforms with our results, is provided in a working paper by Gropp et al. (2016). 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. (2016) 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 demand whereas Gropp et al. (2016) 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 use Pillar 2 (SREP) capital requirements for Belgian banks to study their effect on the composition of a bank balance sheet and supply of loans to firms. They find a relatively small effect of capital requirements on

[5]Ciccarelli et al. (2010) control for loan demand by including in the model indicators of demand obtained from a bank lending survey. See insightful discussion in Peydro (2010) for a critique of this approach.

bank lending. This can probably be attributed to the fact that for many banks capital requirements are not binding. If a bank's actual capital adequacy ratio is above the required capital ratio (i.e., a bank with a capital surplus) it is not expected to contract lending. On the other hand, as we show when we investigate asymmetric effects of a capital shortfall/surplus, the effect of a capital shortfall is quite substantial. In addition, we use the differences-in-differences model, where we look at the change in the outstanding loan amount before and after the new capital requirements were announced. De Jonghe et al. (2016) instead use quarterly loan growth. This could attenuate their coefficients on capital requirements since banks adjust their behaviour around the time of the announcement on the capital requirements and are less likely to do so in the subsequent quarters. In addition, given that capital requirements are announced once per year, they cannot be treated as exogenous in all the quarters.

Three other papers that are close to our research are provided by Jiménez et al. (fortfcoming), Mesonnier and Monks (2015) and Behn et al. (2016). Jiménez et al. (fortfcoming) employ the same estimation strategy, the differences-in-differences 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 we use data on capital requirements. Mesonnier and Monks (2015) study the impact of EBA's 2011/2012 capital exercise on lending. Similar to us they use announced increases in capital requirements, that were largely unexpected. Their analysis however is done at a bank level and can control for demand only on a level of each country. Behn et al. (2016) study the effect of model-based capital regulation on bank lending. Following an exogenous increase in credit risk in the German economy, caused by the collapse of the Lehman Brothers in 2008, model-based capital requirements increased by 0.5 percentage point. Behn et al. (2016) show that as a consequence banks using IRB regulatory approach contracted loan amount by 2.1 to 3.9 p.p. more than banks using standardised approach. Similar as us they use differences-in-differences methodological approach. The main difference is that they study the impact of increased capital requirements endogenous to the IRB regulatory approach, whereas 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.

2 Capital Requirements

The Slovenian banking system is subject to the Basel II regulatory framework since 2007. Under Pillar II of the Basel II regulatory framework the banks are required to fulfil minimum capital requirements which are subject to the 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 regulator to review the banks' self assessment. The key output of the ICAAP-SREP process is summarized in the required capital adequacy ratio. The required capital adequacy ratio is the amount of capital, expressed as the share of risk weighted assets, that a bank is required to hold in order to be considered as adequately capitalized by the regulator.

The supervisory review and evaluation process 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) to the Bank of Slovenia. The Bank of Slovenia takes their assessment into account and issues its own recommendation on the adequate capitalization (SREP)[6], usually by August each year. Upon conclusion of the SREP process 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 the bank where they discuss necessary adjustments. The bank is given six months to submit a written action plan[7]. Except in 2013, banks have always adjusted their capitalization and restored the adequate capital ratio within a year.

Capital adequacy ratio (hereafter CAR) is defined as the ratio of a bank's capital to its risk-weighted assets (hereafter RWA). It can be higher or lower than the required CAR determined in the SREP process. If the banks CAR is lower than the required CAR, the bank is said to have a capital shortfall.

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 equal to 2.8% of the RWA. There are fewer shortfall banks, 4.4 per year, and they hold an average shortfall of 3.3%. In addition to total capital

[6]The regulation on adequate bank capitalization is quite involved. It 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. The action plan defines the steps that the bank will take in order to restore adequate capitalization.

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 three rows of Table 1 we characterize the surplus and shortfall banks according to their capital adequacy ratio, share of non-performing loans and asset size. These statistics are calculated for the period when the letter of notification on SREP capital requirements was sent to banks. As expected, banks with a shortfall have on average lower capital adequacy and higher burden of non-performing loans. In terms of bank size, measured with the total asset of the two groups, there is no difference between the surplus and shortfall banks.

Table 1: Average values across surplus and shortfall banks

	Banks with Surplus	Banks with Shortfall
Number of banks per year	13	4.4
Total Surplus/shortfall (% of RWA)	2.8	-3.3
Tier 1 Surplus/shortfall (% of RWA)	3.4	-3.4
Capital adequacy (% of RWA)	14.0	10.4
Share of NPLs (%)	8.9	15.5
Total assets (EUR bln)	2.6	2.5

Source: Bank of Slovenia, own calculations.
Notes: The table reports the average values in period 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.

