ERASMUS UNIVERSITY ROTTERDAM

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Master Thesis [Financial Economics]

Title

Is there an effective lower bound? The consequences of negative deposit facility rate in banks' lending behavior, maturity transformation and real economy

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ABSTRACT

This thesis investigates how the negative deposit facility rate affects the lending behavior and maturity transformation of different type of banks and how this monetary policy is transmitted to the real economy. It is indicated that banks can offer negative rates to their depositors, increasing at the same time their customer deposits. This transmission effect becomes more pronounced when ECB decides to deepen the negative interest rates even further. High deposit ratio banks that charge negative rates, increase their loan supply more than other banks. This indicates the effectiveness of the monetary policy transmission mechanism. Moreover, high deposit banks with sound balance sheets, manage to increase the maturity of their long-term assets to mitigate their deposit franchise fixed costs. High current assets firms that are associated with banks which charge negative rates, invest more in their fixed assets, and improve their performance. Overall, my results challenging the norm that unconventional monetary policy, cannot achieve much when interest rates cross-over the zero-lower bound.

Keywords: monetary policy, negative rates, deposit ratio, soundness, maturity transformation, real effects

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1. Introduction

Since the European Central Bank (ECB) turned out on being the first major bank to pass its Deposit Facility Rate (DFR) below the zero lower bound, a variety of questions have arisen regarding the riskiness and effectiveness of this monetary policy. However, there is limited empirical research on the effects of negative policy rates because this field was completely unknown before 2014. This study combines the findings of previous work and embeds new ideas, contributing to a more precise and complete outcome.

Altavilla, Burlon, Giannetti, & Holton, (2019), considering bank soundness, have shown that eurozone banks with sound balance-sheet manage to offer negative deposit rates after the ECB had lowered the DFR below zero, in mid 2014. These banks manage to increase their lending, as they experience a positive shock to their net worth by decreasing their overall cost of funding. They also indicate that firms cooperating with sound banks, decrease their holdings in liquid assets and invest more in tangible and intangible assets. As a result, it is shown that these firms manage to increase their profitability. Heider, Saidi, & Schepens, (2019), analyzing bank deposit ratio level, have found that banks with great reliance on deposit funding, decrease their lending and increase their risk taking when policy rate turn into negative. High-deposit banks sustain a negative shock to their net wealth, as they experience higher cost of funding relative to low-deposit banks.

Based on these findings, this paper examines banks' lending behavior and maturity transformation, considering different combinations of bank soundness (sound, non-sound) and deposit ratio levels (high, low), prior and after the ECB sinks the interest rates below the zero lower bound (ZLB). Maturity transformation constitues a completely new idea, aiming to show how different type of banks adjust the maturity of their long-term assets after the implementation of the NIRP in order to hedge interest rate risk or their fixed costs. Last but not least, following Altavilla, Burlon, Giannetti, & Holton, (2019), I investigate how firms' exposure to banks that charge negative rates, affects their investment and performance.

There is a conventional wisdom that when interest rates have already been indistinguishable from zero, monetary policies are not effective anymore (Correia, Farhi, Nicolini, & Teles, 2013). Banks appear reluctant to offer negative deposit rates,

fearing that market shareholders will withdraw their money. If this happens, banks will sustain a negative shock to their major funding source. Therefore, when interest rates are close to zero, central banks would not have the opportunity to encourage credit supply and demand by decreasing even more these rates. However, in June 2014, the ECB lowered its DFR below zero, and, since then, an effective lower bound has not yet met.

My research challenges this conventional wisdom of negative interest rate policy (NIRP) inability to achieve monetary easing accommodation. In the beginning of the NIRP, a few banks lowered their interest rate on a considerable proportion of their deposits. Since then, the ECB has cut the DFR four more times, with the last two being in March 2016 and September 2019 . As a result, even more banks started to charge negative deposit rates. Following previous research, banks with sound balance-sheet are more prompt to pass negative rates. However, my results indicate that non-sound high deposit banks increase their lending in greater extend than the other banks, when policy rate becomes negative. Non-sound banks increase their lending by 10,9%, when their deposit ratio is raised by 1 percentage point. This result is consistent with the fact that, a lot of banks, regardless their soundness, lowered their interest rate on deposits. A large fraction of non-sound banks (59%) in my sample, offers negative deposit rates. According to previous findings, banks with lower non-performing loan ratio, in other words sound banks, do not deal with reductions in their deposits, when they offer negative rates. In my research, these banks experience an increase in their lending by 10,1% when their deposit ratio increases by 1 percentage point. Moreover, banks with sound balance-sheet, headquartered in eurozone countries that are less exposed to the sovereign debt crisis, increase even more the volume of their loans. More specifically, credit supply of these banks raises by 10,2%, when they increase their deposit ratio by 1 percentage point, after the ECB's negative policy rate implementation. The continuous reductions in DFR indicate that the ECB has not yet met the bottom rate which is going to harm banks' profits and shrink their lending.

A standard issue of identifying how banks' credit supply has been impacted by monetary policy, is the endogeneity of the policy. Concerns about the downturn of economic conditions led the ECB to implement negative rates. However, this deterioration period coincides with less lending from banks due to the lower availability of lending opportunities. As the economic downturn drives both negative interest rates

and banks' lending volume, the estimated impact of monetary policy rates is biased. The endogeneity of interest rates policy can be handled by comparing the lending behavior of banks based on their soundness and deposit ratio. The impact of deterioration is canceled out, as every type of bank is dealing with the same downturn in economic conditions. Another concern stands for the uniqueness of policy rates. I examine if banks' deposit ratio is of great import for the transmission of negative rates to banks' credit supply by considering various policy rate changes, regardless their magnitude, point in time and whether they are decreases or raises. I find that the pass-through of policy rates to banks' credit supply, occurs only when policy rate becomes negative.

As a next step, this research investigates the extent that different combinations of banks' deposit ratio and soundness affect their maturity transformation when interest rates turn into negative. High deposit banks, are extremely exposed to interest rate risk once the ECB implements the NIRP. Hence, I expect that these banks increase the maturity of their long-term credit with a view to increase their income. Indeed, I find that after the implementation of negative rates, banks increase the maturity of their long-term assets by 5,3%, when their deposit ratio is raised by 1 percentage point. It is also hypothesized that banks with sound balance sheet and high deposit ratio are more likely to have a great deposit franchise, and, thus, they are immune to interest rate changes. Sound banks increase the maturity of their loans by 11,6% when their deposit ratio is raised by 1 percentage point. These banks hedge the fixed costs of their deposit franchise in that way. A large deposit franchise becomes of great importance, when interest rates turn into negative territory.

Finally, the paper examines whether firms that hold a lot of cash and have relationships with banks that charge them with negative rates, increase their investment and profitability. By increasing the maturity of their assets, these companies aim to improve their performance. I find that firms which are more exposed to negative rates, through their current assets, invest more in their fixed assets. Moreover, these companies improve their earnings before interest, taxes, depreciation, and amortization (EBITDA) and their return on assets (RoA). When firms increase their exposure, to banks that offer negative rates on deposits, by 1%, they improve their EBITDA and RoA by 23,5% and 46,4%, respectively. This behavior is more pronounced when firms are linked to sound banks.

Therefore, in contrast with the conventional wisdom, I find that, when high deposit banks manage to charge negative rates on their deposits, the unconventional monetary policy can provide effective stimulus to the economy, affecting both banks' and firms' behavior.

The rest of the paper is organized as follows. Section II briefly reviews the current literature and the contribution of this paper. Section III provides comprehensive information on the implementation of negative interest rates and expands on the research hypotheses of this study. Section IV describes the sample and data used in the research, as well as the applying methodology. Section V presents the empirical results and the analyses. Section VI contains the summary and conclusions.

2. Related Literature and Contribution

ECB was the first central bank to set its DFR below zero. There are extensive theoretical and empirical analyses, studying how policy rates transmit to the real economy when interest policy rates decline but are still positive (see Correia, Farhi, Nicolini, & Teles, 2013; Eggertsson, 2003; Jiménez, Ongena, Peydró, & Saurina, 2012). However, there are no sufficient empirical studies, indicating the effect of policy rates when they turn into negative, considering that it was a completely unknown field before 2014.

Altavilla, Burlon, Giannetti, & Holton, (2019) show that banks with sound balance-sheet are more likely to offer negative rates to their depositors after the NIRP implementation. They denote as sound, banks with low credit default swaps (CDS) spreads and non-performing loans and find that deposits tend to increase more in sound banks than in non-sound. Since banks that charge negative deposit rates do not deal with any deposit reduction, they experience a positive shock to their net worth. As the overall cost of funding decreases, they increase their lending. The authors also indicate that firms cooperating with sound banks, improve their profitability by investing their liquid asset holdings in tangible and intangible assets. Thus, it appears, banks' heath and soundness contribute to the transmission of monetary policy, when deposit facility rate becomes negative.

Heider, Saidi, & Schepens, (2019) argue that deposit ratio might play a major role in banks' lending channel. High-deposit banks are disinclined in offering negative rates to their depositors; hence their cost of funding will be increased, and their net wealth will be reduced, relative to low-deposit banks. Moreover, banks with a lot of household deposits do not have incentives to transmit negative deposit rates on households, as the latest are more likely to withdraw their money than corporations. Based on this evidence, they examine how banks' credit supply was affected by negative policy rates, comparing the lending behavior of banks with different deposit ratio, prior and after the implementation of the ECB's NIRP. The authors found that high-deposit banks decrease their loan shares and increase their risk-taking, while low-deposit banks increase their credit supply in safer borrowers. This risk-taking behavior suggests that NIRP could pose a risk on financial stability. However, they investigate a small period of time after the NIRP implementation, where the majority of banks had not charged

their depositors with negative rates yet. Thus, they do not consider the effect on lending behavior when the bank is able to offer negative deposit rate.

In this research, both deposit ratio and soundness are taken into account in order to limit the scope for other measures affecting the findings. The explanatory power of individual bank's deposit ratio in credit supply, combined with bank's soundness might be the best indicators to investigate the change in banks' lending behavior.

This study extends current literature, by investigating both banks' deposit ratio and financial stability simultaneously and controlling for possible factors that affect the main findings. I also examine if banks change the maturity of their long-term assets when policy rates turn into negative. Banks with greater reliance on deposit funding tend to increase their long-term loans more than low deposit banks, as the maturity transformation hedges bank's interest rate risk. Moreover, I investigate if sound banks, that are more prompt to have a strong deposit franchise, increase their lending maturity. Deposit franchise gives banks market power which enables them to adjust their deposit rates without being confronted by deposit outflows. Consequently, banks that have strong deposit franchise avoid interest rate risk and have to mitigate only the deposit franchise fixed costs, by increasing the maturity of their long-term assets (Drechsler, Savov, & Schnabl, 2018). I aim to show if indeed deposit franchise has implications to the transmission of monetary policy, through the increased supply of long-term loans from sound banks. This investigation is conducted under the assumption that deposit ratios remain unchanged over time and that sound banks have a strong deposit franchise. As a final step, I examine the change in investment and performance of firms that are exposed to the NIRP.

My work not only takes part in a flourishing literature by investigating the effectiveness of monetary policy transmission mechanism, but also can contribute to several implications for regulators. Stricter monitoring of banks' behavior can extract significant results for further regulatory action.

3. Institutional Background and Hypotheses Development

On June 11, 2014, the ECB reduced the DFR below the zero lower bound and adventured into negative terrain for the very first time in its history. ECB established the DFR to -0.10% and few months later, on September 10, 2014 the DFR was dropped once more to -0.20%. Implementing negative rates in mid-2014 was seen like a risky and debatable decision, as no major central bank had experienced negative rates before[1]. The DFR is the rate on the deposit facility, which banks may use to make overnight deposits with the Eurosystem. The Governing Council of the ECB, is the responsible authority for setting euro area key interest rates, and since 2014 the DFR has been lowered three more times, on December 9, 2015, to -0.30%, on March 16, 2016, to -0.40%, and on September 18, 2019, to -0.50% (see Figure 1). This was part of a more extensive monetary policy easing package, which ultimately also involved the initiation of targeted long-term refinancing operations (TLTROs) and a large-scale asset purchase program (APP) of private and public sector bonds (Eisenschmidt & Smets, 2019).

