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The Impact of Capital Requirements on Bank Lending Behavior

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Master Thesis

by

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Abstract

In this paper, we investigate if stricter capital requirements have a significant impact on bank lending to European households and corporations. The Basel III accords tightened Tier 1 capital and Common Equity Tier 1 (CET1) capital requirements. These requirements must be at least 4.5% and 6% respectively, of risk-weighted assets. We study if Tier 1 capital affect corporate lending and household lending. We have built a data set on European Central Bank (ECB) bank data, which we use to run regressions on lending to households and corporations in Europe. Tier 1 capital ratio and Common Equity Tier 1 ratio both increase household lending when capital requirements tighten. However, when estimating the effect of the two capital requirements on the ratio of growth in loans to households relative to growth in loans to corporations, the results have the opposite effect. Stricter Tier 1 capital requirements suggest that banks substitute towards corporate lending. On the opposite side, an increase in Common Equity Tier 1 suggest that banks substitute towards household lending.

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List of Abbreviations

BIS Bank for International Settlements

BCBS Basel Committee on Banking Supervision

CET1 Common Equity Tier 1

ECB European Central Bank

GDP Gross Domestic Product

GNPD Gross Non-Performing Debt Instruments

MM Modigliani - Miller

NPV Net Present Value

OLS Ordinary Least Squares

RPP Residential Property Prices

Tier 1 Tier 1 Capital

VIF Variance Inflation Factor

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1. Introduction

The Financial Crisis of 2008 was triggered by uncontrolled lending and excessive risk taking by banks prior to 2008. There was a significant growth in credit before the Financial Crisis due to deregulation of financial markets and the development of information technologies in the banking industry (Panopoulou, 2005; Rinaldi & Arellano-Sanchis, 2006). Regulators decided to tighten capital requirements to make sure that banks are stable enough to handle a new potential crisis. After the Financial Crisis of 2008, regulators increased focus on the crucial role of capital requirements to reduce excessive risk-taking by bank shareholders, who may be conditioned by limited liability (Behr, Schmidt, & Xie, 2010). The costs related to the bailouts in the global economy identified the need for better regulations understanding the determinants of bank risk (Baselga-Pascual, Trujillo-Ponce, & Cardone-Riportella, 2015).

The motivation for our thesis is to investigate the relationship between capital requirements and bank lending in European countries. We study two main questions in our thesis: *(1) How have Tier 1 Capital ratio and Common Equity Tier 1 ratio affected lending to the household sector, and (2) when capital requirements tighten, how do banks shift between household lending and corporate lending?* Following these two questions, we run two regressions on bank lending. First, we test the effect of tightened capital requirements on household lending. Second, we regress the ratio of growth in loans to households relative to growth in loans to non-financial corporations on stricter capital requirements. These two regression specifications tell us how banks change their lending behavior as the risk of the loan portfolio changes.

The 2008 Financial Crisis highlighted the importance of effective capital requirements. Bank failures like Lehman Brothers had immense effects on the worldwide economy. We have decided to use the Basel Accords as a regulatory framework and examine what effects Tier 1 capital and CET1 capital have had on bank lending to the household and corporate sectors. We also use other capital ratios that cover areas that are relevant to study bank risk and lending. It is of particular

interest to study the effect stricter capital requirements have had on bank lending and the overall level of activity in the economy.

We find evidence that Tier 1 capital ratio and CET1 ratio both increase household lending when capital requirements tighten. However, when estimating the effect of the two capital requirements on the ratio of growth in loans to households relative to growth in loans to corporations, the variables have opposite effects on lending. That is, when Tier 1 capital requirements tighten, banks substitute away from household lending and towards risker loans to corporations. On the other side, an increase in CET1 suggest that banks substitute towards household lending.

The thesis is structured as follows. First, we review the regulatory background and development of the Basel Accords from inception. This discussion provides a foundation for why we are conducting our research. Moving on, we review literature on bank lending and study empirical evidence on the effects of capital requirements. Then, we discuss the variables in our analysis and provide intuition for the inclusion of each variable. Afterwards, we explain the model we use, analyze our results, hypotheses and examine the robustness of our results. Finally, we conclude and answer the main questions asked in our thesis.

2. Basel Accords

The Bank for International Settlements (BIS) advice central banks as they seek monetary and financial stability. The BIS encourage international cooperation for banking regulation, and they act as a bank for central banks. The Basel Capital Accords are a recommended framework for bank regulation issued by the Basel Committee on Banking Supervision (BCBS), which is a part of the BIS. The Committee does not have any authority or legal power. BCBS is made up of central bankers and finance ministers from 27 countries and it is a forum for matters concerning international banking regulation. The objective is to enhance understanding of key supervisory issues and improve the quality of banking supervision worldwide (BIS, 2013). They formulate supervisory standards and guidelines, and each individual authority decide how they want to implement these guidelines.

Since 1988, the BCBS has issued three different adaptions of the Basel accords, referred to as Basel I (1988), Basel II (2004) and Basel III (2010). These three accords seek to define the main objectives of bank capital, provide a measure of risk for bank assets and the minimum capital required to be held by a credit institution (Shakdwipee & Mehta, 2017). The Basel I Accord provided credit institutions with guidelines regarding the definition of capital, determining risk weights and capital adequacy. However, there were some shortcomings of Basel I. The Basel I Accord was criticized because it focused solely on capital ratios and key financial risk metrics and ignored the need for a risk management process. The BCBS improved the Basel I Accord, and in 2004 they presented the Basel II to address some of the shortcomings of the previous accord.

The Basel II Accord was based on three pillars, the minimum requirements of own funds (Pillar I), the supervisory process for bank activity (Pillar II), and market discipline (Pillar III). Similar to the Basel I Accord, the minimum requirements of own funds were set at 8%, however Basel II provided clearer guidelines regarding the calculation. The capital adequacy ratio between equity and assets was calculated with assets weighted according to three different types of risks: credit risk, market risk, and operational risk. Next, the supervisory process for bank activity should include an internal risk management assessment of capital adequacy. Supervisors oversee if banks are adequately capitalized according to their risk profile. Finally, market discipline required better reporting requirements regarding ownership structure, capital adequacy to risk profile and other risk exposures. An important shortcoming of Basel I and Basel II was the fact that they addressed the solvency of each institution separately, thus not handling systemic risk adequately. The Financial Crisis of 2008 shed light on the systemic risk that the failure of one large institution could cause on its counterparties, which in turn could create a chain reaction. Following the collapse of Lehman Brothers, the BCBS started working on a new set of Basel requirements.

In 2010 the Basel III Accords were issued by the BCBS. The accord provides guidelines on capital adequacy, market liquidity risk and stress testing. Basel III framework is built on the three pillars of the Basel II Accords. Tier 1 capital ratio and CET1 ratio are both essential in our study as capital requirements is our key variable. Tier 1 capital is defined as going-concern capital and is the sum of CET1

capital and Additional Tier 1 capital. CET1 capital consists of the sum of common shares and stock surplus, retained earnings, other comprehensive income, qualifying minority interest and regulatory adjustments (BIS, 2019). CET1 capital is defined as the highest quality of regulatory capital, as it absorbs losses immediately when they occur (BIS, 2019). CET1 was introduced in the Basel III accords in 2010 and must be at least 4.5% of risk-weighted assets. Tier 1 capital must be at least 6.0% of risk weighted assets (BCBS, 2010).

There were also significant concerns that the earlier Basel Accord had not accounted for risk exposure to securitizations and derivatives. Due to the shortcomings of Basel II, the Basel III Accord enhanced transparency, quality of the capital base, introduced an updated leverage ratio and strengthen the liquidity standards. From 1988 to 2010 there were severe changes in the regulatory framework for banks and other credit institutions. These changes have been essential to the banking sector as they have had to adjust to new regulations accordingly.

