THE EFFECTS OF BANK DEPOSIT FUNDING UNDER NEGATIVE INTEREST RATE POLICY ON BANK'S LENDING BEHAVIOUR

Master Thesis Financial Economics
Erasmus University Rotterdam – School of Economics

Author:	Kazimir Barentsen
Student ID:	545267KB
Supervisor:	Renée Spigt
Second Assessor:	[ ]
Date Final Version:	30/4/2021

Abstract

This study examines the effects of banks deposit funding on bank's lending behaviour after the introduction of negative interest rate policy. Using both a difference-in-difference and a triple difference approach, lending behaviour of high-deposit banks is compared with that of low-deposit banks, in terms of total outstanding loan volume, total new extended loans and the risk taking by European banks in the syndicated loan market. Based on bank specific characteristics, this study finds that banks with greater reliance on deposit funding have a relative smaller total lending volume. In addition, higher profitability, lower diversified income, lower credit rating and financially stressed country of origin significantly decreases the new lending volume among banks with a higher deposit ratio. Furthermore, the risk taken by a higher deposit ratio is amplified by banks with a lower diversified income. This study shows the inadequacies of a negative policy rate in terms of lending volume and the effectiveness of the bank lending channel yet challenges the common view that negative interest policy increases financial instability in terms of bank's risk taking.

***Keywords**: NIRP, zero lower bound, monetary transmission mechanism*
***JEL:** E43, E52, G11, G21*

Table of Contents

1. Introduction

In 2012, when the global economy had yet to recover from the 2008 financial crisis, Mario Draghi started an era of unprecedented monetary policy by setting a zero-interest rate on deposits at the European Central Bank's (ECB). Following the reduction of the deposit rate to -0,1% in June 2014 by Denmark's Nationalbank and the ECB's, a growing number of other central banks - including the Bank of Japan, the Hungarian National Bank, the Swedish Riksbank and the Swiss National Bank - also adopted negative interest rates (Feng and Wen, 2017). The efficiency of negative rates is being criticized now that the Bank of England and the FED, which earlier were reluctant to test this boundary, are approaching negative interest rates as an emergency stimulus to fuel the economy during the covid-pandemic (Georgiadis et al., 2020, Wingrove, 2020). Though the adoption of negative rates is more widely accepted, controversy remains on the monetary transmission, as the technical feasibility of the effective lower bound and its liquidity trap are still questioned and criticized for its impact on financial stability (Palley, 2016).

To contribute to the ongoing debate on the effects of negative interest rates and to explain the effects of negative interest rate policies (NIRP), this paper examines the real transmission of NIRP regarding the deposit ratio to the bank lending volume and risk taking of banks in the market for syndicated loans in Europe. In particular, using a difference-in-difference and triple difference methodology, the heterogeneous effects are studied of banks with different amounts of deposit funding and further bank specific characteristics, profitability, diversified income, credit rating and country. This should answer the question, how bank's deposit funding under negative interest rates affects the lending behaviour of banks in terms of total outstanding lending volume, newly issued lending volume and risk taking.

The classical view in Brunnermeier and Koby's baseline model (2018) on the effects of interest rates and the monetary policy transmission had to be reformed when the policy rates became negative. Before 2014, the desired aggregated output effects were reached by interest rate cuts by the ECB, lowering the yield on safe assets. However, when the market interest rates approached zero, the zero lower bound problem occurred thereby causing a liquidity trap limiting central bank's options to stimulate economic growth. Although macroeconomic theory implies expansionary effects when the policy rates set by central banks are reduced, uncertainty persists about the effectiveness on policy rates below the zero lower bound and its imposed threats to the financial stability.

On the one hand, some economists argue that monetary policy becomes ineffective when entering negative territory due to downward stickiness of bank's deposit rates. In short, banks are reluctant to charge negative rates to depositors for fear of losing their deposit funding base to withdrawals and cash holdings as a consequence of negative interest rates (Eggertsson et al., 2017, Ampudia et al., 2018). Therefore, banks hold their deposit rates steady above zero. As a result of the lowered interest margins, banks that heavily rely on deposit funding experience pressure with regard to both their net worth and

their profitability, limiting the bank's lending capacity (Brunnemeier & Koby, 2018) and increased risk taking (Heider et al., 2019). The limited deposit rate pass-through suggests the existence of a lower bound and inefficient monetary transmission, as the deposit rates appear bounded by zero. On the other hand, other economists (Rogoff, 2016, 2017; Altavilla et al., 2019) suggest that -under the right circumstances- a zero lower bound poses no constraint on the effectiveness of monetary policy.

Ultimately, the question how the transmission of NIRP affects bank lending remains unanswered. Therefore, the paper present here contributes to the existing literature by examining the monetary transmission mechanism of NIRP regarding the financial stability measured in lending volume and bank's risk taking. By using a difference-in-difference approach, taking high deposit as treatment group and low deposit banks as control group in the syndicated loan market, this paper captures an in-depth analysis on the lending behaviours of banks under NIRP. Not only does the paper provide meaningful insights in a financially stable policy to identify the effect of deposit exposure during below zero interest rate policy, but it also identifies the determinants that either stimulate or dampen the relation between deposit ratio and bank lending behaviour under negative policy rates. Given that bank performance and bank balance sheet amplify the endogenous responses of monetary policy, this paper assesses the effectiveness of the negative policy on the bank lending channel by focussing on four additional dimensions to the deposit funding. The paper addresses whether higher preforming banks were able to mitigate the effects of deposit exposure and expands the study of Heider et al. (2019) by including multiple bank characteristic interaction terms; that deepens the knowledge on the relation between deposit funding and bank lending by including profitability, net interest income, soundness captured by credit rating and country of origin. By studying banks in the European syndicated market, this study finds evidence that a higher deposit ratio lowers the total outstanding loan volume under negative interest rates. However, Heider et al.'s relation between risk taking and the deposit ratio under negative interest rates, is not found. Furthermore, after the introduction of the negative policy rate, the decrease in new lending due to higher deposit funding is aggravated for banks with higher profitability, lower diversified income, are lower rated or from a country with a struggling economy. The paper shows that, in terms of risk taking, the interaction between deposit ratio and negative rates differs over various levels of diversified income, as a higher net interest income over total assets increases the risk taking.

As countries prepare for the next economic downturn (Fernandes, 2020), it is crucial to understand the transmission of negative interest rates on the lending channel. As interest rates have fallen for three consecutive decades, new worries about secular stagnation arise (Summers, 2013, 2014; Eggertsson et al., 2019). Christine Lagarde, president of the ECB, stated 'While I do not believe that the ECB has hit the effective lower bound on policy rates, it is clear that low rates have implications for the banking sector and financial stability more generally'. However, to ensure the efficiency and financial stability of the bank lending transmission it is crucial to overcome the secular stagnation scenario and overcome the next recession targeting small and medium-sized enterprises (SMEs).

This paper is structured as follows. Chapter 2 summarizes existing literature on the transmission channels, brief institutional background on NIRP and bank lending behaviours. Chapter 3 provides hypotheses development. In Chapter 4, the data, the methodology and framework used in this study are described. In Chapter 5 the underlying assumptions for difference-in-difference studies are explained. Chapter 6 provides an overview of the descriptive statistics. Chapter 7 presents the results, including a multiple robustness check to address the external validity. Chapter 8 is a discussion on the results. Finally, Chapter 9 describes the limitations in this study and makes suggestions for future research.

2. Literature Review

This chapter provides a brief overview of the transmission channels in both conventional and unconventional monetary policy, summarizes existing literature and describes the historical background.

2.1 Transmission Channels

2.1.1 Conventional monetary policy

To understand how policy interest rates impact banks, it is important to first understand the underlying mechanism of conventional monetary policy. Conventional monetary policy is structured around a New Keynesian framework, which represents a set of instruments that are available for central banks to control the supply of money through open market operations. In the framework introduced by John Keynes (1936), conventional monetary policy is defined as the policy used to influence inflation by determining the short-term interest rates (Inoue & Rossi, 2019). The New Keynesian model is essentially based on the effects of interest rates on inflation. The ECB tries to stimulate inflation by stimulating consumption with the time value of money (cost of capital; De Haan et al., 2016). In the framework, there is a trade-off between buying today or saving. By setting lower facility and deposit rates, the ECB eventually influences the deposits offered by banks (Woodford, 2003). Due to the lower interest rates offered by banks on both deposits and new lending, consumers and other parties are discouraged from depositing or saving money and encouraged to lend, which leads to higher consumption and inflation.

2.1.2 Monetary transmission channels

Although conventional views of the transmission mechanism are widely available, there is little empirical evidence to explain the effect of the cost of capital on spending output (Bernanke and Gertler, 1995). This led to alternative explanations that posted imperfect information as the main driver of monetary policy effects. According to the imperfect information theory, the difference between the costs of external funding and internally generated funding (i.e., the external finance premium) is the direct effect of the monetary policy. The size of the external premium is driven by the lender's expected return and the cost associated to borrowing. Therefore, the external finance premium is driven by both the credit demand and the credit supply.

The demand side of credit that amplifies this external finance premium is the balance sheet channel (Bernanke and Gertler, 1995), which is mainly driven by the financial strength of the borrower (Altavilla et al., 2019). Bernanke and Gertler (1989) found that tightening monetary policy decreased borrower's cashflow and profits; this finding is in line with the effects of higher interest rates on floating bonds and corporate loans (Ippolito, Ozdagli and Perez-Orive, 2018). These changes in the borrower's liquidity and profitability influence the demand for credit, which ultimately impacts the profitability of banks.

Altavilla et al. (2019) have suggested that the characteristics of a bank's balance sheet impact the external finance premium through the bank lending channel. Bernanke and Gertler (1989) showed that the availability of funds determined the availability of lending for a bank, given that these funds generally exist of deposits. Therefore, the reaction of banks regarding non-equity liabilities and maturity transformations is essential for the bank lending channel (Van den Heuvel, 2006). As with most banks, the bank loans have a longer maturity than bank liabilities. So, an increase in the short-term interest rates negatively affects banks' profitability, whilst long-term loan remains at a fixed rate or are set at lower interest rates. In short, the maturity transformations are based on the difference between the lending rates and the deposit rates (Eggertsson et al., 2017). Both rates are dependent on the deposit facility rate (DFR) set by the ECB. Therefore, the ECB can impact bank lending and demand for deposits. However, Van den Heuvel (2006) has suggested this transmission of the bank lending channel is subject to capital adequacy showing that low capital banks have a delayed reaction to interest rate changes compared to well-capitalized banks. In addition, Drechsle et al. (2017) found that changes in policy rates and the corresponding increase in banks' deposits rates are also subject to a bank's market power.

2.1.3 Unconventional monetary policy

Unconventional monetary policy occurs when instruments other than policy interest rates are used, including forward guidance, assets purchases, market operations adjustment, lowered term funding facilities, open market adjustment and negative interest rates. Due to the introduction of negative interest rates, unconventional monetary policy has been more widely adopted, eliciting new discussions on the effectiveness of unconventional monetary policy. The effective lower bound is key to the discussions on the unconventional move to NIRP. In essence, the effective lower bound is the rate at which depositors would rather hold cash because of the possibility of storing capital without losing its value, the liquidity trap. Therefore, the lower bound makes interest policy rates obsolete (Eggertsson and Woodford, 2003). It was believed (Hicks, 1937) that the rate at which depositors would hoard cash was zero.

Brunnermeier and Koby (2018) took the discussion on the effectiveness of NIRP further by introducing the interest reversal rate. These authors suggest that further cuts in interest rates, particularly in negative territory, affect a bank's profitability negatively. This decline of banks' profitability decreases equity capital and leads to lower lending when capital constraints are present. As a result, the opposed expansionary effects fail due to pressure on net income, as the yield from each individual liability decreases with NIRP. However, regional factors and bank characteristics should also be taken into account when establishing the actual reversal interest rate (Cavallino and Sandri, 2017, Brunnermeier and Koby, 2018). Heider et al. (2019) support this view, based on the stickiness of deposit rates. In their view, banks are reluctant to charge negative rates to their depositors in fear of the effective lower bound. Therefore, banks keep their deposit ratio above zero resulting in lowered interest margins. In particular

banks that are relatively more funded by deposits experience a decrease in net worth, which leads to lower credit growth and excessive risk taking under unconventional negative interest rates. In a study on a banks' ability to pass negative rates to their depositors, Eggertsson et al. (2017) found that banks show limited pass-through rates. However, Altavilla et al. (2019) describe that pass-through rates are heavily dependent on a bank's overall soundness. In conclusion, the controversy remains whether the unconventional negative rates stabilize the economy in terms of bank lending, or not.

2.2 Institutional Background

The ECB was the first major central bank to enter negative interest rates, in June 2014. Five years later, the ECB, cautiously, lowered the deposit facility rate (DFR) to -0.5%. Though the negative interest rates have become more popular, it still is disputed politically by economists.

DFR is defined as the interest rate at which banks receive capital for depositing money overnight at the ECB. Other rates set by the ECB include marginal lending facility and main refinancing operations. However, the DFR is the key policy rate, as the rate is linked to the overnight interbank interest rates (Eonia) because the excess liquidity can either be stored at the ECB or lent to a different bank. The costs associated with excess liquidity grew even more due to the ECB's expanded asset purchasing programme.

Years after the financial crisis of 2008, the conditional monetary policy remained fragile, and central banks had to find ways to foster economic stability. Therefore, they started to buy government bonds and securities. However, economic prospects remained weak, resulting in low investment and high risk of inflation. When these risks became unacceptable large, Draghi introduced a negative interest rate policy.

2.3 Related Literature on Negative Interest Rates

Research on the impact of negative interest rates on lending behaviour is limited; even fewer papers describe the lending behaviour of banks in relation to their economic performance. Thus, it is imperative to gain more clarity about the effect of negative interest rates on different banks.

Based on Brunnermeier and Koby's (2018) baseline model, the banking sector has three investment possibilities, risky loans, safe bonds and reserves. To finance investments the bank must either raise deposits or equity. In the case of the ECB lowering interest rates, the yield on safe assets and reserves decreases. As a result, the marginal benefit from raising deposits also falters, forcing banks to lower their deposit rates and channel their excess reserves into more lending by decrease the lending rate (Jobst & Lin, 2016). This makes it less attractive to save and increases the supply of bank credit as it reduces the external finance premium (Heider et al., 2019), resulting in the deposition effect desired by the ECB. However, the literature on bank lending channels and the effective lower bound under negative interest rates presents conflicting results. Brunnermeier and Koby (2018) argue the existence of a

'reversal interest rate', or the rate at which the monetary policy transmission 'reverses' the intended effect on bank lending volume. However, these authors do not describe explicitly that this reversal takes place under negative interest rates. Moreover, they suggest that, beyond the three main channels that drive the reversal rate (i.e., assets holdings with fixed interest payments, degree of pass-through to loan and deposit rates and capital constraints), heterogenous effects across regions and the market power of banks should also be examined.