The main purpose of ECB was to provide monetary easing accommodation (Praet, 2014), incentivizing commercial banks to reduce their excess liquidity holdings and reallocate the deposited money. In the past, banks were making limited use of deposit facilities, indicating that the interbank market was functioning normally, until the collapse of Lehman Brothers in September 2008. The situation has changed thoroughly since then, and the amounts on deposits with the ECB by banks which had excess liquidity, increased dramatically (Pisani-Ferry & Wolff, 2012). When Mario Draghi stated that the ECB would do “whatever it takes” to maintain financial stability, and after the implementation of 0% DFR, the deposits’ level fell by half. The fact that the deposited excess liquidity received no interest and the amounts on deposits were still high, prompt the ECB to set a negative interest rate policy in order to encourage euro area banks to increase their credit supply.

In general, banks prefer investing their excess liquidity in two ways. First, by depositing their surplus with the ECB and second lending it to another bank in the Eurosystem

[1] The ECB moved first, on 11 June 2014, National bank of Denmark followed on 5 September 2014, cutting the rate on certificates of deposit from +5 to –5 bp, Swiss National Bank went negative on 18 December 2014 when it announced that sight deposits exceeding a certain threshold would earn –25 bp from 22 January 2015 onwards, Swedish Riksbank cut its repo rate to –10 bp on 18 February 2015, whereas the Bank of Japan announced on 29 January 2016 that it would apply a rate of –10 bp to part of the balances in current accounts (Bech & Malkhozov, 2016).

(Altavilla, Burlon, Giannetti, & Holton, 2019). To ensure that Euro OverNight Index Average (EONIA)[2] is not too volatile, ECB provides banks with credit and deposit facility rates. These rates can then be used to regulate fluctuations in the interbank interest rate. As far as the deposit rate is exceeded by the lending rate, banks will be more willing to invest their excess liquidity by lending to other banks in the interbank market. This is consistent with their attempt to avoid using the relatively lower deposit rate provided by the ECB (Jobst & Lin, 2016). Therefore, it is not sufficient to reduce only the main refinancing rate, to ensure that the monetary policy accommodation is transmitted to the interbank market. As a matter of fact, a central bank's most significant policy rate, is the interest rate at which banks are able to deposit their cash holdings, especially in a surplus liquidity environment (Cœuré, 2014).

To assure the success of the NIRP and to provide even more monetary accommodation, ECB pledged to a policy of APP[3] (Di Maggio, Kermani, & Palmer, 2020). It started in March 2015, and since then, it was extended several times. Therefore, banking costs related with surplus liquidity, increased with every course of further funding through the extension of the APP and not only with the reduction of every rate.

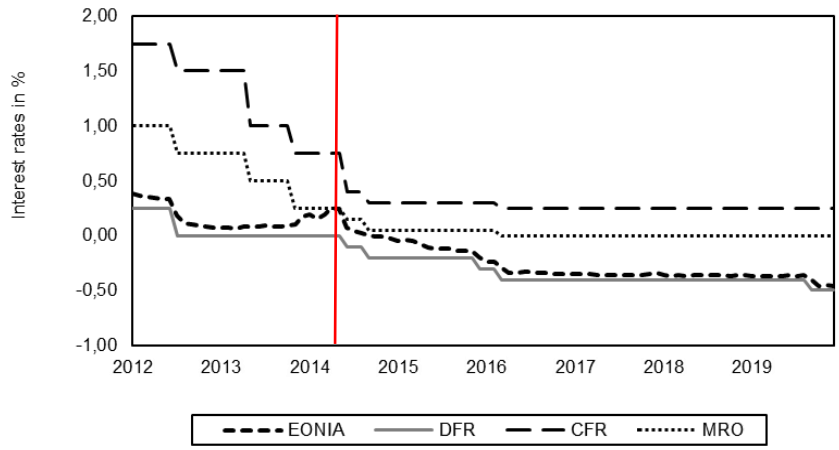

Figure 1
The deposit facility rate, the credit facility rate, the main refinancing operations rate, and the euro overnight index average
This figure shows the evolution of the average monthly euro overnight index average rate for euro-area banks between January 2012 and December 2019, in comparison with the deposit facility rate (DFR), the credit facility rate (CFR) and the main refinancing operations (MRO) rate. The DF rate, the CF rate and the MRO rate are taken from the official ECB website. EONIA average monthly rate is taken from EMMI website. Values in the vertical axis are interest rates in percentages. The vertical red line is drawn in June 2014.

[2] The Euro Overnight Index Average (Eonia) is the average overnight reference rate for which European banks lend to one another in euros. The Eonia is the interest rate for one-day loans between European banks and is considered an interbank rate. It is calculated by the ECB based on the loans made by 28 panel banks. However, due to European regulatory reforms, Eonia is expected to be replaced by 2022 with a more comprehensive benchmark called ESTER (Kenton, 2020).

[3] The ECB's Asset Purchase Program (APP) is part of a package of non-standard monetary policy measures that also includes targeted longer-term refinancing operations, and which was initiated in mid-2014 to support the monetary policy transmission mechanism and provide the amount of policy accommodation needed to ensure price stability (European Central Bank, 2020).

In bank-centered financial systems, similar to the existed one in the euro zone, the transmission of monetary policy impact into the real economy is significantly driven by banks. This transmission happens through changes in the banks' credit supply, which is affected from changes based on banks' external finance premium (Gertler & Kiyotaki, 2010). Regularly, when the policy rates are lowered but remain in positive territory, they transmit to lower rates on deposits as well as on market-based funding. These policy rates increase the banks' credit supply since they decrease the external finance premium of banks[4] (Bernanke & Gertler, 1995). Lower policy rates are translated into lower rates on short-term liabilities. This change on short-term liability rates, decreases the banks' cost of funding. When banks manage to lower their funding expenses, they increase their net wealth and, hence, they are driven to more "skin in the game" for insiders. As a result, they increase their lending and have more incentives to carefully screen and monitor their borrowers. On the other hand, when the bank's net worth is poor, then "skin in the game" is limited, banks cannot achieve sufficient intermediation, and the agency problem is inevitable (Dell'Ariccia, Laeven, & Marquez, 2014). This was a collective description of a bank's balance sheet channel, which focuses on the bank lending volume and contributes to the monetary policy transmission.

Reactions in banks' behavior are unclear when there are continuous transformations in monetary policy rates and when these rates are reduced below zero. For financial intermediaries, the fundamental level of policy rates is not considered of great importance. However they are concerned about the difference between the interest rate they defray and the interest rate they realize for every monad of money they intermediate (Hannoun, 2015). Decreasing the policy rate below zero is significant, considering that the impact on deposit and market-based funding costs, is differentiated. Negative interest rate does not transmit to lower, negative deposit rates; However, they only transmit to lower, below zero market rates (Heider, Saidi, & Schepens, 2019). Consequently, banks' cost of funding remains relatively high and the spread between the interest income and expense declines (Claessens, Coleman, & Donnelly, 2016).

[4] Raising external funds is costly for banks because of agency conflicts between outside investors and inside decision makers. Conforming with the "credit view", a change in monetary policy that reduces the open-market interest rates, also reduces the external finance premium. The size of the external finance premium limits the amount of intermediation that banks can perform (Holmstrom & Tirole, 1997).

Negative rates are only transmitted to market rates because banks are in general unwilling to offer negative deposit rates and charge their depositors. One possible explanation is the concern that depositors will withdraw their money due to the zero-nominal return on cash and banks will not be able to replace easily the lost deposits with other funding sources (Bernanke & Blinder, 1988). However, household deposits should be more affected by this dispute than corporate deposits. According to theory, households are more flexible on removing their deposits and hold cash than the enterprises, since household accounts are fewer and include less amount of money. Consistent with this rationale, some banks avoid charging negative rates to their small household deposits; however they are more willing to offer negative deposit rate to the large amounts held by corporate clients, pension funds and investment firms (Hayes, 2020). This behavior motivates corporate depositors to invest their excess liquidity in bonds and other financial instruments that offer better yields and at the same time protect the bank and economy from the negative effects of running out of cash.

Since the ECB has implemented a negative policy rate in June 2014, high-deposit ratio banks, undeniably experience a trauma on their net wealth compared to low-deposit ratio banks. Figure 2 shows an (unweighted) stock price index for the listed eurozone banks, for which I could extract stock data, in the highest and lowest tercile of the deposit ratio distribution. After March 2016, when the ECB reduce the DFR once more time to -0,40%, there is a greater disconnect: low-deposit banks have better performance, because they manage to charge negative rates to their depositors, in contrast with high-deposit banks which are reluctant to offer negative rates and

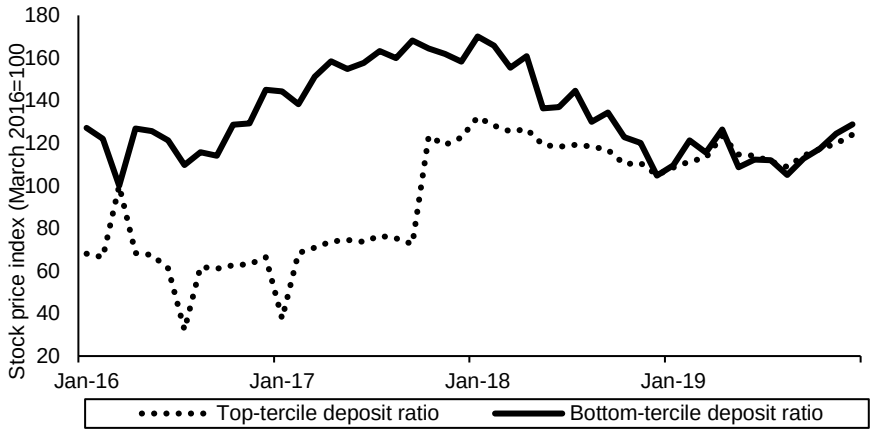

Figure 2
Stock price index of listed euro area banks with high- versus low-deposit ratios
This figure shows the evolution of a monthly stock price index (March 2016 =100) for listed euro-area banks in my sample between January 2016 and December 2019. I calculate a price index for each of the two bank categories and plot the average index for banks in the top (dashed line) and bottom tercile (solid line) of the deposit-ratio distribution in 2013. Stock market data are taken from Datastream

experience an increased cost of funding as well as poor performance. However, it seems that since middle 2017, the stock prices of high-deposit banks perform much better and from 2019 onwards, they are identical with those of low deposit banks. This might be due to the decision of numerous banks to start offering negative rates to their depositors in order to improve their performance. In normal times, an unexpected decrease on the positive short-term policy rate, increases the stock prices of banks despite the level of their deposit-to-asset ratio. These effects were stronger during the crisis period and reversed during the period with negative rates. In negative territory, every interest rate reduction have a detrimental effect on banks' equity value and this is more pronounced for banks with great reliance on deposit funding, compared to other banks (Ampudia & Van den Heuvel, 2018).

The conventional wisdom that banks cannot offer interest rates below zero to their depositors, because of the doubt of withdrawal, was challenged by Altavilla, Burlon, Giannetti, & Holton, 2019. They indicate that banks which have sound balance sheets are capable of charging negative interest rates on a considerable part of their deposits. In periods that policy interest rates are negative concur with lower spent on investments and consumption and necessity for 'risk-free' assets (Altavilla, Boucinha, & Peydró, 2018). As a result, sound banks are strongly preferred by depositors (Goldberg & Hudgins, 2002). Since corporations with large cash holdings cannot simply shift to paper money, banks with sound balance-sheet take advantage the increased demand for safer assets by charging deposit interest rates below zero. In most circumstances banks may retain a zero lower bound for household deposits which are relatively fewer, and thus, can be removed and kept as cash; However this is not the case with corporate deposits, as corporations cannot manage their operations without deposits so efficient. Once the ECB implement the NIRP, healthy banks are more prompt turning their deposit rate into negative. Consequently, when banks are willing to pass negative rates on their depositors, the transmission mechanism of monetary policy is not hampered.

Since the ECB sank the DFR in negative territory for its first time in mid-2014, euro area sound banks started to offer negative rates to their corporate depositors. A small portion of banks implemented interest rates on their corporate deposits, which were even lower than the DFR (Bottero, et al., 2019). ECB lowers even further the DFR, proposing that interest rates have not yet met an effective lower bound, where their

negative effects on bank profitability might compel to a lending shrinkage (Brunnermeier & Koby, 2016). If banks that charge negative rates do not deal with any deposit outflow, their overall cost of funding might be reduced. Hence, these banks may encounter a favorable impact to their net worth when the DFR is in negative territory (Altavilla, Boucinha, Holton, & Ongena, 2018). Figure 3 illustrates that banks which charge their depositors with negative rates, manage to raise their credit supply and even better to slightly increase their deposits (relative to banks that do not offer negative rates), endorsing that the transmission mechanism of monetary policy is successful. Both lending and deposit volume increase, and this increase becomes more pronounced in 2019, when ECB moves further into negative territory.