3. Problem formulation

In this paper, we investigate if stricter capital requirements have a significant impact on bank lending to European households and non-financial corporations. Our study uses two dependent variables; loans to households and a ratio of growth in loans to households relative to growth in loans to non-financial corporations. We study if banks substitute between household lending and corporate lending when capital requirements are tightened. Corporate loans are given higher risk-weights than loans to households, thus we expect bank lending behavior to change as the underlying risk in the loan portfolio changes.

4. Literature Review

The importance of capital requirements and their effects on lending have gained a lot of professional and academic attention in recent time, which has led to a lot of empirical evidence on the topic that is relevant for our study. The relationship between capital requirements and bank risk is an essential one in banking literature. We review and use the empirical literature on the effects of capital requirements on

bank lending as a framework for our study. Furthermore, we study empirical evidence on the effect of macroeconomic variables on bank lending.

Due to stricter capital requirements, the debate on the real consequences of capital requirements has been intense (Fraisse, Lé, & Thesmar, 2017). Capital requirements are key provisions through which bank supervisors ask banks to hold a given share of their assets as equity (Fraisse et al., 2017). The theoretical benchmark for understanding the impact of capital requirements remains with the Modigliani-Miller (MM) theorem (Bridges et al., 2014b). Relating this to the banking sector, the essence is that changes in the composition of a bank's liabilities do not affect the overall funding cost, assuming that risk is kept constant on the asset side of the balance sheet. If the funding cost is kept constant, then a change in the capital ratio of a bank should not affect the price or amount of credit. If a bank wants to maintain their lending with stricter capital requirements, they need to issue more equity. MM claim that equity issuance costs are modest, hence stricter capital requirements should not affect funding costs significantly for banks (Hanson, Kashyap, & Stein, 2011).

On the opposite side of the MM view, we argue that raising equity is expensive due to frictions. A well-known friction in market for bank equity is the tax deductibility of debt interest payments, which implies higher funding costs for banks when capital requirements are increased (Bridges et al., 2014b). Other frictions are asymmetric information (Myers & Majluf, 1984) and debt overhang (Myers, 1977). When the access to equity is limited, banks that focus on maximizing NPV may have to give up positive NPV projects because they require too much regulatory capital. This problem is known as a debt overhang problem. Calem and Rob (1999) present evidence that the relationship between capital and risk is U-shaped. Moral hazard exacerbates the problem due to less capitalized banks often take on maximal risk, especially when close to bankruptcy. On the other side, well capitalized banks engage in riskier activities as they seek to compensate for smaller returns caused by a reduced amount of capital available for lending. Our study does not follow the traditional MM view, as we test for imperfections in the market. In an imperfect market, capital structure and capital requirements matter, and loans to households and corporations are affected by the amount of capital held by banks.

4.1 Impact of stricter capital requirements on bank lending

The implementation of Basel I in 1988 and Basel II in 2004 gave rise to a large collection of literature studying the effect of capital requirements on bank behavior, and more specifically on the relationship between bank capital and lending. In the early 1990s, Bernanke, Lown, and Friedman (1991) studied the effect of changes in bank capital on loan growth. Their findings report that a 1% increase in bank capital resulted in a 2-3% increase in bank loan growth, which confirms the theoretical relationship between capital and bank lending. In the years following the study of Bernanke and Lown, Furlong (1992) conducted a similar study which suggested a positive relationship between bank capital and lending. Furlong (1992) found that loan growth for individual banks is positively correlated with their capital-to-asset ratios. Following the methodology of Bernanke et al. (1991) and Hancock and Wilcox (1994), Berrospide and Edge (2010) found that a 1% increase in bank capital ratio lead to a 0.7-1.2% increase in lending. The studies above are based on U.S bank level data, while our study investigate a selection of European countries.

Furthermore, Ediz, Michael, and Perraudin (1998) found that capital requirements impact the capital ratios of UK banks. Their study provide evidence that banks tend to adjust their capital ratios by boosting capital instead of reducing lending. They argue that capital requirements are an attractive regulatory tool as they help reinforce the stability of the banking system without affecting bank lending choices. The evidence provided is interesting as they argue that banks do not reduce lending when facing stricter capital requirements, which differs from other empirical evidence on the topic.

Moving on, we study empirical evidence assessing what causes lending to different sectors. A study by Alfaro, Franken, Garcia, and Jara (2003) argue that the distinction between commercial, retail and other loans lead to a better identification of determinants in bank-lending. Risk weights differ depending on what sector the loan is granted to. Loans to corporations are given higher risk weights than loans to consumers. This study is highly relevant to our research question as the risk weights of loans explain why bank's loan portfolio change when capital requirements are tightened. A more recent study by Berger and Bouwman (2009) categorize business

loans as illiquid as banks usually cannot easily dispose of them to meet liquidity needs. They categorize residential mortgages and consumer loans as semiliquid as these loans can be securitized and sold to meet demands for liquid funds. Relating this to our research, their findings explain why capital requirements have different implications on lending to households and corporations. Economically, banks tend to shift away from riskier and illiquid loans when capital requirements tighten. This relationship underlies the theory of our study and is examined in detail.

Our study makes a direct link between capital requirements and bank lending to the corporate and household sector in Europe. A paper which is closely related to our study is a working paper from the Bank of England (Bridges et al., 2014b), which studies the effect of changes in capital requirements on bank lending in the UK. There are two key findings in the paper; regulatory capital requirements affect the capital ratios held by banks and capital requirements affect lending with different responses in different sectors. As stated in their paper, "capital requirements affect lending with heterogeneous responses in different sectors of the economy" (2014a, p. 5). They provide evidence that stricter capital requirements cause banks to cut loan growth for commercial real estate, other corporates and household secured lending.

4.2 The real effects of bank capital requirements

A working paper by Martynova (2015) discuss a collection of empirical evidence, which assess the overall effect of higher capital requirements on long-term economic growth. The paper study different research on real effects of bank capital requirements. As we use macroeconomic variables like gross domestic product (GDP) growth, interest rates and residential estate prices in our study, we find the literature of high relevance to our study. There are contradicting evidence on the effect of capital on macroeconomic variables. Bernanke et al. (1991) and Berger and Udell (1994) both argue that the major factor in economic slowdown might be due to lower credit demand than credit supply. Their study does not find a link between bank capital to asset ratios and employment growth. On the other side, most evidence argue that stricter capital requirements reduce lending which causes a slowdown in economic growth. The difficulty lies in clearly identifying if the credit supply effect arises from capital pressure on banks.

In 2004, Gambacorta and Mistrulli (2004) did a study on Italian banks. Their findings suggest that excess capital ratios impose a positive effect on bank lending. Furthermore, they found that the effects of monetary policy on bank lending differ according to how capitalized banks are. Jimenez, Ongena, Peydr, and Saurina (2012) present evidence that a one percent increase in the interest rate decreases loans granted by less-capitalized banks by 3.9 percent more than loans granted by well-capitalized banks. Their findings are relevant to us as we use change in interest rates as a macroeconomic variable in our regression.

A study by Supervision (2010) investigate the link between bank lending and macroeconomic uncertainty using annual and quarterly U.S bank level data. In both their annual and their quarterly datasets, it is evident that there is a negative relationship between macroeconomic uncertainty and the variability in banks' loan-to-assets ratios. In other words, the dispersion of banks willingness to provide customers with loans decreases in times of higher uncertainty. More specifically, this negative relationship is related to three major groups within total bank loans: real estate loans, commercial and industrial loans, and loans to households. Relating this to our research question, we impose macroeconomic variables on bank lending and assess different groups of bank loans.

Brun, Fraisse, and Thesmar (2013) study the macroeconomic effect of the transition from Basel I to Basel II in France. The evidence presented shows that a two-percentage points reduction in capital requirements caused an increase in aggregate corporate lending by 1.5%, increasing aggregate investment by 0.5% and creation or preservation of 235,000 jobs. Martinez-Miera and Suarez (2014) show that capital requirements can be helpful in reducing systemic risk-taking, hence decrease the cost and frequency of systemic crises. Their findings are aligned with the other studies mentioned as banks with stronger balance are better equipped to handle crises.