Repullo (2020) criticizes the view of the effective lower bound being zero and the existence of the reversal rate by Brunnermeier and Koby (2018). He rationalizes that the reversal rate is not determined by capital constraints and therefore is unrelated to unconventional negative interest rates. According to Repullo, the lending is not determined by the future value of bank's capital but by its current value. Therefore, the capital constraint only determines the upper bound on lending, which is further defined by banks specific characteristics and their relative advantage in raising deposits and granting loans. Furthermore, Repullo (2020) argues that, if there is a profitability constraint due to the shareholders' demand on their investments, the banks' future capital value will be determined by profits from lending and deposit-taking. In which case, profits from lending will always be positive, whilst profits from deposit-taking may be negative due to the zero-lower bound; lower policy rates will always increase profits from lending, as banks would decrease the weighted average cost of deposits and capital. This enables increased lending and profit maximization. Arguing that the profitability constraint is only binding if and only if a critical policy rate is reached; this rate has been identified by Ulate-Campos (2019) as the rate at which the entire banking systems shuts down due to an end on deposit-taking. Therefore, Repullo argued that profitability cannot be negatively affected, nor have a negative impact on a bank's lending volume, thereby supporting the unconventional negative interest rate policy. Jackson (2015) provides an overview of international experiences from NIRP, while showing the limited pass-through of deposit rates at the retail and household lending level. However, partial pass-through to non-individual depositors was visible in most cases. Jackson (2015) stated that, under the right conditions, there are theoretically no limitations as to how negative these policy rates could be. Bech and Malkhozov (2016) observed the negative rates in the money market. These authors suggest that the transmission in the money market does not change due to negative rates and argue that zero is not the effective lower bound for central bank policies. Eggertsson, Juelsrud, and Wold (2017) used Swedish data to construct a macroeconomic model that takes negative policy rates into account as well as the deposit and lending rates. They observed a decrease in banks' profits due to bounded positive deposit rates, which resulted in a contractionary lending output.

As the interest rate becomes negative, the downward stickiness of deposit rates gives rise to a trade-off between effective monetary transmission and the bank's profitability (Jobst & Lin, 2016, Basten & Mariathasan, 2018). Heider et al. (2019) explain how limited pass-through rates on deposit funding relative to market-based debt funding led to a smaller decrease in the cost of funding and an upward

pressure on banks' net worth and profitability. These authors show the heterogeneous effects of deposits funding under negative interest rates. By examining the syndicated loan market, they argue that banks that rely more heavily on deposit funding, take more risk whilst lending less because of an increased pressure on net worth. Eggertsson et al. (2017) identify the limited effect of negative policy rates on lending rates; as banks struggle to cope with an unfamiliar environment, heterogeneous responses result in greater dispersion in pass-through. In particular, banks with high deposit funding exhibit smaller lending rate changes and lower credit growth. Eggertsson et al. show heterogenous effects on the barrowing rates of bank according to their reliance on deposit funding. They observe relatively lower growth in the total lending volume, in line with Heider et al. (2019).

Brunnermeier and Koby (2018) found heterogenous effects on the lending volume across weaker and stronger banks, showing that weaker banks have greater difficulty coping with NIRP. Altavilla et al. (2019) studied the negative rate policy on profitability and deposits rates. They argue that banks with negative deposit rates have no decline in deposits and that the lending transmission of monetary policy is still effective with negative interest rates; thus, the ECB had not yet met a reversal rate or an effective lower bound. However, these authors indicate that the soundness and health of the bank plays a vital role in the transmission mechanism, as sound banks were able to transmit negative rates onto their deposit rates and extend their loan volume. Therefore, Altavilla et al. posited that the transmission mechanism under NIRP was not different from that a situation with positive interest rates; however, both Brunnermeier and Koby (2018) and Alavilla et al. (2019) demonstrated that the link between bank performance and coping with monetary contractions is crucial for the effectiveness and stability off the unconditional monetary policy, especially during negative interest rates

One way of coping with the pressure on profitability is to take excessive risk (Schelling & Towbin, 2018). The 'expanding theory' in the baseline model of Brunnermeier and Koby (2018) argues that banks with sticky deposit rates will loosen their lending terms in search of higher yield, as safe securities yield less. Expansionary effects in heavily deposit-funded banks occur through a reallocation to riskier assets to compensate for higher funding costs (see also Heider et al., 2019). Heider et al. suggest that banks with less at stake, banks with high deposit funding or with little equity feel less incentive to audit risky borrowers because of a rise in external finance premium. The search for yields may result a disproportional demand for riskier and higher yield-assets (Rajan, 2013), which leads to financial instability due to the asset price inflation (Reinhart & Rogoff, 2009). In line with Brunnermeier and Koby (2018), Jiménez et al. (2013) indicate that less-capitalized banks are reluctant to cut existing loans lend to higher risk firms. Ioannidou, Ongena and Peydró (2009), Rajan (2006), Borio and Zhu (2008) and Boivin, Lane and Meh, 2010, found similar results studying the impact of low interest rates on the risk appetites of banks that are in search of yields.

Malovaná et al. (2020) emphasize the unintended consequences of a prolonged period of negative interest rates, resulting in a point of no return due to higher indebtedness overvalued assets prices,

under-priced risks and credit misallocation. Bikker and Vervliet (2018) and Urbschat (2018) find that long periods of low or negative interest rates erode profits for most banks and reduce their financial stability. This provides further knowledge on the banks' lending channel and the impact of balance sheet (Kashyap et al., 2000), and on how tighter monetary conditions can decrease the lending volume and increase risk taking (Jiménez et al., 2012, 2013).

3. Hypotheses development

According Heider et al. (2019), limited pass-through rates on deposit funding led to a decrease in bank's profitability due to the smaller changes in cost of funding relative to market-based funding. Therefore, these authors predict -as a result of squeezed margins- an adverse effect of negative interest rate policy on credit supply and risk-taking in search of higher yields. In a difference-in-difference analysis on deposit funding and the introduction of NIRP as an intervention with a high (treatment group) versus low reliance on deposit funding (control group), Heider et al. (2019) support their predictions on deposit funding. Similarly, Eggertson et al. (2019) show that the pass-through of policy rates to deposit rates collapse once the policy rates become negative. They also find an increase in dispersion between policy rates and lending rates. and that high-deposit banks are reluctant to reduce their lending rates, which are accompanied by a lower credit growth. This suggests that the interest reversal rate (Brunnermeier and Koby, 2018) is amplified by deposit exposure. The inconsistent results of Jobt & Lin (2016), Basten & Mariathasan (2018) and Ampudia, (2018) suggest the stickiness of deposit rates and its effects on the lending transmission. As the impact is examined of deposit ratios on loan volumes under NIRP, the following hypothesis formulated:

Hypothesis 1: *Once the policy rates turn negative, banks with higher deposit funding experience relatively low lending volume in the European syndicated loan market.*

Heider et al. (2019) suggest that the effects of NIRP on deposit funding and sickness is accompanied by a pressure to obtain yield. This search for yield leads to lending out to riskier companies. In contrast Bottero et al. (2019) find that negative interest rates lead to portfolio rebalancing; however, risk levels did not increase as a result. Schelling & Towbin (2018), Nucera et al. (2017) contradict that higher funding costs and pressure on profitability are offset by risky loans on more generous lending conditions. Hence, high deposit funded banks are expected to look for higher yields and therefore riskier loans due to squeezed margins; this leads to the following hypothesis:

Hypothesis 2: *Under NIRP, banks with higher deposit funding experience more risk taking in the European syndicated loan market.*

A pressure on probability is associated with how the deposit funding transmits the monetary policy (Eggertson et al., 2017). Heider et al. (2019) claim that profitability matters when lending, but they do not provide any proof for this claim. As the pressure on profitability mounts due to negative rates, it is arguable that banks which are struggling before the implementation of negative interest rates, react differently from high profitable banks. To counter the unconventional monetary policy, banks are induced to maintain shareholder's value and profit maximization (Jensen and Meckling, 1976), by extending less restrictive loans. Traditional corporate finance models predict that risk-taking incentives will be higher in less profitable firms as they lose less shareholders value if downside risk is realized (Keeley, 1990). However, Martynova et al. (2015) found evidence inconsistent with Keeley's view. In

their theoretical framework, more profitable banks allow for more lending and for taking more risk taking. Xu et al. (2019) find that profitability is the largest contributor for banks to both idiosyncratic risk and systematic risk. Although deposit funding appears to be a plausible reason for the limited growth (Heider et al., 2019), economists argue whether pressure on profitability has a diminishing impact on lending and risk. Bunnermeier & Koby (2018) suggest that capital constraints cannot fully explain the relative difference. According to their theoretical framework, the heterogeneity of competitive advantages amplifies the exposure to policy interest rates. Altavilla et al. (2018) state that sound balance sheets and circumstances that affect profitability (other than deposit ratio) are important indicators of pass-through rates onto deposit rates. As pressure on profitability is expected to increase the negative effects associated with deposit funding (IMF Global Financial Stability Report, 2020) the following hypothesis is formulated:

Hypothesis 3: *Lower profitable banks will have a stronger treatment effect of deposit ratio under negative interest rates, thereby suggesting relative i) lower lending volume and ii) higher risk taking in the European syndicated loan market.*

It is arguable whether profitability is a determinant under NIRP. Repullo et al. (2020) criticise the theory of a reversal rate and implied capital constraints and highlighted the importance of decreasing the weighted average of deposits and capital. They state that the effects of negative interest on profitability do not lead to a contraction in lending activity. Klein et al. (2020) find that unchanged deposit rates have a negative impact on net interest margins (NIM); however, the effects of NIM on bank lending vanish under negative policy rates. This suggests that banks that are capable of adjusting their business model are unaffected in the growth of their lending. Bottero et al. (2019) suggest a distinctive approach; rather than performing a difference-in-difference analysis solely on deposit ratio, they broadened their perspective on portfolio rebalancing. This portfolio rebalancing is measured by liquidity in terms of net interbank position and liquid balance sheet position. Bottero et al. (2019) find that more liquid firms rebalanced their portfolio to include more corporate loans, more lending and higher total volume. However, this was not accompanied by more risk taking with non-performing loans. The supply of credit, by difference in deposit funding reliance, did not change. Bottero et al. (2019) and Klein et al. (2020) find that higher deposit funded banks increase their other banking services, identified as non-interest income, to mitigate the loss of income due to the effects of smaller margins; this is important for stable transmission of bank lending. Both studies found that banks were able to adjust their business practises in terms of interest income under NIRP that allowed for further lending growth, despite weak NIMs. Therefore, it can be expected that banks with already strong fundamentals other than income generated from interest, will perform better under NIRP than other banks, leading to the following hypothesis:

Hypothesis 4: *Lower diversified income banks will have a stronger treatment effect of deposit ratio under negative interest rates, thereby suggesting relative i) lower lending volume and ii) higher risk taking in the European syndicated loan market.*

Altavilla et al. (2019) find that sound banks are less restricted in charging negative interest rates, and thus less affected in their lending. The classification as a non-investment grade bank attributed to this soundness. These researchers also find that the pass-through rates for investment grade banks and non-investment grade banks are indistinguishable before the NIRP change. However, after the introduction, these pass-through rates were significantly different, as the rates hardly changed for the investment grade banks and were lower for non-investment grade. In line with Brunnermeier and Koby (2018), it is expected that competitive advantages and soundness captured by the rating impact the lending behaviour differently under NIRP, resulting in the following hypothesis:

Hypothesis 5: *Lower graded banks will have a stronger treatment effect of deposit ratio under negative interest rates, thereby suggesting relative i) lower lending volume and ii) higher risk taking in the European syndicated loan market.*

In 2009, in the wake of the Great Recession, the anxiety of the indebtedness of stressed countries (Cyprus, Greece, Ireland, Italy, Portugal, Slovenia, and Spain) increased. This troubled these countries in refinancing their outstanding debt. As banks in the EU had large domestic sovereign exposures (Acharya and Steffen, 2015), this decay of sovereign creditworthiness had a negative impact on the financial sector and negative shock on banks' balance sheets. This resulted in banks in stressed counties to contract lending. This effect was the opposite in countries which were believed to be financially stable, they received cash inflows for their government bonds. These opposing consequences resulted in a large heterogeneity among bank's economic soundness at the beginning of the NIRP. According to Altavilla et al. (2019) this heterogeneity had a strong impact on the pass-through rates of negative policy. Banks operating from stressed countries (Cyprus, Greece, Ireland, Italy, Portugal, Slovenia, and Spain) were far more reluctant to apply the lower rates, leading to declining credit growth. Therefore, the last hypothesis is formulated:

Hypothesis 6: *Banks of stressed countries will give a stronger effect of deposit exposure resulting in relative i) lower lending volume and ii) higher risk taking in the European syndicated loan market.*

4. Data and Methodology

This section lays out the methods used for testing each hypothesis.

4.1 Data

The dataset comprises of multiple databases. To establish the syndicated loan sample containing loan-level and package-level information, data from DealScan (Thomson Reuters) is obtained. By downloading the entire dataset, a list of the top leading arranging banks in the EU can be retrieved, by only including European banks that have extended more than 50 loans over the course of January 2011 to December 2016.

In a second database, the syndicated loan level data is matched with the bank level characteristics from data in Orbis Bank Focus. From this database, the annual data is retrieved regarding the deposit ratio, total assets, equity ratio, securities ratio, interest income, return on average equity and country. The data available containing smaller European banks comprises 51 European banks. Beside the bank information from Orbis Bank Focus, the long-term issuer credit ratings are retrieved from Fitch.

To obtain the firm specific data, the Compustat Global database is retrieved. With this dataset the syndicated loan level data is matched with the risk of borrowers. From the Roberts Dealscan-Compustat Linking database, provided by Roberts et al. (2008), data on ROA is retrieved. The Compustat database covers public companies only, the whole dataset comprises 52,385 individual loans of 24,223 syndicates, where of 5,393 syndicates contain the ROA information.

4.2 Hypothesis 1: Volume

A difference-in-difference model is used to analyse bank lending behaviour under NIRP in European syndicated loan market. This model allows for panel data setting to cross check a cluster of two groups, exposing the impact of deposit funding on the total loan volume of banks under negative interest rates. The following baseline specification was used:

$$y_{it} = \beta_1 Deposit\ ratio_i \times After\ (06/2014)_t + \gamma X_{it} + \delta_t + \eta_i + \epsilon_{it} \quad (1)$$

Where γ_{it} is the outcome variable that reflects the bank's lending volume measured as the log of total outstanding syndicated loans or the logged total newly issued syndicated loans by euro-zone lead arranging bank *i* in quarter-year *t*. *After (06/2014)*$_t$ is the dummy variable for the time period from June 2014 onward. X_{it} is a vector that represents bank-level control variables, including size, security ratio, equity ratio and country's loan demand; δ_t captures time fixed effects (quarter-year), η_i is bank-fixed effects; ϵ_{it} is the measurement error.

If banks do respond differently according to the deposit ratio, β_1 is expected to be significant. It is assumed that relative differences in lending volume are attributed to the height of deposit funding.

4.3 Hypothesis 2: Risk

The specification towards the bank's risk taking is measured as the risk profile of the financed firm.

Here the same identification can be used as model (1):

$$y_{it} = \beta Deposit\ ratio_i \times After\ (06/2014)_t + \gamma X_{it} + \delta_t + \eta_i + \epsilon_{it} \quad (2)$$

Where γ_{it} is the outcome variable reflecting bank i's risk level measured by the average logged five-year standard deviation of the borrowing company, at quarter-time *t*.