The eurozone constitutes an optimal environment to examine whether the most important issues initiated by the transmission of the NIRP, were caused mainly by a stressed banking system . From 2009 onwards, Greece, Ireland, Italy, Portugal, and Spain (the GIIPS countries) were confronted with a sovereign debt crisis. Their outstanding debt was extremely difficult to be refinanced due to the concerns about their high indebtedness (Acharya & Steffen, 2015). The financial sector was heavily impacted by the deterioration in the countries' creditworthiness due to banks' large sovereign exposures on these countries (Acharya, Drechsler, & Schnabl, 2014) and, as a result, bank lending contracted substantially, causing severe issues on domestic borrowers (Acharya, Eisert, Eufinger, & Hirsch, 2018). The sovereign debt crisis had

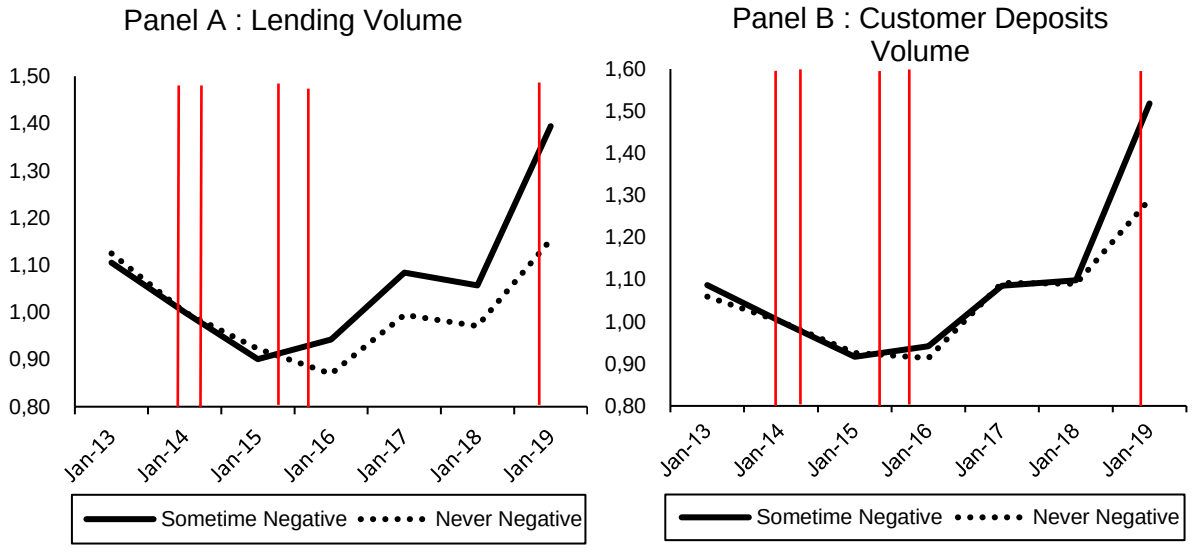

Figure 3
Lending and customer deposit volumes for banks with and without negative rates
This figure shows the total lending (Panel A) and the total customer deposits (Panel B) of banks that never offer negative deposit rates compared to banks that do offer negative deposit rates sometime in the given period. Sometime in the given period means that there are banks which started to charge negative rates later than other banks. Some non-sound banks in the sample implement negative deposit rate after 2016, where the ECB sunk further the DFR. Total volumes for the two categories are calculated as the average volume of each bank category and are normalized to the level in 2014. The red vertical lines indicate the five episodes of DFR reductions below zero.

an adverse effect on countries which were considered as financially stable. The bond prices of these countries inflated as a consequence of investors' desire for safer assets (J Caballero & Farhi, 2018). Consequently, a lot of banks in non-stressed[5] countries were less impacted by the sovereign crisis, as they were more inclined to offer negative deposit rate.

Taking all the above into consideration, the different way that the NIRP is transmitted to deposit and market rates, affect banks' exposure in a distinct way to the negative policy rates, based on the composition of their balance-sheet liability side. Banks which are heavily relied on deposit funding, experience higher funding costs relative to banks with minor reliance on deposit, and, hence, a negative impact to their net worth. Following the work of Heider, Saidi, & Schepens, (2019), high deposit banks decrease their loan supply and increase their risk taking when interest rates turn into negative. I aim to investigate if the first part of this finding holds in my sample through the following hypothesis:

1a) Banks with high deposit ratio, decrease their loan supply.

However, I expect the combination of soundness and deposit ratio to mitigate this effect and lead in an adverse scenario for high deposit banks. Ceteris paribus, my empirical strategy and its robustness is motivated by this assumption throughout the whole analysis. According to Altavilla, Burlon, Giannetti, & Holton, (2019), sound banks increase their lending after the implementation of the NIRP. These banks are more willing to charge negative rates to their depositors and, thus, encounter a positive impact in their net worth, especially when their deposit ratio is high. In sum, I aim to test the following hypothesis:

1b) Sound banks with high deposit ratio, increase their loan supply much more than the other banks.

Maturity transformation is a designated bank operation that includes the ability of banks to finance their long-term assets by short-term liabilities. It is an essential function, because it finances corporations with long-term loans and provides households short-term, liquid deposits. In general, maturity transformation is important for banks' profitability because they intent to obtain the interest margin, which is the difference

[5] Following Altavilla, Burlon, Giannetti, & Holton, (2019), I consider as "stressed" the GIIPS countries as well as Slovenia. They define "stressed" those countries whose 10-year sovereign yield exceeded 6%, for at least one quarter in their sample period.

between the long- and short-term rates; however, banks are exposed to interest rate risk (Flannery, 1983). An unanticipated raise in short term rate, increases banks' cost of funding relative to income of lending, cutting down the term premium and draining banks' capital (Gomez, Landier, Sraer, & Thesmar, 2020). After the implementation of the NIRP high-deposit banks have experienced a negative impact to their net wealth compared to low-deposit banks. Banks with greater reliance on deposits are reluctant to offer negative rates to their depositors and their cost of funding remains relatively high. Hence, these banks may increase the maturity of their long-term credit. Figure 4 depicts the maturity evolution of syndicated loans provided by euro area banks, in the highest and lowest tercile of the deposit ratio distribution. The long-term assets' maturity of high deposit banks seems to remain unchanged until mid-2014, while low-deposit banks increase the maturity of their long-term assets. As it is expected, after the NIRP implementation, banks in the top-tercile of the deposit ratio distribution increase the maturity of their long-term credit, much more than the bottom-tercile deposit ratio banks.

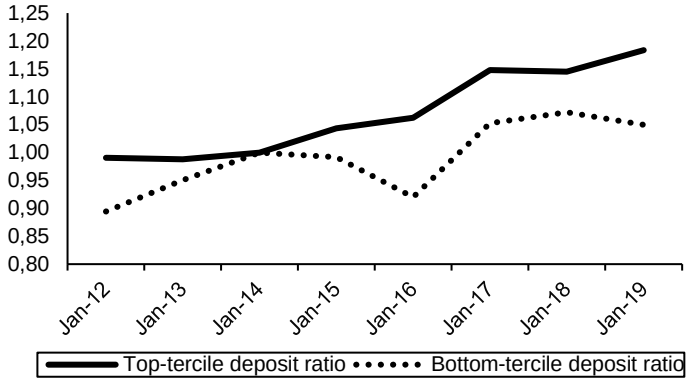

Figure 4
Maturity transformation depending on banks' deposit ratio
This figure shows the change in the maturity of syndicated loans provided from euro-area banks, compering maturity transformation of high-deposit banks with this of low-deposit banks. Maturity is calculated as the average yearly maturity of high- and low-deposit banks and is normalized at the level in 2014.

Some banks are not confronted with interest rate risk, although they may have a considerable maturity mismatch, and the rationale on this, lies on the deposit franchise. Maturity transformation decreases the amount of risk that banks deal with, due to their deposit franchise. Market power over retail deposits is provided by banks that have a strong deposit franchise. These banks are allowed to borrow at rates that are low and at the same time insensitive to the market short rate (Drechsler, Savov, & Schnabl, 2018). Market power is not free of charge as it incurs high costs for banks to run a deposit franchise (branches, salaries, marketing), however these costs are mainly

stable and thus insensitive to the short rate. It is then reasonable for banks to hold long term fixed assets. In this way they mitigate the cost of their deposit franchise by insulating their profits from interest rate risk. I assume that these costs might be afforded only from sound banks. Figure 5 shows the maturity evolution of syndicated loans provided by euro area banks, in the highest and lowest tercile of the non-performing-loans-to-liabilities distribution. Indeed, sound banks which have a considerable deposit franchise, and hence insensitive interest expenses, increase the maturity of their long-term assets. However, figure does not consider how sound banks' deposit ratio could influence their maturity transformation.

Considering that high deposit banks have huger exposure to interest rate risk compared to low deposit banks, I expect that banks which are heavily relied on deposit funding will increase the maturity of their long-term assets:

2a) Banks with high deposit ratio increase their loan maturity.

According to my assumption that sound banks are able to run a deposit franchise, and, thus, manage to hedge the interest rate risk effectively through maturity transformation, I expect that soundness does not have an adverse effect on high deposit ratio banks. Instead, it might have a pronounced effect when the bank has a sound balance-sheet. Hence, I aim to investigate the following hypothesis:

2b) Sound-banks with high deposit ratio increase the maturity of their long-term assets more than the other banks.

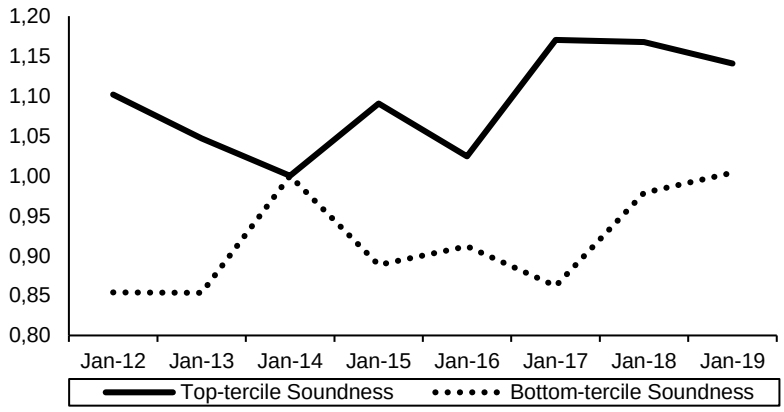

Figure 5
Maturity transformation depending on banks' soundness
This figure shows the change in the maturity of syndicated loans provided from euro-area banks, compering maturity transformation of sound banks with this of non-sound banks. Soundness is captured from the bottom- and top-tercile of non-performing-loans-to-liabilities distribution; Bottom-tercile denotes sound banks and top-tercile denotes non-sound banks. Maturity is calculated as the average yearly maturity of sound as well as non-sound banks and is normalized at the level in 2014.

Since the ECB implemented the NIRP, commercial banks attempt to avoid being charged with negative deposit rate applied to their excess liquidity deposited in the central bank, by expanding their lending (Boucinha & Burlon, 2020). This means that for the customers of banks which manage to expand their lending, the conventional mechanism of monetary policy transmission may be at work. Because negative rates impose increased costs to cash-rich firms of holding deposits, this kind of firms may find it optimal to reduce the volume of their cash holdings and raise their investment. As a result, firms with large cash amount, lengthen the maturity of their assets to improve their performance, having also incentives to take more risk by investing (Altavilla, Burlon, Giannetti, & Holton, 2019).