The bank needs to address its shortfall within a year. It can restore its capital adequacy by increasing capital (the enumerator) 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), increasing safe assets (government bonds are considered to be safe assets and carry zero risk weight[10]), or restructuring its current assets[11]. In expansions, when profit is abundant, the banks often re-capitalize from 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 shortfall/surplus) is expressed in terms of the two capital adequacy ratios:

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

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

[9]To be precise, 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]Banks often ask their premium clients to return their borrowed money and then invest it in safe bonds.

[11]The bank can re-qualify existing loans into a higher quality brackets by obtaining proof that they are safe or by

where CAR_{it} represents bank i's capital adequacy ratio in period t and $RCAR_{it}$ represents the required capital adequacy ratio. 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 in terms of per capital unit. Therefore, the bank has an incentive to increase its risk weighted assets (e.g., by increasing loans) to increase its profitability.

Furthermore, it is reasonable to expect that the effect of capital $shortfall$ and $surplus$ is asymmetric for lending. Banks that exhibit a capital $shortfall$ are required to increase CAR, whereas banks with a $surplus$ are not required to adjust. Therefore, we expect a capital $shortfall$ to have more of an impact upon lending than a capital $surplus$. To account for asymmetric effects we introduce an interaction variable $Surplus/Shortfall \times D_{Shortfall}$:

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

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 where $Surplus/Shortfall$ is positive.

We expect a positive coefficient on the interaction variable. The higher the $shortfall_{it}$ (the more negative the variable is), the larger the expected decrease in loan growth, targeted to restore its capital adequacy.

$RCAR_{it}$ represents the required capital adequacy ratio determined in the SREP process. t relates to the period when a bank received the letter of notification[12] on its adequate capital adequacy ratio and up to the period when a new letter on a new required capital adequacy ratio ($RCAR_{it+1}$) is received. The capital shortfall measure is forward-looking because banks have up to a year to adjust their capital adequacy ratio (CAR_{it}) towards the required ratio ($RCAR_{it}$).

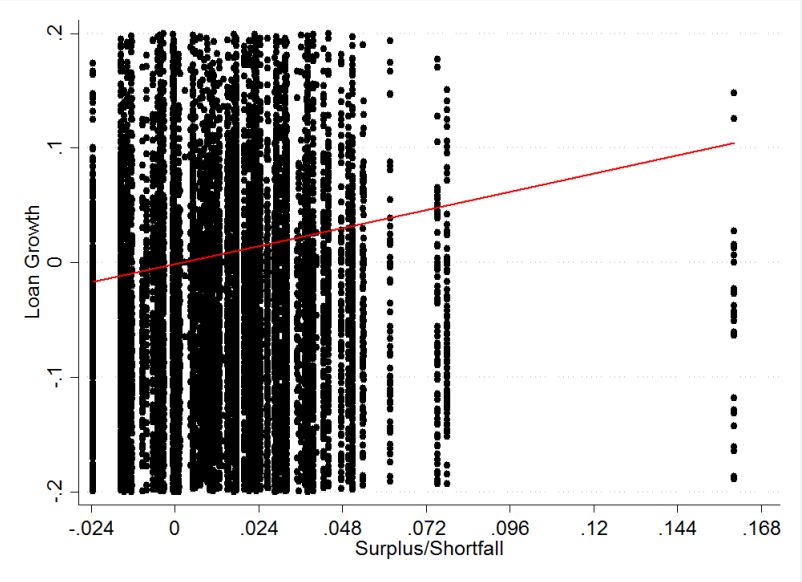
We later show that $Surplus/Shortfall$ is a superior measure in terms of explaining credit growth when compared to the capital adequacy ratio (CAR_{it}). The measure is correlated to firm loan

obtaining new guarantees related to the loan. Banks can also sell of a risky subordinated company to increase its capital adequacy ratio.

[12]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 treated as unexpected.

growth. In Figure 1 we present a zoomed-in scatter plot of loan growth at the firm-level loan growth (y-axis) in relation to $Surplus/Shortfall$ (x-axis). The scatter plot is zoomed in because firm-level loans are dispersed and can achieve very high and very low levels of growth[13] which can obstruct visual representation of results. Black points represent individual loans, and the red line is the fitted line between capital $Surplus/Shortfall$. A positive relation is observed implying that 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 of micro loan growth and $Surplus/Shortfall$ defined in eq. (1). The red line is a simple linear fit.

We expect that most of the adjustment in credit will occur within a year after the bank was found to have a shortfall (or a surplus). Given that banks are required to prepare and start implementing an action plan within the first six months of receiving a notification letter, we expect them to adjust within four quarters. In addition, banks might decide to restore their capital adequacy (and thereby adjust credit) even sooner out of prudential concerns.

We now show that firm-specific loan growth depends on the origin of the loan. Loans originating from the surplus banks are expected to grow faster, or to decrease by less, when 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

[13]E.g. In the first year a firm takes a loan equal to EUR 1.000. Next year it increases the loan to EUR 5.000. This represents a 400% increase in loans to the firm. Note also that in the empirical application we exclude from our sample all the observations at 1^s and 100^{th} percentile of loan growth distribution.

at least one had a surplus.