4.4 Robustness

One concern is that the identification seeks an effect of deposit ratio on bank behaviour under NIRP because of the underlying assumption of the impact of the zero-lower bound, as this could overlook a hitherto unknown effect of deposit ratio on related bank characteristics. To address the problem whether negative policy rates are special, the rate cut of 2012 July 11 from 0.25% to 0 is included, estimating the following regression:

$$\begin{aligned} y_{it} = \ & \beta_1 Deposit\ ratio_i \times After\ (06\ /\ 2014)_t \\ & + \beta_2 Deposit\ ratio_i \times After\ (07/\ 2012)_t + \gamma X_{it} + \delta_t + \eta_i + \epsilon_{it} \end{aligned} \quad (3)$$

Wherein After (07/2012) is the dummy variable for the time period from July 2012 onwards.

4.5 Hypothesis 3: Profitability

To extend the model of Heider et al. (2018), effects of other bank characteristics are examined. The model focusses on deposit ratio as the main determinant for the difference in lending behaviour, but identifying the determinants affecting this relation is equally important for a stable monetary policy.

Therefore, the standard difference-in-difference model by Heider et al. (2018) is extended into a triple difference-in-difference so the model can identify heterogeneous treatment effects. This specification compares the change in lending behaviour between high deposit and low deposit banks which were either highly profitable or lowly profitable, and the following regression is estimated:

$$\begin{aligned} y_{it} = \ & \beta_1 Deposit\ ratio_i \times Profitability_i \times After\ (06/\ 2014)_t + \\ & \beta_2 Deposit\ ratio_i \times After\ (06\ /\ 2014)_t + \ \beta_3 Profitability_i \times \\ & After\ (06\ /\ 2014)_t + \gamma X_{it} + \delta_t + \eta_i + \epsilon_{it} \end{aligned} \quad (4)$$

Where $Profitability_i$ is the return on average equity in 2013 of euro-area lead arranging bank *i*.

4.6 Hypothesis 4: Non-Diversified Income

Another important bank characteristic for stable transmission towards lending is the identified non-interest income (Klein et al., 2020) and Bottero et al., 2019). To test hypothesis 4, the same triple difference identification is used as in formula (4). Here, the third interaction variable is the net interest income over total assets. This specification compares the change in lending behaviour between high deposit and low deposit banks having either diversified income or non-diversified interest income. Therefore, the following regression is estimated:

$$y_{it} = \beta_1 Deposit\ ratio_i \times Non\ Diversified_i \times After\ (06/2014)_t + \beta_2 Deposit\ ratio_i \times After\ (06/2014)_t + \beta_3 Interest\ Income_i \times After\ (06/2014)_t + \gamma X_{it} + \delta_t + \eta_i + \epsilon_{it} \quad (5)$$

Where *Non-Diversified*$_i$ is a dummy variable indicating whether bank *i*'s net interest income over total assets in 2013, belongs either to the top half or the lower half of the banks included in the sample of euro-area lead arranging banks.

4.7 Hypothesis 5: Rating

Next, instead of looking at a banks' balance sheet specifications, the effects of region and overall soundness are estimated on the lending behaviour. To test hypothesis 5, a similar triple difference estimation is used. This allows for the comparing of the change in lending behaviour between deposit exposure in high and low credit rated banks. Therefore, the following regression estimated:

$$y_{it} = \beta_1 Deposit\ ratio_i \times Rating_i \times After\ (06/2014)_t + \beta_2 Deposit\ ratio_i \times After\ (06/2014)_t + \beta_3 Rating_i \times After\ (06/2014)_t + \gamma X_{it} + \delta_t + \eta_i + \epsilon_{it} \quad (6)$$

Where *Rating*$_i$ is a dummy variable indicating whether bank *i*'s rating is above A according to Fitch[1] in June 2014.

4.8 Hypothesis 6: Country

To identify the country's role, again, the triple difference estimation is used to compare the change in lending behaviour in deposit exposure between banks in stressed or non-stressed countries in respect to hypothesis 6. Therefore, the following regression is estimated:

$$y_{it} = \beta_1 Deposit\ ratio_i \times Stressed\ Country_i \times After\ (06/2014)_t + \beta_2 Deposit\ ratio_i \times After\ (06/2014)_t + \beta_3 Stressed\ Country_i \times After\ (06/2014)_t + \gamma X_{it} + \delta_t + \eta_i + \epsilon_{it} \quad (7)$$

Where *Stressed Country*$_i$ is a dummy variable that takes the value equal to one for banks that are headquartered in stressed countries (Cyprus, Greece, Ireland, Italy, Portugal, Slovenia, and Spain).

4.9 Further Robustness checks

4.9.1 Deposit facility rate

To extend the robustness whether negative rates are indeed special, the following regression is estimated which allows the examine the changes up and down individually:

$$y_{it} = \beta_1 Deposit\ ratio_i \times DF\ rate_t \times After\ (06/2014)_t + \beta_2 Deposit\ ratio_i \times DF\ rate_t + \beta_3 Deposit\ ratio_i \times After\ (06/2014)_t + \beta_4 Deposit\ ratio_i + \delta_t + \eta_i + \epsilon_{it} \quad (8)$$

[1] Fitch Ratings is one of the leading provides of credit ratings in the global capital markets, which are determined by forward-looking credit opinions.

Where *DF Rate*$_t$ is the deposit facility rate of the ECB. β1estimates the triple interaction between bank's deposit ratio, the deposit facility rate of the ECB rate and NIRP dummy.

This examines if the transmission of negative policy rates via deposits is different from the transmission of positive policy rates, captured by β2. If β2 is insignificant, it shows that deposit ratio under normal pre-NIRP conditions does not influence the lending behaviour.

4.9.2 Firm-time fixed effects

For further robustness and potential bias identification, firm-time fixed effects are included to control for the different investment opportunities between high-deposit and low-deposits. The included firm-time fixed effects eliminate the time-varying variances in lending options between treatment group (high-deposit banks) and control group (low-deposit banks) and including the placebo effect of After (07/2012). For this robustness check the following identification is estimated:

$$y_{ijt} = \beta_1 Deposit\ ratio_i \times After\ (06/2014)_t + \beta_2 Deposit\ ratio_i \times After\ (07/2012)_t + \delta_{jt} + \eta_{it} + \epsilon_{ijt} \quad (9)$$

Here j captures the firm; δ_{jt} captures firm-time fixed effects and η_{ij} is bank-firm and bank fixed effects.

5. Robustness Checks for Difference-in-Differences

To evaluate the impact of negative interest rates policies, the difference-in-difference method is well suited. As this method allows for non-experimental settings and because of its intuitive appeal, the difference-in-difference is one of the most frequently used method in policy economics. To ensure internal validity of the difference-in-difference evaluation method, specificized in this study, the core underlying assumptions have to identified.

5.1 The consistency assumption

First, the consistency assumption is that both groups can have two potential outcomes, written as:

$$Y(t) = (1 - T) \times Y^0(t) + T \times Y^1(t)$$

In short, if treated (T = 1) the observed outcome is the potential outcome $Y(t) = Y^1(t)$ and potential outcome of no treatment $Y(t) = Y^0(t)$ unobserved. On the other hand, when not treated (T = 0), then $Y(t) = Y^0(t)$ is observed and $Y(t) = Y^1(t)$. This assumption poses no threat as the distribution of back characteristics and ratings imply clear counterfactuals.

5.2 The parallel trend assumption

More critical, is the parallel trend assumptions. Mora and Reggio et al. (2012) consider that, only if parallel paths are identified, the difference in difference can be assumed internal valid. The assumption requires that in de absence of treatment, the difference between both groups is constant over time. Thus, observing time taking before treatment as t' and t^* after treatment written as:

$$E\left[Y^0(t^*) - Y^0(t') | \, T = 1\right] = E\left[Y^0(t^*) - Y^0(t') | \, T = 0\right]$$

To test for this, a visualization is provided. The supplementary graphs in Figure B.2 shows that all outcomes of total volume, new loan volume and the risk-taking approach a common trend in both treatment (high-deposit banks) and control group (low deposit banks).

In the triple difference models, the same parallel trend assumption has to satisfied (Olden and Moen, 2020). However, it requires the relative outcome of high deposit and low deposit in the treatment state to trend in the same way as the relative outcome of high deposit and low deposit in the control state. Thus, to control for this, an outcome visualization is made for profitability, interest income over assets, investment grade and stressed countries. Figures B.3-B-6 show that dichotomy of all 4 dimensions approach a common trend.

5.3 Time varying differences

One threat to the validity of the parallel trend assumption and the model is that the reference group and treatment group show similarities in their time varying differences. i.e. it cannot be excluded that some bank characteristics are not stable in the treatment period, because banks could either switch in their deposit funding, profitability or share of income generated by interest. To account for this, a graphical representation is made to check for the development in respect to deposit ratio and return on average equity (Figure B.7). This figure can show that neither deposit ratio, profitability and interest income share have exceptionally changed. To ensure minimal effects of changing deposit ratio, banks are classified in terciles according to their deposit ratio (Heider et al., 2019).

5.4 No pre-treatment assumptions

Another threat to the model is the assumption of no pre-treatment effect. This assumption states that there is no treatment effect in the treatment group before the treatment is administered, written as:

$$E\left[Y^0(t^*)|\,T=1\right] - E[Y^0(t')|\,T=1] = 0$$

That is, the treatment intervention cannot be anticipated by the treatment group. However, in the identification it cannot be excluded that high deposit banks act differently pre intervention knowing the negative interest rates are implemented.

6. Descriptive Statistics

In this chapter the data is presented, and an overview is provided of the descriptive statistics.

6.1 Summary Statistics

Table 1 (A) provides the summary statistics for the quarterly outstanding syndicated loan sample from January 2011 to December 2016. The European syndicated loans in the sample have an average deposit ratio of 56%. The average size of the packages is 0.6 bn EUR. In terms of risk (measured by return on assets), the packages have an average return on assets (ROA_{t-1}) of 3% in line with the average $\sigma(ROA)^{5y}$, the five-year standard deviation of the firms ROA, of 4%.

Table 1 (B) shows the bank-level summary statistics for all Euro area banks (Appendix, Table A.1). Table 1 (B) shows the that, on average, the loans on the European bank's balance sheet make up for 56.2% of the total assets. Furthermore, on average, 20.5% of the assets are due to securities. However, on average only 3.3% of the total assets is held as cash & balances at the Central Bank. On the liabilities side of the banks' balance sheet, total deposits take up to 60.2% of total funding, of 41.4% by customer deposits and 16.9% by other bank deposits. Other dimensions are the equity ratio, the return on average assets, return on average equity, being rated A and above and whether the banks operate in stressed countries.

Table 1. **Summary Statistics**

A: Loans Sample (Package level)

Variable	N	Mean	Std. Dev.	Min	Max
Loan size (10^9 €)	24,223	0.654	1.320	0	40.300
ROA_{t-1}	5,393	0.031	0.060	-0.644	1.048
$\sigma(ROA_t)^{5y}$	5,393	0.041	0.042	0.000	0.683
Deposit ratio	24,223	0.559	0.156	0.013	0.854
Bank deposit ratio	24,223	0.110	0.058	0.008	0.411
Equity ratio	24,223	0.055	0.012	0.018	0.128
Reserve ratio	24,223	0.005	0.004	0.000	0.066
Securities ratio	24,223	0.226	0.052	0.021	0.410
NPL ratio	24,223	0.033	0.022	0.001	0.382
Tier 1 Capital	24,223	0.047	0.010	0.021	0.111

B: Bank Sample

Variable	N	Mean	Std. Dev.	Min	Max
Bank Characterizations					
Total assets (10^8 €)	51	3.386	3.928	2.310	16.880
Cash balances at CB (mil. €)	51	11.426	18.670	1.081	77.103
Stressed	51	0.314	.469	0	1
A-rated	51	0.588	.497	0	1
Bank Ratio's					
Deposit ratio	51	0.609	0.186	0.013	0.917
Bank deposit ratio	51	0.167	0.101	0.008	0.411
Equity ratio	51	0.062	0.029	0.018	0.212
Reserve ratio	50	0.006	0.010	0	0.066
Securities ratio	51	0.206	0.101	0.001	0.41
NPL ratio	50	0.06	0.076	0.001	0.382
Return on average assets (%)	51	0.33	0.937	-1.55	4.429
Return on average equity (%)	51	5.745	17.202	-29.743	82.251

In the top panel (A), the summary statistics of all syndicated loans are presented, comprising 5,415 packages. ROA_{t-1} is firms *j*'s return on assets in year t-1 from the extension of the loan, using the P&L before tax from Compustat Global. The bottom panel (B) resents the descriptive statistics of the bank-level sample. All variables are calculated using the annual balance-sheet and P&L. The variable Stressed indicates whether the bank is located in a financially unstable country. A-rated indicates whether the bank is in the top segment of banks with a rating greater than A

Table 2 and 3 compare the differences in bank regarding the characteristics high-deposits and low-deposits, high-profitable and low-profitable, high-interest revenue share and low-interest revenue share, A rated, and non-A rated and stressed and stable. Not surprisingly, on average the deposit ratio 74% of high deposit banks is significantly higher than that of low deposit banks, 45%. Moreover, high deposit banks have a higher equity ratio, smaller size and higher net interest margins. Comparing net interest incomes over assets, the banks show strong differences in deposit ratio, equity ratio and return on average equity. Table 3 shows a large difference in deposit ratio between banks from stressed countries and from stable countries. This also holds for the difference between high and low rated banks. To further address the time variations in respect to deposit ratio and return on average equity, graphs are presented that examine the development over time are computed (Figure B.7).

Finally, an overview is given of the top ten lead arrangers and their market share. The top ten banks differ in their rating and in their deposit ratio; seven out of the ten banks originate from economically stable countries.

Table 2. **Characteristics of High- vs Low-deposit Bank, High- vs Low-profit Bank and High vs Low-net interest Banks**

	Segment	N	Mean	Std dev	t-stat
Panel A - Deposit ratio					
Deposit ratio	Top	17	0.784	0.060	9.630
	Bottom	17	0.403	0.151	
Equity ratio	Top	17	0.069	0.018	0.414
	Bottom	17	0.064	0.044	
Total assets (10^8 €)	Top	17	0.998	5.250	3.355
	Bottom	17	5.310	5.250	
Return on average equity	Top	17	3.662	7.505	1.596
	Bottom	17	13.504	24.280	
Panel B - Profitability					
Deposit ratio	Top	27	0.626	0.216	0.674
	Bottom	24	0.590	0.146	
Equity ratio	Top	27	0.067	0.035	1.336
	Bottom	24	0.056	0.020	
Total assets (10^8 €)	Top	27	3.230	3.970	0.304
	Bottom	24	3.560	3.950	
Return on average equity	Top	27	13.977	18.064	4.180
	Bottom	24	-3.518	10.262	
Panel C – Net interest income					
Deposit ratio	Top	27	0.687	0.200	3.536
	Bottom	24	0.521	0.131	
Equity ratio	Top	27	0.066	0.018	1.201
	Bottom	24	0.056	0.038	
Total assets (10^8 €)	Top	27	3.630	3.890	0.473
	Bottom	24	3.110	4.02	
Return on average equity	Top	27	8.894	20.997	1.400
	Bottom	24	2.201	10.962	

High and low deposit banks are compared in panel A. High deposit (low deposit) banks are defined as bank in the top (bottom) tercile; banks are arranged from top to bottom by a decreasing ratio deposits divided by total asset. A t-test indicate whether the difference in means differs from zero. In panel B high and low profitability banks are compared. High profitability (low profitable) banks are defined as banks that are at the top (bottom) in terms of return on average equity. Panel C compares the characteristics of high vs low net interest banks. High net interest (low net interest) banks are defined as banks that are at the top (bottom) in terms of net interest divided by total assets. The sample period for the statistics is the year 2013.