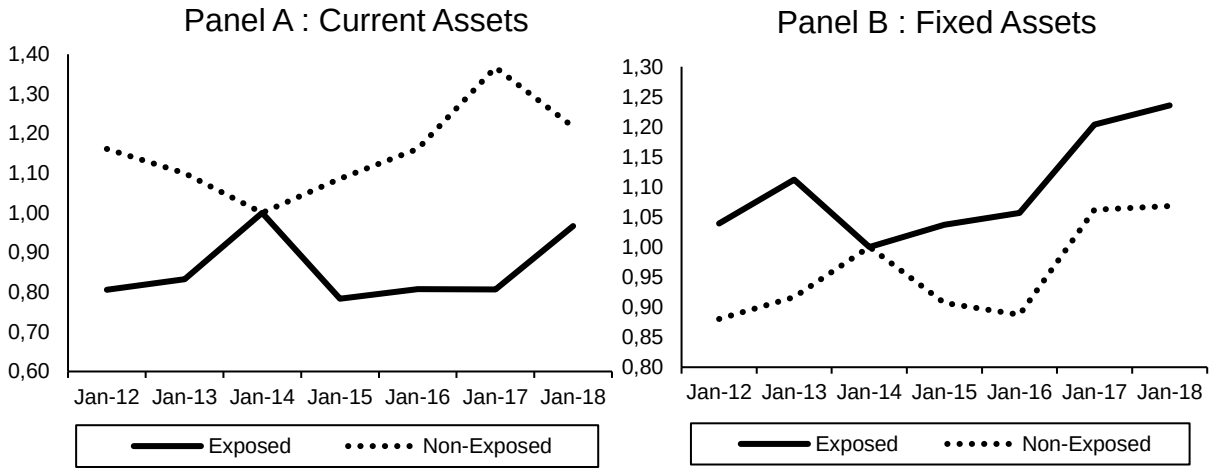

Figure 6

Current and fixed asset values for firms exposed and non-exposed to negative rates
This figure shows the total current assets (Panel A) and the total fixed assets (Panel B) of firms that are exposed to the NIRP compared to firms that do not have relations with banks offering negative deposit rates in the given period. Values of current and fixed assets are calculated as the average volume of each bank category and are normalized to the level in 2014.

Figure 6 shows the evolution of current and fixed assets before and after the negative rate implementation, considering if the firm is exposed to bank which charges negative interest rate on deposits. Panel A tracks the performance of current assets, and Panel B of fixed assets, before and after NIRP was put into effect for the same sample of firms.

Indeed, firms that are exposed to the NIRP, decrease their current asset ratio after the implementation of negative interest rates, relative to firms linked with banks that never offer negative rates to their depositors. Panel B illustrates that firms related to banks offering negative rates invest more in their fixed assets. In contrast, non-exposed firms

seem to even decrease their investment for a two-year period after the implementation of negative rates.

Credit supply is not the only driver of ECB's NIRP transmission to the real economy. Except from the lending channel, it is emerged a corporate channel of monetary policy as well. Corporations which are associated with banks that manage to charge them with negative deposit rate, reduce their short-term assets, and cash and raise their fixed investment. This happens because firms that hold large amounts of cash, have greater exposure to below zero rates. In summary, I intent to analyze the following hypothesis:

3a) High exposed firms to the NIRP increase their fixed assets.

3b) EBITDA and RoA increase when firms are highly exposed to the NIRP.

4. Data and Methodology

4.1 Data description

My empirical analysis depends on numerous data sources. The sample includes bank and firm individual information separately as well as bank-firm relationships in Europe. Bank-firm relationships originate from the European syndicated loan market. Syndicated loan data is obtained from DealScan through WRDS web queries, for the period between 2007 and 2019. Dealscan database provides comprehensive and reliable information on the commercial loan market in a global level. It contains extensive information on loan and contracts details. Only the lead arrangers in a syndicate are included in my sample, as they are more prone to hold on the loan share until the expiration and not to sell it in the secondary market. The top panel of Table 1 displays summary statistics for my sample of syndicated loans with any euro-area lead arrangers from June 2007 to December 2019. The average maturity of the European syndicated loans in my sample is five years. The average number of lead arrangers is 1,7 and more than 60% of the loans in the sample have a unique lead arranger. Approximately half of the banks are headquartered in a stressed country and 60% of the whole banks' sample offers negative rates to their depositors.

A limit of DealScan is that it contains mostly large, syndicated loans. Single-bank and smaller loans are also present in the dataset, but the sample is nevertheless by construction biased towards big banks and big firms. While a more representative sample would obviously be desirable, for my purpose this characteristic does not constitute a major problem, as there is still sufficient heterogeneity in the data to derive the stylized facts of interest.

The bank and firm specific information are collected over the period 2012 and 2019. Bank- and firm-level data are obtained in a yearly basis in the period given. A 5-year gap, from syndicated loans and bank specific data, is consistent with the average maturity of loans which compose banks' total loan portfolio.

I collect bank level information from Orbis Bank Focus which contains annual report data for financial institutions, both banks and insurers worldwide. This dataset provides information on the banks' balance-sheet, such as deposits, assets, loans, equity,

financial liabilities, non-performing loans, and relevant performing ratios. In the middle panel of Table 1, I present separate bank-level summary statistics for all euro-area banks included in my sample. Bank assets are structured from loans and financial assets, contributing 52,64% and 21,2% of total assets, respectively. Customer deposits are a major bank funding source, as they finance the 46,29% of total assets. Bank deposits (18,92%), and equity (8,82%) constitute different sources of funding. Stock prices of euro area banks are compiled from Datastream, which provides services and significant historical data for a variety of securities around the globe. Finally, I obtain firm level data from Bureau Van Dick's Orbis, which contains information on more than approximately 375 million both private and publicly listed companies around the world and is the ultimate source of business data. Orbis provides data on firms' balance-sheet and profit and loss (P&L), like total assets, current assets, fixed assets, liabilities, number of employees, EBITDA, and other performance measures. The bottom panel of Table 1 summarizes the main variables of the firm-level dataset. Firms' assets mainly consist of current and fixed assets, constituting 40,43% and 59,59% of total assets, respectively. The average EBITDA is USD 0,79 bn and the average number of employees is 13.900. Only 25% of firms in my sample are publicly traded and the rest are private listed firms.

Panel A of Table 2 examines potential differences in bank characteristics between different combinations of banks soundness and deposit ratios, that are my treatment and control groups. As sound (non-sound) banks are specified the banks in the lowest (highest) tercile of the non-performing loans ratio distribution in 2013. As high (low) deposit banks are specified the banks in the highest (lowest) tercile of the deposit ratio distribution in 2013. The last column of Table 2 shows the absolute value of *t*-statistic for a test whether the difference in means between bottom and top terciles of soundness and deposit ratio distribution for several variables, is equal to zero. Equity ratio and number of loans as lead arranger are the only variables that I do not find a statistically significant difference in the means between different subsamples. The average non-performing loan ratio in non-sound, high deposit group is almost 19 times as high as in the sound, low deposit group (19% vs. 1%). Sound, low deposit banks have also higher total assets, lower loans-to-assets ratio and the highest number of loans that are lead arrangers than any other type of bank. On average sound, low deposit banks are lead arrangers of 612 syndicated loans during my sample, whereas

non-sound, low deposit ratio banks are lead arrangers of just 60 syndicated loans. Moreover, non-sound, high deposit banks have almost 4 times higher deposit ratio than sound, low deposit banks (72% vs. 19%) and the biggest ratio of loans over total assets (72%).This is an indicator that non-sound, high deposit banks use almost all of their customer deposits to provide loans.

Panel B indicates that the European syndicated loan market is concentrated. Ten banks overwhelm 86,2% of the market share in the sample. Non-performing loans of these banks do not seem to have large variation. Most of them belong to the bottom tercile of non-performing loans ratio distribution. The deposit ratio within these banks strongly varies, with most of these ratios coming from the medium and lowest tercile of the deposit ratio distribution.

The link of borrowers from Dealscan with firms in Orbis, and lenders with banks in Orbis Bank Focus, conducted by storing in three lists all the firms and banks names presented in DealScan and those I searched manually from Orbis and Orbis Bank Focus. I then removed any parentheses and their content, as well as any character different from number, letter, and single space from the lists. Regarding the banks' sample, I matched the banks which have exactly the same name in the two databases with the VLOOKUP function in Excel and the rest of them manually one by one. Due to the small size of the sample it was relatively easy. Regarding the firms' sample, I matched the firms which have the same name in the two databases, took the remaining and used the ticker to reduce the number of possible matches. As a next step, I took all the companies that have not been matched and proceed to a pure fuzzy match, looping on every possible Orbis name via FUZZY VLOOKUP add in, which performs approximate matches. A precise fuzzy match is considered to be above 75% similarity index (Bottazzi, De Sanctis, & Vanni, 2020). I visually inspected all the matches, which have an index below the threshold of 75%.

Table 1

Summary Statistics

Loans sample	Mean	Median	SD	Min	Max	N
Stressed country bank ∈ {0,1}	0,54	1	0,50	0	1	178
Euro-area firm ∈ {0,1}	0,36	0	0,48	0	1	7.390
Loan size $ Billion	0,59	0,21	1,42	0,00	50	23.668
Maturity of loan in months	60,02	60	36,93	1	492	23.668
No. of lead arrangers	1,68	1	1,35	1	25	23.668
Negative rate bank ∈ {0,1}	0,60	1	0,49	0	1	136
Bank-level sample	Mean	Median	SD	Min	Max	N
Total assets (in bill. usd)	232,17	72,66	347,53	0,03	1.910,65	129
Loans-to-assets ratio (%)	52,64	55,34	24,18	0,00	99,39	123
Total financial assets ratio (%)	21,20	18,31	16,52	-0,07	99,65	126
Fixed Assets ratio (%)	0,62	0,53	0,55	0,00	2,58	124
Cash and balances with central banks ratio (%)	2,70	1,40	3,53	0,00	20,77	125
Customer deposits-to-assets ratio (%)	46,29	48,61	21,85	0,01	86,68	123
Bank deposits-to-assets ratio (%)	18,92	15,60	14,96	0,35	78,61	122
Total liabilities-to-assets ratio (%)	90,32	92,91	12,66	0,00	100,11	127
Fin. liabilities-to-assets ratio (%)	2,40	0,37	4,52	0,00	19,64	23
Non-performing loans-to-assets ratio (%)	7,79	5,47	7,90	0,00	41,59	111
Total equity-to-assets ratio (%)	8,82	6,88	9,75	-0,11	96,79	127
Firm-level sample	Mean	Median	SD	Min	Max	N
Public/Private ∈ {0,1}	0,25	0	0,43	0	1	4.502
Total assets (in bill. usd)	10,38	1,08	44,58	0,00	976,82	2.956
Cash flow-to-assets ratio (%)	4,21	6,07	54,14	-1.712,31	121,36	2.365
Current assets ratio (%)	40,43	36,25	27,30	0,00	100,00	2.742
Fixed assets ratio (%)	59,59	63,77	27,29	0,00	100,00	2.741
Total Liabilities-to-assets ratio (%)	67,94	62,94	77,37	3,89	2.588,89	1.257
EBITDA (in bn usd)	0,79	0,08	3,18	-1,12	64,84	2.389
No. of employees in thousands	13,90	1,55	44,22	1	648,25	2.203

In the top panel, the baseline sample consists of all completed syndicated loans (package level) of both private and publicly listed firms *i* at date *t* granted by any euro-area lead arranger from June 2007 to December 2019. *Euro-area firm i* is an indicator for whether firm *i* is headquartered in the euro area. *Public/Private* is an indicator for whether firm *i* is private or publicly listed. *Stressed country bank* is an indicator for whether a bank in my sample is headquartered in a stressed country in the euro area. *Negative rate bank* is an indicator for whether a bank charges its depositors with negative rates sometime in the sample. The middle panel presents the bank-level summary statistics for all euro-area banks included in the sample. The bottom panel presents the firm-level summary statistics for all firms included in the sample. All bank- and firm-level variables are calculated using annual balance-sheet and P&L data for the year 2013.

