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The impact of capital requirements on Swedish bank lending:

A study on the effects of higher capital regulations

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Abstract

The increased capital requirements, as a result of Basel III regulations, have been widely debated among bankers, regulators and other agents. In this thesis, we aim to evaluate if the increased capital requirements have had an effect on bank lending in Sweden. To analyze this, we gather quarterly data from the four largest Swedish banks and divide lending to the public into five categories. We use a dynamic panel regression on our novel data set and regress loan growth for the different lending sectors on increased capital requirements. We find that the increased capital requirements seem to have no effect on loan growth for any of the sectors analyzed. Also, we find indications that capital ratios have been affected by higher capital requirements since the banks seem to gradually rebuild their capital buffer that they initially held above the regulatory minimum. We conclude that regulators seem to have been successful in not harming Swedish banks' lending behavior.

Title: The Impact of Capital Requirements on Swedish Bank Lending: A Study on the Effects of Higher Capital Regulations.

Purpose: The purpose of this study is to evaluate how the increased capital requirements have affected banks' capital ratios and lending.

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1. Introduction

The financial crisis of 2008 made it clear that bank failures have systemic costs that are not fully borne by the banks. This has resulted in new global standards for financial institutions in order to lower the systemic risk in the financial system. In 2010, the Basel Committee presented a package of new reforms for international banks - Basel III - in order to improve banks' resilience to adverse shocks. These reforms implied higher requirements on primary capital to risk-weighted assets. Basel III also allowed national regulators to set additional capital requirements for banks. In 2017, the final version of Basel III was presented. According to the finalized version of Basel III, banks have to meet three different capital requirements: Risk-weighted capital requirements, capital requirements according to the floor rules for risk-weighted assets, and leverage ratio requirements (Edlund, 2017).

The consequences of increased capital requirements for banks is a much-discussed topic. Banks admit that there should exist some limit on leverage, but say that the distressed times after a financial crisis should not be the time to introduce tighter regulations. Banks also argue that these regulations will bring higher costs for funding the banks, which will have a negative impact on lending, consequently harming economic growth (Onaran, 2017).

For banks to keep up the same amount of lending when their capital ratios increase, banks need to raise more equity. According to the Modigliani-Miller theorem (the MM theorem), higher capital requirements will not increase funding costs. The intuition behind this theorem is that banks with higher capital ratios can issue less risky equity, which implies cheaper equity. Therefore, this argument gives no reason to why an increase in capital requirements should affect lending (Modigliani and Miller, 1958). On the other hand, it is possible to argue that raising equity might increase funding costs because of frictions on both short and long term such as

asymmetric information (Myers and Majluf, 1984). This argument states that an increase in capital requirements actually does affect lending.

In this thesis, we estimate the effect of changing regulatory capital requirements on bank capital and bank lending. We use quarterly data from 2007Q1 to 2017Q4 for the four largest banks in Sweden: Nordea, Handelsbanken, Swedbank and SEB. The data has been collected from each bank's quarterly report, thus we use a novel data set. This is a strength since it gives us the opportunity to divide lending into five loan growth categories: *secured household lending, unsecured household lending, lending to real-estate companies, lending to non real-estate companies* and *total lending*. We do this first to test if the change in capital requirements has an effect, and second if it affects some lending sectors more than others. First we run panel regressions of bank capital ratios on capital requirements and second we run panel regressions of bank lending to different sectors on capital requirements and capital ratios. Due to limitations in access to data before 2006, we have limited our research to a shorter time period. We estimate the effect of changing regulatory capital requirements on bank capital and bank lending to implicitly test if the Modigliani-Miller theorem holds or if the results indicate the opposite.

First, when looking at the effect of capital requirements on capital ratios, we find that at lags above one, increased capital requirements tend to lead to increased capital ratios. Second, an increase in capital requirements does not have a significant effect for any of the sectors of public lending analyzed. However, the one lag capital requirements coefficient shows a negative relationship between lending and capital requirements. This indicates that there might exist a negative relationship, but that we do not have enough power in our statistical tests to confirm it. Though, we conclude that increased capital requirements have not affected bank lending due to the lack of significance. This implies that Basel-III has been effective since banks seem to have increased their capital ratios without affecting lending. We therefore conclude that the MM theorem holds.