Table 3. **Characteristics of Healthy vs Stressed origin Banks, High- vs Low rated Banks and Loan Market Shares of Top Lead Arrangers**

Panel D – Country's financial health					
	Segment	N	Mean	Std dev	T-stat
Deposit ratio	Top	35	0.570	0.194	2.324
	Bottom	16	0.695	0.133	
Equity ratio	Top	35	0.058	0.032	1.302
	Bottom	16	0.069	0.021	
Total assets (10^8 €)	Top	35	3.640	4.230	0.672
	Bottom	16	2.840	3.240	
Return on average equity	Top	35	4.493	7.818	0.766
	Bottom	16	8.482	28.917	
Panel E – Rating					
Deposit ratio	Top	30	0.558	0.202	2.462
	Bottom	21	0.682	0.132	
Equity ratio	Top	30	0.053	0.019	2.629
	Bottom	21	0.074	0.037	
Total assets (10^8 €)	Top	30	4.480	2.800	2.497
	Bottom	21	1.820	0.819	
Return on average equity	Top	30	4.905	7.254	0.413
	Bottom	21	6.944	25.708	

Panel F - Loan market shares − Top 10 banks	Deposit Ratio	Stressed	Rated	Market share
1. BNP Paribas Fortis	0.612	No	A	11.18%
2. Credit Agricole	0.380	No	BB+	8.76%
3. ING	0.603	No	A-	6.71%
4. Deutsche Bank	0.328	No	A+	6.67%
5. Commerzbank	0.503	No	BBB-	6.33%
6. UniCredit	0.434	Yes	BBB	5.46%
7. Natixis	0.118	No	A+	5.03%
8. BBVA	0.516	Yes	A+	4.11%
9. Société General	0.275	No	BBB	4.08%
10. Banco Santander	0.545	Yes	B-	3.85%

In panel D the characteristics of bank originating from financially stressed countries vs those in financially stable countries are compared. Stable (stressed deposit) banks are defined as banks from Cyprus, Greece, Ireland, Italy, Portugal, Slovenia, and Spain. Panel E compares high rated vs low rated banks. High rated (low rated) banks are rated by Fitch above A (below A). In both panels the last column presents a t-statistic indicating whether the difference in means differs from zero. Panel F is a list of the top 10 banks in terms of market share with additional bank characteristics.

7. Results

This chapter presents the results of equations 1 tot 9. First, the findings are compared to the baseline model of Heider et al. (2019) in terms of total lending volume and risk. Secondly, the results from extending the model are presented. Finally, the results from the robustness checks are given.

7.1 Total Loan Volume, New Loan Volume and Risk Taking under Negative Interest Rates

First, Heider et al.'s (2019) model was tested and used for further alterations to examine the heterogenous effects among different banks. In the first two columns of Table 4, the results from the estimating equation (1) are presented. Here, the dependant variable y_{it} is the total outstanding volume of bank *i* on quarter *t.* In the first column the basic difference-in-difference is presented with bank and quarter-year fixed effects. In line with the model of Heider et al., the model estimated a negative and significant treatment effect. In economic terms this means one standard deviation in deposit ratio (=0.186) translates into a reduction in lending of 7.6% (0.186 x -0.411).

In the second column of Table 4, control variables are added to the first equation in order to control for the bank's specific characteristics and loan demand. The difference-in-difference estimates are mostly unaffected and remained highly significant. The regression results show that a higher security ratio decreases to the total lending volume.

To extend the knowledge on how NIRP impacts lending behaviour, an alternative measure is introduced for lending volume. Table 5 estimated equation (1) with y_{it} containing the new loans extended by bank *i* in quarter *t*. Both Column 1 and 2 in Table 5 give no evidence for any treatment effects in term of deposit ratio. Furthermore, the effect of the security ratio is lost when testing for new lending volume.

From these results no clear conclusion can be drawn about hypothesis (1): Although both Column 1 and 2 of Table 4 models suggest an inverse relation between deposit ratio and the lending volume in the range between 2013-2015 in European banks, this inverse relation cannot be drawn from Column 1 and 2 in Table 5. Therefore, hypothesis (1) is rejected. In addition, the Tables 4 shows that apart from deposit ratio, other bank specific characteristics (*Security Ratio*) explain some of their lending behaviour. These heterogenous effects among different banks will be described in 7.2 onwards.

Table 4. **Impact of NIRP on Bank's Total Loan Volume**

	ln (Total-loan volume)		
Sample	2013-2015		2011-2015
Variable	(1)	(2)	(3)
Deposit Ratio x After (06/2014)	-0.411***	-0.441***	-0.456***
	(0.062)	(0.062)	(0.088)
Security Ratio$_{t-1}$		-1.064**	-0.348
		(0.389)	(0.279)
Equity Ratio$_{t-1}$		0.367	0.767
		(0.519)	(0.506)
Size$_{t-1}$		-0.011	-0.047
		(0.794)	(0.819)
Credit-demand index		-0.000	-0.000
		(0.000)	(0.000)
Deposit Ratio x After (07/2012)			-0.146
			(0.096)
Bank FE	Y	Y	Y
Quarter-year FE	Y	Y	Y
R^2	0.110	0.128	0.080
N	408	408	628

The level of observation is a bank's quarter-year, based on all syndicated loans extended by European banks that acted as lead arranger at date t from January 2011 to December 2015. The dependant variable is the logged total loan volume granted by bank *i* that acted as lead arranger in the syndicated European loan market at quarter *t*. *Deposit ratio* is the bank's deposits divided by total assets in the year 2013. *After (06/2014)* is a dummy variable which indicates the period after June 2014. *Security ratio$_{t-1}$* is the bank's securities divided by total assets in the year t-1. *Equity ratio$_{t-1}$* is the bank's balance sheet's equity divided by total assets in the year t-1. *Size$_{t-1}$* is the bank's total assets in the year t-1. *After (07/2012)* is a dummy variable for the period indicating after July 2012. *Consumer-demand index* is the Bank Lending Survey index based on country-level loan demand (in net percentage) from the Statistical Data Warehouse of the ECB. In the parentheses the standard errors (cluster at the bank level) are included.

Table 5. **Impact of NIRP on Bank's New Loan Volume**

	ln (New-loan volume)		
Sample	2013-2015		2011-2015
Variable	(1)	(2)	(3)
Deposit Ratio x After (06/2014)	0.020	0.038	0.355
	(0.366)	(0.376)	(0.367)
Security Ratio$_{t-1}$		-1.319	0.525
		(2.515)	(0.391)
Equity Ratio$_{t-1}$		-4.727	-5.972*
		(3.390)	(1.319)
Size$_{t-1}$		-0.326	0.107
		(0.803)	(0.386)
Credit-demand index		0.004	0.003
		(0.002)	(0.002)
Deposit Ratio x After (07/2012)			-0.467
			(0.233)
Bank FE	Y	Y	Y
Quarter-year FE	Y	Y	Y
R^2	0.004	0.013	0.017
N	377	377	585

The level of observation is a bank's quarter-year, based on all syndicated loans extended by European banks that acted as lead arranger at date t from January 2011 to December 2015. The dependant variable is the logged new loan volume granted by bank i at quarter t that acted as lead arranger in the syndicated European loan market. *Deposit ratio* is the bank's deposits divided by total assets in the year 2013. *After (06/2014)* is a dummy variable which indicates the period after June 2014. *Security ratio$_{t-1}$* is the bank's securities divided by total assets in the year t-1. *Equity ratio$_{t-1}$* is the bank's balance sheet's equity divided by total assets in the year t-1. *Size$_{t-1}$* is the bank's total assets in the year t-1. *After (07/2012)* is a dummy variable for the period indicating after July 2012. *Consumer-demand index* is the Bank Lending Survey index based on country-level loan demand (in net percentage) from the Statistical Data Warehouse of the ECB. In the parentheses the standard errors (cluster at the bank level) are included.

As the results suggested that deposit ratio had a negative impact on the relative lending volume, at least to some degree, it was interesting to check whether high deposit banks under stress and in a situation with negative interest rates also experience a pressure for yield and therefore are lending to riskier companies. Table 6 shows the estimated risk expressed by equation (2). Rather than lending volume, the dependant variable is now defined as the logged five-year standard deviation of the borrowing company to measure bank *i*'s loan risk. The first column of Table 6 gives the estimated baseline difference-in-difference. Using the average risk level by bank *i* in quarter *t*, the findings show positive yet insignificant treatment effects, which is in contrast of the results of Heider et al (2019) and the common view that negatives rates increase the risk taking of banks. To refine the comparison of deposit ratio, control variables are added which increases the difference-in-difference estimate from 0.007 to 0.066 (Column 2 of Table 6). *Security Ratio* has a negative and significant effect in terms of the bank's risk taking. Furthermore, the relation suggested by Alfonso (2011), who found that larger banks take more risk due to their "too-big-to-fail" incentives, is in contrast to the results presented in the table.

The bank's deposit exposure acted, only partly, as expected based on existing literature. However, to make sure that specification used does not pick up a more general effect of deposit ratio, a dummy variable is added for the period from July 2012 in equation (3). First, the model including the dummy variable is estimated in terms of total lending volume. There is an insignificant coefficient for the interaction *Deposit ratio x After (07/2012)* while at the same time the coefficient *Deposit ratio x After (06/2014)* remains significant and only slightly changed (Table 4 Column 3): The model shows that negative rates are special in terms of total lending volume. The new granted lending volume shows an insignificant negative treatment effect (Table 5 Column 3). In Figure B:2 plot (b): there is a dispersion of new loans after the second quarter of 2012, while the difference of new loan volume between high deposit and low deposit banks remains relative constant after June 2014. This explains why the treatment of (*Deposit ratio x After 06/2014*) remains insignificant (Table 5, Column 1 and 2). Hence, the new lending volume does not rely on the deposit funding exposure under negative interest rates.

Table 6 Column 3 does not support the view that negative interest rates are special in terms of bank's risk taking. There is a significant coefficient at the 10% level on the interaction *Deposit ratio x After (07/2012)* while at the same time coefficient *Deposit ratio x After (06/2014)* remains insignificant and positive (Table 6 Column 3). This indicates that different deposit ratios do not affect banks only once the rates are negative in terms of risk taking and new loans granted, however, in terms of total outstanding loans the effects of deposit ratio are solely during negative rates.

Table 6. **Impact of NIRP on Bank's Loan Risk**

	$\ln(\sigma(ROA_t)^{5y}$		
Sample	2013-2015		2011-2015
Variable	(1)	(2)	(3)
Deposit Ratio x After (06/2014)	0.074	0.039	0.048
	(0.106)	(0.105)	(0.100)
Security Ratio$_{t-1}$		-1.213**	-0.858***
		(0.502)	(0.237)
Equity Ratio$_{t-1}$		0.129	0.202
		(0.770)	(0.404)
Size$_{t-1}$		0.093	0.090
		(0.103)	0.114
Credit-demand index		-0.000	-0.000
		(0.000)	(0.000)
Deposit Ratio x After (07/2012)			0.167*
			(0.100)
Bank FE	Y	Y	Y
Quarter-year FE	Y	Y	Y
R^2	0.007	0.066	0.069
N	408	408	628

The level of observation is a bank's quarter-year, based on all syndicated loans extended by European banks that acted as lead arranger at date t from January 2011 to December 2015. The dependant variable is the average logged five-year standard deviation of the borrowing company to measure the bank's loan risk, granted by bank i at quarter t that acted as lead arranger in the syndicated European loan market. *Deposit ratio* is the bank's deposits divided by total assets in the year 2013. *After (06/2014)* is a dummy variable which indicates the period after June 2014. *Security ratio* is the bank's securities divided by total assets in the year t-1. *Equity ratio* is the bank's balance sheet's equity divided by total assets in the year t-1. *Size* is the bank's total assets in the year t-1. *After (07/2012)* is a dummy variable for the period indicating after July 2012. *Consumer-demand index* is the Bank Lending Survey index based on country-level loan demand (in net percentage) from the Statistical Data Warehouse of the ECB. In the parentheses the standard errors (cluster at the bank level) are included.

7.2 Profitability on High vs Low Deposit Banks

As the effects of the bank's deposit exposure under negative rates are partly confirmed, the heterogenous effects among banks are further specified to explore the relation of deposit exposure under NIRP. As Heider et al (2019), Eggertson et al. (2017) and Xu et al. (2019) mostly blame profitability for the relative lower lending growth and risk taking, profitability was used to further specify the deposit ratio relation. A triple difference is added to the baseline model by interacting the treatment *Deposit ratio x After (06/2014)* with the variable *Profitability* capturing the bank's return on average equity in 2013 (Table 7). An insignificant and negative coefficient on the triple interaction shows that high deposit banks with a higher return on average equity are not affected differently in lending under NIRP (Column 1 of Table 7).

The three-way interaction on the volume of new loans issued shows a significant and negative coefficient on the triple interaction is shown (Column 3 and 4 of Table 7). As the change in outcome of high profitable banks differ from that of low profitable banks: it is concluded that higher profitability with higher deposit ratio results in a lower loan volume granted than the loan volume granted of low profitable banks under negative policy rates. That being said, the significant negative coefficient illustrates that the relation between deposit ratio and negative interest rates differs across the levels of profitability. The results in Table 7 are the opposite of what was expected based on the literature: the first part of hypothesis (3) is rejected.

To test the second part of hypothesis (3), the triple interaction is estimated in terms of lending risk. The triple interaction is insignificantly negative meaning that banks do not necessarily take higher risk for high deposit with lower profitability under negative interest rates (Columns 5 and 6 of Table 7). Therefore, the results contrast the suggested effects by Heider et al. (2019) that lower profitability under negative rates does induce higher risk taking. From the results, the first part of hypothesis (3) is rejected and the second, regarding risk, is failed to reject.