Table 2

Characteristics of different type of banks and loan market shares of top lead arrangers

Sound versus non-sound and high- versus low-deposit banks

Panel A	Soundness Tercile	Deposit ratio Tercile	Mean	Median	SD	N	*t*-stat
Ln(Total assets)	Bottom	Bottom	4,96	5,07	1,99	20	2,69
	Bottom	Top	2,78	3,29	1,48	10	
	Top	Bottom	1,92	1,92	1,94	4	2,69
	Top	Top	3,05	2,79	1,54	14	
Loans-to-assets ratio (%)	Bottom	Bottom	0,25	0,23	0,19	20	5,60
	Bottom	Top	0,62	0,53	0,16	10	
	Top	Bottom	0,65	0,73	0,28	4	6,14
	Top	Top	0,72	0,75	0,12	14	
Customer deposits-to-assets ratio (%)	Bottom	Bottom	0,19	0,18	0,12	20	4,04
	Bottom	Top	0,70	0,71	0,08	10	
	Top	Bottom	0,32	0,37	0,15	4	15,79
	Top	Top	0,72	0,73	0,09	14	
Non-performing loans-to-assets ratio (%)	Bottom	Bottom	0,01	0,007	0,01	20	11,13
	Bottom	Top	0,02	0,02	0,007	10	
	Top	Bottom	0,17	0,14	0,06	4	3,07
	Top	Top	0,19	0,16	0,09	14	
Total equity-to-assets ratio (%)	Bottom	Bottom	0,10	0,05	0,02	20	0,05
	Bottom	Top	0,07	0,07	0,03	10	
	Top	Bottom	0,13	0,10	0,07	4	0,82
	Top	Top	0,08	0,07	0,03	14	
Number of loans as lead arranger	Bottom	Bottom	612,16	25	1.729,14	20	0,27
	Bottom	Top	69,62	29,5	107,16	10	
	Top	Bottom	60	9	95,34	4	0,64
	Top	Top	404,23	11	1.169,83	14	

Loan market shares – top 10 banks

Panel B	Non-Performing Loans (tercile)	Deposit Ratio (tercile)	Market Share	Total Assets (in bn usd)
Deutsche Bank AG	Bottom	Bottom	0,274	1.910,65
Credit Suisse AG	Bottom	Medium	0,198	680,16
Societe Generale SA	Top	Top	0,122	14,46
Commerzbank AG	Bottom	Medium	0,114	647,16
Rabobank	Bottom	Bottom	0,043	661,34
ING Bank	Bottom	Medium	0,038	684,73
Bayerische Landesbank GZ	Bottom	Bottom	0,019	277,25
ABN AMRO Bank NV	Bottom	Medium	0,019	513,06
Banco de Sabadell SA	Bottom	Bottom	0,018	217,55
Bankia	Medium	Medium	0,017	339,61

Panel A of this table compares the characteristics of different combinations of banks according their soundness and deposit ratio. Sound (non-sound) banks are defined as banks that are in the bottom (top) tercile of the non-performing loans ratio distribution of 2013. Non-performing loans ratio is defined as total non-performing loans to total assets. High deposit (low deposit) banks are defined as banks that are in the top (bottom) tercile of the deposit ratio distribution of 2013. Deposit ratio is defined as total customers deposits to total assets. The last column shows the absolute value of the *t*-statistic for a test whether the difference in means between bottom and top terciles is equal to zero. For the first *t*-stat value in every variable, the test is conducted between bottom and top soundness tercile samples, and for the second value, between bottom and top deposit ratio tercile samples. The sample period for the five first summary statistics of Panel A is the year 2013. The summary statistics in the last line of Panel A are based on the sample of all completed syndicated loans of both private and publicly listed firms granted by any euro-area bank from June 2007 to December 2019. Panel B lists the top-10 banks with the highest market share in my syndicated-loans sample. Market shares are calculated using loan volumes granted by banks in their function as lead arrangers in syndicated loans, on the basis of the unweighted loan shares. Together, these 10 banks provide 86,2% of the syndicated-loan volume in my sample. I also report their 2013 non-performing loan ratio and deposit ratio terciles and total assets (in bill. usd). Non-performing loan ratios, deposit ratios and total assets are taken from Orbis Bank Focus, market shares are calculated using DealScan data.

One of my main assumptions is that firms that borrow from financial institutions which manage to charge negative deposit rates, have higher exposure to the NIRP. The lack of information regarding the amount of deposits and outstanding loans a firm has with a particular bank is the key driver of this assumption. A broad range of financial services are offered by a lot of banks to their customers, including credit and deposits (Santikian, 2014). In fact, banks' proficiency to take deposits and manage the customer's payments is at the genesis of banks' information advantage (Fama, 1985). Consequently, I anticipate firms to both have deposits and assume credit from their lending banks, as these operations are consistently associated. Not obtaining actual credit exposure in not a large limitation in my context. As I will show later, there is insufficient evidence that the real effects of the NIRP derive from more credit supply. Instead, when firms have ex ante large deposits on banks that charge them with negative rates, reduce their current assets and cash balances and invest more in fixed assets.

4.2 Methodology

To test my hypotheses, I solely base my methodology on the work of Heider, Saidi, & Schepens (2019) and Altavilla, Burlon, Giannetti, & Holton (2019). Firstly, I compare the lending behavior and maturity transformation of euro area banks with different non-performing loan and deposit ratios, and firms with different exposures, prior and after the ECB's implementation of the NIRP on June 2014, using a difference-in-difference strategy. Moreover, I investigate the change in banks' lending behavior, maturity transformation and the real effects since DFR became negative, using a linear regression estimation.

Evidence from the syndicated loan market is used to examine the banks' change in credit supply. In syndicated loan market, a number of different banks align together to shape a syndicate, which is lended to firms. In this investigation, I focus on the lead arrangers[6] of a syndicate, as they are mainly responsible for conducting various operations including asset management, loan monitoring, and due diligence (Ivashina & Scharfstein, 2010). Therefore, it is more possible for them to keep their loan share

[6] I define lead arrangers as banks that provide 100% of the loan, or have any one of the following lender roles in DealScan: lead bank, lead manager, (mandated) lead arranger, joint arranger, co-lead arranger, co-arranger, coordinating arranger, mandated arranger, (admin) agent, or bookrunner. Moreover, I do not distinguish between different types of syndicated loans, for example, revolvers or term loans. This is because the hypothesis that I test has implications only for the granting of new loans in general, regardless of the type of loan.

until the expiration, compared with the other members, which are more likely to sell their loan share in the secondary market.

To test how banks' lending is affected, I consider two types of demarcation. The first is the soundness of a bank, which is captured by the non-performing loans ratio in 2013 of the eurozone lead arrangers in syndicate *j.* The second type is bank's reliance on its deposits, which is defined by the total amount of bank's customer deposits divided by its total assets in 2013. Due to the difficulty in defining the loan share of each lead arranger in the case that a syndicated loan has multiple lead arrangers, I assume equal weights for every lead arranger in the syndication. For that purpose the whole amount of the loan is divided by the number of lead arrangers in order to examine every banks' lending behavior separately.

The loan characteristics such as loan volume or maturity, associated with syndicated loan *j* provided to firm *i* at time *t*, are used as dependent variables to test the change of individual bank's lending behavior to firms as well as their maturity transformation. To deduce percentage changes directly, I use the outcome variable in logs. To track the banks' loan portfolio, I expand the syndicated loans until their end date. The expansion is quarterly, decreasing the loan's volume and maturity until reaching their last quarter. This is an important implication, as the average maturity of the syndicated loans sample is 5 years and, thus, they will have a share in banks' loan portfolio until their expiration date.

My difference-in-difference specification is:

$$y_{ijt} = \beta_1 After(06/2014)_t + \beta_2 Depositratio_j + \beta_3 Depositratio_j \times After(06/2014) + \delta_t + \eta_j + \varepsilon_{ijt}$$

Where y_{ijt} is an outcome variable which denotes the loan volume or maturity of syndicated loan *j,* associated with firm *i* at time *t. After(06/2014)*$_t$ is a dummy variable that equals to one after June 2014, when the NIRP was implemented, and zero before this period. *Depositratio*$_j$ is a dummy variable to identify the group exposed to the treatment. In this research, high deposit ratio banks are treated, and low deposit are non-treated. Hence, the dummy takes the value of one when the deposit ratio in 2013 of eurozone lead arranger in syndicate *j* is above median. δ_t denotes time fixed effects and η_j denotes a bank or firm fixed effect for each euro area lead arranger or company.

My baseline linear regression model is:

$$y_{ijt} = \beta Depositratio_j + \gamma X_{ijt} + \delta_t + \eta_j + \varepsilon_{ijt}$$

Where y_{ijt} is the same outcome variable as in the above specification. $Depositratio_j$ is the ratio (in %) of deposits over total assets in year 2013 across each euro area lead arranger of syndicate *j*. X_{ijt} is reflecting firm level and syndicated level control variables for each euro area lead arranger or company.

I assess the robustness of my difference-in-difference strategy, investigating whether high- and low-deposit banks modify their deposit ratio in a different way, either in response to or in anticipation of the NIRP. If they do, high deposit banks could become low deposit banks and vice versa. Therefore, would no longer provide the counterfactual for the lending behavior of banks based on their deposit ratio.

For the linear regression model, I vary the set of control variables X_{ijt} , including bank related indicators that, according to the previous literature, are important for the transmission of positive policy rates to the credit supply of banks.

Another concern is that negative rates are not special. To test this hypothesis, I estimate the following regression:

$$y_{ijt} = \beta_1 Depositratio_j \times DFrate_t \times After(06/2014)_t + \beta_2 Depositratio_j \times DFrate_t$$
$$+ \beta_3 Depositratio_j \times After(06/2014)_t + \delta_t + \eta_j + \varepsilon_{ijt}$$

where $DFrate_t$ is the deposit facility rate of the ECB at monthly level.

Changes in the policy rate are examined with this model more generally, without considering their timing, size, or whether they are increases or decreases. Data used in the sample varying from June 2007 to December 2019, during which the DFR of the ECB deviates from +3% to −0.50%. The coefficient of interest in this equation is on the triple interaction of banks' deposit ratio, the ECB's DF rate, and the dummy for the period of negative policy rates since June 2014. The estimate of β_1 shows whether the transmission of negative policy rates through deposits is different from the transmission of positive policy rates, which is captured by β_2. A significant estimation of β_1 and β_2 denotes that the deposit ratio is not significant on the pass through of policy rates to the banks' lending behavior. To ensure the importance of negative rates, I anticipate that the estimation of β_1 should be significant and the estimation of β_2 insignificant.

As an extension, I explore the real effects of the NIRP to the economy through firms that deposit their cash holdings within their lending banks. An independent variable is defined, $Exposure_j$, which is firm's proportion of current assets in year$_{t-1}$. A dummy variable that takes the value of one if a firm is related with a bank that charges negative rates on deposits, after the NIRP starts and the value of zero otherwise, is multiplied by $Exposure_j$ (Altavilla, Burlon, Giannetti, & Holton, 2019). To test the reaction of those firms, I investigate the change in their investment, which is the change in their fixed assets, and some performance measures, such as EBITDA and RoA. These are defined as depended variables in my sample. I also examine if these firms are associated with sound or non-sound banks during the period given.

I test these hypotheses using the same difference-in-differences strategy by substituting the treated variable $Depositratio_j$ with $Exposure_j$ for the period from January 2013 to December 2015.

$$y_{it} = \beta_1 After(06/2014)_t + \beta_2 Exposure_i + \beta_3 Exposure_i \times After(06/2014) + \delta_t + \eta_i + \varepsilon_{it}$$

The baseline linear regression model is also used to track the change in investment behavior and performance of the treated firms for the period from June 2014 to December 2019.

$$y_{it} = \beta Exposure_i + \gamma X_{it} + \delta_t + \eta_i + \varepsilon_{it}$$

Every model in this paper meets the assumptions of the OLS regression. Every unusual and influential data has been identified and removed from the sub-samples used in the different regression models. Various checks regarding the normality of residuals and multicollinearity have been performed in this investigation, as well as the use of robust standard errors that account for heteroskedasticity across "clusters" of observations, in order to verify that all the assumptions underlying OLS regression have been met by the dataset and my results are not distorted. Moreover, the validity of the Parallel Trend Assumption is investigated for the difference-in-difference specification. This assumption requires the difference between the treatment and control group to be constant over time, in the absence of the treatment. The main weakness of the difference-in-difference is when something other than the treatment changes in one group but not in the other at the same time as the treatment, implying a violation of the parallel trend assumption. Since this assumption cannot be tested with any statistical assessment, I inspect this with the help of graphical analysis (see

Appendix, Figure A). It is visible from the graphs that the difference between the treatment and control group is fairly stable at least in the pre-treatment period. This analysis provides a robust, difference-in-difference estimate of treatment effects.

5. Results

I present my results in three steps. In the first step, the effect of the NIRP is investigated on the volume of bank lending and the robustness of my results is examined. Next, I evaluate the effect of the negative policy rate on banks' maturity transformation. Finally, I appraise if the real effects of negative rates arise from increased credit supply or from the existence of a corporate channel.

5.1 Effect of negative policy rates on bank lending

In Table 3, the results of estimating the difference-in-difference model are presented when the dependent variable y_{itj} is the measure of bank's lending volume. The second column shows the reaction in negative rates of the whole euro area bank sample, without considering their soundness. I find a positive and significant effect of the treatment. Banks with more deposits, increase their credit supply when rates become negative. In terms of economic significance, 1 percentage point increase in *Deposit ratio* translates into 6,7% increase in loans volume. This result contradicts Heider, Saidi, & Schepens, (2019) who found that high deposit banks reduce their lending when interest rate becomes negative. The increased credit supply of banks with high deposit ratio, after NIRP implementation is consistent with the fact that a large fraction of banks in my sample manage to offer negative rates to their depositors.