5. Data

The European Central Bank (ECB) provides loan data for European countries. We have created a data set consisting of aggregated national bank data based on ECB data. Our data stretches from 2009 to 2019 and covers 17 European countries. The data set has a representative collection of different European countries with banking sectors that are all different. The loan data consists of two dependent variables, which are loans to household and loans to non-financial corporations. We include several bank sector specific and macroeconomic variables that are included to assess their impact on lending. All of these variables are collected from the ECB database. We have selected capital ratios that are relevant from the Basel Accords and relevant for the areas that are of particular importance to our study on bank lending. Data has also been chosen based on the availability in the ECB database. Variables that have been updated in the recent Basel III Accords lack sufficient data for a longer timer period. For example, the data for Common Equity Tier 1 ratio exists only from 2014 to 2019 due to its recent implementation. Certain countries in our dataset are missing values in some quarters for both bank sector specific and macroeconomic variables, hence it is difficult to create a dataset that is entirely complete. We have also assessed loans granted by financial vehicle corporations. Financial vehicle corporations carry out securitization transactions, it issues debt securities, other debt instruments, securitization fund units and other financial instruments. Due to insufficient cross-country data we have decided to not include loans to financial vehicle corporations.

6. Variables

6.1 Dependent variables

Bank lending is a thoroughly researched topic in economics. Researching loans to households and corporations are sectors that are of particular interest to us as we compare bank lending trends. The different risk weights of the two loan classes makes the trend even more interesting to research. Our study employs two different dependent variables as we study the impact on bank lending. We run two different regressions, one on growth in loans to households and the other one on the ratio of growth in loans to households relative to the growth in loans to non-financial corporations. The two regression specifications let us examine whether banks

substitute towards household lending or corporate lending when capital requirements tighten.

6.1.1 Loans to Households

Our first dependent variable is loans to households, which include loans to households and non-profit institutions serving households. All loans to households are displayed in Euros. The quarterly change in loans to households is assessed over a ten-year period to study bank lending trends in Europe.

$$Growth\ in\ Loans\ to\ Households = \left(\frac{Loans\ to\ Households_t}{Loans\ to\ Households_{t-1}}\right) - 1$$

6.1.2 Ratio of Loans to Households to Loans to Financial Corporations

The second dependent variable is a ratio of growth of loans to households relative to growth in loans to non-financial corporations. All loans to non-financial corporations are also displayed in Euros. Studying the ratio of loans to households to loans to non-financial corporations tell us how banks substitute loans between households and corporations. Assessing how banks prioritize loans to households versus corporations during stricter capital requirements suggest what sector banks are most reluctant to lend to during stricter conditions. Loans to the corporate sector are given higher risk weights than loans to households (Naceur, Roulet, & Marton, 2017). Furthermore, Berger and Bouwman (2009) classified loans to households as semiliquid assets, and loans to corporations as illiquid assets (i.e., cannot typically be sold quickly without major losses). Thus, during difficult economic conditions one could see banks shifting their lending towards certain sectors to mitigate potential loan losses. The calculation of the ratio can be seen below.

$$\text{Ratio HH to Corp} = \frac{Growth\ Loans\ to\ Households}{Growth\ Loans\ to\ Non-Financial\ Corporations}$$

6.2 Explanatory variables

Baselga-Pascual et al. (2015) argue that we can divide the risk of a bank into two main areas. First, factors that are specific to each bank. In our case, factors that are specific to each bank sector. These factors are asset structure, capitalization, non-deposit funding, profitability, efficiency, revenue diversification and size. We

include variables that capture bank risk as these variables are important in determining lending to households and corporations. The second area relevant to bank risk are systemic factors that are equal for all banks. For example, GDP growth, inflation, interest rates, unemployment and other macroeconomic factors. Our study take use of both, variables that are specific to each bank sector and macroeconomic variables.

6.2.1 Bank Sector Specific Explanatory Variables

In this paper we consider four different capital ratios that are specific to each bank sector. Asset structure and capitalization are both key areas in determining bank lending behavior. Both of the areas mentioned are well documented variables in empirical evidence on determining bank lending behavior.

6.2.2 Asset Structure

A commonly criticized practice in banking has been how easy banks have provided credit in good economic times. The amount of loans to total assets is an important driver of credit risk. Credit risk is essential when considering bank lending behavior. Increasing non-performing loans support that banks provide less credit when credit risk increases (Naceur et al., 2017). Our study uses gross non-performing debt instruments (GNPD) as our proxy of credit risk. ECB define a bank loan as non-performing when more than 90 days go by without the borrower paying the agreed installment or interest (Bank, 2016). Studies have showed that the relative percentage of loans to total assets is positively correlated with the increasing amount of nonperforming loans and insolvency due to bad bank management (Blasko & Jr., 2006; Mannasoo & Mayes, 2009; Nicolo, Geadah, & Rozhkov, 2003). Gross non-performing debt instruments is calculated as follows:

$$Gross\ Non-Performing\ Debt\ Instruments = \frac{Non-Performing\ Loans}{Total\ Debt\ Instruments}$$

6.2.3 Capitalization

The necessity to regulate bank capital is essential for a well-functioning banking sector. Our study take use of three important capitalization variables. We include CET1 capital ratio, Tier 1 capital ratio and a leverage ratio to consider their effects on bank lending. Tier 1 capital ratio has been an integral part of the Basel Accords

since they were first published. CET1 capital ratio was increased from 4.0% to 4.5% in the Basel III Accords, hence we only have data to study the effects of this variable from 2014. The leverage ratio is important in examining how banks behave when leverage increases. The three ratios mentioned are calculated as follows.

$$Common\ Equity\ Tier\ 1\ Ratio = \frac{Common\ Equity\ Tier\ 1\ Capital}{Total\ Risk\ Exposure\ Amount}$$

$$Tier\ 1\ Capital\ Ratio = \frac{Tier\ 1\ Capital}{Total\ Risk\ Exposure\ Amount}$$

$$Leverage\ Ratio = \frac{Total\ Assets}{Total\ Equity}$$

6.2.4 Macroeconomic variables as determinants of bank lending

In addition to the bank sector specific variables, we examine macroeconomic variables and their effect on bank lending. We include three different macroeconomic variables that work as proxies for the state of the economy. The level of economic activity and the macroeconomic activity is likely to impact bank lending and investments (Chen, Shen, Kao, & Yeh, 2018; Pana, Query, & Park, 2010).

6.2.5 Economic Growth

The gross domestic product (GDP), is a control variable that measures the percentage change in GDP in each of the countries in our sample. There is a general perception that the bank sector is pro-cyclical and that better economic times are associated with lower risk and fewer defaults. This control variable allows us to control for the demand side of the market. Higher economic activity should result in higher demand for loans as investment opportunities arise and conditions for approving loans improve. There is a range of literature providing evidence that support this relationship (Baselga-Pascual et al., 2015; Poghosyan & Cihak, 2011). Bofondi and Ropele (2011) argue that higher real GDP growth rate is associated with lower risk. Our study includes quarterly GDP growth, and we expect a positive relationship between GDP growth and bank lending.

6.2.6 Interest Rates

There is a large selection of literature that argue that interest rates have a strong influence on bank risk. Hoggarth, Sorensen, and Zicchino (2005) show that important factors indirectly impact financial stability and loan portfolio quality are the dynamics of inflation and interest rates. To capture bank lending behavior in response to monetary policy we use quarterly interest rates for each bank sector. More recent literature argue that the recent low interest rate environment has encouraged banks to take on more risks as they search for yield (Agur & Demertzis, 2012; Delis & Kouretas, 2011). Studying the effect of interest rates is particular interesting due to low interest rate environment which has developed even more in recent times.

