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BANK NET INTEREST MARGINS IN A LOW INTEREST RATE ENVIRONMENT

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Irem Korkmazer

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This master’s dissertation marks the end of my education at Ghent University and is thus the final hurdle before receiving my degree of Master of Science in Economics: Financial markets and institutions. This journey has been beyond expectations, especially if one considers that my last year was dominated by the COVID-19 pandemic. In essence, the virus has not caused any complications while writing this thesis.

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Finally, to the reader of this thesis, I hope you enjoy the reading!

Irem Korkmazer
Ghent, 2020

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1

Introduction

Since the Global Financial Crisis (GFC), the economic landscape of many countries has been characterized by low inflation and sluggish growth. Initially, central banks have tried to reverse this situation by pursuing a conventional monetary policy i.e. by lowering their policy interest rates. Even though these key rates have reached their historic lows and bumped into the so-called zero lower bound, the recovery proceeded at a very slow pace (ECB, 2014). Therefore, central banks have decided to adopt a broad range of unconventional monetary policy (UMP) measures such as quantitative easing and forward guidance (Borio & Gambacorta, 2017; Altavilla, Boucinha, & Peydró, 2018). This extra monetary stimulus was intended to further encourage lending, investment and consumption in two ways. On the one hand, they were aimed at lowering long-term interest rates in order to influence the slope of the yield curve. On the other hand, these measures were designed to improve liquidity in the banking system. However, it seems like those monetary policy instruments have failed to fuel the weak economic environment as inflation and growth continue to disappoint. Policymakers are therefore willing to keep interest rates low for as long as necessary (Genay, 2014; Bean, Broda, Ito, & Kroszner, 2015; Nassr, Wehinger, & Yokoi-Arai, 2015; Claessens, Coleman, & Donnelly, 2018).

While monetary policy has a major impact on the interest rate structure, it undoubtedly also influences the banking system (Borio, Gambacorta, & Hofmann, 2017). A traditional bank is mainly engaged in performing maturity transformations, which consists of borrowing short and lending out long (Genay, 2014). This in consequence implies that the net interest income (NII) is considered to be the major source of a bank's total income. However, to judge a bank’s health and efficiency in this role, it is more likely to consider the net interest margin (NIM); calculated as the NII relative to the amount of interest-earning assets (Alessandri & Nelson, 2015; Busch & Memmel, 2015; Angori, Aristei, & Gallo, 2019). Accordingly, it has become of interest to understand how banks’ profitability is affected by volatile interest rates. Especially from the point of view of bank shareholders and other investors, this relationship gained a lot of importance (Claessens et al., 2018; Stockerl, 2019).

Against this background, financial experts are convinced that an accommodative monetary policy i.e. a reduction in short-term interest rates and a flattening of the yield curve, have notable effects on the NIM (English, 2002). In particular, a low interest rate environment would significantly contribute to the deterioration of banks' interest margins (Covas, Rezende, & Vojtech, 2015). Moreover, this negative impact would feed through to banks' ability to generate adequate profits and eventually harm the soundness of the banking sector (English, 2002; Altavilla et al., 2018).

This short introduction should make clear that it is very important to shed light on the relationship between (low) interest rates and banks' NIM. It is essential to know how and to what extent a low interest rate environment, caused by an accommodative monetary policy, influences the NIM of banks and which factors (bank-specific and macroeconomic factors) play a role in this. Furthermore, this relationship is also interesting from the perspective of policy makers as it will allow them to evaluate the effectiveness of their monetary policy. Therefore, the overall aim of this thesis is twofold. On the one hand, it gives an overview of how an interest rate environment can affect the banking industry. On the other hand, it quantifies the impact of a changing interest rate environment on banks' NIM.

This master's dissertation contributes to the existing literature by examining the effect of (low) interest rates on banks' NIM and its components (deposit spread and loan spread). More precisely, this thesis aims to answer the following questions: *"If falling interest rates have left their mark on banks' NIM, how and to what extent are the separate components of the NIM impacted?" "Furthermore, can we observe any compensation between the loan and deposit spread?"*

Using a panel dataset of 2550 banks operating in the 10 countries over the period from 2003 to 2019, we aim to assess the impact of (low) interest rates on the components of banks' NIM (interest rate spread, lending and deposit spread). By applying static panel models, we find that monetary policy easing (a reduction in short-term interest rates and a flattening of the yield curve) is associated with narrower interest rate and deposit spreads, but wider lending spreads. These results therefore provide strong evidence for the presumption that the components of the NIM on both sides of the balance sheet are asymmetrically affected by changes in interest rates. We further find that a negative interest rate environment weighs on banks' NIM as it gives rise to an imperfect pass-through of monetary policy measures.

The remainder of this master's dissertation proceeds as follows: section 2 clarifies the NIM and its components. Section 3 provides an overview of several theoretical mechanisms that outline the interaction between monetary policy and the banking sector. Section 4 then reviews the existing literature concerning the relationship between interest rates and banks' NIM, whereas section 5 outlines the empirical framework, the data and the results. In the final section, we conclude.

2

Net interest margin (NIM)

Before focusing on the empirical evidence regarding the relationship between the interest rate environment and the NIM, it is important to clearly define the latter. In what follows, we aim to describe this concept and its interpretation based on the existing academic literature.