We report the test of means in Table 2. The null hypothesis states that there is no statistically significant difference in the mean loan growth rates regardless if a firm is being financed by a bank with a shortfall or a surplus position. If the difference exists, we can further investigate whether it is caused by a shortfall/surplus position of a bank, or other factor like loan demand.

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's 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's 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 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 capital shortfall and at least one had surplus when a SREP letter was sent. Statistics are reported across three different periods of data selection and separately 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 bank (*Mean*). *1q*, *2q* and *3q average* refer to the different periods before and after the notification letters were received by banks, over which we calculate loan growth. $1q$ stands for a loan growth calculated as an increase in the loan amount in the quarter after the notification compared to the quarter before the notification (similar for $2q$). $3q$ *average* stands for a loan increase in the average loan amount in the 3 quarters after the notification compared to the average loan amount in the 3 quarters before the notification. A few points are in order. First, note that the number of firms refers to firms that are present in both periods, before and after the notification on future capital requirements is received by a bank. The reason is clear. We estimate how capital surplus/shortfall notifications affects loan growth and loan growth needs to be calculated from two data points. Next, note that loans enter loan growth and capital adequacy ratio, since it is an accounting identity that itself contains the stock of loans. This could cause reverse causality bias in

our empirical part. However, each firm's specific loan is small compared to the bank's total stock of loans, and therefore unlikely to be causal. Further, regulatory capital requirements are derived from data that pre-date the loans included in the above calculation since it takes time for the regulator to analyze the data and draft a decision in the SREP process. This is portrayed in Figure (2).

Figure 2: Timeline and calculation of variables

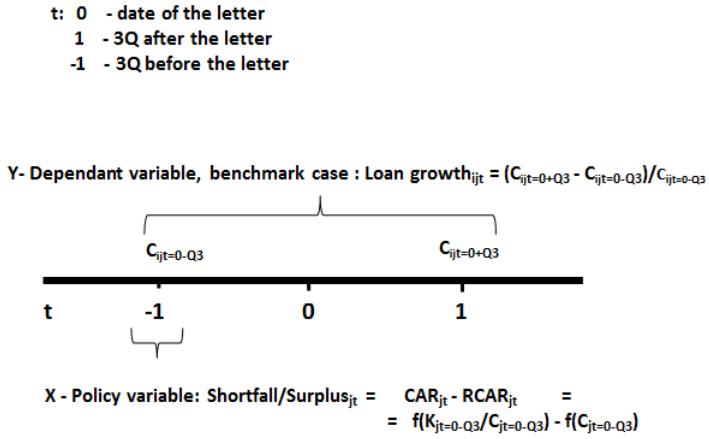


Figure shows a time diagram of the timing convention in the calculation of variables. Calculation of the dependent variable (Y) is presented above the black line. Calculation of the policy variable (X) is presented below the black line. **C** - loan/credit, **CAR** – capital adequacy ratio, **RCAR** – required capital adequacy ratio, **K** – capital. **i** stands for i-th firm, **j** for j-th bank and **t** for time.

Figure (2) shows the timing of variables for an example year *t*. The thick black line characterizes the timeline and progresses from left to right. Calculation of the dependent variable (Y) is presented above the line. Loan growth is calculated as a +/-3 quarters loan growth of the i-th firm originating from a j-th bank (from t=-1 to t=1), centered on the date of the letter receipt (t=0). Calculation of the policy variable (X) is presented below the black line. Capital *Surplus/Shortfall* is the difference between the j-th bank capital adequacy ratio and required capital adequacy ratio. Note that capital *Surplus/Shortfall* is dated *t=0* but the (bank j) aggregate credit entering the calculation of capital shortfall/surplus is dated three quarters before the date of the letter receipt (t=0-Q3). This is because supervision process is long. It takes time for the regulator to analyze the data and draft a decision in the SREP process.

Note also that in exceptional cases capital shortfall/surplus can be calculated from data dated 2 quarters before the notification letter was received. For this reason we also perform a robustness check with firm specific loan growth calculated as a +/-2 quarter (or a +/-1 quarter) growth centered on the date of the letter receipt. Finally, we ensure there is no overlapping in the credit growth

calculation 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 (see the definition of own funds and the Tier I capital in the introduction of this section). 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 in the regressions the type of capital that is more likely to be causal for loan growth.

Finally, in the third row of each of the two blocks of rows we report exact significance levels for the Welch's test of sample means[14]. We conclude that for both types of capital and for the three horizons the average growth rates of loans are statistically different in shortfall banks compared to surplus banks.