6.2.7 Residential Property Prices

Hofmann (2003) present international evidence on bank lending and property prices. He finds evidence of a cointegrating relationship between property prices, bank lending and GDP. There is also evidence of short-run causality going both ways, hence a mutually reinforcing element in earlier boom-bust cycles in credit and property market cannot be ruled out. Anundsen and Jansen (2013) study the interaction effects between housing prices and credit in Norway. Their analysis show that higher property prices lead to higher credit growth due to collateral effects, which again cause property price growth and so on, presenting that there is a financial accelerator at work. There is a large body of literature on the effects of property prices, hence we include property prices in our analysis. Our study takes use of a residential property price index for each European country in our dataset.

Table 1: Description of Explanatory Variables

Classification Bank-Specific Variables	Explanatory Variables	Notation	Expected Signs	Data Source
Asset Structure	Gross Non-Performing Debt Instruments	GNPD	-	ECB
Capitalization	Tier 1 Capital Ratio	Tier 1	+	ECB
Capitalization	Common Equity Tier 1	CET1	+	ECB
Capitalization	Leverage Ratio	LR	+	ECB
Economic Growth	GDP Growth	GDP	+	ECB
Interest Rates	Interest Rates	IR	-	ECB
Residential Property Prices	Real Estate Prices	RPP	+	ECB

Table 1 is an overview of the explanatory variables included in our regressions. Expected sign for each variable is included. All data is collected from the European Central Bank (ECB).

Table 2: Descriptive Statistics

Variables	Mean	Std.Dev.	Min	Max
Change Loans to Households	.005	.026	-.138	.377
Log Ratio HH to Corp	-.3	1.424	-5.109	5.131
Tier 1 Capital Ratio	.15	.032	.075	.23
Common Equity Tier 1	.157	.028	.107	.234
Leverage Ratio	15.039	4.246	7.205	29.899
Gross Non-Performing Debt Instruments	.067	.081	0	.421
Interest Rates	.026	.022	-.006	.167
Residential Property Prices	.005	.031	-.124	.13
GDP Growth	.013	.033	-.102	.292

Table 2 exhibits descriptive statistics from our two regressions. Mean, standard deviation, minimum and maximum is included for all variables.

Table 3 displays a matrix of correlations between our dependent variable and explanatory variables. This shows that each explanatory variable has its own specific effect on explaining bank lending. We run a variance inflation factor (VIF) test to check for multicollinearity (Appendix A), there are no signs of multicollinearity between the variables.

Table 3: Matrix of Correlations

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
(1) Change Loans to HH	1.000								
(2) Ratio HH to Corp	0.167	1.000							
(3) Tier 1 Capital Ratio	0.240	0.144	1.000						
(4) Common Equity Tier 1	0.064	0.058	0.845	1.000					
(5) Leverage Ratio	0.347	0.108	0.122	-0.134	1.000				
(6) GNPD	-0.358	-0.033	-0.266	-0.068	-0.483	1.000			
(7) Interest Rates	-0.277	-0.003	-0.280	-0.203	-0.455	0.782	1.000		
(8) Residential Property Prices	0.166	-0.017	0.080	0.048	-0.156	-0.059	-0.121	1.000	
(9) GDP Growth	-0.176	0.032	0.082	0.354	-0.194	0.068	-0.101	0.160	1.000

The table shows a matrix of correlations between all of our dependent and independent variables. (1) and (2) are our dependent variables, while (3) – (9) display our independent variables.

7. Methodology

We run a pooled OLS and a fixed effect model to estimate the effect of capital requirements on bank lending. Due to some limitations in the pooled OLS model, we also run a fixed effect model using time dummies. The pooled OLS model assumes that the intercept and the slope of the explanatory variables are constant. As our dataset is based on observations over a specific time period, the implication of using this model is that we assume that time-specific characteristics do not affect the volume of loans to households at the point of the implementation.

Both of our models assume that bank lending is explained by bank sector specific and macroeconomic variables. All of the right-hand side variables are lagged at least once to mitigate endogeneity problems. The intuition behind including macroeconomic variables is that it allows us to control for demand effects (Carlson, Shan, & Warusawitharana, 2013). We have selected a model using growth rates as variables in levels are typically integrated of order one. Kashyap and Stein (1995) used the same approach to mitigate spurious correlation.

First, we run a pooled OLS model and a fixed effect model with time dummies on the quarterly growth in loans to household from 2010 to 2019. We use two separate

measures for capital requirements. Our first regression includes Tier 1 capital ratio from 2010 to 2019, while the second regression is measuring the effect of the CET1 ratio from 2015 to 2019. We include CET1 ratio in a separate regression as the Basel III accords increased the amount of CET1 capital banks must hold from 4% to 4.5%. We run the following regressions:

$$\Delta LoansHH = \beta_1 + \beta_2 Tier1_{i,t-1} + \beta_3 LR_{i,t-1} + \beta_4 GNPD_{i,t-1} + \beta_5 IR_{i.t-1} + \beta_6 RPP_{i,t-1} + \beta_7 RPP_{i,t-2} + \beta_8 GDP_{i.t-1} + \beta_9 GDP_{i,t-2} + u_{i,t}$$

$$\Delta LoansHH = \beta_1 + \beta_2 CET1 + \beta_3 LR_{i,t-1} + \beta_4 GNPD_{i,t-1} + \beta_5 IR_{i.t-1} + \beta_6 RPP_{i,t-1} + \beta_7 RPP_{i,t-2} + \beta_8 GDP_{i.t-1} + \beta_9 GDP_{i,t-2} + u_{i,t}$$

When including time dummies, the regression equation becomes as follows:

$$\Delta LoansHH = \beta_1 + \beta_2 Tier1_{i,t-1} + \beta_3 LR_{i,t-1} + \beta_4 GNPD_{i,t-1} + \beta_5 IR_{i.t-1} + \beta_6 RPP_{i,t-1} + \beta_7 RPP_{i,t-2} + \beta_8 GDP_{i.t-1} + \beta_9 GDP_{i,t-2} + \delta_2 \mathrm{D2_t} + \cdots + \delta_\mathrm{T} DT_t + u_{i,t},$$

where only $T - 1$ dummies are included (D1 is omitted) as the model includes an intercept. The model removes omitted variable bias excluding unobserved variables that change over time but are constant across countries (Hanck, Arnhold, Gerber, & Schmelzer, 2019).

Moving on, we run the pooled OLS on a ratio of growth in loans to households relative to growth in loans to non-financial corporations. As our original dataset for the ratio contains outliers (Appendix B), we use a log-linear model to overcome the issue. Taking a logarithm on our dependent variable help us rescale the data so that the variance is more constant, and in turn overcome the heteroskedasticity problem. Furthermore, as shown in Appendix B, the use of logarithms helps normalize our distribution. Lastly, taking logarithms is a way to make a non-linear multiplicative relationship between variables into a linear, additive one (Brooks, 2014). In this part of the analysis, we run a secondary regression with the CET1 ratio from 2015 to 2019. See regression equations:

$$logRatioHHtoCorp = \beta_1 + \beta_2 Tier1_{i,t-1} + \beta_3 LR_{i,t-1} + \beta_4 GNPD_{i,t-1} + \beta_5 IR_{i.t-1} + \beta_6 RPP_{i,t-1} + \beta_7 RPP_{i,t-2} + \beta_8 GDP_{i.t-1} + \beta_9 GDP_{i,t-2} + u_{i,t}$$

$$logRatioHHtoCorp = \beta_1 + \beta_2 CET1 + \beta_3 LR_{i,t-1} + \beta_4 GNPD_{i,t-1} + \beta_5 IR_{i.t-1} + \beta_6 RPP_{i,t-1} + \beta_7 RPP_{i,t-2} + \beta_8 GDP_{i.t-1} + \beta_9 GDP_{i,t-2} + u_{i,t}$$

Both the pooled OLS and the fixed effect model is estimated using the same dependent and independent variables as listed in Section 6. In addition to these independent variables, the fixed effects model includes a dummy for all but one time period. The selection of the base year is immaterial. Any time period can be selected as a base, as long as the number of time dummies are one less than the total number of time periods in our sample. Including the dummy variables allow us to check whether the period when Basel III was introduced is a factor which is accounted for when banks lend to households and corporations.