2.1. Defining NIM and its components

As already mentioned, the primary business of banks is to channel funds from savers to firms and/or individuals making investments. The net revenues, generated by this activity, are referred to as the NIM. In the literature, some authors simply define the NIM as the difference between the lending rates and the borrowing rates (López-Espinosa, Moreno, & de Gracia, 2011; Busch & Memmel, 2016; Wang, 2017; Angori et al., 2019) while others are more specific in their description and denote it as the difference between interest income and interest expense expressed as a percentage of its average earnings assets (Wong, 1997; Sensarma & Ghosh, 2004; Claeys & Vander Vennet, 2008; Memmel & Schertler, 2013; Genay, 2014; Klein, 2020). This thesis will rather decompose the NIM into several parts after the example of Hempel & Simonson (1999) and examine their development.

The NIM consists of three components, namely the interest rate spread, the loan spread and the deposit spread (figure 1). First, we'll consider the interest rate spread. It represents the gap between short-term and long-term interest rates and hence alludes to the slope of the yield curve. In other words, it refers to the earnings of a bank directly obtained by performing maturity transformations. Usually, the yield curve has a positive slope, which implies that long-term rates are higher than short-term rates due to the risks associated with the maturity. Although an upward sloping curve is considered to be normal, it can also be flat or downward sloping depending on changing economic conditions (Hempel &

Simonson, 1999). For example, recent economic developments and central bank measures, in particular the asset purchase programmes (APP), have had a significant downward impact on the slope of the curve, making it almost flat.

On top of the interest rate spread, financial intermediaries also strive to gain profit on both sides of their balance sheet. On the one hand, banks try to earn a loan spread or commercial loan margin when selecting earning assets. This margin is formed by the wedge between the loan rate and a swap rate with a similar maturity (Busch & Memmel, 2016). On the other hand, if banks are able to attract deposits and raise funds at a lower cost compared to the interbank rate, they will profit from a funding spread or a commercial deposit margin on their liability side (Banking Supervision Committee, 2000).

In addition, it’s worth mentioning that the interest rate spread applies to all banks whereas the loan and deposit spreads are rather bank-specific. This is quite obvious as the former represents the reward on the market while the other two parts demonstrate banks’ efficiency.

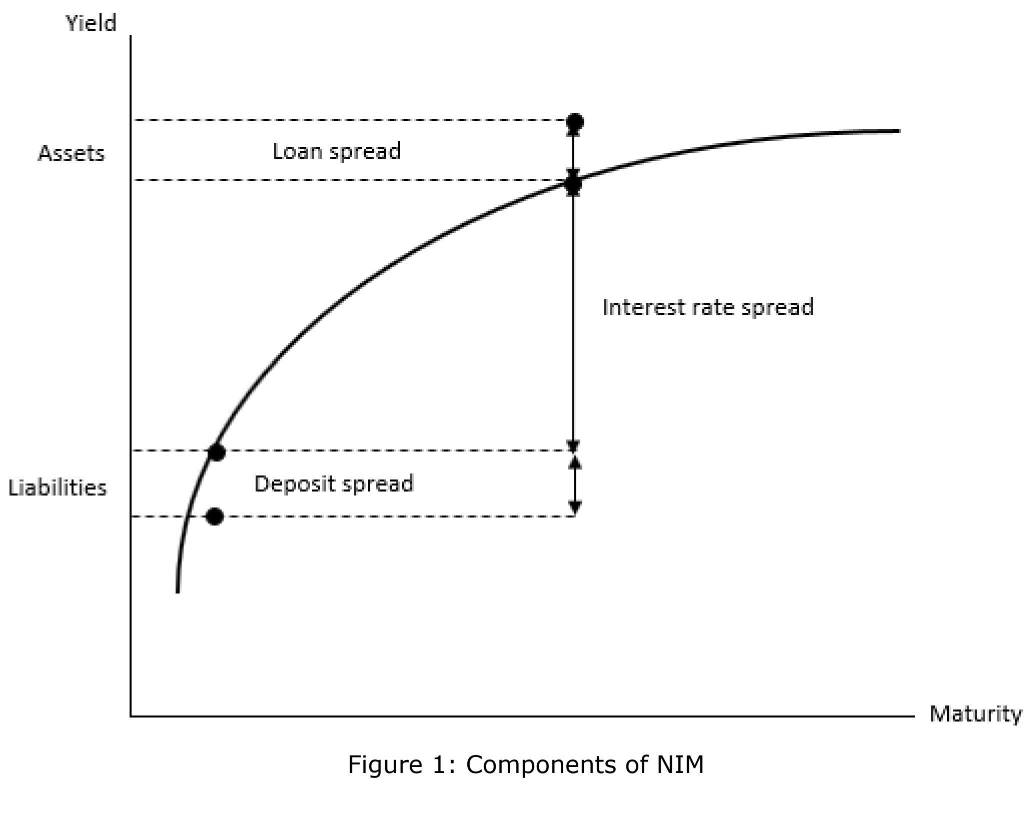

Figure 1: Components of NIM

2.2. Relevance of NIM

The NIM is often used as a proxy of banks’ profitability. Consequently, one could easily think that the higher the NIM, the more favourable it is. However, this assumption does not hold as there is controversy in the literature regarding the size of the interest margin. Put differently, a high NIM isn’t always a good sign as its interpretation involves a trade-off that will be outlined below.