Note also, that it is always the case that the average loan growth in surplus banks is higher than in shortfall banks, even when both are negative. This is a good indication that a shortfall affects loan growth. Note also that loan demand is implicitly controlled for in Table 2. The table only includes firms with loan relations in surplus and shortfall banks. Therefore, if the firms' loan demand has decreased, it should affect both surplus and shortfall banks simultaneously and in the same direction[15]. It is not however yet a proof, since the difference in the average loan growth rates could be due to other characteristics of the bank besides its surplus/shortfall status. In our empirical application we control for several other bank specific characteristics that could affect results.

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).

Khwaja and Mian (2008) use a clever estimation technique that allows one to control for loan demand. Loan demand is an unobserved variable[16]. This implies that any model explaining credit

[14]Welch's test is a version of a t-test that allows for different variances across the two sub-samples. See Welch (1947).

[15]Here we make an assumption that loan demand is independent of the bank. This assumption is necessary for the difference-in-difference methodology to work. We discuss this assumption further in the paper.

[16]Only in rare instances is the researcher lucky enough to work with data on loan applications which are a good proxy for loan demand. See for example Jiménez et al. (2012).

growth is missing a key control variable. If this control variable is correlated with other regressors the coefficients are biased and inconsistent. The extent of bias depends on the strength of correlation between the missing variable and the variable that we are interested in. One can still use the model by introducing reasonable proxies for loan demand, such as the real GDP or investment, but he will remain uniformed on the extent of bias left in the model.

Khwaja and Mian (2008) bypass this issue by exploiting the data at loan level. In their model the data is based on borrowers who have at least two banking relations. The idea is simple. If the borrower's loan demand is constant over the two banks in a given time period, we can introduce a borrower-time specific dummy that controls for loan demand in each time period. An analogus approach is used in a fixed effects model by means of transforming the data over the time dimension of the data[17]. 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 that we have N borrowers with at least two banking relationships[18]:

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

Where y_{ijt} stands for borrower i's loan (where $i = 1...N$) borrowed from bank j (where $j = 1...M$) in time period 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. The conventional fixed effects control for loan specific characteristics of the borrower that do not change over time and on which we have no data. Suppose we now add to eq. (3) a dummy variable that takes the value of 1 for individual i and zero elsewhere[19]. Because η_i is time invariant it will be absorbed by

[17]By employing a dummy variable estimator, within, between and the fixed effects transformation. 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 of observations they can be controlled for using a dummy for each borrower or by means of data transformation. On the other hand, loan demand changes over time so one cannot control for it using a time constant dummy for each borrower.

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

[19]The estimator of this kind of model is called the least squares dummy variable estimator. If the number of

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 inconsistent. Jiménez et al. (2012) note this fact and control for loan demand in eq. (4) by introducing a dummy variable that takes the value of 1 for borrower i, over all banks j ($j = 1...M$), for each single time period [20]:

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

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

We now present the results. We present three tables with multiple regressions and one figure. They highlight different aspects of how a capital shortfall or surplus is related to bank behaviour. The first regression table shows that banks with a capital shortfall tend to decrease loan supply. We also show that restructuring of distressed banks has strong positive effects on bank lending. When a capital surplus/shortfall is controlled for, the capital adequacy ratio (which is often used in empirical

borrower's (N) is large one can use time related transformations of the data that cause the fixed effects to drop from equation 3. If for example we time difference the data then equation 3 becomes: $\Delta_t y_{ijt} = \beta \Delta_t X_{ijt} + \Delta_t \nu_{it} + \Delta_t \epsilon_{ijt}$, where Δ_t represents differencing over time.

[20] To avoid introducing a large number of dummies we can difference the data for each individual i, for each single 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 $\Delta_{j=1,2}$ now represent the difference with respect to bank 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.

literature to identify the effects of capital requirements on loan supply) becomes economically and statistically insignificant. We then add a firm's credit rating to the regression and reveal that banks with a capital shortfall decrease financing to risky firms by less compared to banks with capital surplus. This implies that banks engage in more risk-taking behaviour when subject to additional capital requirements. We further support this claim in a regression table that shows that the higher the capital shortfall, the less banks provision for bad loans. We also estimate the effect of capital shortfall on aggregate firm borrowing and observe that firms are not able to substitute a decrease in loans from shortfall banks by borrowing from surplus banks. This result should be interpreted with caution since in this regression we cannot fully control for loan demand. Finally, we conclude that increasing capital requirements are contractionary and result in higher riskiness within the credit portfolio. In the conclusion we discuss policy implications.

In Table 3, we present the benchmark regressions. We show that banks that suffer from a capital shortfall at the time when they are notified of the shortfall, decrease their loans to the same firm by more than banks that do not suffer from a capital shortfall, and that they are more willing to finance less creditworthy firms compared to banks with capital surplus.