The structure of this thesis is as follows: Chapter two will give a background of the history of the Basel accords. Chapter three outlines previous research and literature, and chapter four describes the data and the transformation of the data. In chapter five, we outline the theory and in chapter six, we will provide the methodology of our model specification. Chapter seven will give a specification of the results and chapter eight will give a discussion of the results.

2. History of the Basel accords

The Basel Committee was founded in 1974 with the purpose to preserve financial stability by developing international standards for bank regulation. The committee includes 27 countries and the European Union (Bank for International Settlements, 2018).

In 1988, the Basel Committee issued its first accord, Basel I. Basel I implied a minimum ratio of capital to risk-weighted assets, which was a completely new approach to risk measurement. Assets were divided into five different risk-weight categories 0 %, 20 %, 50 %, 100 % and assets that were classified as risk free. The ratio of capital to risk-weighted assets had to be at least 8 %. Basel I was easy to implement, but provided little insight into risk management (Bailey, 2014).

Basel II was released in 2004. The new capital ratio framework was developed to further improve the way capital requirements reflect the underlying risk. Basel II comprised three pillars: *Minimum capital requirements* including credit, market and operational risk, *supervisory review* of financial institutions' capital ratios enabling supervisors to regulate on a firm-to-firm basis and *disclosure requirements* in order to increase transparency (Bank for International Settlements, 2018).

In 2010, the Basel Committee released the third Basel accord. Compared to Basel II, Basel III implied increased requirements on the ratio of capital to risk-weighted

assets, limitations on banks' internal models for credit risk measurement, improved floor rules for risk-weighted assets and a completely new requirement on the leverage ratio. Basel III also allowed national regulators to implement additional capital requirements such as a countercyclical capital buffer and a systemic risk buffer. For the largest banks in Sweden, these additional capital requirements currently constitute more than half of the total capital requirements (Edlund, 2017).

Table 1.

Ratio	Basel II	Basel III
Common Equity Tier 1 Ratio	2 %	7 %
Tier 1 Capital Ratio	4 %	8,5 %
Total Capital Ratio	8 %	10,5 %
Leverage ratio	-	3 %

(Chesnokova, 2016)

3. Literature review

As the regulatory capital requirements have increased, we have seen a growing number of studies investigating the effect of higher capital requirements. In this section, we review literature on the subject: if banks have gotten safer and how lending behaviour is affected.

Our thesis closely relates to Bridges, Gregory, Nielsen, Perzzini, Radia and Spaltro (2014). By using a rich set of panel data on UK banks they investigate the impact of changes in capital requirements on lending. The authors use a *true lending flow* as opposed to changes in lending flow. They argue that for example write-offs and reclassifications should be removed from the lending flow since these could otherwise contaminate the results. They start off by dividing bank lending into four categories: *secured household, unsecured household, real-estate companies and non real-estate companies*. Later, they regress bank lending for different sectors on capital requirements and capital ratios. The estimates are then used to create impulse response functions in order to investigate how each sector reacts to a one percentage

point increase in capital requirements. They find that one year after an increase in capital requirements, bank lending tend to decrease over all sectors except in unsecured household lending. Even though there exists a short-term effect, the long-run effect seems to be quite little since loan growth mostly recovers within three years. In the paper, the authors claim to have found evidence for a negative relationship between capital requirements and lending.

Berrospide and Edge (2016) study how U.S bank lending has been affected by the post-crisis regulatory reforms. The post-crisis regulatory reforms implied different increases in capital requirements depending on bank size. To account for this, Berrospide and Edge divide banks into two groups, small and large banks, and conduct two separate analyses. Their findings state that an increase in capital requirements gives a negative effect for both small and large banks. The effects were quite limited for the small banks but more substantial for the large banks.

Hanson, Kashyap and Stein (2011) suggest that higher capital requirements increase the long-run costs of lending, but the effect is quite limited. By discussing deviations from the Modigliani-Miller conditions (the MM theorem is further discussed in section 5) they find empirical evidence that equity is less risky when firms have less leverage.

Aiyar, Calomiris and Wieladek (2014) study the effects of capital requirements on UK banks by regressing loan growth for private non-financial corporations directly on capital requirements. They find that while the increased capital requirements actually do decrease lending for the regulated banks in the UK, there is significant leakage from regulated banks to unregulated banks; the effect is offset by unregulated banks increasing lending when regulated banks decrease it.