At first sight, high margins may reflect several positive qualities that banks possess. For instance, high NIMs can be associated with excellent management quality and a high degree of efficiency. This implies that banks with a sound and efficient management are able to choose the most profitable assets and low-cost liabilities in order to boost their interest margins (Maudos & de Guevara, 2004; Angori et al., 2019; Cruz-Garcia, de Guevara, & Maudos, 2019).

Secondly, high margins can also be a sign of a solid capital position, built up by retained earnings. This has three implications. On the one hand, banks absorbing capacity will be increased as they then hold more capital than the minimum capital requirements under Basel III. This in turn will improve the health of the banking sector, thereby contributing to financial stability (Valverde & Fernández, 2007; Shin, 2016; Angori et al., 2019; Klein, 2020). On the other hand, banks can also use the excess capital to expand their portfolio of risky assets. As long as the new assets have an attractive risk-return profile, the interest margins will widen further. Additionally, the level of capital also determines external ratings and investor perceptions as it acts as a signal of banks’ credibility. Better capitalized banks will therefore have the possibility to reduce their funding cost, which will benefit the NIM again (Claeys & Vander Vennet, 2008).

While these aforementioned elements all seem advantageous, we should also look at the other side of the coin since high margins may also reflect some shortcomings. To begin with, several authors (Maudos & de Guevara, 2004; Angori et al., 2019; Cruz-Garcia et al., 2019) state that high margins can only arise in a relatively non-competitive market. After all, in such an environment, banks will have the opportunity to set their prices autonomously thanks to their greater market power. Furthermore, this implicitly means that economic agents will face higher intermediation costs.

Finally, high NIMs can be considered as a reflection of weak supervisory power in a given country. This refers to the capability of official supervisory authorities to directly influence bank behaviour and activity (Angori et al., 2019). So, if the regulatory banking environment is insufficiently developed, this could lead to excessive risk-taking behavior, which will manifest itself in higher margins and ultimately in increased financial vulnerability (Claeys & Vander Vennet, 2008; Angori et al., 2019).

Altogether, we conclude that the NIM in itself can give a distorted picture of reality. It is therefore important to interpret this measure taking into account various other factors such as management skills, capital position, competitiveness, supervisory power and many more.

3

The transmission of monetary policy on banks

Monetary policy has always been an important factor in determining the behaviour of the banking industry, whether it is conducted conventional or unconventional. Especially in the wake of the financial crisis, the additional non-standard measures have thoroughly changed banks' liquidity and income structure (Bernoth & Haas, 2018). One of the key moments was the implementation of the negative interest rate policy (NIRP) (ESBG, 2016). Several central banks (Swedish, Danish, European, Swiss and Japanese) decided to loosen their monetary policy even more by pushing the deposit facility rate into the negative territory. As a result, banks had to pay interest to place their excess liquidity with the central bank (Alessandri & Nelson, 2015; Klein, 2020). Mario Draghi, the former president of the ECB, justified this policy by saying that negative rates were the only way to quell market expectations concerning the future course of official interest rates. Otherwise, the private sector would revise its long-term expectations upward, which would significantly affect important economic decisions, thereby undermining the effectiveness of monetary policy (Draghi, 2016; Beyer et al., 2017).

Despite the accommodative stance of monetary policy, the desired results regarding price stability and economic conditions are not forthcoming. Consequently, policymakers are confronted with a lot of criticism from politicians, economists and especially banks. In the following paragraphs, we therefore examine how conventional (reduction in short-term interest rates) and unconventional (flattening of the yield curve caused by quantitative easing & NIRP) monetary policy measures are transmitted to the banking sector. In other words, we distinguish four theoretical transmission mechanisms through which an accommodative monetary policy flows to banks, namely the interest rate channel, the credit channel, the risk-taking channel and the portfolio rebalancing channel (see figure 2).

3.1. The interest rate channel

Within this framework, the interest rate channel is often considered to be the main channel of monetary policy transmission as it affects the most important part of financial intermediaries' income, namely the NIM (Loayza & Schmidt-Hebbel, 2002). After all, lowering policy rates does not only affect the money-market rates but also the bank lending and deposit rates. Usually, banks always try to preserve their NIM when setting their rates for customers. However, this has become very difficult in a low and even negative interest environment. Two reasons were put forward (Beyer et al., 2017). On the one hand, banks find it very hard to adjust deposit rates in line with the declining market interest rates. They believe that passing on negative rates to their retail depositors would only increase the chance of losing them. These rates are therefore not set below zero in contrast to deposit rates to corporate and institutional clients, which may dip below zero. On the other hand, banks have also become reluctant to lower their lending rates. The transition from higher to lower interest rates changed the banking environment, thereby creating more competition among banks and improving overall efficiency. As a result, lending rates have been trending down, making banks reluctant to cut them even more as it would only further impair the NIM (Jobst & Lin, 2016; Shin, 2016; Bikker & Vervliet; 2017; CGFS, 2018).