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	0.26
Surplus/Shortfall $\times D_{trans}$	-3.81***	-4.79***		-6.79***	-7.19***
Capital adequacy	0.00	0.00	0.78**	0.00	0.00
Capital adequacy $\times D_{trans}$			1.11***		
Surplus/Shortfall $\times D_{shortfall}$				3.17*	3.84**
Rating					-0.04***
Rating $\times D_{Shortfall}$					0.02*
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	0.04
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 of the same firms borrowing from at least two banks that differ in the size of surplus/shortfall. Dependent variable is defined as credit growth between 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. The results are reported using robust standard errors. Significance: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

The dependent variable, *Loan Growth*, is expressed as a percent and is specific to the firm

and bank. Sample is 2009Q3-2015Q3. We explain loan growth using firm-time fixed effects (see eq.(5) in the Model section) and several bank specific variables[21]. The choice of control variables is driven by theory and related research (see for example Khwaja and Mian (2008), Jiménez et al. (fortfcoming) and Bonaccorsi di Patti and Sette (2016)). *Surplus/Shortfall* is described in eq. (1) in the section on Capital Requirements. *Capital adequacy* stands for capital adequacy ratio and controls for capitalization of the bank, *NPL ratio* for share of non-performing loans[22] (it controls for bank's risk preferences) and *Total assets* controls 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 $bank_j$ in year t was subjected to a transfer of NPLs to a Bank Asset Management Company (BAMC) and capitalization by the government. In 2013, Slovenian authorities collaborated with the ECB and the European Commission in a comprehensive review consisting of the asset quality review and stress tests (for details, see Bank of Slovenia (2013)). Following the review, several banks were found distressed or insolvent. In an attempt to prevent the collapse of the banking sector, the distressed banks were capitalized by the government and a portion of their bad assets was transferred to the BAMC in exchange for bonds[23].

Note that although we excluded credit data on firms whose debt was transferred to the BAMC, it is still important to control for this effect. Distressed banks had a large capital shortfall (see Bank of Slovenia (2013)). In the context of our analysis, we would expect them to contract lending extensively in order to meet capital requirements. These cases are however different. It was known a priori that the government will capitalize them, and therefore they were not constrained by a capital shortfall even though it was high. In addition, not only was the capital shortfall not binding for them, they also received an extensive capital injection from the government. We therefore expect them to lend more, not less. Not controlling for this effect would result in underestimation of the true effect of the capital surplus/shortfall on lending. The interaction variable *Surplus/Shortfall*$\times D_{trans}$ controls for this unique event specifically related to the bank and year.

Table 3 includes five columns. In the first column, we present the results for the full sample. In the second column, we present the results for the sample of firms that are performing over the whole sample period. In the regressions, described in detail later in the text, we rather use this

[21]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 GDP, borrowers financial soundness, etc...

[22]Non-performing loans are defined as the share of borrowers classified in rating classes C, D or E in five-grade rating scale from A to E.

[23]Further information can be found in Bank of Slovenia (2015) and on the BAMC webpage.

sample because the sample of all firms is prone to bias. Due to accounting rules, non-paid interest of defaulted firms are added to the outstanding amount of loan. This can be falsely interpreted as an increase in loan amount. For this reason, we focus on the sample of performing firms. In column (3,) we present results from a regression that excludes capital Surplus/Shortfall. In column (4), we investigate an asymmetric response of shortfall and surplus banks to capital requirements. Finally, in column (5), we present evidence that banks with a capital shortfall are more prone to allocate their loans to riskier borrowers.

Before we focus on policy variables, we observe that all significant control variables have the expected signs. Banks with a higher share of non-performing loans decrease their credit supply more than the banks that have a lower share of non-performing loans. The effect is significant but rather small. Bank size, measured in terms of total assets, is statistically and economically insignificant.

Results in column (2) show that the same firm faces on average a 0.91 p.p. (or 0.61 p.p. when the sample of all firms is used, see column (1)) lower loan growth in banks with 1 p.p. lower Surplus/Shortfall. The result is significant at the 10% level. This follows from a shortfall bank's effort to restore their capital ratio and a surplus bank's effort to increase their profitability in terms of a per-unit of capital. It is noted that the coefficient on Surplus/Shortfall for distressed banks, subject to 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 shortfall implies on average a 3.88 p.p. ($= -1 \times (-4.79 + 0.91)$) increase in loan growth to the same firm at the time of the transfers. This result conforms our expectations. Capital shortfall, though very high, was not binding for these banks because they were recapitalized extensively by the government. Therefore we observe a strong and positive effect resulting from the bank restructuring process that followed the comprehensive review.

In column (3), we present the results of a regression where capital Surplus/Shortfall is omitted. The coefficient on the capital adequacy ratio is now positive and statistically significant (the exact level of significance is 1.7%). The effect is slightly smaller in magnitude compared to Surplus/Shortfall. In addition, we have established that the transfers of distressed assets to BAMC and capitalization by the state affected the response to changes in capital Therefore, we also include an interaction term in this regression (Capital adequacy $\times D_{trans}$)[24]. As previously demonstrated, we find a strong positive effect for distressed banks that were recipients of large capital injections from

[24]If the interaction term is omitted from the regression the coefficient on capital adequacy ratio becomes insignificant at a 14.4% level of exact significance.

the government.[25] Note that the coefficient on the capital adequacy ratio becomes economically and statistically insignificant when capital Surplus/Shortfall is included in the regression (compare column (3) to column (2)). The reason is that Surplus/Shortfall, by its construction, conveys more information about future loan growth than the capital adequacy ratio. It is constructed from the notifications on the required bank's capital adequacy that will become legally binding in a year's time. It is a forward-looking measure of bank capitalization.