Studies have also been made on the risks with introducing capital requirements. Hellmann, Murdock and Stiglitz (2000) study the Pareto-efficiency of capital requirements by arguing that even though they can induce sensible behaviour in

banks, the policies can create Pareto-inefficient outcomes. The authors claim that even though putting equity at risk by introducing capital requirements, which will probably reduce incentives to gamble, the policies can have the opposite effect by endangering the franchise value of the bank.

By evaluating the market risk for the 50 largest banks in the U.S and the 50 largest banks in the world excluding U.S and Chinese banks, Sarin and Summers (2016) investigate if banks have gotten safer after the increase in capital requirements. By calculating the market risk before and after the financial crisis in 2008, they found no empirical evidence that banks have not gotten safer, despite an increase in capital requirements. Though the unambiguous results, Sarin and Summers argue that the market might have underestimated risk before the crisis. They also argue that without the increase in capital requirements, market risk for banks might have been even greater.

Jordà, Richter, Schularick and Taylor (2017) are critical to the increased capital requirements. By studying the long-run relationship between capital ratios and systemic financial stability, they find that an increase in capital ratios might result in riskier assets in the balance sheet.

4. Data

In the following section we will present our data by a description of the origin of the data, present briefly some advantages of the data and present descriptive statistics. We will also present what calculations have been made to transform the data and give explanations of each variable that is included in the data set.

4.1 Origin of the data

We have retrieved the data used in this thesis ourselves from quarterly reports of the four major Swedish banks from the *Investor Relations* page of each bank's website. We were unable to collect quarterly data for the banks earlier than 2006, hence we

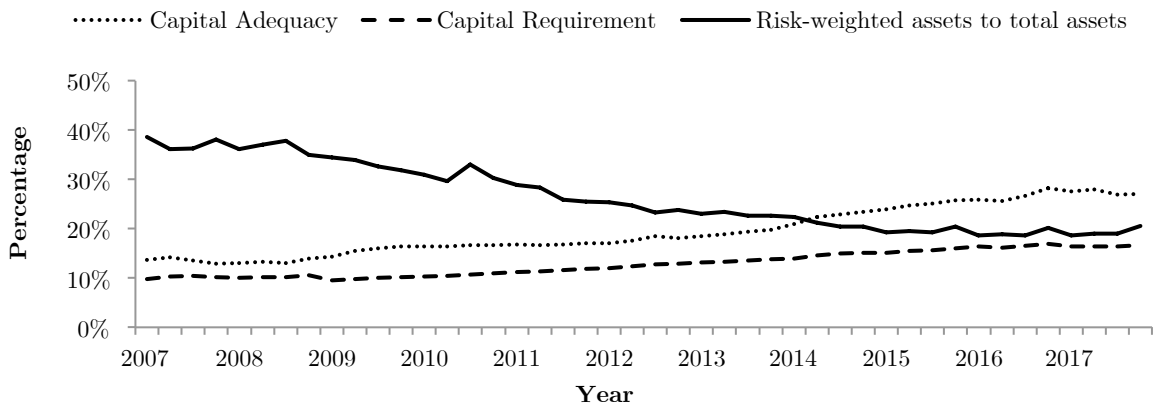
have chosen the time period 2007Q1-2017Q4. There are two major advantages of choosing this time interval. One is that we have data before and after the financial crisis, which struck the global markets in late 2008, and the second is that we have data before and after 2010 when Swedish banks started implementing transitional rules toward the Basel III-regulation of capital requirements. With the use of quarterly data from the given time period it resulted in 176 observations. One advantage of examining quarterly data instead of for example annual data, as in Bridges et al. (2014), is that quarterly data will provide more observations for the same time period. This might lead to more power when conducting statistical testing.

One important issue we had to deal with when choosing appropriate data was if we would look at merely the Swedish branches of the banks or if we would collect data from the whole banking group of each bank. Following the example from Bridges et al. (2014) we chose to consider each banking group. Our main argument for choosing this strategy is that in most banks in the study, business abroad does not make up for a majority of the operations, hence changes in abroad lending pattern will not affect lending growth for the whole group. We also argue that since the banks' foreign business takes place in countries like Sweden, where similar regulations hold and lending behaviour should be similar to those in Sweden, loan growth will not differ much in each banking group. Another aspect is that we believe lending policies of each bank should not differ largely between their Swedish branch and their foreign branch.