These two ways of protecting themselves eventually give rise to a slowdown of the pass-through of a loose monetary policy. In other words, the monetary stimulus will not fully reach the economy as households and firms are only encouraged to invest and consume to a limited extent (Garza-Garcia, 2010; Bernoth & Haas, 2018; CGFS, 2018).

3.2. The credit channel

The banking industry is a key player in helping policymakers achieve its objectives. In this context, the credit channel comes into play as it sheds light on the impact of monetary policy on both supply and demand of bank credit. Traditionally, a further distinction is made within this channel between two different, albeit related, mechanisms, namely *the bank lending channel* and *the balance sheet channel* (Ireland, 2010; Beyer et al., 2017; Bernoth & Haas, 2018).

The bank lending channel or the credit channel in strict sense emphasizes the importance of central banks' UMP for sustaining loan origination (Beyer et al., 2017). It posits that a policy-induced interest rate drop causes a decline in the opportunity cost of holding deposits. Subsequently, as bank deposits rise, bank reserves will also increase, creating more funds to lend. The increased availability of credit leads then to eased borrowing constraints and triggers banks to expand their loan portfolio. This eventually translates into higher consumption and more investments by households and firms, fostering economic growth (Bernanke &

Blinder, 1988; Bernanke & Gertler, 1995; Hernando, 1998; Disyatat, 2010; Apergis, Miller, & Alevizopoulou, 2012; Bean et al., 2015).
However, it should be noted that in a world with three assets - money, bank loans and government bonds - three important conditions must be fulfilled for this channel to work. First, money shouldn't be neutral, at least in the short run. This means that market imperfections must exist such that prices cannot fully and immediately adjust to money supply changes (Apergis et al., 2012; Peek & Rosengren, 2013). Second, central banks should be able to influence the quantity of loans in the banking system (Oliner & Rudenbusch, 1995; Farinha & Robalo Marques, 2001; Disyatat, 2010; Apergis et al., 2012). Third, bank loans should be an imperfect substitute for other types of finance. This implies that activities of economic agents depend on the availability of credit. In other words, they shouldn't be able to fully switch to other funding sources such as savings, donations, commercial papers or loans from finance companies for any transaction in the economy (Oliner & Rudenbusch, 1995; Hernando, 1998; Gambacorta, 2005; Apergis et al., 2012).

Unlike the bank lending channel, the balance sheet channel, also known as the broad credit channel, states that monetary policy modifies the balance sheet of borrowers, thereby altering credit demand (Bernanke and Gertler, 1995; Kishan & Opiela, 2000; Bernoth & Haas, 2018). More precisely, a loose monetary policy is expected to improve the health of households and firms in terms of both net income and net worth. Regarding borrowers' net income, a drop in key interest rates has a dual effect. On the one hand, it reduces borrowers' interest costs and on the other hand, it boosts firms' revenues since such a policy is intended to spur the economy. With respect to the net worth, borrowers' assets are discounted using lower interest rates, increasing the value of their collateral. Combining both factors - increase in wealth and asset prices - strengthen the financial position of households and firms, which in turn induces a decline in the cost of borrowing, more specifically the external finance premium[1]. Their increased borrowing ability will subsequently be reflected in higher demand for credit, leading to a thriving economy (Bernanke & Gertler, 1995; Kishan & Opiela, 2000; Peek & Rosengren, 2013; Bernoth & Haas, 2018).

3.3. The risk-taking channel

Banks' perception and tolerance of risk vary over time and are subject to interest rate policies pursued by central banks (Beyer et al., 2017; Dell'Ariccia et al., 2017). Rajan (2005) and Borio & Zhu (2008) were among the first to point this out by suggesting that a low interest rate environment stimulates the risk appetite of banks on both sides of their balance sheet.

[1] The difference between the cost to the borrower of raising external finance and the opportunity cost of using internally generated funds (Bernanke & Gertler, 1989).

On the asset side, the increased risk appetite translates into a search-for-yield behavior. Banks are willing to take on more risk, especially when they are faced with a decline in their income from financial assets and therefore unable to meet their nominal return targets (Gambacorta, 2009; Beyer et al., 2017; Bonfim & Soares, 2017; Bernoth & Haas, 2018). Low interest rates also indirectly affect the quality of loan portfolios because it alters banks' risk perception. At first glance, the banking sector assumes a decrease in credit risk due to the positive impact of low interest rates on asset and collateral values (supra section 3.2.). As a result, they adjust their estimates of default probabilities on outstanding loans downwards and reduce their provisions for non-performing loans. More specifically, banks start to overestimate borrowers' repayment capacity, which entices them to soften their lending standards and issue more loans. Consequently, these developments amplify the bank lending channel and lead to less qualitative loan portfolios and considerable risk positions (Paligorova & Sierra, 2012; Bikker & Vervliet, 2017; Delis, Hasan, & Mylonidis, 2017; Neuenkirch & Nöckel, 2018).