We have controlled for distressed banks and shown that a p.p. higher surplus or a p.p. lower shortfall increases bank lending by 0.91 p.p. on average. We implicitly assumed that the response of shortfall and surplus banks is symmetric (0.91 p.p.). Shortfall banks are required to adjust their capital adequacy ratio within a year after the letter was issued. There is no such obligation for surplus banks. Therefore, it could be that the response of banks with a shortfall is more intense than the response of banks with surplus. In regression (4), we test for asymmetric effects. We add to the benchmark regression (2) an interaction term between *Surplus/Shortfall* and a dummy variable $D_{Shortfall}$ that takes value 1 if bank had a shortfall (see eq. (1)) in section on Capital Requirements). The coefficient on the interaction variable is statistically significant at 10%. We estimate that the same firm has on average a 3.54 p.p. $(= 0.37 + 3.17)$ lower loan growth in banks with a 1 p.p. higher capital shortfall. The effect is economically significant. We interpret this finding as an attempt of a Shortfall bank to decrease credit in order to improve its capital adequacy ratio.

We next investigate if policy-induced changes in bank capital affect risk-taking behaviour by banks. To decrease risk weighted assets, we expect that banks with capital constraints will show a greater decrease in loans to riskier borrowers than to safe borrowers. This is especially true for the internal rating based (IRB) regulatory approach[26]. Under the IRB approach the 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. Under the standardized approach banks use external credit ratings to determine risk weights[27]. However, these are available only for a small fraction of Slovenian firms. As a result, banks must apply a common risk weight of

[25]Note that the capital adequacy ratio in regression is from a period before the notification letter on capital requirements was sent to the bank. This implies that we use the capital ratio that was recorded in advance of recapitalization, which is lower than the capital ratio recorded after recapitalization.

[26]The Internal rating based (IRB) regulatory approach is an approach to portfolio and credit risk evaluation under which banks devise credit risk estimates under their own discretion.

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

100% for all performing firms, except those for which external credit ratings are available[28]. Under the standardized approach, similar to Basel I, there is little incentive, when capital requirements increase, for banks to decrease loans to risky borrowers. Contracting loans to risky borrowers would not lead to a higher decrease of the RWA comparing to contracting loans to more creditworthy borrowers because risk weights for the majority of firms are set at 100%. Banks under pressure from capital requirements might even have an incentive to lend more to riskier borrowers, since this could increase profit and cover some of the capital shortfall.

Regression (5) in Table 3 resembles the previous regression except that we now add a firm's rating (*Rating*) and firm rating interacted with a dummy variable for the capital shortfall ($Rating \times D_{Shortfall}$). Ratings are assigned by banks to each borrower and take values from 0 (rating A) to 4 (rating E). The coefficient on *Rating* is negative and significant. It tells us that the lower the credit rating of the firm the less banks lend to this firm. Finally, the coefficient that interacts a firm's rating with the capital shortfall is positive and significant (at a 10% significance level). It implies that banks with a shortfall are more inclined to finance firms with a lower credit rating because the negative effect of credit rating on bank lending is reduced if a bank is under pressure from higher capital requirements. Banks with capital shortfall contract loans to riskier borrowers by less than banks with surplus. This could also result from the fact that banks can not contract the RWA on borrowers who don't repay their loans and have lower ratings. However, this is a less probable explanation since we use the sample of performing firms.

The implication for policymakers is clear. Regulatory capital requirements affect the risk-taking behaviour by banks. From a policy perspective, it is certainly not desirable for a risky bank to engage in more risk-taking when pressured by capital requirements. Therefore, following dissemination of notification letters on capital requirements, the supervision process should be enhanced with a close supervision of a bank's risk-taking behavior. More specifically, the supervisors should limit the bank's options in adjusting assets in response to a capital shortfall in a way that prohibits them from further risk taking. In addition, the result above reveals a weakness in the standardized regulatory approach. Detachment from the risk weights and risk characteristics among borrowers was also a critique applicable to Basel I. For this reason, Basel II introduced the IRB approach, under which the risk characteristics of borrowers are directly linked to risk weights. Under the IRB approach, there is less incentive to participate in risky behavior since it is penalized with higher risk weights.

[28]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.

The results presented up to this point refer to a specific time window that was used in the calculation of credit growth before and after the notification was received by the bank. We compared the average loan amount in the three quarters after the notification was received by the bank with the average loan amount in the three quarters before the notification was received. These results could be an artifact of a specific time window that was chosen by a researcher.