4.2 Descriptive statistics

In this subsection we introduce a summary of the descriptive statistics in *Table 2*. In *Figure 1* we illustrate how capital requirements have increased over time following Basel regulations, and as an effect how the actual capital held by banks has increased. As the capital requirements are set to risk-weighted assets, we also illustrate how the risk-weighted assets to total assets have changed over time.

Figure 1.[1]



In *Table 2* we observe the descriptive statistics of our novel data set. We get that on average the capital requirement on the banks are 12,9 % with a standard deviation of 3,4 %. When looking at the changes in capital requirement (calculations are described in section 4.3) we can see that the average change in capital requirement is 0,2 %, a positive change. When excluding the smallest changes as in Bridges et al. (2014), those that fall in the interval of -0,1 pp (percentage point) to 0,1 pp, we see that removing them have very little impact on the mean and standard deviation. The highest mean of the change of a variable is *secured loan growth* which is at 1,7 %. The variable with the highest standard deviation is *unsecured loan growth.*

What is also noticeable is that the changes in *minimum capital requirement* and *capital ratio* are low at an average level and show little volatility. The different lending variables also show low average growth, however, they exhibit relatively large volatility in comparison with changes in *minimum capital requirement* and *capital ratio.* This can also be seen in *Figure 1* where the growth in the variables is positive and steady but far from extreme.

[1] The data presented in figure 1 is the average capital adequacy, capital requirement and risk-weighted assets to total assets for the banks studied. We used the same data as the data in the panel regression.

Table 2.

Description (All numbers in decimal form)	**Observations**	**Mean**	**Standard deviation**	**10% percentile**	**90% percentile**
Minimum capital requirement	176	0,129	0,034	0,090	0,182
Changes in minimum capital requirement	176	0,002	0,005	-0,003	0,006
Changes in minimum capital requirement excluding [-0,1; 0,1]	140	0,002	0,005	-0,004	0,007
Capital ratio	176	0,195	0,056	0,127	0,283
Changes in capital ratio	176	0,003	0,010	-0,007	0,017
Secured loan growth	176	0,017	0,023	0,000	0,034
Unsecured loan growth	176	0,001	0,084	-0,037	0,050
Non-CRE loan growth	176	0,010	0,061	-0,036	0,054
CRE loan growth	176	0,010	0,048	-0,025	0,052

4.3 Type of data and calculations

The data set consists of a number of variables that we have collected from the quarterly reports of the banks. Some of the variables are ratios and the calculations are shown in the appendix. We have transformed all the variables from absolute values to growth values. This means that we have also collected data for the fourth quarter of 2006 for each bank to be able to get the growth value for 2007Q1. The reason we did not choose to adapt the true lending flow method of Bridges et al. (2014) is that we found it rather speculative to specify which factors that were to be removed from the lending flows.

We have collected and calculated values for several variables to be used in our model. *Trigger ratio/Trig* is the percentage of minimum capital requirement through the risk-weighted assets that the banks need to hold according to Basel regulation. We refer to it as capital requirement. *Capital/Cap* is the capital ratio that the banks actually hold which is calculated by taking capital base through risk-weighted assets. *Tier 1 ratio* and *Leverage ratio* are "bank-specific micro controls that might affect lending" (Bridges et al. 2014, p. 15). *Unsecured lending* is lending to households which

excludes mortgage lending, S*ecured lending* is mortgage lending to households, *CRE Loan* is lending to corporations in real estate (CRE), *non-CRE loan* is lending to companies not in real estate and *Total lending* is the sum of these four types of lending.

5. Theory

The Modigliani-Miller theorem was developed in 1958 and is the most widely used theorem to evaluate changes in the cost of equity due to leverage. In the banking perspective, the MM theorem states that under certain assumptions lending should be independent of the capital ratios. The assumptions include no taxes, symmetric information, rational risk-based pricing and cash flow that are independent of financial policies (Hanson, Kashyap and Stein, 2011). The intuition behind the MM theorem is that when a bank is funded with more equity, the bankruptcy risk goes down, which implies less risk for shareholders. This results in both a lower risk premia for the expected ROE and a lower interest rate on debt. These effects counteract the effects of shifting from debt finance to equity finance, i.e. shifting to an instrument with a higher rate of return from an instrument with low required rate of return (Admati, DeMarzo, Hellwig & Pfleiderer, 2010).