The risk-taking channel also takes place along the liability side. In particular, banks have the intention to increase their leverage ratio in view of a declining cost of debt ascribable to monetary easing. In other words, they would rather finance themselves more with debt than with equity since it will be more profitable (Adrian & Shin, 2009; Delis et al., 2017; Bonfim & Soares, 2017) However, the extent to which banks can switch to debt financing depends on two elements (Dell'Ariccia et al., 2010; Valencia, 2014). First, banks should be able to adjust their capital structure at the time of a cut in policy rates. In that case, lower rates will lead to lower bank monitoring and greater leverage. Second, debt contracts should afford limited liability protection to banks. This will result in a greater willingness to take on more risk as banks will suffer no losses in case of failure.

3.4. The portfolio rebalancing channel

As mentioned earlier, the asset purchase programmes (APP) and the introduction of the NIRP have been defining moments in the course of monetary policy. So far, we have shown that these measures had an impact on various aspects of the banking system, such as the interest income, the willingness to lend, the quality of banks loan portfolios and their attitude towards risk. However, we can bring all these elements together under one umbrella as they give rise to the portfolio rebalancing channel (Gambetti & Musso, 2017).

The crucial starting point for this channel is the impact that the APP has on the yield of an asset. That is to say, central banks exert a direct effect on the supply of an asset by purchasing the asset in question. Thus, for a given demand, this results in a decreased availability of that asset in the market which pushes its price up. Due to the inverse relationship between the price and the yield, this process ends in a lower yield for that particular asset. Moreover, this means that the return that banks are hoping to receive in the future will be adjusted downwards. Several authors (Shah, Schmidt-Fischer, & Malki, 2018; Tischer, 2018; Lane, 2019; Bottero, Minoiu, Peydró, Polo, Presbitero, & Settle, 2019) claim that banks don't throw in the towel because at that moment the portfolio rebalancing channel kicks in. Once the yield differential between the asset classes increases, banks are incentivized to rebalance their portfolios in order to preserve their profitability. In other words, portfolio rebalancing will then not only take place between different maturities, but also between different asset classes. This effect is further enhanced by implementing the NIRP. Negative rates penalize the holding of safer, more liquid assets thus prompting banks to shift to riskier, higher-yielding and less liquid assets. For instance, bank-asset managers are inclined to switch from low-risk government bonds to higher-yielding corporate and emerging market bonds or to corporate loans (Gambacorta, 2009; Beyer et al., 2017).

In addition, Borio et al. (2015), Delis & Kouretas (2011), CFGS (2018) and Brei, Borio, & Gambacorta (2019) discuss another way in which banks can rebalance their portfolio, namely by switching from traditional interest-generating activities to more non-traditional i.e. fee-related and trading activities. In this way, banks reduce their interest rate exposure and maintain their level of income.

It is worth noting that this channel could have undesirable consequences in the long term. While it may encounter shrinking margins and profits in the short term, it also increases banks' risk exposure to financial markets, which in turn could harm the soundness of the banking industry in the long run.

3.5. Sub-conclusion

The aforementioned transmission channels reveal the inseparability of monetary policy and the banking system. After all, the decisions of policymakers will set the tone for banks behavior and financial stability (Capie, Mills, & Wood, 2018). Theoretically, there is uncertainty about the effectiveness of monetary policy instruments - conventional and/or unconventional - as they produce countervailing effects. On the one hand, a looser monetary policy boosts credit supply, lowers banks' funding cost and ameliorates the financial position of households and firms. In the latter case, banks also dodge a higher inflow of non-performing loans. On the other hand, historically low interest rates put downward pressure on the NIM and lead to less efficient credit allocation. These elements, in turn, incentivize banks to rebalance their portfolios towards higher-yielding assets, thereby increasing their risk exposure and jeopardizing financial stability. Ultimately, it remains an empirical question whether very low interest rates are beneficial for the banking industry, or for the economy as a whole (Altavilla, Burlon, Giannetti, & Holton, 2019).