Table 7. **Triple-Difference model, Deposit ratio and Profitability, on Bank's Total Lending Volume**

	ln (Total loan volume)		ln (New loan volume)		$\ln(\sigma(ROA_t)^{5y}$	
Sample			2013 -2015			
Variable	(1)	(2)	(3)	(4)	(5)	(6)
Deposit Ratio x After (06/2014)	0.332*	-0.380**	1.069*	1.062*	0.149	0.151
	(0.173)	(0.183)	(0.603)	(0.599)	(0.116)	(0.117)
Profitability x After (06/2014)	0.184	0.015	0.117	0.126	0.012	0.011
	(0.126)	(0.012)	(0.053)	(0.052)	(0.011)	(0.011)
Deposit Ratio x Profitability	-0.208	-0.015	-0.168**	-0.178**	-0.014	-0.014
x After (06/2014)	(0.015)	(0.014)	(0.065)	(0.640)	(0.013)	(0.013)
Security $Ratio_{t-1}$		0.911		0.249		1.080
		(1.075)		(2.310)		(0.502)
Equity $Ratio_{t-1}$		-0.258		-1.202		0.230
		(1.224)		(4.084)		(0.757)
$Size_{t-1}$		-0.641		-0.331		0.120
		(0.116)		(0.880)		(0.111)
Credit-demand index		0.000		0.004		-0.000
		(0.000)		(0.002)		(0.000)
Bank FE	Y	Y	Y	Y	Y	Y
Quarter-year FE	Y	Y	Y	Y	Y	Y
R^2	0.137	0.153	0.052	0.062	0.024	0.028
N	408	408	377	377	408	408

The level of observation is a bank's quarter-year, based on all syndicated loans extended by European banks that acted as lead arranger at date t from January 2011 to December 2015. The dependant variable in column 1 and 2 is the logged total loan volume granted by bank i at quarter t that acted as lead arranger in the syndicated European loan market. In column 3 and 4 the dependant variable is the logged new loan volume extended by bank i at time t. In the last two columns the dependant the average logged five-year standard deviation of the borrowing company, of bank i at quarter t. *Deposit ratio* is the bank's deposits divided by total assets in the year 2013. *Profitability* is the bank's return on average equity in 2013. *After (06/2014)* is a dummy variable which indicates the period after June 2014. The control variables include: *Security ratio$_{t-1}$, Equity ratio$_{t-1}$, Size$_{t-1}$* and the *Consumer Loan demand Index*. The robust standard errors (clustered at bank level) are in the parentheses.

7.3 Net-Interest Income on High vs Low Deposit Banks

Because higher profitability does not necessarily make banks adapt better to negative interest rates, it was tested whether banks that have a more diversified income are more capable of dampening the negative effects of NIRP. To test for this, the bank sample is divided into two sections, either low diversified income or high diversified income represented by the dummy variable *Non-Diversified.* The triple interaction term regarding interest income over total assets is computed (Table 8). The values of triple interaction *Deposit ratio x After (06/2014) x Non-Diversified* are insignificant (Columns 1 and 2 of Table 8). The positive sign does suggest that high deposit banks with a higher net interest income to total assets had more outstanding loans under negative interest rates, which is actually not surprising as these banks have a higher reliance on their funding from lending.

In the computation of the new lending volume, the triple interaction terms are both negative and significant: High deposits banks with higher interest income reliance have a significant relative lower new lending volume under negative interest rates. Table 8 shows that, although the outstanding lending volume seems unchanged, high deposit banks with larger net interest income over total assets are struggling with granting new loans under negative interest rates.

To check whether these banks had to make consensus in their risk taking because of their decrease in relative lending, the triple interaction accounting for ROA volatility was estimated: this triple interaction is significant and positive (Table 8, Column 5 and 6). This suggests that high deposit banks with higher net interest income take more risk under negative interest rates. However, after adding control variables, the coefficient becomes insignificant. These results suggest that high deposit banks with lower diversified income, in terms of interest income dependences, struggle in lending volume and took on more risk under negative policy rates. Therefore, hypothesis (4) is not rejected.

Table 8. **Triple-Difference model, Deposit ratio and Interest Income over Total Assets, on Bank lending behaviour**

	ln (Total loan volume)		ln (New loan volume)		$\ln(\sigma(ROA_t)^{5y}$	
Sample			2013 -2015			
Variable	(1)	(2)	(3)	(4)	(5)	(6)
Deposit Ratio x After (06/2014)	-0.482**	-0.486**	0.884	0.951	0.000	0.032
	(0.180)	(0.200)	(0.554)	(0.571)	(0.106)	(0.099)
Non-Diversified x After (06/2014)	0.122	0.185	0.821	0.782	-0.261**	-0.186*
	(0.115)	(0.182)	(0.554)	(0.560)	(0.020)	(0.107)
Deposit Ratio x Non-Diversified	0.066	-0.161	-1.699*	-1.742*	0.351**	0.214
x After (06/2014)	(0.220)	(0.336)	(1.058)	(1.072)	(0.030)	(0.182)
Security $Ratio_{t-1}$		-1.139		-1.736		-1.099
		(1.232)		(2.386)		(0.520)
Equity $Ratio_{t-1}$		0.548		-5.095		-0.039
		(1.557)		(4.084)		(0.776)
$Size_{t-1}$		-0.047		0.632		0.104
		(0.135)		(0.784)		(0.119)
Credit-demand index		0.000		0.003		-0.000
		(0.000)		(0.002)		(0.000)
Bank FE	Y	Y	Y	Y	Y	Y
Quarter-year FE	Y	Y	Y	Y	Y	Y
R^2	0.126	0.147	0.014	0.028	0.041	0.088
N	408	408	377	377	408	408

The level of observation is a bank's quarter-year, based on all syndicated loans extended by European banks that acted as lead arranger at date t from January 2011 to December 2015. The dependant variable in column 1 and 2 is the logged total loan volume granted by bank i at quarter t that acted as lead arranger in the syndicated European loan market. In column 3 and 4 the dependant variable is the logged new loan volume extended by bank i at time t. In the last two columns the dependant the average logged five-year standard deviation of the borrowing company, of bank i at quarter t. *Deposit ratio* is the bank's deposits divided by total assets in the year 2013. *Low Diversified* is the dummy variable indicating a high or low net interest income over total assets in the year 2013 of bank i. *After (06/2014)* is a dummy variable which indicates the period after June 2014. The control variables include: *Security ratio$_{t-1}$, Equity ratio$_{t-1}$, Size$_{t-1}$* and the *Consumer Loan demand Index*. The robust standard errors (clustered at bank level) are in the parentheses.

7.4 High Rating on High vs Low Deposit Banks

After assessing the different effects of bank's financials on the deposit exposure under negative rates, the effects of the overall financial health, soundness and competitiveness of the banks, captured by the Fitch rating, are estimated. The results of the triple interaction between *Deposit Ratio*, *After (06/2014)* and the rating is presented in Table 9. To determine the impact of the credit rating, the bank sample is divided in high and low rated banks using dummy variables. High Rating indicates a Finch rating above A. This cut-off is used, instead of a non-investment grade to an investment grade rating, due to an overall high level of credit ratings of the banks included in the sample. The total loan volume is presented Column 1 and 2 of Table 9. The three-way interaction shows a significant and positive result only at the 20% level: High deposit banks with a higher credit rating do not experience less restrictions in terms total lending volume under negative interest rates.

As to new total lending, the results of Column 4 and 5 of Table 9 are, somewhat, in line with the results from the first two columns. High rated banks are less affected by the deposit exposure when negative rates are applied in than low rated banks. Thus, high rated banks only had a higher loan volume in newly granted loans when the interest rates were negative.

The triple interaction gives an insignificant and negative coefficient risk (Table 9, Columns 5 and 6). This means that the high deposit banks do not take risks differently when negative rates are applied. Therefore, the results are neither in line with Peydro et al. (2017), suggesting higher risk taking for higher rated banks or Buckeck et al.'s (2020) high risk bearing capacity for high rated banks theory. Because once the rates go negative, no clear relation can be drawn between higher rating and risk taking under negative rates. These findings are partly in line with the hypothesis (5) as the impact of soundness captured by the ratings does not affect risk taking and being sounder increases the lending volume granted under negative interest rates. Therefore, only the first part of the hypothesis is not rejected and second part of hypothesis 5 is failed to reject.

Table 9. **Triple-Difference model, High Rated, on Bank's Total Lending Volume**

	ln (Total loan volume)		ln (New loan volume)		$\ln(\sigma(ROA_t)^{5y}$	
Sample			2013 -2015			
Variable	(1)	(2)	(3)	(4)	(5)	(6)
Deposit Ratio x After (06/2014)	-0.614**	-0.714**	-1.478	-1.499	0.234	0.136
	(0.265)	(0.353)	(0.975)	(0.985)	(0.187)	(0.210)
Rating x After (06/2014)	-0.147	-0.191	1.202	-1.165	0.168	0.115
	(0.207)	(0.235)	(0.749)	(0.764)	(0.154)	(0.154)
Deposit Ratio x Rating	0.375	0.444	2.021*	2.040*	-0.073	-0.012
x After (06/2014)	(0.312)	(0.366)	(1.173)	(1.173)	(0.221)	(0.233)
Security $Ratio_{t-1}$		-0.632		-1.676		-0.807
		(1.143)		(2.167)		(0.483)
Equity $Ratio_{t-1}$		0.999		-2.975		0.498
		(1.528)		(3.917)		(0.697)
$Size_{t-1}$		-0.036		-5.017		0.094
		(0.113)		(0.743)		(0.091)
Credit-demand index		0.000		0.003		-0.000
		(0.000)		(0.002)		(0.000)
Bank FE	Y	Y	Y	Y	Y	Y
Quarter-year FE	Y	Y	Y	Y	Y	Y
R^2	0.150	0.164	0.014	0.020	0.089	0.119
N	408	408	377	377	408	408

The level of observation is a bank's quarter-year, based on all syndicated loans extended by European banks that acted as lead arranger at date t from January 2011 to December 2015. The dependant variable in column 1 and 2 is the logged total loan volume granted by bank i at quarter t that acted as lead arranger in the syndicated European loan market. In column 3 and 4 the dependant variable is the logged new loan volume extended by bank i at time t. In the last two columns the dependant the average logged five-year standard deviation of the borrowing company, of bank i at quarter t. *Deposit ratio* is the bank's deposits divided by total assets in the year 2013. *Rating* is the variable for the credit rating assed by Fitch at June 2014 of bank i. *After (06/2014)* is a dummy variable which indicates the period after June 2014. The control variables include: *Security ratio$_{t-1}$, Equity ratio$_{t-1}$, Size$_{t-1}$* and the *Consumer Loan demand Index*. The robust standard errors (clustered at bank level) are in the parentheses.

7.5 Stressed country on High vs Low Deposit Banks

Next, the country where banks are located are categorized as stable countries or stressed countries[2]. The three-way interaction, *Deposit Ratio x Stressed x After (06/2014),* is only significant at the 20% level (Table 10, Columns 1 and 2).

The coefficient for triple interaction is significant and negative for newly granted loans at bank-quarter level. This is alarming as the high deposit banks that are operated from stressed countries show a relative decrease to stable countries in granting new loans, which increases financial instability. Altavilla et al. (2019) mentions that these results could be explained by the valuation shocks for bank's balance sheets due to domestic sovereign bonds price drops or their weaker positions to charge negative rates on corporate deposits.

Risk taking by high deposit banks in stressed countries is not impacted different from stable countries as evident from the insignificant coefficient for the triple interaction (Table 10, last two columns). The problems identified by Altavilla et al. (2019) do not seem to push these banks to take more risk under negative rates. These results are not completely in line with literature, however, both results regarding total loans and risk taking are insignificant, yet high deposit bank in stressed countries do seem affected in their level of new loans granted. Therefore, the first part of hypothesis (6) rejected, and the second part of the hypothesis is failed to reject.

[2] "Stressed" countries are defined for the countries that had a higher yield than 6% on their 10-year sovereign yield for at least one quarter in the sample period. These countries are Cyprus, Greece, Ireland, Italy, Portugal, Slovenia and Spain.

Table 10. **Triple-Difference model, Stressed, on Bank's Total Lending Volume**

	ln (Total loan volume)		ln (New loan volume)		$\ln(\sigma(ROA_t)^{5y}$	
Sample			2013 -2015			
Variable	(1)	(2)	(3)	(4)	(5)	(6)
Deposit Ratio x After (06/2014)	-0.305**	-0.336**	0.468	0.431	0.121	0.098
	(0.144)	(0.145)	(0.518)	(0.520)	(0.118)	(0.104)
Stressed x After (06/2014)	0.120	0.187	1.329*	1.256	-0.134	-0.063
	(0.120)	(0.177)	(0.490)	(0.505)	(0.124)	(0.133)
Deposit Ratio x Stressed	-0.294	-0.396	-2.266**	-2.191**	0.071	-0.037
x After (06/2014)	(0.225)	(0.333)	(0.961)	(0.970)	(0.195)	(0.215)
Security $Ratio_{t-1}$		--0.930		-2.144		-1.031
		(1.073)		(0.506)		(0.467)
Equity $Ratio_{t-1}$		0.773		-2.955		0.280
		(1.581)		(4.354)		(0.771)
$Size_{t-1}$		0.070		-0.308		0.155
		(0.147)		(0.821)		(0.113)
Credit-demand index		0.000		0.004		-0.000
		(0.000)		(0.002)		(0.000)
Bank FE	Y	Y	Y	Y	Y	Y
Quarter-year FE	Y	Y	Y	Y	Y	Y
R^2	0.133	0.152	0.016	0.027	0.090	0.097
N	408	408	377	377	408	408

The level of observation is a bank's quarter-year, based on all syndicated loans extended by European banks that acted as lead arranger at date t from January 2011 to December 2015. The dependant variable in column 1 and 2 is the logged total loan volume granted by bank i at quarter t that acted as lead arranger in the syndicated European loan market. In column 3 and 4 the dependant variable is the logged new loan volume extended by bank i at time t. In the last two columns the dependant the average logged five-year standard deviation of the borrowing company, of bank i at quarter t. *Deposit ratio* is the bank's deposits divided by total assets in the year 2013. *Stressed* is a dummy variable indicating the financial condition of the bank's origination. *After (06/2014)* is a dummy variable which indicates the period after June 2014. The control variables include: *Security ratio$_{t-1}$, Equity ratio$_{t-1}$, Size$_{t-1}$* and the *Consumer Loan demand Index*. The robust standard errors (clustered at bank level) are in the parentheses.

7.6 Robustness to individual rates changes

Up until this point, the identification model used dummy variables to indicate the time period associated with negative rates. To assure the robustness of the model, the individual effects of the *DF rate* are specified in terms of lending volume and risk behaviour of the banks: however, the coefficient *Deposit ratio x DF rate* is never significant (Table 11). Therefore, the deposit ratio under positive interest rates does not influence the banks' lending behaviour. The triple interaction *Deposit ratio x DF rate x After(06/2014*), indicating whether negative rates do influence the banks' behaviour, is only statistically significant for the total lending volume. Thus, for high deposit banks only negative lower rates are associated with lower total lending (Column 1 and 2). As for the risk taking, negative rates are not experienced differently for the various levels of deposit ratios.

7.7 Further Robustness for firm-time fixed effects

To address the different investment opportunities for high-deposit and low deposit banks, the model is moved to loan-bank level to include firm-time fixed effects. This is done to compare the lending behaviour of both bank groups the same borrower, as the sample now consists of each bank's loan of the syndicate. Bank-firm fixed effects are added to relate the same banks to the same companies before and after the introduction of negative rates in June 2014. The model is estimated using the loan amount contributed to the syndicate by bank *i* and find a negative coefficient for *Deposit Ratio x After (06/2014) (*Table 12, Column 1). The results show that high deposit banks reduce their lending amount to the same firm when the policy rate turns negative; however, the estimate is only significant at the 30% level. After including the placebo treatment in Column 2, the difference-in-difference estimate is even more insignificant.