However, the Modigliani-Miller conditions are uncertain in reality. In Fraisse, Lé and Thesmar (2017) the authors describe the non-MM approach, which is a result of a collection of ideas regarding frictions when rasing equity. Myers and Majluf (1984) state that information might be assymetric in reality. Consider a firm that must issue common stock to raise cash for an investment opportunity. By developing an equilibrium model where management is assumed to know more than investors, it is possible to show that management may refuse to issue stock in favor of old investors and therefore miss out on potential valuable investments. In the long run, it is therefore plausible to argue that information is asymmetric, which contradicts the MM theorem. Diamond and Rajan (2000) also contradicts the MM theorem by

describing that increased bank management uncertainty may risk making deposits more fragile thus increasing costs. Also, as we mentioned in the literature review, Hanson, Kashyap and Stein (2011) discusses deviations from the Modigliani-Miller conditions and suggests that higher capital requirements increase the long-run costs of lending.

6. Model specification

In this chapter, we introduce the models that are used in our panel regressions. We also describe some concepts that were used in the process.

6.1 General model

We used dynamic panel equations that estimate bank capital and lending for the different sectors being analyzed. We used the same equations as Bridges et al. (2014). The two equations described in the article are:

$$cap_{it} = \alpha_1 + \sum_{k=1}^{n} \gamma_{1k} cap_{i,t-k} + \sum_{k=1}^{n} \delta_{1k} trig_{i,t-k} + \theta_{11i} + \theta_{12t} + \epsilon_{it} \qquad (1)$$

where cap_{it} is capital ratio for bank i at time t. This is the dependent variable and it is regressed on a constant α_1, lagged capital ratio and $trig_{i,t-k}$, which is lagged capital requirement. The θs are cross-section and period fixed effects (bank and time specific). ϵ_{it} is an error term.

$$lending_{it} = \alpha_2 + \sum_{k=1}^{n} \beta_{2k} lending_{i,t-k} \sum_{k=1}^{n} \gamma_{2k} cap_{i,t-k} + \sum_{k=1}^{n} \delta_{2k} trig_{i,t-k} + \varphi_2 M_{it-1} + \theta_{21i} + \theta_{22i} + \varepsilon_{it} \qquad (2)$$

In equation (2), *lending* consists of either unsecured lending, secured lending, CRE lending, Non-CRE lending or total lending. This is then regressed on a constant α_2, lagged lending, plus lagged capital ratio and lagged capital requirement. The next component of the regression is the vector of the two bank-specific micro control measures, namely *Tier 1 ratio* and *Leverage ratio*. The θs are bank and time specific fixed effects and ε_{it} is an error term.

6.2 Stationarity and the Fischer test

To fit our data to this model, we first perform stationarity tests. In models that involve time series, it is of great importance that the data is stationary so that we can make correct inference about the results. Verbeek (2008, p. 106) states that "a stationary process is such that the mean, variance and covariances of ε_t do not change over time". When the condition $|\rho| < 1$ is satisfied, where ρ is the coefficient in front of the lagged variable in the first-order AR-model, the process can be described as stationary. Stationary time series also often show signs of high degree of mean-reversion and absence of a unit root (Verbeek, 2008). We use the *Fischer test* to test for a unit root in the data by using the null hypothesis that all individual units have a unit root in any of the time series. Thus, the null hypothesis can be rejected at values smaller than standard significance levels (Verbeek, 2008).

6.3 Fixed and random effect models

When progressing with fitting our data to the model, we want to provide some intuition behind the choice of the *fixed effects* in our model. The fixed effects model is a linear regression that varies across different units, or in our case banks, by different intercepts. The model uses deviations from individual means to transform the data thus removing the individual effects. The fixed effects model analyzes differences within individuals, between y_{it} and $\bar{y}_i$ (Verbeek, 2008). In the *random effects model*, we assume that the individual component is a random factor, "independently and identically distributed over individuals" (Verbeek. 2008, p. 364) so the individual specific component plus the remaining error term make up the individuals' error term. The individual specific component does not vary over time while the remaining error term is assumed to be uncorrelated over time. This leads to all correlation of the error term being related to the individual specific component (Verbeek, 2008).

The common view to approach the choice between using a fixed and random effects model is that when dealing with individuals that are special or unique, for example when dealing with countries or large companies the researcher should use fixed effects. This as opposed to when uses a sample of individuals that are drawn from a larger population. Then the researcher should use random effects (Verbeek, 2008). For our data we therefore use fixed effects, which is also what Bridges et al. (2014) do.