8. Discussion of results

We have divided this section into four parts. First, we discuss our results from the regressions for loans to households and the ratio for loans to households to loans to non-financial corporations. Moving on, we compare our results to our expected signs earlier mentioned. Finally, we present the results from our robustness checks.

8.1 Discussion of results

We start off by discussing the results from the pooled OLS model with growth in loans to households as our dependent variable. An increase in the dependent variable suggest a larger growth rate in loans to households compared to the previous quarter. We test the model with two different measures of capital requirements from the Basel Accords, starting with the Tier 1 capital ratio. Following this regression, we run a regression on the same dependent variable but using CET1 ratio as our variable of interest. Banks faced stricter CET1 capital requirements after the implementation of Basel III, which makes it interesting to test if this has had an effect on bank lending.

First, Table 4 shows that the coefficient of Tier 1 capital ratio is positive and insignificant at all levels. The results indicate that banks are not as constrained by Tier 1 capital ratio post financial crisis in 2008. One argument is that banks have strengthened their capital provisions in the aftermath of the crisis. Another argument is that banks do not change their level of Tier 1 capital once they have fulfilled the regulatory requirements. The result from the leverage ratio suggests that banks lend more to households. An increase in a bank´s total assets means that

the loan portfolio is growing. A reduced amount of equity would also increase leverage ratio, which is explained by higher loan losses or rising lending. Moving on, GNPD instruments is significant. A rising amount of non-performing loans tell us that banks have more loans which are deemed non-performing. The negative coefficient sign suggests that lending decreases when the amount of non-performing loans increase. Banks that have a lot of non-performing loans tend to be less aggressive on lending, which suggest that they expect losses on their loan portfolio. Finally, the second lag of residential property prices (RPP) is significant at the 0.05 level. This is an interesting finding as the first lag is neither significant nor sharing the same coefficient sign of the second lag. As residential property prices rise, loans to households increase, which indicate that the borrowers have more collateral to put up. In addition, increasing real estate prices will create demand for higher loans as the general price-level of residential property increases.

Table 4: Pooled OLS with Tier 1 Capital Ratio

Dependent Variable: Loans to Households	Coef.	Std.Err.	t-stat	p-value	Sig.
Tier 1 Capital Ratio (Lagged once)	0.029	0.029	1.01	0.314	
Leverage Ratio (Lagged once)	0.001	0.000	3.38	0.001	***
GNPD (Lagged once)	-0.026	0.013	-2.03	0.043	**
Interest Rates (Lagged once)	-0.072	0.058	-1.24	0.216	
Residential Property Prices (Lagged once)	-0.015	0.043	-0.34	0.731	
Residential Property Prices (Lagged twice)	0.107	0.045	2.39	0.017	**
GDP Growth (Lagged once)	0.010	0.041	0.26	0.799	
GDP Growth (Lagged twice)	-0.053	0.039	-1.35	0.178	
Constant	-0.007	0.007	-1.14	0.254	

Mean dependent variable	0.004	SD dependent variable	0.017
R-squared	0.131	Number of observations	438
F-test	8.092	Prob > F	0.000
Akaike crit. (AIC)	-2387.088	Bayesian crit. (BIC)	-2350.348

**** p<0.01, ** p<0.05, * p<0.1*

Moving on, we run the same model again with CET1 ratio to see if the tightened CET1 capital requirements following Basel III change our results. CET1 ratio has a positive and significant effect on household lending while Tier 1 capital ratio does not adequately explain the variation in household lending. This is an interesting finding as the two capital requirements have contradicting impact. One explanation is that they cover different time periods. Another reason is that Tier 1 capital consists of CET1 capital and Additional Tier 1 capital. CET1 capital is the first layer of Tier 1 capital, while Additional Tier 1 capital is the second layer. CET1 capital is the highest quality of regulatory capital, as it absorbs losses immediately when they occur (BIS, 2019). Hence, higher Tier 1 capital ratio does not necessarily make banks more comfortable with their capital base. Therefore, when banks hold more CET1 capital they hold a higher amount of high- quality capital, which makes them more comfortable with a larger loan portfolio. Another argument is that the strengthened CET1 ratio from 2014 increased capital provisions, leading to growth in lending. We argue that the recovery after the financial crisis has strengthened the banking sector, thus the impact of non-performing loans on lending is not as important because banks hold more high-quality capital. Aligned with earlier findings, leverage ratio and residential property prices are significant. Real estate prices have the strongest explanatory power on lending to households. R^2 increases from 13.1% to 21.5% with a shorter time period and CET1 ratio included. Hence, our model better explains changes in lending when using CET1 ratio opposed to Tier 1 capital ratio.

Table 5: Pooled OLS with Common Equity Tier 1

Dependent Variable: Loans to Households	Coef.	Std.Err.	t-stat	p-value	Sig.
Common Equity Tier 1 Ratio (Lagged once)	0.056	0.031	1.79	0.074	*
Leverage Ratio (Lagged once)	0.001	0.000	3.95	0.000	***
GNPD (Lagged once)	-0.016	0.014	-1.12	0.263	
Interest Rates (Lagged once)	-0.090	0.079	-1.14	0.257	
Residential Property Prices (Lagged once)	0.034	0.045	0.76	0.450	
Residential Property Prices (Lagged twice)	0.117	0.044	2.64	0.009	***
GDP Growth (Lagged once)	-0.022	0.038	-0.58	0.564	
GDP Growth (Lagged twice)	-0.056	0.038	-1.48	0.140	
Constant	-0.017	0.007	-2.38	0.018	**

Mean dependent variable	0.004	SD dependent variable	0.015
R-squared	0.215	Number of observations	307
F-test	10.175	Prob > F	0.000
Akaike crit. (AIC)	-1767.091	Bayesian crit. (BIC)	-1733.549

**** p<0.01, ** p<0.05, * p<0.1*

The second model we run is a linear regression with time fixed effects. Each time period in our sample is characterized by a different intercept, incorporated in the regression by the use of dummy variables. The model seems to improve the statistical fit of our data due to a higher R^2. To confirm if the model is a better statistical fit, we test the fixed effect model against the pooled OLS model. See results in Table 6. The F-test of the null hypothesis that all time dummies, the intercept terms across all time periods, are jointly equal to zero was rejected even at the smallest level of significance (p-value < 0.000). Hence, it does matter that we account for time differences in our estimation.

The leverage ratio and the second lag of the residential property prices are both significant. Compared to the pooled OLS model, GNPD instruments are no longer statistically significant. This suggest that non-performing loans are highly correlated across banks, and as a result of this, their explanatory power is picked up by the time dummies. However, we find it interesting that all time periods except for two are statistically significant. Adding time dummies allows us to control for the exogeneous increase in lending growth to households which is not explained by any of the explanatory variables, and for variables which are constant across the countries in our sample. As most of our time periods are significant, they suggest

that there are multiple factors specific to each period that explain changes in our dependent variable. What is most noticeable regarding the time dummies is that all of them have negative coefficient signs. This propose that there was less growth in loans to households during these periods, which may coincide with the implementation of Basel III and the recovery from the Financial Crisis in 2008. The regulatory framework for Basel III was introduced in 2010 and implemented in 2014. From the time dummies we see that there are multiple quarters from 2010 to 2014 that are statistically significant. Both the implementation of Basel III and the Eurozone debt crisis were important events that decreased lending during these quarters.