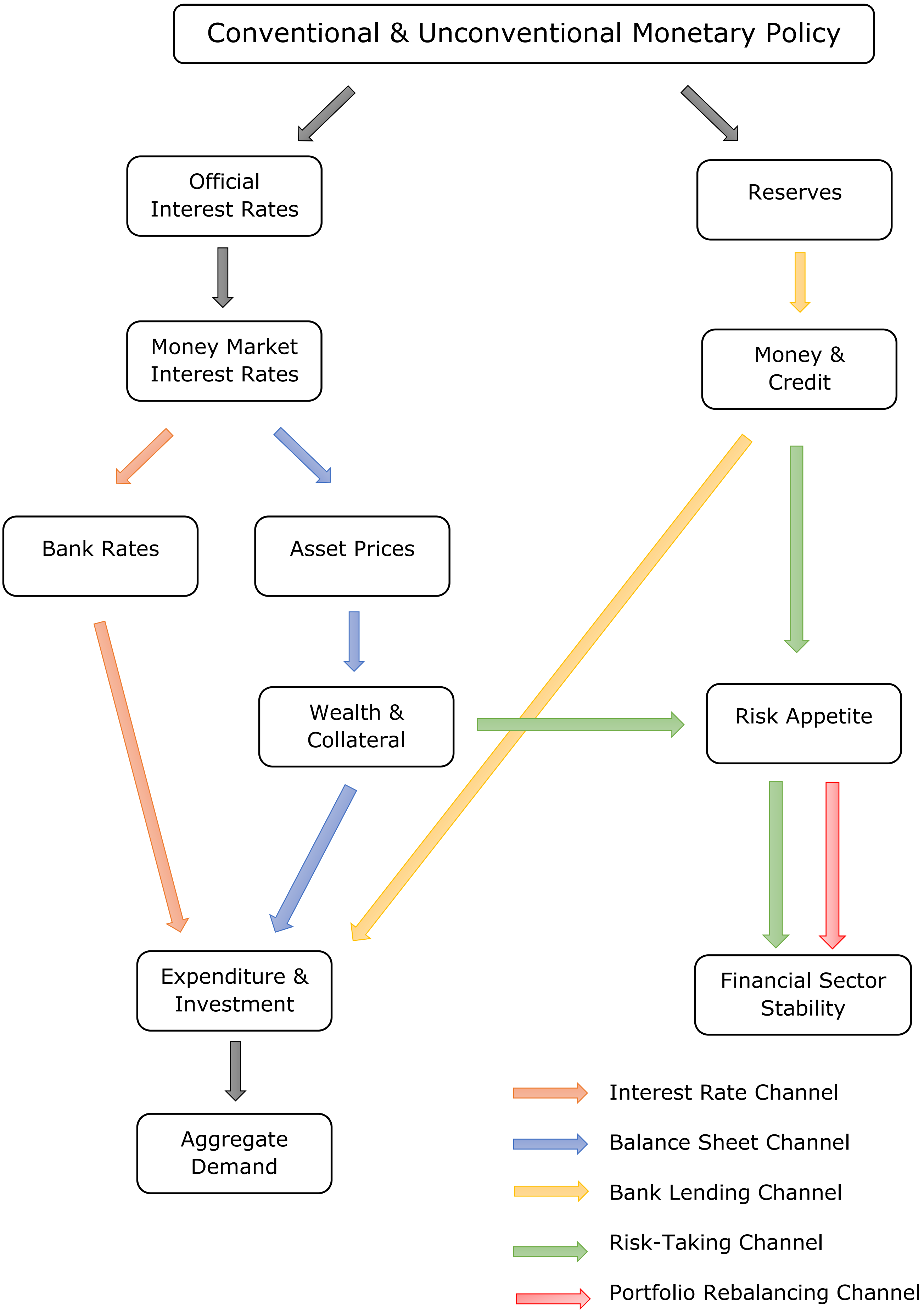

Figure 2: Overview of the transmission channels

4

Literature review

Following the interest rate channel, there is a widespread agreement that a low interest rate environment tends to reduce profits, mainly by depressing the banks' NIM. Surprisingly, however, little empirical evidence on the relationship between interest rates and the NIM has been provided in literature as many studies preferred to use alternative profitability indicators such as the return on assets (ROA), the net operating income margin or the loan loss provisions margin (Genay, 2014; Brei et al., 2019; Klein, 2020). In what follows, we will review the scarce literature in an attempt to clarify the net impact of monetary policy easing on banks' NIM.

4.1. Interest rates and banks' NIMs

English (2002) analyses to what extent changes in market interest rates affect commercial banks' NIM. The author aims to distinguish short-term effects from long-term effects by using bank data from ten industrial countries over 20 years. In order to conduct this research, English (2002) first formulates two hypotheses. The first hypothesis proposes that interest rate changes reach bank assets and liabilities at a different pace due to the existence of maturity mismatches and repricing frictions. More specifically, returns on liabilities are expected to adjust more quickly to changes in short-term rates compared to returns on assets, which may either amplify or dampen monetary policy shocks (Andreasen, Ferman, & Zabczyk, 2013). So, as long as assets and liabilities are not fully repriced, a decrease in short-term interest rates would temporarily boost banks' NIM (Heider, Saidi, & Schepens, 2019). The second hypothesis states that a steeper yield curve is presumed to give rise to higher NIMs. This implies that as the yield difference between assets and liabilities increases, banks' NIM would widen. In line with Borio (1995), Alessandri & Nelson (2015) and Bush & Memmel (2015), regression results provide evidence for the first hypothesis; returns on bank liabilities usually have a shorter repricing period than returns on bank assets. In other words, a reduction in short-term rates will initially increase banks' NIM. Afterwards, once the repricing process is completed on both sides of the balance sheet, the impact will reverse

and hence compress banks' NIM in the long run. Following these findings, Dell'Ariccia, Marquez, & Laeven (2010) study the knock-on effects that are triggered by this decline. They find that narrow margins are unfavourable for banks' return on assets (ROA) and ultimately harm their return on equity (ROE). This, in turn, encourages banks to take on more risk and start building up excessive leverage.
Regarding the second hypothesis, English (2002) finds little evidence that the slope of the yield curve has a significant impact on the NIM. While this may seem strange at first sight, it is not inconsistent with most of the literature as they find that the impact of the interest rate spread on the NIM is either very low or statistically insignificant. According to English (2002), this results from the dominant pricing strategy of each bank. For example, if the degree of maturity mismatches between loans and deposits is low, the slope of the yield curve will have little effect on the behavior of the NIM. Similar results and arguments are found by Klein (2020). Interestingly, however, English (2002) also finds no correlation between interest margins and the level of interest rates, which shows that banks in question have successfully limited their exposure to market rates.