6.4 Lag determination

One way to determine the correct amount of lags for a model is to look at the Akaike Information Criterion (AIC) and the Bayesian Information Criterion (BIC).

$$AIC = T * \ln(sum\ of\ squared\ residuals) + 2 * n \quad (3)$$

$$BIC = T * \ln(sum\ of\ squared\ residuals) + n * \ln(7) \quad (4)$$

By using AIC and BIC we can see the relative loss of information given different amount of lags and shocks. By finding the minimum value of AIC or BIC, we can minimize the loss of information and thus use these in our estimation. BIC is often preferred to AIC since it seldomly overestimates the model dimensions (Ender, 2015). To determine the number of lags to use in our model, we therefore use the BIC & AIC tests.

6.5 Our model

Taking this information into consideration we check for stationarity and include fixed effects in the model. By applying the BIC & AIC tests we find that the number of lags which fit our data best when we regress banks' capital ratios on capital requirements are three. When we regress bank lending for different sectors on capital requirements and capital ratios, the number of lags with best fit is one. These results are provided in the appendix.

When adjusting the models in 6.1 to the amount of lags with the best fit, we therefore arrive at the suitable model for our data and we run the regressions.

$$cap_{it} = \alpha_1 + \sum_{k=1}^{3} \gamma_{1k} cap_{i,t-k} + \sum_{k=1}^{3} \delta_{1k} trig_{i,t-k} + \theta_{11i} + \theta_{12t} + \epsilon_{it} \quad (5)$$

$$lending_{it} = \alpha_2 + \beta_{2k} lending_{i,t-1} + \gamma_{2k} cap_{i,t-1} + \delta_{2k} trig_{i,t-1} + \varphi_2 M_{it-1} + \theta_{21i} + \theta_{22i} + \varepsilon_{it} \quad (6)$$

7. Results

The following chapter presents the results on how banks change their lending given a change in capital requirements. The results are based on the two panel regressions (5) and (6). For each of the regressions we set the null hypothesis that capital requirement, capital ratio, tier 1 ratio or leverage ratio does not have any effect on lending. We then analyze the p-values and set significance levels at 10 %, 5 % and 1 %. We say that we can reject the null hypothesis if p $<$ 5 %. At 10 %, we say that there exists a weak significance, at 5 % there is significance and at the 1 % level there is strong significance.

7.1 The impact of capital requirements on capital ratios

Our first model examines how capital ratio is affected by a change in lagged capital requirement and lagged capital ratio. The results from regression (5) with three lags show that as the minimum capital requirement increases in the first lag, capital ratio will decrease in the next quarter. The opposite relationship holds for two and three quarters lag. We find weak significance for three lags. As capital ratio increases in one, two and three lags capital ratio in the next quarter will decrease. There is a strong significance on two and three lags, and weak significance for one-quarter lag.

Table 3.

Capital	
Trigger ratio (-1)	−0,417* (0,229)
Trigger ratio (-2)	0,373 (0,230)
Trigger ratio (-3)	0,408* (0,240)
Capital (-1)	−0,189* (0,099)
Capital (-2)	-0,344*** (0,092)
Capital (-3)	-0,441*** (0,114)
Constant	0,006*** (0,001)
Time and bank fixed effects	Yes
Observations	164
R-squared	0,508
Number of banks	4

*White diagonal standard errors in parentheses. Fisher-type panel unit root test suggests no unit roots. ***p<0.01, ** p<0.05, * p<0.10.*

7.2 The impact of capital requirements and capital ratios on sectoral loan growth

Our second model (6) examines how loan growth for different sectors is affected by a change in lagged capital requirement, lagged capital ratio and lagged loan growth.

7.2.1 Unsecured lending

The results from regression (6) with unsecured loan growth as dependent variable show a negative but not significant effect from increased capital requirement. We find weak significance for lagged dependent variable and significance for leverage but the effect is quite small and the null hypothesis cannot be rejected, except for leverage ratio.

Table 4.