In columns 3 and 5, I check how banks' health in combination with their deposit ratio may influence their lending behavior. I find a positive and significant relation between the deposit ratio and credit supply of the two subsamples. Non- sound banks with great reliance on deposits, increase their credit supply more than sound banks which have high deposit ratios when I compare the periods prior and after the NIRP implementation. The outcome is not in line with my first hypothesis, where sound banks with high deposit ratios increase their lending more than the other banks, when interest rate becomes negative. This unexpected result is because the proportion of non-sound banks that charge negative rates to their depositors, is greater than that of sound-banks in my sample (see Appendix, Figure B). This is a limitation in my research as I assume that banks offer negative rates to their depositors during the whole sample period and do not have time differences on setting their deposit rates below zero.

In columns 4 and 6-7, I further restrict my sample to banks that are headquartered into stressed and non-stressed countries. There is no evidence about sound banks that are

located in stressed countries, as the sovereign debt problems in these countries are associated with bank health and the number of sound banks is extremely low. In the fourth column, there is evidence that sound banks with large deposits, that are headquartered in non-stresses countries, increase their lending volume by 10,2%, when their deposit ratio is increased by 1 percentage point (significant in 10% level). In column 7 of Table 3, there is a positive and significant treatment effect. Non-sound banks as well as the sound banks, provide more credit in the economy of non-stressed countries when they increase their deposit ratio and the DFR is negative. This effect is significant in 10% level and the main driver is the ability of these banks to pass the negative rates to their depositors. However, there is no evidence for non-sound banks operating in stressed countries as the difference-in-differences coefficient is insignificant.

Finally, I replace the stable deposit ratio with the actual deposit ratio and shorten the time window for robustness. The estimate of the coefficient on *After(06/2014) x Deposit ratio* is positive but insignificant. After the implementation of negative rates, deposit ratio is not an important predictor of banks' loan supply anymore. At the end of 2014, a few months after the implementation of the NIRP, less than 10% of non-financial corporation deposits in the euro area had negative rates (Altavilla, Burlon, Giannetti, & Holton, 2019). Consequently, there could be severe cross-sectional differences in the transmission of monetary policy.

The conventional wisdom that deposit rates do not take negative values does not exist anymore, as they appear to exceed the zero-lower bound to a significant fraction of euro area banks' deposits. In Table 4, the results of estimating the linear regression model are presented, denoting the change in banks' credit supply during the NIRP. In columns 1 and 2, I examine the lending behavior of total bank's sample and in columns 3 to 6 I limit the sample into sound and non-sound banks. Column 2 shows a positive and significant relation between banks' deposit ratio and their credit supply. Sound high-deposit banks seem to increase their lending volume during negative interest rates even when controlling for some bank characteristics and time fixed effects. Taking the estimate from the fourth column, 1 percentage point increase in deposit ratio of sound banks, leads to an increased lending of 76%. Non-sound banks have an adverse effect in their lending behavior which is statistically significant in 5% level. When these banks decide 1 percentage point increase in their deposit ratio, they

contract their lending by 77% (column 6). In the previous paragraph, it is indicated that non-sound banks with high deposit ratios increase their lending in a greater extent than other bank types, when comparing the changes prior and after the NIRP implementation. This is not the case during the NIRP period, where non-sound banks seem to decrease their credit supply as long as their deposit ratio increases. These banks may want to reduce their excess liquidity holdings by increasing their government bonds holdings instead of expanding their loan supply (Demiralp, Eisenschmidt, & Vlassopoulos, 2017).

In Table 5, I provide further robustness check for my results on the bank lending. It is showed that banks with distinct level of deposit funding, do respond in the same way to policy rate variations when the DFR is still positive, as the coefficient on *Deposit ratio x DF rate* is not significant. This is different after the NIRP implementation, as demonstrated by the significant estimation coefficient on *Deposit ratio x DF rate x After(06/2014).* Consequently, only negative deposit rates are responsible for banks' lending increase.

Table 3
Impact of negative policy rates on banks' lending volume

	ln(Syndicated Loan Volume)						
Sample	2013-2015	2007-2019			2007-2019		
	Whole Sample		Sound Banks			Non-Sound Banks	
				Non-Stressed		Stressed	Non-Stressed
Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)
After(06/2014)							
Deposit ratio	-0.0239						
	(0.097)						
After(06/2014)	0.014	0.067*	0.101*	0.102*	0 .109*	-0.046	0.614*
x Deposit ratio	(0.0912)	(0.0398)	(0.0565)	(0 .0581)	(0.0629)	(0.1044)	(0.3612)
_cons	20.07***	19.62***	19.88***	19.72***	19.34***	19.06***	19.45***
	(0.0433)	(0.0362)	(0.0505)	(0.0566)	(0.0539)	(0.0685)	(0.0833)
Bank FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	3216	12703	6700	6660	5903	1699	3035
adj. R^2	0.01	0.045	0.05	0.05	0.052	0.021	0.074

The sample consists of all completed syndicated loans *j* (package level) of both private and publicly listed firms *i* at date *t* granted by any euro area lead arranger(s), from January 2013 to December 2015 in the first column and from June 2007 to December 2019 in the remaining columns. The sample, in the first two columns consists of all completed syndicated loans *j* (package level) of both private and publicly listed firms *i* at date *t* granted by any euro area lead arranger(s), from January 2013 to December 2015 in the first column and from June 2007 to December 2019 in the second column. In the next two columns, I limit the sample to sound and in the last three columns to non-sound euro area lead arranger(s). The depended variable is the logged total loan volume granted by a bank in its function as lead arranger in syndicated loans, calculated based on the unweighted loan shares between the lead arrangers. *Deposit ratio* is a dummy variable to identify the group exposed to the treatment in my difference-in-differences regression. In this sample, high deposit ratio banks are treated, and low deposit are non-treated. *After(06/2014)* is a dummy variable for the period from June 2014 onward which indicates when the treatment started. In columns 4,6, and 7 the sample is further separated into sound and non-sound banks that operate in stressed or non-stressed countries. Bank fixed effects are included for all euro area lead arrangers. Quarterly time fixed effects are used for more robustness checks. All regressions use robust clustered standard errors to obtain unbiased standard errors of OLS coefficients under heteroscedasticity. Standard errors are reported in parentheses and levels of statistical significance are indicated by *, ** and *** for 10%, 5%, and 1% respectively.

Table 4
Banks' lending volume under negative policy rates

	ln(Syndicated Loan Volume)					
Sample	2014-2019					
	Whole Sample		Sound Banks		Non-sound banks	
Variable	(1)	(2)	(3)	(4)	(5)	(6)
Deposit ratio	0.26***	0.33**	0.95***	0.76***	-0.148	-0.77**
	(0.102)	(0.162)	(0.159)	(0,207)	(0.1320)	(0 .312)
Assets $_{t-1}$		0.485*		-2.253		-0.947**
		(0.2789)		(2.0408)		(0.4265)
Equity $_{t-1}$		0.115				0.244***
		(0.0715)				(0.0928)
Liabilities $_{t-1}$		-0.338		-2.105		0.944**
		(0.2765)		(1.9814)		(0.4014)
_cons	19.60***	19.11***	19.57***	15.55***	19.63***	14.58***
	(0.0548)	(0.00994)	(0.0719)	(3.2655)	(0.0844)	(2.462)
Bank FE	Yes	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes	Yes
N	16179	16179	8612	8612	7567	7567
adj. R^2	0.032	0.188	0.063	0.273	0.072	0.082

The sample consists of all completed syndicated loans *j* (package level) of both private and publicly listed firms *i* at date *t* granted by any euro area lead arranger(s), from June 2014 to December 2019. The sample, in the first two columns consists of all completed syndicated loans *j* (package level) of both private and publicly listed firms *i* at date *t* granted by any euro area lead arranger(s), from June 2014 to December 2019. In the remaining columns, I limit the sample into sound and non-sound banks. The depended variable is the logged total loan volume granted by a bank in its function as lead arranger in syndicated loans, calculated based on the unweighted loan shares between the lead arrangers. *Deposit ratio* is the ratio (in %) of deposits over total assets in year 2013 across each euro area lead arranger of syndicate *j.* In second, fourth and sixth column, I control for the total assets, equity, and liabilities of a bank's balance sheet. *Assets* $_{t-1}$ is the logged average value of total assets in year *t-1* across all euro area lead arrangers of syndicate *j*. *Equity* $_{t-1}$ is the logged average value of total equity in year *t-1* across all euro area lead arrangers of syndicate *j. Liabilities* $_{t-1}$ is the logged average value of total liabilities in year *t-1* across all euro area lead arrangers of syndicate *j*. Bank fixed effects are included for all euro area lead arrangers. Quarterly time fixed effects are used for more robustness checks. All regressions use robust clustered standard errors to obtain unbiased standard errors of OLS coefficients under heteroscedasticity. Standard errors are reported in parentheses and levels of statistical significance are indicated by *, ** and *** for 10%, 5%, and 1% respectively.

Table 5
Effect of changes in the deposit facility rate on banks' lending volume and maturity

	ln(Syndicated Loan Volume)	ln(Syndicated Loan Maturity)
Sample	2007-2019	
Variable	(1)	(2)
Deposit ratio x DF rate x After(06/2014)	1.049**	-0.043
	(0.518)	(0.185)
Deposit ratio x DF rate	-0.122	0.029
	(0.093)	(0.0735)
Deposit ratio x After(06/2014)	0.234	0.074
	(0.227)	(0.0729)
_cons	19.76***	3.49***
	(0.1114)	(0.096)
Bank FE	Yes	Yes
Time FE	Yes	Yes
N	13446	12905
adj. R^2	0.0325	0.012

The sample consists of all completed syndicated loans *j* (package level) of both private and publicly listed firms *i* at date *t* granted by any euro-area lead arranger(s) from June 2007 to December 2019. In column 1, the dependent variable is the logged total loan volume granted by a bank in its function as lead arranger in syndicated loans, calculated based on the unweighted loan shares between the lead arrangers. In column 2, the depended variable is the logged maturity of a loan granted by a bank in its function as lead arranger in syndicated loans. *Deposit ratio* is a bank's ratio (in %) of deposits over total assets in 2013. *DF rate* is the ECB's deposit facility rate (in %) at the monthly level. *After(06/2014)* is a dummy variable for the period from June 2014 onward. Bank fixed effects are included for all euro area lead arrangers. Quarterly time fixed effects are used for more robustness checks. All regressions use robust clustered standard errors to obtain unbiased standard errors of OLS coefficients under heteroscedasticity. Standard errors are reported in parentheses and levels of statistical significance are indicated by *, ** and *** for 10%, 5%, and 1% respectively.

5.2 Effect of negative policy rates on bank maturity transformation

In Table 6, the results of estimating the difference-in-difference model are presented, when the dependent variable y_{itj} is the measure of bank's lending maturity. In column 1 the estimation coefficient of *After(06/2014) x Deposit ratio* is not significant; hence I cannot extract an important outcome. However, in column 2 the estimation coefficient of the interaction variable is positive and significant at 5% level. More specifically, 1 percentage point increase in a bank's deposit ratio leads to an increase in bank's lending maturity by 5,3%. In the third and fourth columns, where my sample is limited to sound banks, the interaction coefficient is positive and significant. Sound banks with large deposits, increase the maturity of their long-term assets in response to negative interest rates. Taking the estimate from the third column, 1 percentage point increase in sound banks' deposit ratio, drive to an economically relevant increase in the maturity of bank's long-term assets of 11,6%. This phenomenon has a more pronounced effect in sound banks that are headquartered in non-stressed countries. This result is consistent with my hypothesis, that sound banks with high deposit ratio increase their loan maturity. Sound banks need to hedge their deposit franchise by holding long term fixed assets, insulating their profits from interest rate risk. Non-sound bank sample cannot give a precise conclusion as the interaction coefficient is positive but not significant. However, when I limit the sample of non-sound banks into banks that are headquartered in non-stressed countries, I extract a negative and significant interaction coefficient. As a result, non-sound banks that operate in non-stressed countries decrease the maturity their long-term assets by 12,7%, when their deposit ratio raises by 1 percentage point. These banks are not exposed to interest rate risk, as they managed to pass negative deposit rates, and as a response they decrease their loans' maturity.