Table 6: Linear Regression with Time Dummies

Dependent Variable: Loans to Households	Coef.	Std.Err.	t-stat	p-value	Sig.
Tier 1 Capital Ratio (Lagged once)	0.048	0.034	1.43	0.154	
Leverage Ratio (Lagged once)	0.001	0.000	2.48	0.014	**
GNPD (Lagged once)	-0.019	0.014	-1.38	0.169	
Interest Rates (Lagged once)	-0.112	0.069	-1.63	0.103	
Residential Property Prices (Lagged once)	-0.007	0.046	-0.14	0.886	
Residential Property Prices (Lagged twice)	0.100	0.049	2.03	0.043	**
GDP Growth (Lagged once)	-0.034	0.044	-0.78	0.436	
GDP Growth (Lagged twice)	-0.022	0.043	-0.52	0.602	
2010 Q1 (Base year)	.	.	.	.	
2010 Q2	-0.018	0.007	-2.60	0.010	**
2011 Q1	-0.009	0.007	-1.24	0.216	
2011 Q4	-0.008	0.007	-1.24	0.218	
2012 Q1	-0.013	0.007	-1.97	0.049	**
2012 Q3	-0.017	0.007	-2.61	0.009	***
2013 Q1	-0.019	0.007	-2.87	0.004	***
2013 Q3	-0.013	0.006	-1.95	0.052	*
2014 Q1	-0.017	0.007	-2.58	0.010	**
2014 Q3	-0.015	0.007	-2.20	0.028	**
2015 Q1	-0.015	0.007	-2.14	0.033	**
2015 Q2	-0.012	0.007	-1.71	0.089	*
2015 Q3	-0.017	0.007	-2.51	0.013	**
2015 Q4	-0.011	0.007	-1.62	0.105	
2016 Q1	-0.021	0.007	-3.00	0.003	***
2016 Q2	-0.021	0.007	-3.08	0.002	***
2016 Q3	-0.017	0.007	-2.42	0.016	**
2016 Q4	-0.012	0.007	-1.77	0.077	*
2017 Q1	-0.015	0.007	-2.23	0.026	**
2017 Q2	-0.013	0.007	-1.99	0.048	**
2017 Q3	-0.012	0.007	-1.79	0.073	*
2017 Q4	-0.018	0.007	-2.56	0.011	**
2018 Q1	-0.018	0.007	-2.54	0.011	**

Table 6: Continued

Dependent Variable: Loans to Households	Coef.	Std.Err.	t-stat	p-value	Sig.
2018 Q2	-0.015	0.007	-2.21	0.028	**
2018 Q3	-0.013	0.007	-1.81	0.071	*
2018 Q4	-0.018	0.007	-2.62	0.009	***
2019 Q1	-0.017	0.007	-2.43	0.016	**
2019 Q2	-0.015	0.007	-2.11	0.035	**
2019 Q3	-0.025	0.010	-2.44	0.015	**
Constant	0.007	0.008	0.82	0.411	

Mean dependent variable	0.004	SD dependent variable	0.017
R-squared	0.181	Number of observations	438
F-test	2.394	Prob > F	0.000
Akaike crit. (AIC)	-2355.147	Bayesian crit. (BIC)	-2200.023

**** p<0.01, ** p<0.05, * p<0.1*

Table 7 and Table 8 display regression results for the pooled OLS model with a ratio of growth in loans to households relative to growth in loans to non-financial corporations. The ratio tells us how the composition of banks loan portfolios develops when bank specific and macroeconomic variables change. We use two different capital requirements in the regressions. One regression is run with Tier 1 capital ratio and the other with a CET1 ratio.

Leverage ratio and residential property prices are significant for both of our regressions. The leverage ratio suggests that banks shift lending towards households when capital requirements are tightened. An increase in the leverage ratio is explained by either growing total assets or less equity. If equity decreases, banks substitute towards household lending as it is considered to be less risky than corporate lending. Our findings support the previous results where banks have larger amounts of loans to households relative to corporations. Residential property prices have a positive relationship with loans to households, and banks tend to substitute toward household lending when real estate prices increase.

Tier 1 capital ratio has a negative coefficient, resulting in a shift towards increased corporate lending. Well-capitalized banks handle higher risk, thus shifting towards riskier corporate loans. Our results are supported by Alfaro et al. (2003), who argues that corporate loans have higher risk-weights than loans to households. CET1 ratio indicates that banks lend more to households when the amount of required capital increases. It is interesting that the two capital requirements seem to have a different

effect on the ratio of growth in loans to households relative to growth in loans to corporations. One reason for the opposite coefficient signs is shorter time span of the CET1 sample, and that the number of observations is not large enough to fully capture the explanatory power of the variable.

Another interesting result is that non-performing loans have a positive coefficient sign for both Tier 1 capital ratio and CET1 ratio. This suggest that when banks have more non-performing loans, they increase lending to households. As corporations have higher a risk-weight than loans to households, banks substitute towards safer lending to households in economic downturns.

Table 7: Ratio Household to Corporations with Tier 1 Capital Ratio

Dependent Variable: Ratio HH to Corp	Coef.	Std.Err.	t-stat	p-value	Sig.
Tier 1 Capital Ratio (Lagged once)	-1.424	2.854	-0.50	0.618	
Leverage Ratio (Lagged once)	0.083	0.023	3.67	0.000	***
GNPD (Lagged once)	1.377	1.213	1.14	0.257	
Interest Rates (Lagged once)	0.839	5.554	0.15	0.880	
Residential Property Prices (Lagged once)	-1.246	4.329	-0.29	0.774	
Residential Property Prices (Lagged twice)	12.758	4.536	2.81	0.005	***
GDP Growth (Lagged once)	-1.475	3.746	-0.39	0.694	
GDP Growth (Lagged twice)	-4.672	3.565	-1.31	0.191	
Constant	-1.456	0.658	-2.21	0.028	**

Mean dependent variable	-0.337	SD dependent variable	1.372
R-squared	0.097	Number of observations	312
F-test	4.080	Prob > F	0.000
Akaike crit. (AIC)	1068.010	Bayesian crit. (BIC)	1101.697

**** p<0.01, ** p<0.05, * p<0.1*

Table 8: Ratio Households to Corporations with CET1

Dependent Variable: Ratio HH to Corp	Coef.	Std.Err.	t-stat	p-value	Sig.
Common Equity Tier 1 (Lagged once)	1.088	3.506	0.31	0.757	
Leverage Ratio (Lagged once)	0.097	0.034	2.88	0.004	***
GNPD (Lagged once)	1.428	1.636	0.87	0.384	
Interest Rates (Lagged once)	3.439	9.229	0.37	0.710	
Residential Property Prices (Lagged once)	-3.379	5.234	-0.65	0.519	
Residential Property Prices (Lagged twice)	12.406	5.329	2.33	0.021	**
GDP Growth (Lagged once)	-0.887	4.077	-0.22	0.828	
GDP Growth (Lagged twice)	-5.083	3.976	-1.28	0.202	
Constant	-2.063	0.842	-2.45	0.015	**

Mean dependent variable	-0.412	SD dependent variable	1.371
R-squared	0.083	Number of observations	223
F-test	2.435	Prob > F	0.015
Akaike crit. (AIC)	771.132	Bayesian crit. (BIC)	801.797

**** p<0.01, ** p<0.05, * p<0.1*

In the next section, we will be discussing how the results align with our expectations for the impact of the independent variables.

8.2 Discussion of expected signs

We summarize expected signs and results in Table 9 and Table 10.