Unsecured loan growth	
Trigger ratio (-1)	-0,051 (1,912)
Capital (-1)	1,212 (1,007)
Dependent variable (-1)	-0,21* (0,127)
Tier 1 ratio (-1)	-0,397 (0,323)
Leverage ratio (-1)	0,276** (0,11)
Constant	0,003 (0,007)
Time and bank fixed effects	Yes
Observations	172
R-squared	0,376
Number of banks	4

*White diagonal standard errors in parentheses. Fisher-type panel unit root test suggests no unit roots. ***p<0.01, ** p<0.05, * p<0.10.*

7.2.2 Secured lending

Looking at the results from regressing secured loan growth on the lagged factors of model (6), we see that increased minimum capital requirement should have a negative effect on mortgage loan growth, however, this does not show signs of significance on any of the three significance levels.

Table 5.

Secured loan growth	
Trigger ratio (-1)	-0,274 (0,433)
Capital (-1)	0,267 (0,234)
Dependent variable (-1)	-0,079 (0,081)
Tier 1 ratio (-1)	0,127 (0,084)
Leverage ratio (-1)	0,052 (0,040)
Constant	0,016*** (0,002)
Time and bank fixed effects	Yes
Observations	172
R-squared	0,345
Number of banks	4

*White diagonal standard errors in parentheses. Fisher-type panel unit root test suggests no unit roots. ***p<0.01, ** p<0.05, * p<0.10.*

7.2.3 CRE lending

The results from regression model (6) with CRE loan growth as dependent variable show a negative but not significant effect from increased capital requirement. We find leverage ratio weakly significant with a positive effect on loan growth.

Table 6.

Non-CRE loan growth	
Trigger ratio (-1)	1,688 (1,384)
Capital (-1)	-0,176 (0,596)
Dependent variable (-1)	-0,251 (0,218)
Tier 1 ratio (-1)	-0,083 (0,139)
Leverage ratio (-1)	0,03 (0,064)
Constant	0,011* (0,006)
Time and bank fixed effects	Yes
Observations	172
R-squared	0,43
Number of banks	4

*White diagonal standard errors in parentheses. Fisher-type panel unit root test suggests no unit roots. ***p<0.01, ** p<0.05, * p<0.10.*

7.2.4 Non-CRE lending

Loan growth to non-real estate corporations does not seem to be affected by increased capital requirement or capital ratio. The results are ambiguous and no factor shows any sign of significance at the given significance levels.

Table 7.

CRE loan growth	
Trigger ratio (-1)	-1,116 (1,104)
Capital (-1)	0,592 (0,408)
Dependent variable (-1)	-0,016 (0,112)
Tier 1 ratio (-1)	-0,206 (0,176)
Leverage ratio (-1)	0,110* (0,059)
Constant	0,012*** (0,004)
Time and bank fixed effects	Yes
Observations	172
R-squared	0,334
Number of banks	4

*White diagonal standard errors in parentheses. Fisher-type panel unit root test suggests no unit roots. ***p<0.01, ** p<0.05, * p<0.10.*

7.2.5 Total lending

Total loan growth shows a negative but non-significant effect from increased capital requirement. We find leverage ratio highly significant but the effect seems to be quite small.

Table 8.

Total lending	
Trigger ratio (-1)	-0,03 (0,622)
Capital (-1)	0,521 (0,343)
Dependent variable (-1)	-0,046 (0,102)
Tier 1 ratio (-1)	-0,139 (0,091)
Leverage ratio (-1)	0,12*** (0,04)
Constant	0,01*** (0,003)
Time and bank fixed effects	Yes
Observations	172
R-squared	0,512
Number of banks	4

*White diagonal standard errors in parentheses. Fisher-type panel unit root test suggests no unit roots. ***p<0.01, ** p<0.05, * p<0.10.*

8. Discussion

First, we find that an increase in capital requirement affects capital ratio positively after one lag. The results are however only weakly significant, but this indicates that it takes more than one quarter for a bank to act on an increase in capital requirement. Second, capital requirement do not seem to have an effect on lending in any of the loan sectors analyzed. We find significance in leverage for total lending and unsecured lending and weak significance for CRE lending. We could not find significance in Tier 1 for any of the variables. Since we conclude that there is no effect on lending, we could not evaluate if some sectors analyzed were affected more than others.