Table 11. **Impact of DF rate on Banks' Lending Volume and Risk Taking**

	ln (Total loan volume)		ln (New loan volume)		$\ln(\sigma(ROA_t)^{5y})$	
Sample			2010 - 2015			
Variable	(1)	(2)	(3)	(4)	(5)	(6)
Deposit Ratio x DF-rate x After (06/2014)	2.160**	2.160**	6.888	-3.646	-0.572	-0.577
	(0.937)	(0.936)	(7.724)	(7.243)	(0.724)	(0.572)
Deposit Ratio x DF-rate	0.200	0.200	1.305	0.047	-0.223	0.223
	(0.372)	(0.372)	(0.948)	(0.837)	(0.200)	(0.200)
Deposit Ratio x After (06/2014)	-0.064	-0.064	2.108	0.805	-0.056	-0.056
	(0.123)	(0.123)	(1.455)	(1.362)	(0.117)	(0.117)
Deposit Ratio	-3.265**		-3.745**		-0.085	
	(1,554)		(1.742)		(0.261)	
Bank FE	N	Y	N	Y	N	Y
Quarter-year FE	Y	Y	Y	Y	Y	Y
R^2	0.190	0.053	0.138	0.001	0.005	0.011
N	782	782	719	719	782	782

The level of observation is a bank's quarter-year, based on all syndicated loans extended by European banks that acted as lead arranger at date t from January 2011 to December 2015. The dependant variable in column 1 and 2 is the logged total loan volume granted by bank i at quarter t that acted as lead arranger in the syndicated European loan market. In column 3 and 4 the dependant variable is the logged new loan volume extended by bank i at time t. In the last two columns the dependant the average logged five-year standard deviation of the borrowing company, of bank i at quarter t. *Deposit ratio* is the bank's deposits divided by total assets in the year 2013. *DF rate* is the EBC's facility rate at the quarterly level t. *After (06/2014)* is a dummy variable which indicates the period after June 2014. The robust standard errors (clustered at bank level) are in the parentheses.

Table 12. **The impact of negative rates on loan volume and risk taking: Firm-time fixed effects**

	ln (Loan amount)	
Sample	2013 – 2015	2011-2015
Variable	(1)	(2)
Deposit Ratio x After (06/2014)	-0.042	-0.042
	(0.045)	(0.035)
Deposit Ratio x After (07/2012)		0.019
		(0.030)
Firm-time FE	Y	Y
Bank-firm FE	Y	Y
Bank-country FE	Y	Y
R^2	0.969	0.977
N	3,887	7,745

The sample consists of all completed syndicated loans of both private and publicly listed firms j at date t granted by European banks that acted as lead arranger from January 2013 to December 2015 in the first column and from January 2011 to December 2015 in the last column. All singletons are dropped from the total number of observations. The dependant variable in column 1 and 2 is the logged loan amount by bank i to firm j at time t. *Deposit ratio* is the bank's deposits divided by total assets in the year 2013. *After (06/2014)* is a dummy variable which indicates the period after June 2014. *After (06/2014)* is a dummy variable which indicates the period after July 2012. The robust standard errors (clustered at bank level) are in the parentheses.

8. Discussion & Limitations

This chapter discusses the results, and their practical implications are considered.

8.1 Discussion

After the 2008 financial crisis, the ECB responded with an unconventional monetary policy to rescue European financial institutions and prevent further economic downturn. Because of the worsening economic conditions, the ECB introduced negative interest rates in June 2014. After the unconventional policy of lowering the deposit facility rate in negative territory was introduced to avoid a deflationary spiral, researchers started arguing whether the negative interest might create an adverse reaction due to the limited pass through on deposit rates.

As previous research focussed on deposit ratio, this thesis adds to the literature by providing valuable insights in different bank specific items which determine the effectiveness and viability of the unconventional monetary policy. Thereby, assessing which banks should be closely watched regarding both future lending and risk lending behaviour.

To explore the effect of different determinants on bank lending and risk taking under negative policy rates, the approach of Heider et al. (2019) is used first, using a difference-in-difference estimation of the syndicated loan market in Europe. Doing so, a strong fundamental framework was established that allowed for further identification of other factors shaping the deposit exposure under negative interest rates. The initial results partly support the effects identified by Heider et al. in the inverse relation of deposit ratio on total lending volume, however, show no relation between deposit ratio on risk taking. The results are also in line with Eggertson et al. (2017) as limited lending growth is caused by higher deposit ratios. However, in terms of excessive risk taking because of reduced margins argued by Shelling & Townbin's (2018), is not confirmed.

Thereafter, multiple dimensions (Altavilla et al., 2019) are examined regarding banks' financial stability. Using triple difference models, the effects of lending behaviour are observed on financial stability and on the extent of deposit funding. This study examined whether higher profitability mitigates the effects of deposit ratio on lending volume and risk taking. This study suggests that more profitable banks were not relatively better suited to reduce the risk taking associated with higher deposit funding; and had a relative lower granted lending volume. These findings are in conflict with Altavilla et al. (2019) and Jensen and Meckling (1976) in terms of lending volume and the results do not confirm the risk seeking behaviour of more profitable banks found in other studies (Martynova et al., 2015; Xu et al., 2019).

A triple difference estimation was used to check whether banks that had a higher diversified income limited the effects of the negative effects of deposit ratio under negative interest rates. Although the effects on outstanding loans are insignificant, the results suggest that a lower diversified income,

measured by the ratio net interest income over total assets, increased the risk taking but lowered the newly granted loan volume for higher deposit ratios under negative interest rates. These findings are partly in line with the effects described by Klein et al. (2020) and Bottero et al. (2019).

Another the triple difference is used to address the ratings, capturing the overall soundness of the bank. In line with Brunnermeier and Koby's (2018), this study shows that higher rated banks are less restricted by their deposit exposure under negative rates in terms of new lending, possible because of their competitive advantages of attracting new loans or the advantage of less capital restrictions.

Altavilla et al. (2019) show the importance of the economic state of the country where banks are located in supporting the transmission mechanism under negative interest rate policies. The findings of the paper presented here partly confirms the importance of country's financial health, as deposit ratio was found to have a stronger negative effect on the new lending volume under NIRP for banks from stressed countries than for banks from stable countries. This could be explained by the higher stickiness of pass-through rates in stressed countries suggested by Altavilla et al. (2019).

The results of this research have some practical implications. This study confirms that the ECB should be cautious implementing negative policy rates. As traditional monetary policy cuts have been proven to act expansionary in lending volume, the unconventional monetary policy still have its imperfections. It is important for the ECB to understand the implications of prolonged negative rates. Furthermore, the ECB has to understand the role of deposit funding in the transmission channel and its interaction with important bank aspects to determine which banks need better supervision.

As the findings confirm, the negative effects of deposit ratio are aggravated for banks struggling with profitability, with lower diversified income, overall soundness and where operated from stressed countries are, in either lending volume or risk behaviour. Therefore, regulators from the ECB might have to reconsider whether negative rates are *de facto* improving the economic conditions. The ECB should consider that profitability is further hampered due to prolonged squeezed interest margins, which could drive banks to potentially derestrict lending terms and encourage the existence of 'zombie-lending'. However, this study finds little evidence for this higher risk seeking behaviour among higher deposit exposed banks after the introduction of negative rates.

9 Conclusions

This paper documents the relation between deposit funding and bank's lending behaviour under negative interest rates, using difference-in-difference and triple differences models. This study shows that, under negative rates, high-deposit banks have smaller total lending volume but not necessarily take more risk or grant less loans in the European syndicated market than low-deposit banks.

Once the ECB rates are negative, a decrease in new lending is found among higher deposit banks with either a higher profitability, or less diversified income, which are lower rated or operated from a financially stressed country. This research shows that an increase of risk taking among higher deposit ratios is stimulated by lower diversified income.

Although the methods used were applied to ensure validity and reliability, there are several limitations. One weakness is the limited number of banks in the sample, because of limited availability of data from Orbis BankFocus. As this database has limited information on smaller European bank, the sample covers only 53 banks which does not give a complete overview of the impact of negative monetary policy of the ECB. This becomes clear when estimating the difference-in-differences, as the total observations, quarters for each bank in either the top or lower tercile, is only about 400. In further estimations this could result in variables losing their statistical significance. To overcome this problem, future research should include the use of a larger database to broaden the scope the external validity.

Another potential shortcoming of the research is the absence of significant results in the robustness of new lending volume and risk taking. The triple interaction *Deposit Ratio x DF-rate x After (06/2014)* does not produce any significant outcomes (Table 10, Column 3, 4, 5 and 6). This shows that policy rate changes do not differ the banks new loan level and risk taking under negative policy rates. Future research might consider the impact of different negative interest rate changes on new lending and the risk-taking behaviour of banks.

Although the model accounted for the time variations in respect to deposit ratio and return on average equity over time (Figure B.7), it cannot be excluded that, over time, banks change their funding or business model. That is a limitation in the identification of the right strategy and the adoptability of this study. Similar, is the violation of the no pre-treatment assumption for applying difference-in-difference models. Given the assumption that there are no treatment effects in the treatment group before the treatment is administered, it cannot be excluded that banks have anticipated the negative interest rates and acted accordingly. Therefore, future studies might consider these anticipations and identify the deposit ratio changes pre-NIRP and during the period of negative rates.

Due to the insignificant results from the robustness check regarding the firm-time fixed effects, it cannot fully be excluded that the effects found in this study are fully attributed to the deposit ratio itself. Therefore, the concerns remain that high-deposit banks and low deposit banks face different investment

opportunities (loan demand) and that the time-varying differences drive the results, such as the lower total lending volume for higher deposit ratios under negative interest rates, found in this study. Therefore, future studies should identify the different investments that both groups of banks (high deposit vs low deposit) face.

References

Acharya, V.V., & Steffen, S. (2015). The "greatest" carry trade ever? Understanding eurozone bank risks. Journal of Financial Economics, 115(2), 215-236.

Acharya, V. V., Eisert, T., Eufinger, C., & Hirsch, C. (2019). Whatever it takes: The real effects of unconventional monetary policy. The Review of Financial Studies, 32(9), 3366-3411.

Afonso, G., Santos, J.A., & Traina, J. (2014). Do'Too-Big-To-Fail'Banks Take on More Risk? Economic Policy Review, Forthcoming

Altavilla, C., Burlon, L., Giannetti, M., & Holton, S. (2019). Is there a zero lower bound? The effects of negative policy rates on banks and firms.

Altavilla, C., Canova, F., & Ciccarelli, M. (2016). Mending the broken link: heterogeneous bank lending and monetary policy pass-through.

Ampudia, M., & Van den Heuvel, S. (2018). Monetary policy and bank equity values in a time of low interest rates.

Basten, C., & Mariathasan, M. (2018). How banks respond to negative interest rates: Evidence from the Swiss exemption threshold.

Bech, M.L., & Malkhozov, A. (2016). How have central banks implemented negative policy rates? BIS Quarterly Review March.

Bernanke, B.S. (2007). The financial accelerator and the credit channel (No. 296).

Bernanke, B.S., & Gertler, M. (1995). Inside the black box: the credit channel of monetary policy transmission. Journal of Economic perspectives, 9(4), 27-48.

Bikker, J.A., & Vervliet, T.M. (2018). Bank profitability and risk-taking under low interest rates. International Journal of Finance & Economics, 23(1), 3-18.

Boivin, J., Lane, T. and Meh, C.. 2010. "Should Monetary Policy Be Used to Counteract Financial Imbalances?" Bank of Canada Review (Summer): 23–36

Borio, C., & Zhu, H. (2008). Capital regulation, risk-taking and monetary policy: a missing link in the transmission mechanism, BIS Working Paper No. 268. Retrieved from Bank or International Settlements website: http://www. bis. org/publ/work268. pdf.

Bottero, M., Minoiu, M. C., Peydró, J.L., Polo, A., Presbitero, M.A. F., & Sette, E. (2019). Negative monetary policy rates and portfolio rebalancing: Evidence from credit register data. International Monetary Fund.

Brunnermeier, M.K., & Koby, Y. (2018). The reversal interest rate: An effective lower bound on monetary policy. unpublished paper, Princeton University.

Brunnermeier, M. K., & Sannikov, Y. (2016). The I theory of money (No. w22533). National Bureau of Economic Research.

Cavallino, P., and D. Sandri (2017). "The Expansionary Lower Bound: A Theory of Contractionary Monetary Easing." Mimeographed, International Monetary Fund.

Chakraborty, I., Goldstein, I., & MacKinlay, A. (2019). Monetary stimulus and bank lending. Journal of Financial Economics.

Dawson, J., & Richter, A.W. (2004). A significance test of slope differences for three-way interactions in moderated multiple regression analysis. Aston Business School.

Dell'Ariccia, G., Laeven, L., and Suarez, G.A. (2017). Bank Leverage and Monetary Policy's Risk-32 Taking Channel: Evidence from the United States. Journal of Finance, 72(2):613–654

Demiralp, S., Eisenschmidt, J., & Vlassopoulos, T. (2017). Negative interest rates, excess liquidity and bank business models: Banks' reaction to unconventional monetary policy in the euro area. Excess Liquidity and Bank Business Models: Banks' Reaction to Unconventional Monetary Policy in the Euro Area (February 1, 2017).

Dong, Feng; & Wen, Yi.(2017) Optimal Monetary Policy under Negative Interest Rate. Working Paper No. 019A, Federal Reserve Bank of St. Louis.

Drechsler, I., Savov, A., & Schnabl, P. (2017). The deposits channel of monetary policy. The Quarterly Journal of Economics, 132(4), 1819-1876.

Eggertsson, G.B., & Woodford, M. (2003). Optimal monetary policy in a liquidity trap (No. w9968). National Bureau of Economic Research.

Eggertsson, G.B., Juelsrud, R.E., & Wold, E.G. (2017). Are negative nominal interest rates expansionary? (No. w24039). National Bureau of Economic Research.

Eggertsson, G.B., Mehrotra, N.R., & Robbins, J.A. (2019). A model of secular stagnation: Theory and quantitative evaluation. American Economic Journal: Macroeconomics, 11(1), 1-48.

Fernandes, N.. "Economic effects of coronavirus outbreak (COVID-19) on the world economy." Available at SSRN 3557504 (2020).

Georgiadis. P. (2020) BoE makes emergency rate cut to cushion economy. Financial Times retrieved from http://www.ft.com

Gertler, M., & Bernanke, B. (1989). Agency costs, net worth and business fluctuations. In Business cycle theory. Edward Elgar Publishing Ltd..

Goddard, J., Molyneux, P., & Wilson, J. O. (2004). The profitability of European banks: a cross-sectional and dynamic panel analysis. The Manchester School, 72(3), 363-381.

Hasan, I., Liu, L., & Zhang, G. (2016). The determinants of global bank credit-default-swap spreads. Journal of Financial Services Research, 50(3), 275-309 for determining the CDS spread measure.

Heider, F., Saidi, F., & Schepens, G. (2019). Life below zero: Bank lending under negative policy rates. The Review of Financial Studies, 32(10), 3728-3761.

Heuvel, S.J. van den (2006) 'The Bank Capital Channel of Monetary Policy', 2006 Meeting Papers 512, Society for Economic Dynamics

Hicks, J.R. (1937). Mr. Keynes and the" classics"; a suggested interpretation. Econometrica: journal of the Econometric Society, 147-159.