Table 9: Summary Table Loans to Households

			Results
Variable	**Expected Sign**	**2010 - 2019**	**2015 - 2019**
Tier 1 Capital Ratio	+	YES	
Common Equity Tier 1	+		YES (*)
Leverage Ratio	+	YES (***)	YES (***)
GNPD	-	YES (**)	YES
Interest Rates	-	YES	YES
Residential Property Prices	+		
Lag 1		NO	YES
Lag 2		YES (**)	YES (***)
GDP Growth	+		
Lag 1		YES	NO
Lag 2		NO	NO

"YES" indicates that the sign of the coefficient estimate is in line with our expectation. "NO" indicates the opposite. P-value < 0.01: ***, P-value < 0.05: **, P-value < 0.10: *.

Table 10: Summary Table Ratio Households to Corporations

		Results	
Variable	**Expected Sign**	**2010 - 2019**	**2015 - 2019**
Tier 1 Capital Ratio	-	YES	
Common Equity Tier 1	-		NO
Leverage Ratio	+	YES (***)	YES (***)
GNPD	+	YES	YES
Interest Rates	+	YES	YES
Residential Property Prices	+		
Lag 1		NO	NO
Lag 2		YES (***)	YES (**)
GDP Growth	-		
Lag 1		YES	YES
Lag 2		YES	YES

"YES" indicates that the sign of the coefficient estimate is in line with our expectation. "NO" indicates the opposite. P-value < 0.01: ***, P-value < 0.05: **, P-value < 0.10: *.

Tier 1 Capital Ratio:

We expected that higher Tier 1 capital ratio increase bank lending as banks have a higher capital provision. The coefficient sign is positive, supporting our expectation. However, the Tier 1 capital ratio is insignificant in our model, but we do not exclude the possibility that this variable is significant with a more complex dataset. When assessing the ratio of growth in loans to households relative to growth in loans to corporations, we see that the results are aligned with our prediction. A negative coefficient sign on the Tier 1 capital ratio suggest that banks substitute towards corporate lending. An explanation is that when banks have higher capital provisions, they are more willing to take on riskier loans, and loans to corporations have a higher risk-weight than loans to households.

Common Equity Tier 1 Ratio:

Our prediction is that CET1 ratio increase lending. The result for loans to households tells us that banks have been more willing to lend to households after 2015 when they hold more capital. On the other side, the CET1 ratio was insignificant for the ratio, while having a positive coefficient sign. The result is not what we expected as lending shift towards households when CET1 ratio improved.

Leverage Ratio:

This variable is one of our variables with the highest explanatory power across both regressions. Our hypothesis suggests that an increase in leverage ratio result in an increase in bank lending, and a substitution towards lending to households versus corporations. For loans to households, the leverage ratio is significant both when controlling for Tier 1 capital ratio and CET1 ratio. Thus, we argue that a rising leverage ratio does in fact increase loans to households. When we run regressions on the ratio of growth in loans to households to growth in loans to corporations, the coefficients are aligned with what we predicted.

Gross Non-Performing Debt Instruments:

We obtain results which are aligned with our expectation as a higher amount of non-performing loans lead to lower lending to households. When running the CET1 ratio on growth in loans to households, our results are insignificant. We argue that banks have recovered from the Financial Crisis and have a stronger capital buffer. We predicted that an increase in bad loans shift lending towards household lending as it is less risky than corporate loans. While the results are insignificant, both of our regression on the ratio have positive coefficient signs. Our findings are aligned with what we predicted as the results suggest that banks shift towards household lending.

Interest Rates:

We expected that rising interest rates decrease lending to households. The coefficient estimates for both regressions on household lending are as predicted, but they are both insignificant. Moving on, we predicted that banks substitute towards household lending. Our results are insignificant, but the coefficients indicate that banks shift towards household lending, which is aligned with our prediction.

Residential Property Prices:

The results from residential property prices have high explanatory power. Our results from the second lag on household lending are significant and aligned with our expectation for Tier 1 capital ratio and CET1 ratio. Residential property prices have a lagging effect on bank lending. It takes time from when the change in price

occurs to when it affects bank lending. The results on the ratio are mixed compared to our prediction. The results from the second lag are significant and indicate that banks hold a larger portion of household loans when property prices rise. The findings for the second lag are as expected.

GDP Growth:

None of our coefficients are significant. A possible explanation is that GDP growth often lag the economic cycle. The first lag of GDP growth on loans to households is aligned with our prediction for Tier 1 capital ratio, while it is the opposite for CET1 ratio. Our second lag is not as we expected as an increasing GDP indicates lower lending to household. Our second lag is not as we expected as an increasing GDP indicates lower lending to household for both of our capital requirements. All of our findings for the ratio is aligned with our expectation. Lending shift towards corporations as GDP growth rise, hence banks are willing to take on more risk when the state of the economy improves. However, it lacks significance and its explanatory power is somewhat limited.

8.3 Robustness of results

We run two tests to check the robustness of our results. First, we run an F-test to check if the fixed effects model is preferred to the pooled OLS model. The null hypothesis states that there are no time-period specific characteristics. On the contrary, the alternative hypothesis states that there is a substantial inter-period variation and that a fixed effects model is preferred over a pooled OLS model. Next, we check for heteroskedasticity by running a Breusch-Pagan test. This allows us to see whether too much of the variance is explained by the inclusion of additional explanatory variables. Due to a limited time span of our sample, we choose not to test for autocorrelation.

Table 11: Summary of Robustness Checks for Loans to Households

Test		F-test	Breusch-Pagan
Purpose		Fixed Effects vs Pooled OLS	Test for heteroskedasticity
Hypothesis	Null	No fixed effects	Homoskedasticity
	Alternative	Significant effects	Presence of heteroskedasticity
P-value		0.000	0.000
Rejection rule		< 0.05	< 0.05
Results		Reject the null	Reject the null

We see from Table 11 that the null of the F-test that all dummies are jointly equal to zero is rejected, hence we need to account for time-specific effects in our analysis. From the Breusch-Pagan test, we reject the null hypothesis of homoskedasticity, thus detecting a presence of heteroskedasticity. Kleiber and Zeileis (2008) states that it is still possible to estimate coefficients when heteroskedasticity is present, but it is necessary to compute a consistent covariance matrix. We apply their methodology in order to estimate the heteroskedasticity-consistent coefficients. Our results show that the leverage ratio, non-performing loans and the second lag of residential property prices are still significant at the same levels as before. Hence, it does not change the interpretation of our results. The output of the test can be found in Appendix C.

Table 12: Summary of Robustness Checks for Ratio of Growth in Loans to Households Relative to Growth in Loans to Non-Financial Corporations

Test		F-test	Breusch-Pagan
Purpose		Fixed Effects vs Pooled OLS	Test for heteroskedasticity
Hypothesis	Null	No fixed effects	Homoskedasticity
	Alternative	Significant effects	Presence of heteroskedasticity
P-value		0.0011	0.0443
Rejection rule		< 0.05	< 0.05
Results		Reject the null	Reject the null

When running the robustness checks on the ratio of growth in loans to households relative to growth in loans to non-financial corporations, we get the same results as

in Table 11. We reject the null of the F-test that fixed effects are appropriate, and we detect a presence of heteroskedasticity. When estimating heteroskedasticity-consistent coefficients and robust standard errors, the significance of our variables remains the same as our previous results. The estimation of the coefficients can be found in Appendix C.

9. Conclusion

We analyze the impact of capital requirements on bank lending to households and corporations in Europe. First, we test if stricter Tier 1 - and CET1 capital requirements increase lending to households. Secondly, we examine if banks substitute household lending for riskier loans to corporations. Our main result is that stricter CET1 ratio increase household lending. The Tier 1 capital ratio does not have enough explanatory power to capture the variation in loans to households. The main findings from the secondary regression indicate that banks shift towards corporate lending when Tier 1 capital requirements tighten, and towards household lending when CET1 requirements increase.