For the reason specified above we now present results when we vary the time window. We estimate the same regression as presented in column (2) in Table 3 using two additional time windows to calculate credit growth. The first window refers to the first quarter before and after notification and the second window to the second quarter before and after the notification. The denominator in the equation for credit growth is always the loan amount in the quarter before the notification was received. In addition, we present the same estimates using the alternative definition of a capital shortfall derived from Tier 1 capital requirements (see the section on Capital Requirements).

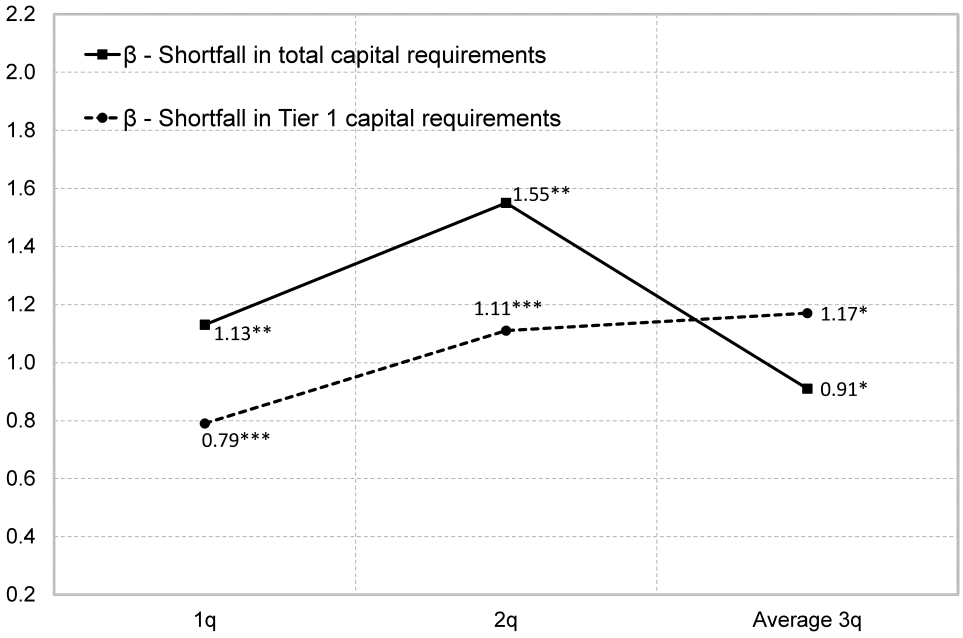
We summarize the results with Figure 3. The two lines show the estimated coefficients for a capital shortfall derived from the total (solid line) and the Tier 1 (dashed line) capital requirements. They show that the effect of a capital $Surplus/Shortfall$ on lending is positive across all horizons for both definitions of shortfall. Using robust standard errors, all the estimated effects are statistically significant on at least the 10% level. This confirms that our results are robust with respect to the time window used in the calculation of credit growth as well as to two different measure of shortfall.

So far we showed that banks that received notification for an increase in capital requirements, decreased their loan growth by more than banks with capital surplus. This was to be anticipated as stated in the discussion on how banks can adjust to an increase in capital requirements (see section on Capital requirements). They adjust by decreasing loans. This decreases risk weighted assets and the capital adequacy ratio improves.

We now further investigate how bank loan loss provisioning is affected by pressing capital requirements. The dependent variable in the regressions presented in the Table 4 is the change in the coverage ratio observed for firm i in bank j in the period when the SREP letter was sent.[29] We present the results for four sub-samples. In column (1), we show the results obtained by using the full sample of firms. In columns (2) to (4), we show the results for several samples of firms where firms differ according to the loan payment deferment. In Column (2), we show the results obtained

[29]More specifically 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 when the SREP letter was sent. Provisions and loans in $t-1$ and $t+1$ are calculated as three-quarter averages before and after the letter, respectively.

Figure 3: Coefficient for Loan growth across three different horizons



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

by using the sample of firms that have loans with repayment overdue by at least one day. In column (3), the results are obtained by using the sample of firms that have loans overdue 90 days or more. In column (4), we present the results for firms that have loans overdue 90 days or more and only defaulted after the bank has received the notification letter on a new capital requirement. These last three samples contain borrowers for which banks should be setting the highest provisioning rates.

The results are intuitive and 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 typically used to classify loans as non-performing. We find that the coverage ratio of the same firm increases on average by 1.117 p.p. more in banks with a 1 p.p. higher Surplus/Shortfall. Therefore, 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. The

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 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) includes 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: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

overall conclusion is that pressing capital requirements decrease the provisioning rates for defaulted borrowers (or increase them by less), which is not an outcome that a policymaker desires.

Again we find the opposite effect for banks that are subject to the transfer of bad assets to the BAMC. The estimates across all subsamples show that these banks provisioned more despite a high capital shortfall. Large state-lead recapitalization enabled them to do so.