Compared to previous research, we get similar results when looking at how banks' capital ratios are affected by a change in capital requirements. We find weakly significant results for three lags and Bridges et al. (2014) find that after an increase

in capital requirements, banks gradually rebuild the capital buffer that they initially held above the regulatory minimum. When looking at how bank lending to different sectors is affected by increased capital requirements, our results differ from the ones Bridges et al. (2014) get. While we do not find significance for any sector, Bridges et al. find that in the year following an increase in capital requirements, the loan growth is descending for CRE, non-CRE and household secured lending while the unsecured household lending is insignificant.

The Modigliani-Miller theorem states that under certain assumptions, lending should be independent of capital ratios. The fact that our results show no decrease in lending, despite an increase in capital requirements, gives empirical evidence that the Modigliani-Miller theorem holds for banks. We have given many examples of studies that dismiss the Modigliani-Miller theorem, among them Bridges et al. (2014). One explanation to why our results differ from the Bank of England report could be that we use changes in loan stock when computing lending while Bridges et al. (2014) use true lending flows, as the authors state it. Due to lack of observations, another explanation could be that we do not have enough power in our statistical tests.

Our results show that the increased capital requirements have not had any significant effect on bank lending. Therefore, it seems that policymakers have been successful in implementing the Basel regulations, in the aspect that the increased requirements have not been harmful to bank lending behaviour. However, one also needs to evaluate if the banks have gotten safer during the process of introducing higher capital requirements to estimate the effectiveness of the regulations. Therefore, we encourage future research on this subject.

Also, as seen in figure 1, the risk-weighted assets to total assets have decreased over time. This might imply that the increased capital requirements have negatively affected lending to more risky companies, while lending to more secure borrowers have remained at the same level or even increased. If lending to more risky companies

decreases, according to this reasoning, the result of increased capital requirements might imply difficulties for small companies and start-ups to get funding for their business. For future research we therefore suggest to divide lending into different categories depending on the borrowers credit worthiness and run similar panel regression.

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Appendix

Calculations for included variables.

Code	Formula	Growth
Trigger Ratio	$\frac{\text{Minimum Capital Requirement}}{\text{Risk Weighted Assets}}$	$x_1 - x_0$
Capital	$\frac{\text{Capital Base}}{\text{Risk Weighted Assets}}$	$x_1 - x_0$
Tier 1 Ratio	$\frac{\text{Tier 1 Capital}}{\text{Total Regulatory Capital}}$	$\frac{x_1 - x_0}{x_0}$
Leverage Ratio	$\frac{\text{Total Assets}}{\text{Tier 1 Capital}}$	$\frac{x_1 - x_0}{x_0}$
Unsecured loan growth	Absolute Value	$\frac{x_1 - x_0}{x_0}$
Secured Loan Growth	Absolute Value	$\frac{x_1 - x_0}{x_0}$
CRE Loan Growth	Absolute Value	$\frac{x_1 - x_0}{x_0}$
Non-CRE Loan Growth	Absolute Value	$\frac{x_1 - x_0}{x_0}$
Total lending	Absolute Value	$\frac{x_1 - x_0}{x_0}$

Regression: banks´capital ratios on capital requirements.

Lags	AIC	BIC	Adjusted R^2
1	-6,443	-5,565	0,151
2	-6,499	-5,588	0,202
3	-6,622	-5,677	0,297
4	-6,648	-5,668	0,265

Regression: banks' lending to different sectors on capital requirements and capital ratios

CRE lending

Lags	AIC	BIC	Adjusted R^2
1	-3,052	-2,119	0,058
2	-3,058	-2,072	0,079
3	-3,073	-2,034	0,114
4	-3,042	-1,947	0,089

Non-CRE lending

Lags	AIC	BIC	Adjusted R^2
1	-2,704	-1,771	0,195
2	-2,703	-1,717	0,217
3	-2,748	-1,708	0,271
4	-2,718	-1,622	0,262

Secured household lending

Lags	AIC	BIC	Adjusted R^2
1	-4,557	-3,624	0,075
2	-4,537	-3,552	0,063
3	-4,497	-3,458	0,049
4	-4,505	-3,409	0,071

Unsecured household lending

Lags	AIC	BIC	Adjusted R^2
1	-1,977	-1,043	0,118
2	-1,947	-0,962	0,114
3	-1,950	-0,911	0,141
4	-1,911	-0,816	0,128

Total lending

Lags	AIC	BIC	Adjusted R^2
1	-4,335	-3,401	0,286
2	-4,338	-3,352	0,291
3	-4,316	-3,276	0,283
4	-4,267	-3,172	0,240