Inoue, A., & Rossi, B. (2019). The effects of conventional and unconventional monetary policy on exchange rates. Journal of International Economics, 118, 419-447.

Ioannidis, C., Pasiouras, F., & Zopounidis, C. (2010). Assessing bank soundness with classification techniques. Omega, 38(5), 345-357.

Ioannidou, V., Ongena, S., & Peydró, J.L. (2009). Monetary policy and subprime lending: a tall tale of low federal funds rates, hazardous loans and reduced loan spreads. European banking centre discussion paper, 45.

Ippolito, F., Ozdagi, A.K., & Perez-Orive, A. (2018). The transmission of monetary policy through bank lending: The floating rate channel. Journal of Monetary Economics, 95, 49-7

Jackson, H. The international experience with negative policy rates. No. 2015-13. Bank of Canada, 2015.

Jensen, M.C., & Meckling, W. H. (1976). Theory of the firm: Managerial behavior, agency costs and ownership structure. Journal of financial economics, 3(4), 305-360.

Jiménez, G., Lopez, J.A., & Saurina, J. (2013). How does competition affect bank risk-taking?. Journal of Financial stability, 9(2), 185-195.

Jiménez, G., Ongena, S., Peydró, J-L., & Saurina, J. 2012. "Credit Supply and Monetary Policy: Identifying the Bank Balance-Sheet Channel with Loan Applications." American Economic Review, 102 (5): 2301-26.

Jobst, A., & Lin, H. (2016). Negative interest rate policy (NIRP): implications for monetary transmission and bank profitability in the euro area. International Monetary Fund.

Karr J. Performance measurement in banking: Beyond ROE. Journal of Performance Management. 2005;18(2):56-70.

Kashyap, A.K., & Stein, J.C.. 2000. "What Do a Million Observations on Banks Say about the Transmission of Monetary Policy?" American Economic Review, 90 (3): 407-428.

Keeley, M.C. (1990). Deposit insurance, risk, and market power in banking. The American economic review, 1183-1200

Keynes, J.M., & Waeger, F. (1936). Allgemeine Theorie der Beschäftigung, des Zinses und des Geldes (Vol. 6). Berlin: Duncker & Humblot.

Klein, M. (2020). Implications of negative interest rates for the net interest margin and lending of euro area banks.

Malovana, S., Bajzik, J., Ehrenbergerova, D., & Janku, J. (2020). A Prolonged Period of Low Interest Rates: Unintended Consequences. Research and Policy Notes, (2020/02).

Martynova, N., Ratnovski, M.L., & Vlahu, M.R. (2015). Bank profitability and risk-taking. International Monetary Fund.

Molyneux, P., Xie, R., Thornton, J., & Reghezza, A. (2017). Did Negative Interest Rates Impact Bank Lending? (No. 17002).

Mora, R., & Reggio, I. (2012). Treatment effect identification using alternative parallel assumptions.

Nucera, F., Lucas, A., Schaumburg, J., & Schwaab, B. (2017) 'Do negative interest rates make banks less safe?' Economics Letters 159(C), 112–115

Olden, A., & Møen, J. (2020). The triple difference estimator. NHH Dept. of Business and Management Science Discussion Paper, (2020/1).

Palley, T.I. (2016). Why negative interest rate policy (NIRP) is ineffective and dangerous. Real-World Economics Review, 76, 5-15.

Pérez Montes, C., & Ferrer Pérez, A. (2018). The impact of the interest rate level on bank profitability and balance sheet structure. Revista de Estabilidad Financiera, (NOV)

Rajan, R. (2013). A step in the dark: unconventional monetary policy after the crisis. Andrew Crockett Memorial Lecture, Bank for International Settlements, 23.

Rajan, R.G. (2005). Has Financial Development Made the World Riskier? In Proceedings - Economic Policy Symposium - Jackson Hole, Federal Reserve Bank of Kansas City, pages 313–369

Rajan, R.G. 2006. "Has Finance Made the World Riskier?" European Financial Management 12 (4): 499–533.

Reinbold, B., & Wen, Y. (2017). Looking for the Positives In Negative Interest Rates. The Regional Economists, 4th Quarter.

Reinhart, C.M. & Rogoff, K. S. (2009). The aftermath of financial crises. American Economic Review 99 (2), 466–472

Repullo, R. (2020). The Reversal Interest Rate: A Critical Review. Centro de estudios monetarios y financieros

Rogoff, K. (2016). The Curse of Cash. Princeton University Press.

Rogoff, K. (2017). Dealing with Monetary Paralysis at the Zero Bound. Journal of Economic Perspectives 31, 47–66.

Schelling, T., & Towbin, P. (2020). Negative interest rates, deposit funding and bank lending (No. 2020-05). Swiss National Bank.

Segoviano Basurto, M., & Goodhart, C. (2009). Banking stability measures. IMF working papers, 1-54.

Summers, L.H. (2013). Why stagnation might prove to be the new normal. Financial Times, 15, 12.

Summers, L.H. 2014. "U.S. Economic Prospects: Secular Stagnation, Hysteresis, and the Zero Lower Bound." Business Economics 49 (2): 65–73.

Ulate-Campos, M. (2019), ìGoing Negative at the Zero Lower Bound: The E§ects of Negative Nominal Interest Rates,î Federal Reserve Bank of San Francisco Working Paper 2019-21.

Urbschat, F. (2018). Three essays in modern macroeconomics and monetary policy (Doctoral dissertation, lmu).

Utzig, S. (2010). The financial crisis and the regulation of credit rating agencies: A European banking perspective.

Wingrove. (2020, May 12) Trump Hails 'Gift' of Negative Rates That Fed Officials Disdain. Bloomberg retrieved from http://www.bloomberg.com

Woodford, M. (2003). Optimal interest-rate smoothing. The Review of Economic Studies, 70(4), 861-886.

Xu, M.T., Hu, K., & Das, M.U.S. (2019). Bank profitability and financial stability. International Monetary Fund.

A. Appendix Supplementary Tables

Table A.1: **Overview of included ECB Banks**

Name (Group)	Country	Deposit Ratio
ABANCA CORPORACION BANCARIA SA	ES	0.830
ABN AMRO BANK NV	NL	0.665
ALLIED IRISH BANKS PLC	IE	0.755
ALPHA BANK AE	GR	0.832
BANCA MONTE DEI PASCHI DI SIENA SPA	IT	0.618
BANCA NAZIONALE DEL LAVORO SPA	IT	0.758
BANCO BILBAO VIZCAYA ARGENTARIA SA	ES	0.661
BANCO BPI SA	PT	0.729
BANCO DE SABADELL SA	ES	0.766
BANCO SANTANDER SA	ES	0.656
BANKIA, SA	ES	0.709
BANKINTER SA	ES	0.693
BANQUE EUROPEENNE DU CREDIT MUTUEL SAS	FR	0.838
BANQUE PALATINE SA	FR	0.917
BAYERISCHE LANDESBANK	DE	0.618
BNP PARIBAS FORTIS SA/ NV	BE	0.733
BRED BANQUE POPULAIRE SC	FR	0.714
CAIXA GERAL DE DEPOSITOS	PT	0.683
COMMERZBANK AG	DE	0.650
COOPERATIEVE RABOBANK U.A.	NL	0.591
CREDIT AGRICOLE	FR	0.440
CREDIT DU NORD SA	FR	0.628
CREDIT INDUSTRIEL ET COMMERCIAL SA – CIC	FR	0.718
1CREDIT MUTUEL (COMBINED - IFRS)	FR	0.474
DEKABANK DEUTSCHE GIROZENTRALE	DE	0.558
DEUTSCHE BANK AG	DE	0.374
DEXIA SA	BE	0.557
DVB BANK SE	DE	0.424
DZ BANK AG	DE	0.492
ERSTE GROUP BANK AG	AT	0.696
EUROPEAN INVESTMENT BANK EIB	II	0.012
HAMBURG COMMERCIAL BANK AG	DE	0.541
IKB DEUTSCHE INDUSTRIEBANK AG	DE	0.807
ING BANK NV	NL	0.701
INSTITUTO DE CREDITO OFICIAL	ES	0.279
INTESA SANPAOLO	IT	0.451
KBC BANK NV	BE	0.718
KFW BANKENGRUPPE	DE	0.052
LANDESBANK BADEN-WUERTTEMBERG	DE	0.476
LANDESBANK HESSEN-THUERINGEN GIROZENTRALE – HELABA	DE	0.447
LSF LOAN SOLUTIONS FRANKFURT GMBH	DE	0.626
MEDIOBANCA - BANCA DI CREDITO FINANZIARIO SOCIETA PER AZIONI	IT	0.392
NATIONAL BANK OF GREECE SA	GR	0.818
NATIXIS SA	FR	0.368
NIBC BANK NV	NL	0.513
NORDDEUTSCHE LANDESBANK GIROZENTRALE NORD/LB	DE	0.578
NORDEA BANK ABP	FI	0.495
OBERBANK AG	AT	0.774
PB INTERNATIONAL S.A	LU	0.893
PIRAEUS BANK SA	GR	0.875
PORTIGON AG	DE	0.237
RAIFFEISEN BANK INTERNATIONAL AG	AT	0.742
SOCIETE GENERALE	FR	0.349
UNICREDIT SPA	IT	0.616

Table A.2: **Results Hypotheses**

Hypothesis	(1) Volume	(2) Risk
H1: Under NIRP, banks with higher deposit-to-assets experience relative less lending growth in the European syndicated loan market.	*Not rejected*	-
H2: *Under NIRP, banks with higher deposit-to-assets experience more risk taking in the European syndicated loan market*	-	*Failed to reject*
H3: Lower profitable banks will experience a stronger treatment effect of deposit exposure, resulting in a i) lower lending volume and ii) higher risk profile.	*Rejected*	*Failed to reject*
H4: *Lower diversified income banks will experience a stronger treatment effect of deposit exposure, resulting in a i) lower lending volume and ii) higher risk profile.*	*Not rejected*	*Not rejected*
H5: *Lower grade banks will experience a stronger treatment effect of deposit exposure, resulting in a i) lower lending volume and ii) higher risk profile.*	*Not rejected*	*Failed to reject*
H6: *Banks of stressed countries will experience a stronger treatment effect of deposit exposure, resulting in a i) lower lending volume and ii) higher risk profile.*	*Not rejected*	*Failed to reject*

B. Appendix Supplementary Figures

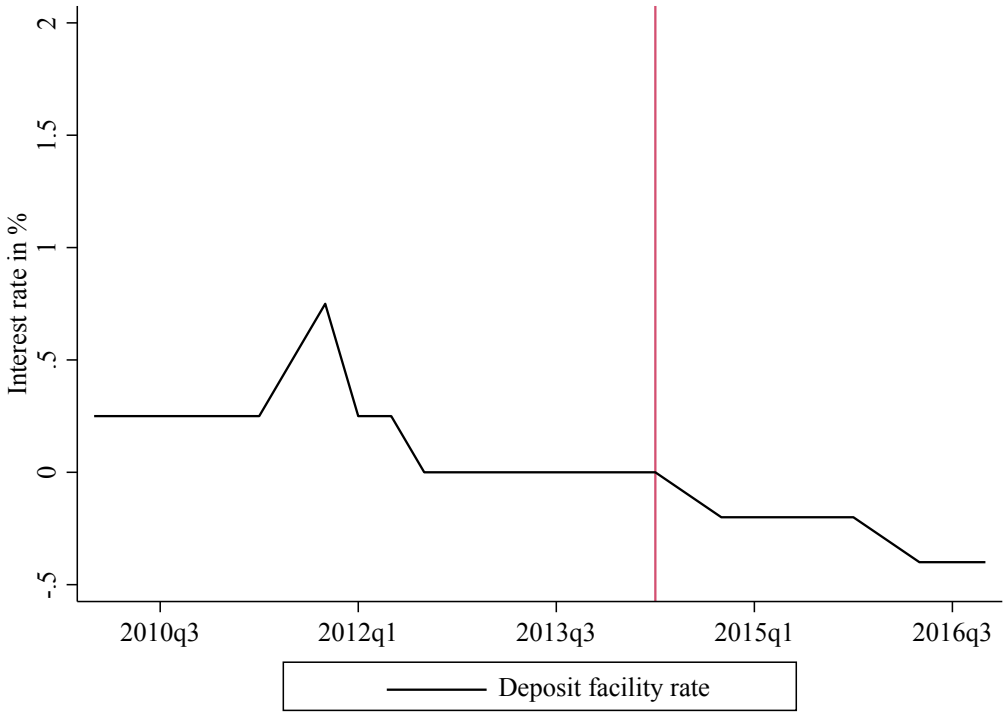
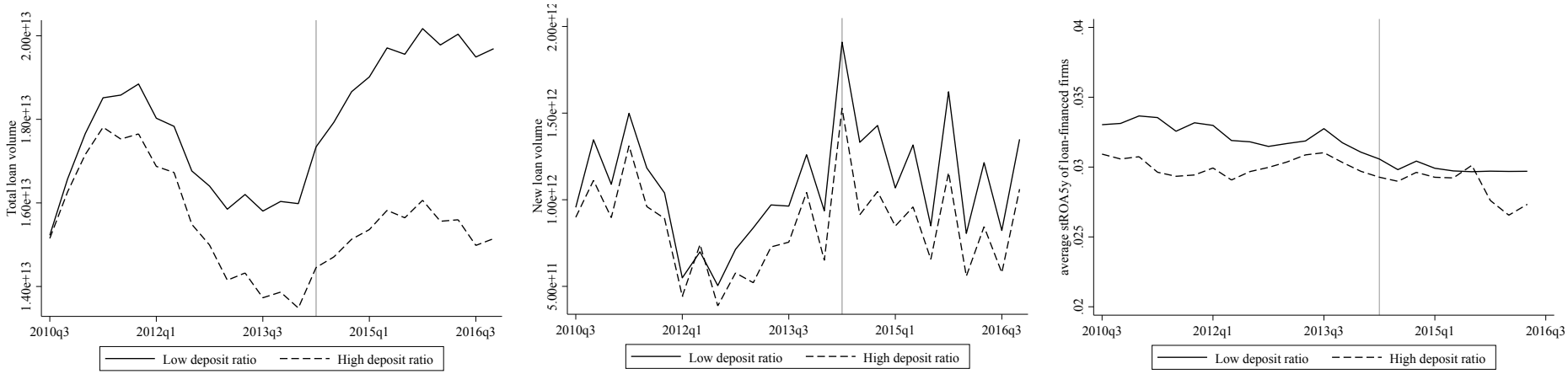
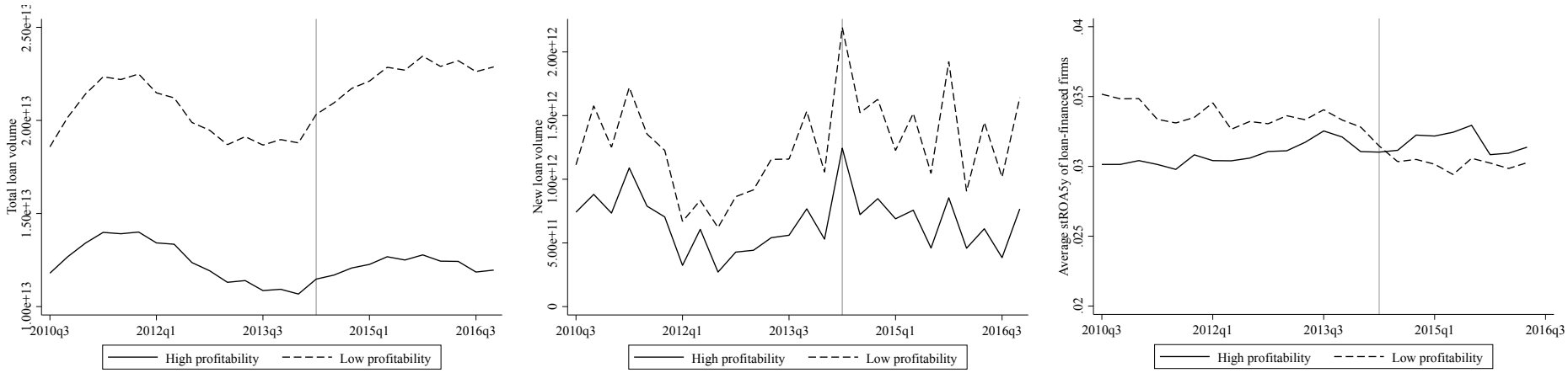


Figure B.1: **The Deposit Facility Rate expressed in (%) by quarter.** This figure plots the deposit facility rate, taken from the ECB index statistics, for the period of January 2010 to December 2016. With the red vertical reference line, the period after the introduction of negative interest rate in June 2014 is indicated.