A recent study conducted by Hofmann, Illes, Lombardi & Mizen (2020) seems to agree with this last conclusion. They investigate the impact of UMP on retail lending and deposit rates in four euro area countries (Germany, Spain, France & Italy) from 2007 to 2019. Regarding the intermediation margin, they do not find a clear-cut impact of the ECB's UMP. The results only show a statistically significant decrease in the lending-deposit spread in Germany and Italy. Hence, it turns out that the magnitude of the impact varies widely across countries as it depends on country-specific financial and economic tensions.

In contrast to English (2002) and Hofmann (2020), several other papers (Genay & Podjasek, 2014; Borio et al., 2015; Bikker & Vervliet, 2017; CGFS, 2018; Claessens et al., 2018; Angori et al., 2019; Brei et al., 2019; Cruz-García et al., 2019) with larger datasets draw a different conclusion regarding the latter finding. They re-examine this relationship by relating the NIM to two different monetary policy indicators. On the one hand, they use the 3-month money market rate to represent the short-term interest rate. On the other hand, they take the spread between the 3-month money market rate and the 10-year government bond yield to display the slope of the yield curve. Overall, regression results reveal a positive relationship between the NIM and both monetary policy indicators, confirming conventional wisdom. For example, the study of CGFS (2018) finds that a one percentage point decrease in the short-term interest rate is associated with a 6 basis points decline in the NIM. Furthermore, when allowing for non-linearities by adding quadratic terms of the two explanatory variables to the specifications, the corresponding relationships are found to be concave. The negative coefficients for these terms therefore suggest that the impact of an interest rate change on bank margins are stronger in a low interest environment (Borio et al., 2015; Bikker & Vervliet, 2017; Klein, 2020).

Based on the previous findings, Claessens et al. (2018) explore the behaviour of the NIM in different interest rate environments for 3385 banks across 47 countries between 2005 and 2013. To decide whether a country is situated in a low or high interest environment, the authors set a threshold for the three-month interest rate. If the average is less than or equal to 1.25 percent, the country is considered to operate in a low interest environment. Otherwise, if the rate lies above this threshold, it is categorized as a high interest environment. They show that the relationship between the interest margin and an interest rate change is more prominent in a low interest rate environment. More precisely, a one percentage point decrease in the short-term interest rate causes a drop of 20 basis points in banks' NIM in the low-rate environment, whereas the effect in the high-rate environment is limited to a decline of 8 basis points. Regarding the slope of the yield curve, the results differ in both interest environments. A statistically significant positive association is only found in a low interest rate environment, indicating a higher sensitivity of banks to this variable when interest rates are low. A one percentage change in the slope then leads to a decline of 13 basis points in the NIM. Despite the different methodology, these findings are in line with Borio et al. (2015). Their sample consists of a smaller group of banks in 14 major advanced economies over a period of 17 years (1995-2012). Instead of specifying a threshold, they investigate a one percentage fall in the short-term rate in two possible cases. In the first case, the short-term rate declines from 1 to 0 percent, which reduces the NIM by 50 basis points. In the second case, there is a drop from 7 to 6 percent, pushing banks' NIM down by just 20 basis points. As for the slope of the yield curve, Borio et al. (2015) prove that the flattening of this curve has a greater impact on the NIM at low interest rate levels than at high interest rate levels.

The previous studies are based on interest rate changes in the positive area. However, as we have already mentioned in this thesis, many economies are now facing negative interest rates. Therefore, it is interesting to explore the difference in impact of both positive and negative rates on interest margins. Using a panel dataset of euro area banks, Boungou (2019) maps the development of the NIM in a negative and positive interest rate environment. Before exploring this field, it is worth mentioning that his findings regarding the relationship between interest rates and banks' NIM are consistent with the studies above; the short-term interest rate is positively related to the NIM. Moreover, this relationship is characterized by an inverted U-shape. Once this has been established, Boungou (2019) wonders to what extent negative rates have contributed to the deterioration of banks' NIM. In order to answer this question, he adds an interaction term in his analysis. The results seem to confirm intuition since the coefficient for the negative rates (1.02) is larger than for the positive rates (0.43). In other words, negative interest rates exert a stronger downward pressure on the interest margins compared to positive interest rates. In addition, Klein (2020) reports considerably stronger effects of the positive and negative rates on the NIM, 1.1 percent and 3.2 percent respectively. However, this isn't surprising as her sample consists of retail banks whose core activity consists of performing maturity transformations.

Altavilla et al. (2018) and Lopez, Rose, & Spiegel (2020) approach this subject from a different angle by scrutinizing the impact of conventional and unconventional monetary policy measures on the main components of bank profitability, being net interest income, non-interest income and provisions. In a certain sense, this study sheds light on the channels above as it focuses on the asymmetric impact of an expansionary monetary policy on banks. Consistent with the findings in other papers, the results display a significant positive relationship between the level of short-term rates and banks' interest margins. Although this creates a very pessimistic framework for banks in times of unconventional policy, the latter produces countervailing effects. Lowering interest rates appears to have a positive impact on non-interest income and loan loss provisions. Additionally, banks enjoy capital gains due to the increase in the value of the securities they hold. All these positive effects together largely outweigh the negative effect on the margins. Consequently, the authors conclude that under such circumstances banks do not struggle to generate profits. Alternatively, a survey conducted by the ECB (2016) suggests the opposite. More than half of the participating banks declared that the positive effects do not compensate for the loss on their interest margins.