Table 7, shows results of estimating the linear regression model, indicating the banks' maturity transformation during the NIRP. I find that, high deposit banks decrease the maturity of their loans during the negative interest rate period. When banks' deposit ratio increases by 1%, loans' maturity declines by 89%. The negative relation between loans' maturity and deposit ratio holds for both sound and non-sound banks during the NIRP period. Sound banks with high deposit ratios tend to decrease the maturity of their long-term assets considering bank and time fixed effects. The estimation coefficient of *Deposit ratio* is negative and significant at 1% level. Non-sound banks

with great reliance on deposits lower their maturity mismatch during negative interest rates as well. Since the majority of banks in the sample manage to charge negative rates to their depositors, they are concerned about maturity mismatch and try to limit the difference between their short-term liabilities and long-term assets. During the period of the NIRP, banks that offer negative deposit rate, borrow short-term from depositors without an interest expense. Instead, borrowers are paying these banks to deposit their money because of their demand for safer assets. As a result, high deposit banks do not require the spread for profitability anymore, and they reduce their maturity mismatch by decreasing their loans' maturity.

In Table 5, further robustness check is provided for my results on banks' maturity transformation. It is indicated that long-term assets' maturity is not influenced exclusively from policy rate changes, but there are other factors that may affect banks' maturity transformation.

Table 6
Impact of negative interest rates on banks' maturity transformation

	ln(Syndicated Loan Maturity)						
Sample	2013-2015	2007-2019			2007-2019		
	Whole Sample		Sound Banks			Non-Sound Banks	
				Non-Stressed		Stressed	Non-Stressed
Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)
After(06/2014)							
Deposit ratio	-0.039						
	(0.0619)						
After(06/2014)	0.082	0.053**	0.116**	0.120**	-0.009	0.099	-0.127**
x Deposit ratio	(0.0585)	(0.0252)	(0.0494)	(0.0488)	(0.0584)	(0.0814)	(0.0478)
_cons	3.401***	3.53***	3.48***	3.47***	3.57***	3.69***	3.51***
	(0.0278)	(0.0225)	(0.0652)	(0.0653)	(0.0558)	(0.0630)	(0.0891)
Bank FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	3228	12951	6808	6759	5066	1947	3123
adj. R^2	0.082	0.01	0.016	0.014	0.01	0.025	0.01

The sample consists of all completed syndicated loans *j* (package level) of both private and publicly listed firms *i* at date *t* granted by any euro area lead arranger(s), from January 2013 to December 2015 in the first column and from June 2007 to December 2019 in the remaining columns. The sample, in the first two columns consists of all completed syndicated loans *j* (package level) of both private and publicly listed firms *i* at date *t* granted by any euro area lead arranger(s), from January 2013 to December 2015 in the first column and from June 2007 to December 2019 in the second column. In the next two columns, I limit the sample to sound and in the last three columns to non-sound euro area lead arranger(s). The depended variable is the logged maturity of a loan granted by a bank in its function as lead arranger in syndicated loans. *Deposit ratio* is a dummy variable to identify the group exposed to the treatment in my difference-in-differences regression. In this sample, high deposit ratio banks are treated, and low deposit are non-treated. *After(06/2014)* is a dummy variable for the period from June 2014 onward which indicates when the treatment started. In columns 4,6, and 7 the sample is further separated into sound and non-sound banks that operate in stressed or non-stressed countries. Bank fixed effects are included for all euro area lead arrangers. Quarterly time fixed effects are used for more robustness checks. All regressions use robust clustered standard errors to obtain unbiased standard errors of OLS coefficients under heteroscedasticity. Standard errors are reported in parentheses and levels of statistical significance are indicated by *, ** and *** for 10%, 5%, and 1% respectively.

Table 7
Banks' maturity transformation under negative policy rates

	ln(Syndicated Loan Maturity)					
Sample	2014-2019					
	Whole Sample		Sound Banks		Non-Sound Banks	
Variable	(1)	(2)	(3)	(4)	(5)	(6)
Deposit ratio	-0.892***	-1.023**	-1.229***	-1.230***	-0.496	-2.157***
	(0.1545)	(0.4220)	(0.1386)	(0.0653)	(0.3052)	(0.3421)
Loans $_{t-1}$		0.140				4.277***
		(0.4657)				(0.4140)
Cash $_{t-1}$		0.588		0.065		0.962*
		(1.003)		(0.4000)		(0.4902)
_cons	3.99***	3.95***	3.95***	3.95***	3.91***	1.78***
	(0.1184)	(0.1598)	(0.0628)	(0.0653)	(0.1770)	(0.2691)
Bank FE	Yes	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes	Yes
N	17782	17723	8999	8940	6581	6581
adj. R^2	0.13	0.13	0.148	0.148	0.14	0.154

The sample consists of all completed syndicated loans *j* (package level) of both private and publicly listed firms *i* at date *t* granted by any euro area lead arranger(s), from June 2014 to December 2019. The sample, in the first two columns consist of all completed syndicated loans *j* (package level) of both private and publicly listed firms *i* at date *t* granted by any euro area lead arranger(s), from June 2014 to December 2019. In the next two columns, I limit the sample into sound banks and in the last two columns in non-sound banks. The depended variable is the logged maturity of a loan granted by a bank in its function as lead arranger in syndicated loans. *Deposit ratio* is the average ratio (in %) of deposits over total assets in year 2013 across all euro area lead arrangers of syndicate *j*. In second, fourth and sixth column, I control for gross loans and cash of a bank's balance sheet. *Loans* $_{t-1}$ is the average ratio (in %) of gross loans over total assets in year *t-1* across all euro area lead arrangers of syndicate *j*. *Cash* $_{t-1}$ is the average ratio (in %) of cash and balances with central banks over total assets in year *t-1* across all euro area lead arrangers of syndicate *j*. Bank fixed effects are included for all euro area lead arrangers. Quarterly time fixed effects are used for more robustness checks. All regressions use robust clustered standard errors to obtain unbiased standard errors of OLS coefficients under heteroscedasticity. Standard errors are reported in parentheses and levels of statistical significance are indicated by *, ** and *** for 10%, 5%, and 1% respectively.

5.3 The real effects of negative rates

It is very possible for firms to be affected from negative rates through their assets and liabilities. As I have demonstrated, banks that charge their depositors with negative rates, manage also to increase their lending. As a result, the transmission mechanism of monetary policy should be in place, for the costumers of these banks. Negative rates are also responsible for changes in firms' asset composition. Table 8 examines whether more exposure to banks charging negative rates to their depositors, has real effects. In column 1, I show that firms with more current assets, which are exposed to banks that charge their depositors with negative rates, rebalance towards fixed assets by investing more the next year. This result is robust as the estimating coefficient of *After(06/2014) x Exposure* remains significant after controlling for firms' characteristics, including firm, bank, and time fixed effects. In my difference-in-differences estimation, 1% increase in firm's exposure in every euro-area lead arranger offering negative deposit rates, leads to an important increase in firm's investment of 8%. This outcome is more intense during the NIRP because interest rates have not yet reached a lower bound and they are constantly decreasing. This situation forces firms to invest more according to their exposure to negative interest rates. Firms that have relations with sound banks tend to increase their fixed assets; 1% increase in their current assets, increases firm's investment again by 8,2%. This is more pronounced during the negative interest rate period, where 1% increase in current assets translates into a fixed asset increase of 25,5%. This effect, except from statistically significance, has also economically significance. I cannot extract a significant conclusion in my different-in-differences estimation, for firms that are exposed to non-sound banks. However, I find that firms associated with non-sound banks that charge negative deposit rate, increase their investment as well when negative policy rate is established. Therefore, firms that are highly exposed to the NIRP, manage to expand their investment.

Finally, Table 9 explores how firms with large cash holdings, which are customers of banks charging negative interest rates, are performing comparing different profitability measures after the implementation of the NIRP. As I have shown before these firms tend to invest more. When interest policy rate turns into negative, there is no evidence related to firms' performance compared to the period prior the NIRP implementation, as the interaction coefficient *After(06/2014) x Exposure* is insignificant for both EBITDA and RoA. However, during NIRP period, different performance measures show that

the profitability of firms with high exposure to banks that charge negative deposit rates, improves. The interaction between *Exposure* variable and the dependent variables of EBITDA and RoA is positive and significant. When firms are exposed to negative rates, 1% increase in their current assets, drive to the increase of their EBITDA and RoA by 23,5% and 46,4%, respectively. This result is robust as I control on firms' characteristics and use firm-bank, and time fixed effects. Moreover, I find that firms that end up being highly exposed to negative rates, improve even more their performance when they are associated with sound banks. Columns 4 and 7 indicate that 1% increase in the current assets of exposed firms to sound banks, leads to an economically relevant and EBITDA and RoA increase of 25,3% and 66,6%, respectively.

These findings show, that before the NIRP implementation, firms' preventive behavior led them to stockpile their excess cash holdings. As a result, they applied a high discount rate on investment opportunities, to deal with the uncertain economic environment. Negative deposit interest rates increase the cost of holding large amounts of cash and firms are more inclined to start investing these liquid assets. This behavior drives to increased profitability, which was previously constrained by the decision of holding back investment opportunities because of looming uncertainty (Bernanke, 1983).

Table 8
Exposure to negative rates and firms' investment

	ln(Fixed Assets)						
Sample	2013-2015			2014-2019			
Variable	Whole Sample (1)	Non-Sound (2)	Sound (3)	Whole Sample (4)	(5)	Non-Sound (6)	Sound (7)
After(06/2014)							
Exposure $_{t-1}$	0.127***	0.237***	0.0699	0.151***	0.227***	0.193***	0.255***
	(0.0335)	(0.0519)	(0.04409)	(0.0124)	(0.01706)	(0.0266)	(0.0212)
After(06/2014)	0.080**	0.084	0.082*				
x Exposure $_{t-1}$	(0.0358)	(0.0526)	(0.0490)				
Cash Flow $_{t-1}$					0.0914***	0.082***	0.102***
					(0.0064)	(0.0093)	(0.0086)
_cons	20.89***	20.88***	20.90***	18.75***	16.14***	16.82***	15.36***
	(0.0215)	(0.0323)	(0.0289)	(0.1583)	(0.2366)	(0.3332)	(0.3255)
Firm – Bank FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	5911	2811	3100	11601	10239	5446	4793
adj. R^2	0.115	0.099	0.084	0.06	0.091	0.062	0.144

The sample consists of all completed syndicated loans *j* (package level) of both private and publicly listed firms *i* at date *t* granted by any euro area lead arranger(s), from January 2013 to December 2015 in the first three columns, and from January 2014 to December 2019 in the remaining columns. The sample in the first column consists of all completed syndicated loans *j* (package level) of both private and publicly listed firms *i* at date *t* granted by any euro area lead arranger(s), from January 2013 to December 2015. In the second column, I limit the sample to non-sound and in the third column to sound euro area lead arranger(s). In the first three columns I follow a difference-in-differences approach, with depended variable the logged fixed assets in year *t* across every firm *i*. *After(06/2014)* is a dummy variable for the period from June 2014 onward which indicates when the treatment started. *Exposure* is a dummy variable, denoting the group exposed to the treatment, in columns 1 to 3. In this sample, firms, which have above median logged current assets in year *t-1* and are exposed to negative rates, are treated and firms without exposure to negative rates and with below median current assets ratio in year *t-1*, are non-treated. The depended variable remains the same for all the columns. In the last four columns *Exposure* is a variable that takes the value of *0* if firm *i* is not exposed to negative rates and the value of the logged current assets of firm *i* in year *t-1* if the firm is exposed to negative rates. In the fifth column, I control for the *Cash flow*, which is the logged cash flow in year *t-1,* across every firm *i.* In the last two columns I limit the sample to firms that have relations with sound and non-sound euro area lead arrangers. Firm-Bank fixed effects are included for all firms. Quarterly time fixed effects are used for more robustness checks. All regressions use robust clustered standard errors to obtain unbiased standard errors of OLS coefficients under heteroscedasticity. Standard errors are reported in parentheses and levels of statistical significance are indicated by *, ** and *** for 5%, 1%, and 0.1% respectively.