Among our bank-specific variables, leverage ratio and non-performing loans are our strongest predictors of bank lending behavior. Rising amounts of non-performing loans shift lending towards households. This is aligned with what we predicted as banks that expect losses on their loan portfolios are less willing to provide credit. Leverage ratio is a strong predictor of bank lending behavior. A rising leverage ratio reduces bank risk appetite as lending shift to household lending.

Residential property prices is the macroeconomic variable with the highest explanatory power. This is aligned with our expectations as real estate prices are directly impacting loans to households. The variable had a significant impact across our two regressions, and higher property prices indicate both an increase in household lending, as well as a shift in bank lending towards households.

Appendix

Appendix A:

We display a table of correlations, and to make sure are no signs of collinearity between our explanatory variables, we run a Variance Inflation Factor (VIF). A variable whose VIF values greater than 10 should be investigated further. As displayed in the output, 1/VIF checks the degree of collinearity. A value of lower than 0.10 is equivalent to a VIF value of 10.

Table 13: Variance Inflation Factor – Loans to Households

Variance Inflation Factor	VIF	1/VIF
Residential Property Prices (Second lag)	2.707	.369
Residential Property Prices (First lag)	2.61	.383
GDP Growth (Second lag)	2.591	.386
GDP Growth (First lag)	2.578	.388
Interest Rates	2.251	.444
GNPD	1.844	.542
Tier 1 Capital Ratio	1.542	.648
Leverage Ratio	1.458	.686
Mean VIF	2.198	.

Table 14: Ratio of growth in loans to households relative to growth in loans to corporations

Variance Inflation Factor	VIF	1/VIF
GDP Growth (First lag)	2.644	.378
GDP Growth (Second lag)	2.621	.381
Residential Property Prices (First lag)	2.495	.401
Residential Property Prices (Second lag)	2.352	.425
Interest Rates	2.297	.435
GNPD	1.782	.561
Tier 1 Capital Ratio	1.513	.661
Leverage Ratio	1.419	.705
Mean VIF	2.14	.

Appendix B:

In order to clean up the data in the ratio of growth in loans to households relative to growth in loans to corporations, we use a logarithm to normalize the data. As seen in the histograms, the effect of the logarithm is great in removing outliers from the dataset.

Figure 1: Original Distribution of Dependent Variable

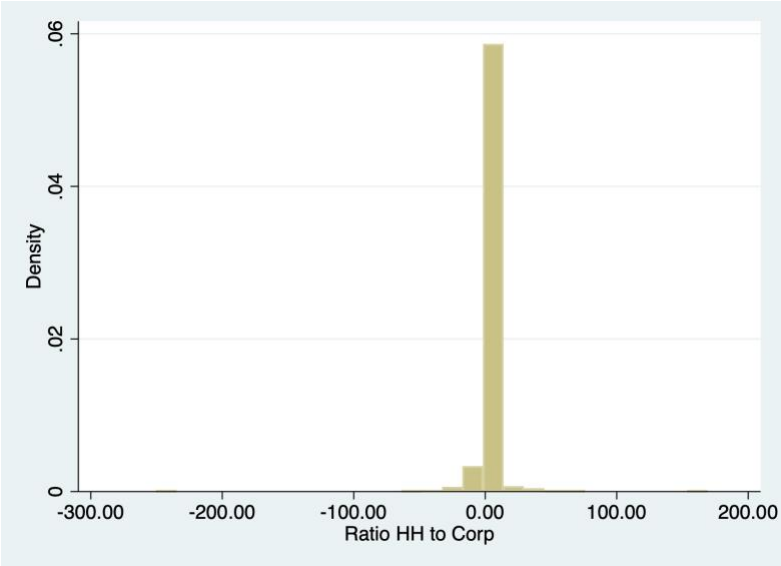
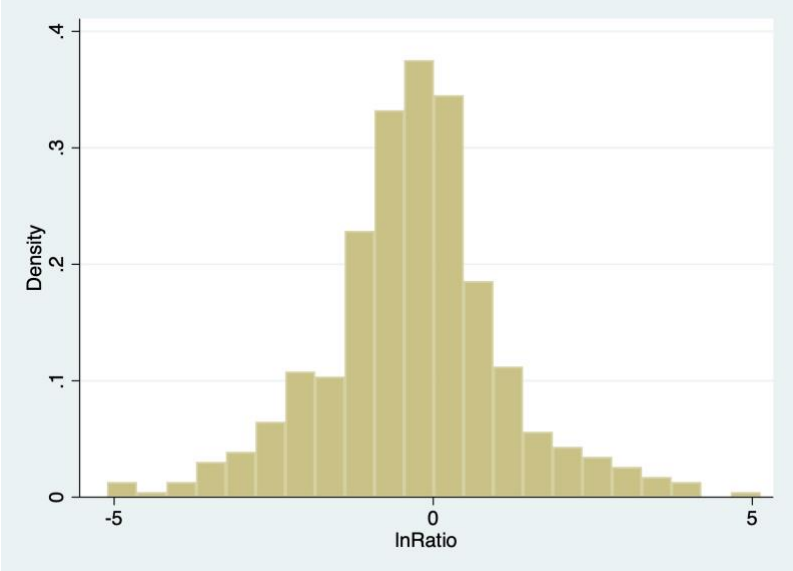


Figure 2: Distribution after taking logarithm



Appendix C:

When running robustness checks on our regressions, we detect a presence of heteroskedasticity in both regressions. As Kleiber and Zeileis (2008) do in their study, we estimate heteroskedasticity-consistent coefficients in order to obtain robust standard errors.

Table 15: Heteroskedasticity-consistent coefficients for Loans to Households

Dependent Variable: Change Loans to HH	Coef.	Robust Std.Err.	t-stat	p-value	Sig.
Tier 1 Capital Ratio (Lagged once)	0.029	0.028	1.06	0.287	
Leverage Ratio (Lagged once)	0.001	0.000	3.27	0.001	***
GNPD (Lagged once)	-0.026	0.011	-2.26	0.025	**
Interest Rates (Lagged once)	-0.072	0.044	-1.63	0.104	
Residential Property Prices (Lagged once)	-0.015	0.035	-0.42	0.671	
Residential Property Prices (Lagged twice)	0.107	0.042	2.57	0.011	**
GDP Growth (Lagged once)	0.010	0.058	0.18	0.859	
GDP Growth (Lagged twice)	-0.053	0.049	-1.08	0.282	
Constant	-0.007	0.005	-1.37	0.172	

Mean dependent variable	0.004	SD dependent variable	0.017
R-squared	0.131	Number of observations	438.000
F-test	10.359	Prob > F	0.000
Akaike crit. (AIC)	-2387.088	Bayesian crit. (BIC)	-2350.348

**** p<0.01, ** p<0.05, * p<0.1*

Table 16: Heteroskedasticity-consistent coefficients for Ratio Households to Corporations

Dependent Variable: Log Ratio	Coef.	Robust Std.Err.	t-stat	p-value	Sig.
Tier 1 Capital Ratio (Lagged once)	-1.424	2.789	-0.51	0.610	
Leverage Ratio (Lagged once)	0.083	0.020	4.11	0.000	***
GNPD (Lagged once)	1.377	1.222	1.13	0.261	
Interest Rates (Lagged once)	0.839	5.464	0.15	0.878	
Residential Property Prices (Lagged once)	-1.246	4.809	-0.26	0.796	
Residential Property Prices (Lagged twice)	12.758	5.260	2.42	0.016	**
GDP Growth (Lagged once)	-1.475	2.875	-0.51	0.608	
GDP Growth (Lagged twice)	-4.672	3.033	-1.54	0.124	
Constant	-1.456	0.629	-2.31	0.021	**

Mean dependent variable	-0.337	SD dependent variable	1.372
R-squared	0.097	Number of observations	312.000
F-test	4.118	Prob > F	0.000
Akaike crit. (AIC)	1068.010	Bayesian crit. (BIC)	1101.697

**** p<0.01, ** p<0.05, * p<0.1*

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