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

The first omitted control variable, the time in default could affect our results. The time in default of a firm is not the same across all banks. Therefore, we control for it by using the number of days overdue. We use number of days overdue only for the sample of firms presented by column (4). In that sample, the difference in the number of days overdue could be important because it includes new defaulters. However, we find it insignificant.

Unfortunately, due to the lack of data we cannot control for the effect of the omitted collateral. The omission of 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 since 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

downwardly 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 to a large extent 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 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. Finally, we determined 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 downwardly biased and, given that the coefficient on the surplus/shortfall is positive, the estimated coefficient represents the lower boundary on the coefficient estimate.

We conclude this section by noting that not only do banks with a shortfall engage in more risky behaviour, but they also tend to provision less than the banks with a surplus. The conclusion is that the increased regulatory capital requirements can have undesirable effects on bank risk taking behavior. Banks adapt to regulatory requirements by engaging in risky behavior. Regulators should devise mechanisms that would prevent/prohibit banks with a shortfall to further increase 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 when compared to banks with a surplus. However, this does not prove that the aggregate effect on lending to firms is negative. If firms can compensate for a decrease in lending from a shortfall bank by borrowing more from surplus banks, there could be no effect on aggregate lending. In this section we show that firms cannot fully compensate for a decrease in lending from a shortfall bank. Therefore, the aggregate effect should be negative. However, these results should be interpreted with caution. To estimate the aggregate effect, we need to depart from the differences-in-differences approach and therefore can no longer fully control for loan demand.

We now explain how we constructed the dependent and the policy variable. The dependent variable is constructed by summing over firm i's loans across all banks. We then calculate credit

growth (corresponding to the SREP notification dates) by using our benchmark time window: 3 quarters before and after the letter was received by the bank. Our policy variable is defined as a share of firm i's loans borrowed from banks with a capital shortfall, and calculated at the time the notification letter was received by the bank.

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

To control for loan demand, we include several firm specific financial ratios, credit rating and fixed effects at the firm and the time level. Even though we include a large number of control variables, this identification strategy is weaker in controlling for loan demand by firms compared to the differences-in-differences estimates. Results presented in this section should thus be interpreted with caution.

Table 5 shows three sets of results that are different with respect to controls that are included in the model. We estimate these models by using 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 the regressions. We judge that the most realistic estimate is presented in column (3). The reason is that in column (3) we present estimates with a full set of controls for: firm financial ratios, average firm credit rating, firm fixed effects and time fixed effects. We estimate that a firm that borrows only from banks with shortfall is expected to have on average a 3 p.p. lower credit growth when compared to a firm that borrows entirely from surplus banks. This result, on average, implies that firms cannot compensate for a decrease in lending by banks with a shortfall by borrowing more from banks with a surplus. This result was expected. Changing banks in a crisis period is extremely difficult for firms to do since sources are limited and banks are cautious.

5 Conclusions

We investigate how bank behaviour responds to policy-induced changes in a bank's capital. We provide two contributions to the literature.

First, we show that bank capital ratios, or changes in capital requirements, that are often used to estimate the effect of policy-induced changes in capital on bank behaviour are an inferior measure.

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 share of total firm loans borrowed from banks with capital shortfall. Additionally, we control for firm liquidity (Quick ratio), indebtedness (Debt-to-asset ratio), efficiency (Asset turnover ratio), profitability (Return on assets) and riskiness assessed as average credit rating assigned by banks. The results are reported using robust standard errors. Significance: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

The reason is that capital ratios are derived from past policy related capital requirements. Banks respond to them before they become effective. We instead collect letters of notification on capital requirements to private Slovenian banks for the period 2009-2015. The letters contain notification dates on capital requirements that will only become effective a year after the letter was issued. We use these dates to construct a forward looking measure of bank capital surplus/shortfall. We show that when we include the surplus/shortfall in a regression equation the coefficient on the capital adequacy ratio becomes insignificant and the values of the two coefficients are quite different.

The implication is that for an unbiased assessment of the effect of policy induced changes in capital on bank behavior the policymakers and researchers should not use capital adequacy ratios. They should rather collect the dates when banks were notified on the changes in capital requirements. Then construct a forward-looking measure of capital requirements and use it to obtain results that are not biased.

Second, using our shortfall variable we show that following an increase in capital requirements the banks with a capital shortfall decrease their loans more than the banks with a surplus of capital. In addition, banks with a shortfall, following a notification on an increase in regulatory capital requirements, tend to engage in more risk-taking behaviour. They are more willing to finance riskier firms and increase loan loss provisions by less compared to banks with capital surplus. A potential explanation might be that banks, unable to raise additional capital, extend credit to riskier firms in

a hope to delay or prevent creation of new non performing loan.

This result carries strong policy implications. To prevent distressed banks from engaging in an even riskier behaviour after an increase in capital requirement, close supervision, and perhaps even a prohibitive action is warranted.

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