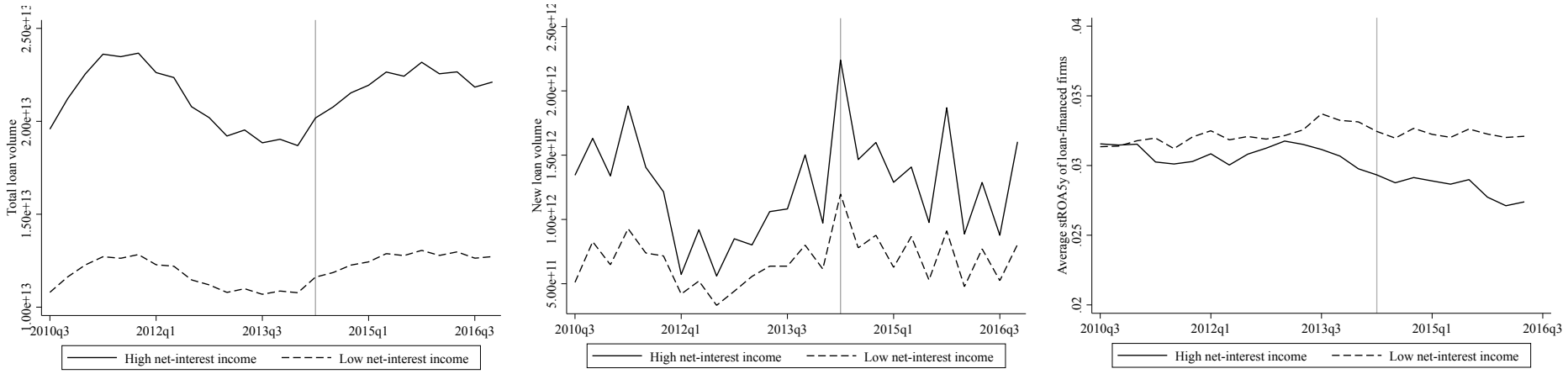
(a) Total loan volume (b) New loan volume (c) $\sigma\ (ROA_t)^{5y}$

Figure B.2: **Parallel path assumption of bank's deposit ratio (High vs Low).** This figure plots the (a) total loan volume, (b) the new loan volume and (c) the average five-year standard deviation of the borrowing company of banks in the European syndicated market in both the top tercile and the bottom tercile of the average ratio of deposits over total assets in the year 2013. The figure depicts the averages of the sample database from June 2013 to December 2016. $\sigma(ROA_t)^{5y}$ is average five-year standard deviation of firm j's return on assets using the P&L before tax from Compustat Global. The total loan volume is the sum of all sample bank's quarter-year outstanding loans. The new loan volume is the sum of all sample bank's quarter-year newly extended loans. The grey vertical reference line indicates the period of June 2014 onwards.



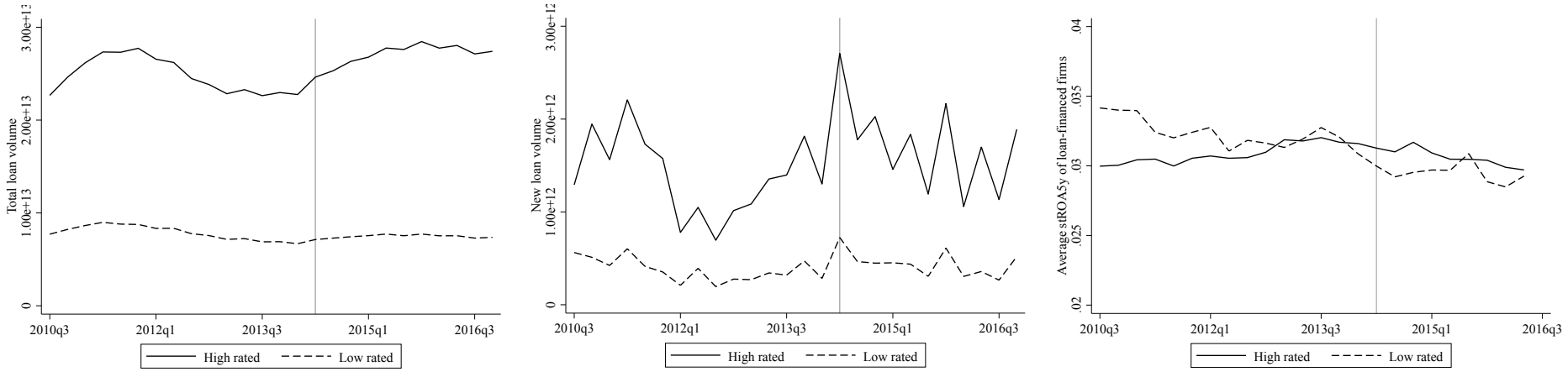
(a) Total loan volume (b) New loan volume (c) σ $(ROA_t)^{5y}$

Figure B.3: **Parallel path assumption of bank's profitability (High vs Low).** This figure plots the (a) total loan volume, (b) the new loan volume and (c) the average five-year standard deviation of the borrowing company of banks in the European syndicated market in both the top half and the bottom half of the return on average equity in the year 2013. The figure depicts the averages of the sample database from June 2013 to December 2016. $\sigma(ROA_t)^{5y}$ is average five-year standard deviation of firm j's return on assets using the P&L before tax from Compustat Global. The total loan volume is the sum of all sample bank's quarter-year outstanding loans. The new loan volume is the sum of all sample bank's quarter-year newly extended loans. The grey vertical reference line indicates the period of June 2014 onwards.



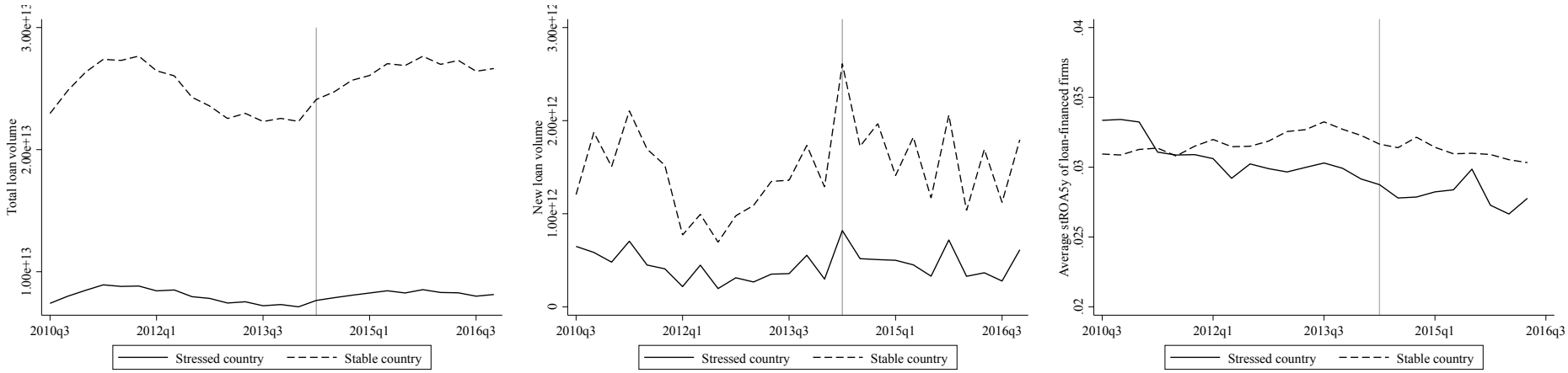
(a) Total loan volume (b) New loan volume (c) $\sigma\ (ROA_t)^{5y}$

Figure B.4: **Parallel path assumption of bank's net interest income over assets (High vs Low).** This figure plots the (a) total loan volume, (b) the new loan volume and (c) the average five-year standard deviation of the borrowing company of banks in the European syndicated market in both the top half and the bottom half of the net interest income over total assets in the year 2013. The figure depicts the averages of the sample database from June 2013 to December 2016. $\sigma(ROA_t)^{5y}$ is average five-year standard deviation of firm j's return on assets using the P&L before tax from Compustat Global. The total loan volume is the sum of all sample bank's quarter-year outstanding loans. The new loan volume is the sum of all sample bank's quarter-year newly extended loans. The grey vertical reference line indicates the period of June 2014 onwards.



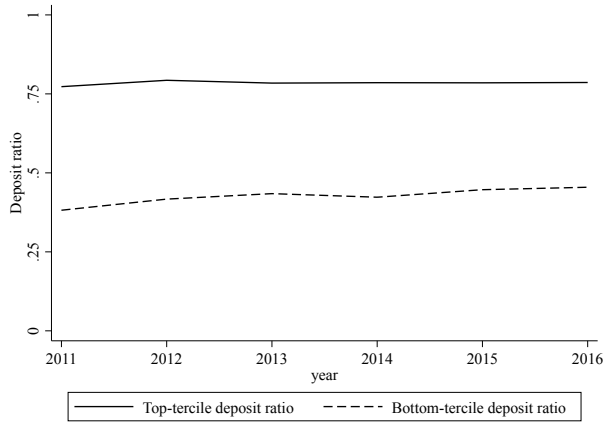
(a) Total loan volume (b) New loan volume (c) $\sigma(ROA_t)^{5y}$

Figure B.5: **Parallel path assumption of bank's rating (High vs Low).** This figure plots the (a) total loan volume, (b) the new loan volume and (c)) the average five-year standard deviation of the borrowing company of banks in the European syndicated market in both the top half and the bottom half of the Fitch rating in the year 2013. The figure depicts the averages of the sample database from June 2013 to December 2016. $\sigma(ROA_t)^{5y}$ is average five-year standard deviation of firm j's return on assets using the P&L before tax from Compustat Global. The total loan volume is the sum of all sample bank's quarter-year outstanding loans. The new loan volume is the sum of all sample bank's quarter-year newly extended loans. The grey vertical reference line indicates the period of June 2014 onwards.

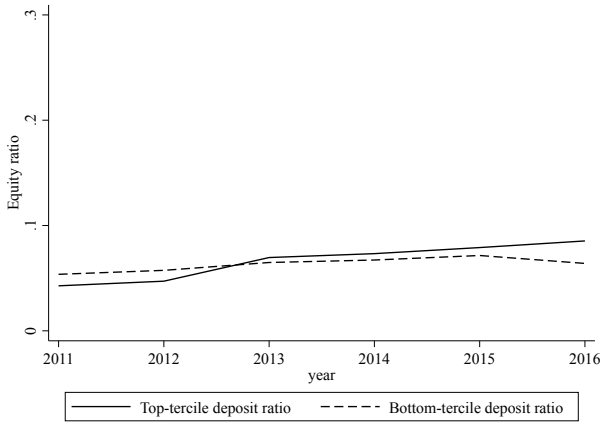


(a) Total loan volume (b) New loan volume (c) $\sigma(ROA_t)^{5y}$

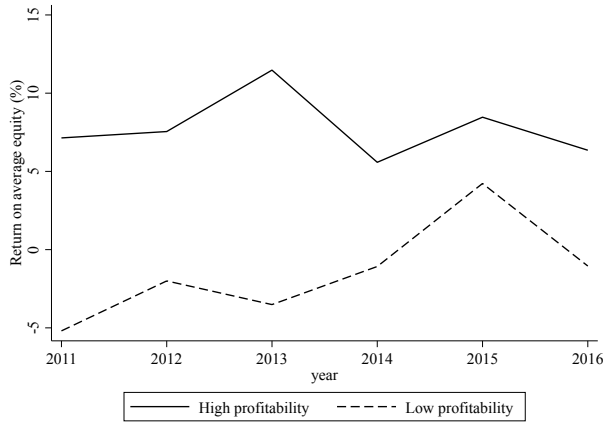
Figure B.6: **Parallel path assumption of bank's country's financial condition (Stressed vs Stable).** This figure plots the (a) total loan volume, (b) the new loan volume and (c) the average five-year standard deviation of the borrowing company of banks in the European syndicated market in both the top half and the bottom half of the financial condition of originated country in the year 2013. The figure depicts the averages of the sample database from June 2013 to December 2016. $\sigma(ROA_t)^{5y}$ is average five-year standard deviation of firm j's return on assets using the P&L before tax from Compustat Global. The total loan volume is the sum of all sample bank's quarter-year outstanding loans. The new loan volume is the sum of all sample bank's quarter-year newly extended loans. The grey vertical reference line indicates the period of June 2014 onwards.



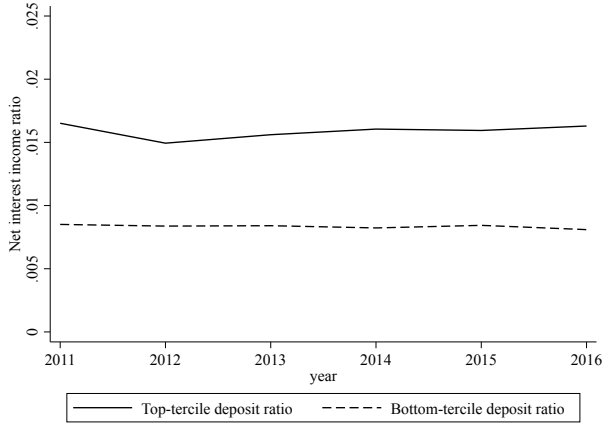
(a) Deposit ratio



(b) Equity ratio



(c) Return on average equity



(d) Net interest income ratio

Figure B.7: **The Development of Bank's specific Characteristics in term of High vs Low Deposit ratio (a, b, and d) and High vs Low Profitability (c).** This Figure plots the development of deposit ratio, equity ratio, return on average equity and net interest income over assets for ECB banks in the top or bottom tercile of deposit ratios in figure (a), (b) and (d) and top and bottom half of return on average equity in the year 2013