Table 9
Exposure to negative rates and firms' performance

Sample	2013-2015		2014-2019					
	EBITDA	RoA	EBITDA			RoA		
	Whole Sample		Whole Sample	Sound	Non-Sound	Whole Sample	Sound	Non-Sound
Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
After(06/2014)								
Exposure $_{t-1}$	-0.447***	0.007	0.235***	0.253***	0.223***	0.464***	0.666***	0.068***
	(0.0843)	(0.0078)	(0.0206)	(0.0301)	(0.0279)	(0.1242)	(0.1872)	(0.0098)
After(06/2014)	0.028	0.006						
X Exposure $_{t-1}$	(0.1328)	(0.0101)						
Cash Flow $_{t-1}$			0.414***	0.392***	0.428***	0.891***	0.891***	0.779***
			(0.0086)	(0.0122)	(0.0118)	(0.0033)	(0.0041)	(0.0119)
_cons	18.91***	0.0769***	8.03***	8.20***	7.92***	-0.122***	-0.223***	-0.023***
	(0.0348)	(0.0042)	(0.2853)	(0.4441)	(0.3684)	(0.0406)	(0.0724)	(0.0025)
Firm – Bank FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	6848	7437	10343	4358	5985	10155	3639	3639
adj. R^2	0.22	0.01	0.286	0.303	0.28	0.91	0.64	0.64

The sample consists of all completed syndicated loans *j* (package level) of both private and publicly listed firms *i* at date *t* granted by any euro area lead arranger(s), from January 2013 to December 2015 in the first two columns, and from January 2014 to December 2019 in the remaining columns. In the first two columns I use difference-in-differences estimation with depended variables *EBITDA* and *RoA* in the first and second column, respectively. *EBITDA* is the logged EBITDA and *RoA* is the ratio (in %) of returns over total assets in year *t* across every firm *i.* . *After(06/2014)* is a dummy variable for the period from June 2014 onward which indicates when the treatment started. *Exposure* is a dummy variable, denoting the group exposed to the treatment, in columns 1 and 2. In this sample, firms, which have above median current assets ratio and are exposed to negative rates, are treated and firms without exposure to negative rates and with below median current assets ratio, are non-treated. *EBITDA* is the depended variable for columns 3 to 5 and *RoA* for columns 6 to 8. In columns 4 and 7 the sample is limited to firms that have relations with sound euro area lead arrangers and in columns 5 and 8 I limit the sample to firms that have relations with non-sound euro area lead arrangers. In columns 3 to 8, *Exposure* is a variable that takes value of *0* if firm *i* is not exposed to negative rates, and the value of *current assets' ratio* of firm *i* in year *t-1* if the firm is exposed to negative rates. In the third and sixth column, I control for *Cash flow*, which is the ratio (in %) of cash flow over total assets in year *t-1,* across every firm *i.* Firm-Bank fixed effects are included for all firms. Quarterly time fixed effects are used for more robustness checks. All regressions use robust clustered standard errors to obtain unbiased standard errors of OLS coefficients under heteroscedasticity. Standard errors are reported in parentheses and levels of statistical significance are indicated by *, ** and *** for 10%, 5%, and 1% respectively.

6. Conclusion

The ECB's negative DF rate implementation in June 2014, was considered as an unpresented and controversial move. This paper shows that negative rates lead to more lending by high deposit banks that manage to offer negative rates on a large part of their deposits without experiencing a contraction to their deposits. Moreover, high deposit ratio banks increase the maturity of their long-term assets as a response in their sensitiveness to interest rate changes. The same holds when I restrict the sample into sound banks. Although high deposit banks that offer negative rates increase their credit supply more than banks with low deposit ratio, the real effects of the negative policy rates on firms' investment and performance are linked to the firms' exposure to these banks. Firms with high current assets, associated with banks that charge negative rates to their depositors, manage to rise their investment, and improve their performance.

Despite the fact, I was not able to investigate in depth and with a lot of details the transmission of monetary policy to the real economy, due to the lack of confidential data, it is indicated by my results that the pass-through mechanism of monetary policy is effective, when policy rates turn into negative. In normal times, interventions of monetary policy are transmitted from high deposit banks which are considered as the traditional intermediaries providing most of credit supply and financial stability. However, negative policy rates are able to initiate an adverse effect to the role of these banks if they do not pass negative rates to their depositors. Once they manage to charge negative deposit rates, without any reduction on their deposits, the NIRP has a positive impact to the real economy by affecting both banks' and firms' behavior.

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Appendix

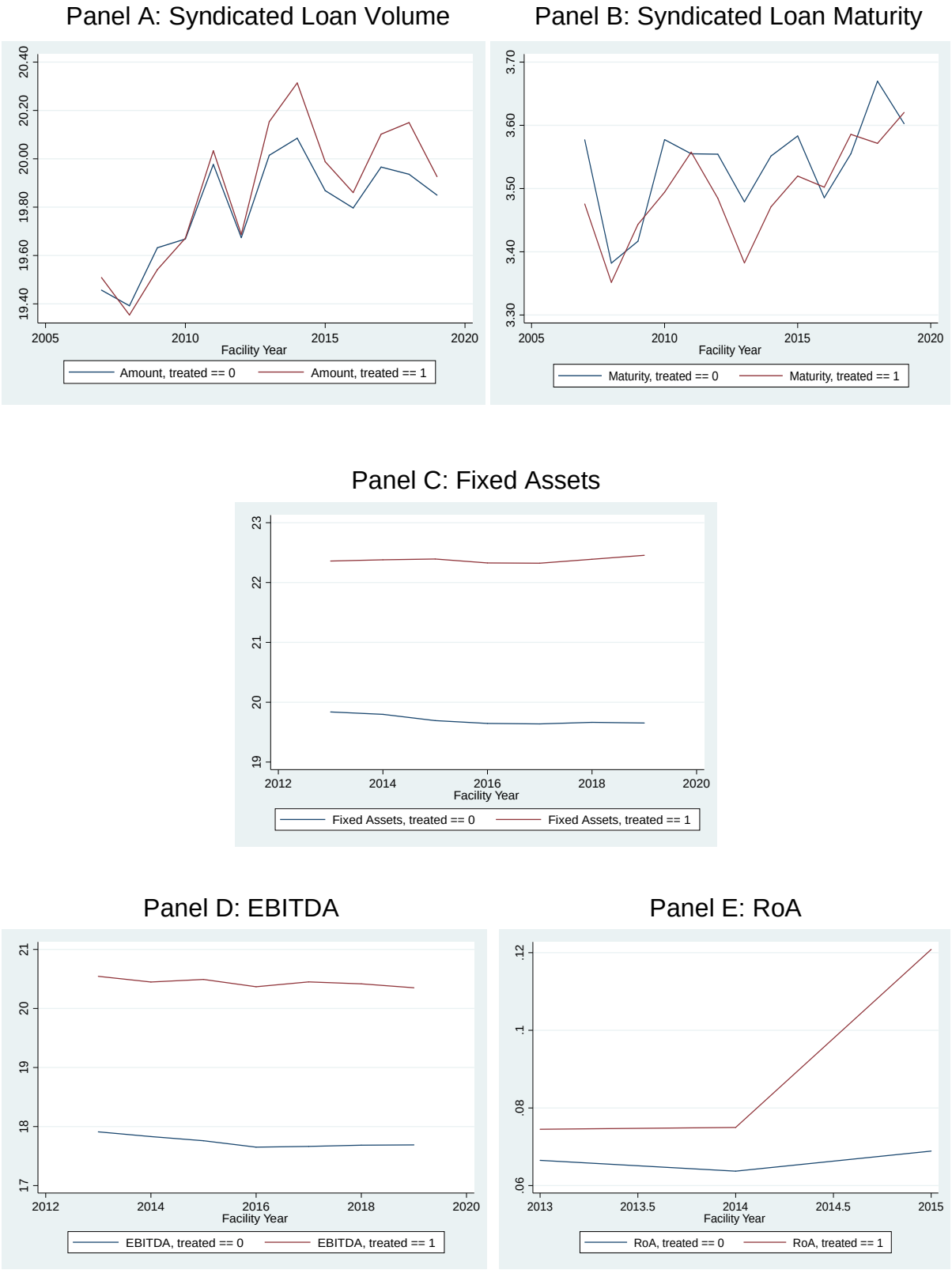

Figure A
Visualization of Parallel Trend Assumption
This figure illustrates the parallel trend assumption that holds for different dependent variables. Panel A shows the parallel trend for the syndicated loan volume, Panel B for the syndicated loan maturity, Panel C for the fixed assets of the firms, Panel D for the firms' EBITDA and Panel E for firms' RoA.

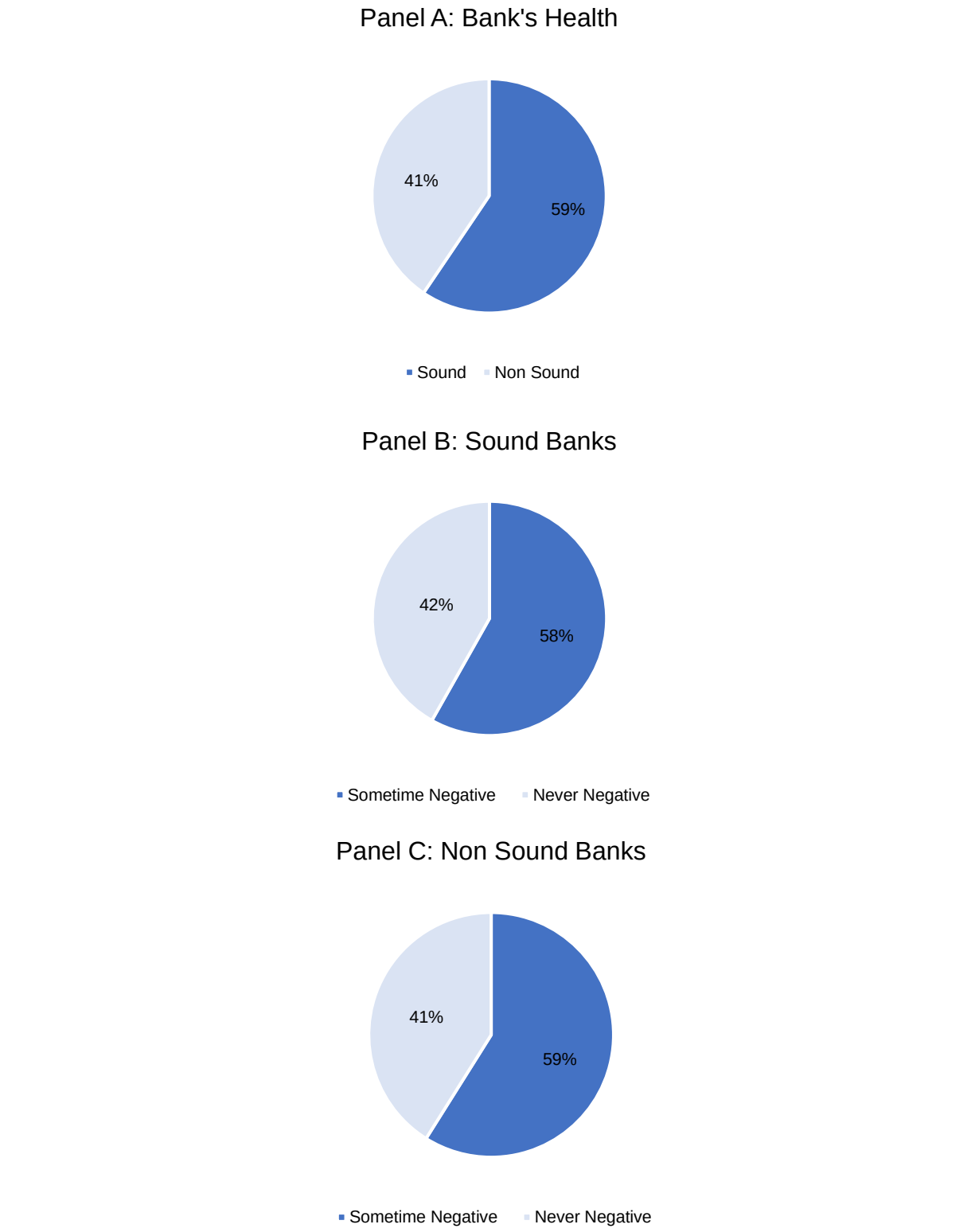

Figure B
Bank's health and negative rates
This figure shows the percentage of sound and non-sound banks in my sample, according to their non-performing loans ratio (Panel A) and the percentage of sound banks (Panel B) and non-sound banks (Panel C) that manage to offer negative interest rates to their depositors. Banks in my sample, are considered to charge negative rates to their deposits if the country that they are headquartered charges negative rates as well.