Last but not least, the previously mentioned study of Hofmann et al. (2020) also provides evidence for the arguments mentioned in the interest rate channel (supra section 3.1.). Their findings show that the ECB's measures have led to an overall fall in lending and deposit rates. Moreover, the lending rates have been falling more than the deposit rates in all four countries. The authors next identify two significant moments responsible for this deterioration, namely the Outright Monetary Transactions announcement in 2012 and the introduction of the asset purchase programmes since mid-2014. Klein (2020) takes a different view and believes that this effect rather arises from the introduction of the NIRP in the eurozone in June 2014. In contrast to Hofmann et al. (2020) and Klein (2020), Cœuré (2016) argues that conventional and unconventional measures were neither the cause nor the cure for declining rates, as they have been falling since the financial crisis.

4.2. Low-for-long

So far, much of the empirical evidence reveals that a low interest rate environment has an undesirable impact on banks' NIM. However, there is disagreement about when this effect will occur, in the short-term or long term. Against this backdrop, policymakers still have a long way to go to bring price stability and the economy to the desired level. As long as these targets are not met, interest rates will be kept low. Consequently, the question arises what impact a prolonged period of low interest rates, also known as low-for-long, will have on banks' interest margins.

Claessens et al. (2018) investigate this question by adding specific variables to their base regression. First, they take into account the number of years that a bank has been in a low interest rate environment. The coefficient for this variable turns out to be statistically significant and negative. In other words, the more time a bank spends in a low interest rate environment, the greater the negative impact on its interest margin. To be more specific, each additional year causes a drop in the NIM of 8 basis points. The authors next wonder whether a time pattern can be found in this effect. Accordingly, they add four dummies representing each additional year in such an environment. The dummy variables for first and second year are found statistically insignificant, indicating that banks' interest margins are immune to lower rates for the first two years. Regarding the third and fourth year, a low interest rate environment appears to contribute to a decrease of the NIM by 38 and 40 basis points, respectively. These results therefore imply that the effect of low interest rates must be monitored closely as banks ultimately cannot fully protect their NIMs. Similar results are found by the Bundesbank (2015). Based on a sample of 1500 German banks, they show that persistently low interest rates undermine German banks' profitability, mainly due to shrinking margins.

Along the same line, Demirgüç-Kunt & Huizinga (1999) and Altavilla et al. (2018) find relatively small coefficients for the variables in question. This, in consequence, implies that the downsides associated with UMP will not materialise in the near future. Two reasons are brought forward for this. First, the fact that assets and liabilities are repriced at different times plays in favor of the banks in the short-term (see English, 2002). Secondly, the downward impact on interest margins is counterbalanced by an improved macroeconomic outlook fueled by low rates. After all, favorable economic conditions will initiate the credit channel by stimulating the supply and demand for credit. For example, Brei et al. (2019) detect that the increase in interest margins is mainly caused by a simultaneous increase in the supply of bank demand.

The study of Albertazzi & Gambacorta (2009) sheds light on the relationship between long-term interest rates and the NIM. They establish a negative relationship between a prolonged period of low long-term rates and banks' NIM. In particular, NIMs will decline by one percent in the first year while after four years this decrease will rise to almost four percent.

Finally, Brei et al. (2019) provide indirect evidence that, in the long term, banks try to offset the deterioration of their interest margins with higher non-interest income, mainly fees and commissions. Results indicate that after one year of low interest rates, the coefficient for non-interest income is only 0.12, whereas after seven years, it rises considerably to 0.37.

4.3. The role of bank-specific and macroeconomic characteristics

We denoted in section 2.2 that various elements contribute to the size of the NIM. So, it goes without saying that some of these determinants will interfere in the relationship between the NIM and the interest rates. That is to say, those elements may either strengthen or weaken the relationship in question, implying that not every bank will be affected in the same way. The literature provides evidence for five factors, namely the size, the business model and the banking and economic environment and inflation.

First, the size of banks plays an important role. For example, Claessens et al. (2018) divide his sample into two groups (small and large banks), based on the size of banks' assets. He then investigates how the NIM of both groups responds to an interest rate change in a low interest rate environment. The results show that smaller banks are relatively more sensitive to interest rate changes and therefore experience a greater impact on their NIM. The coefficients of a one percentage point decrease in the short-term interest rate for small and large banks are 0.197 basis points and 0.153 basis points, respectively. Genay & Podjasek (2014) also applies the same methodology to banks in the US to shed light on this hypothesis. Although the magnitude of the results differs, small banks' NIM experience a drop of 1.5 basis points while large banks' NIM decreases by only 0.3 basis points.

Secondly, the size of the banks is undoubtedly linked to their business model. In general, small banks tend to engage more extensively in maturity transformations and are thus characterized by their typically low level of income diversification. Conversely, large banks are more diversified and carry out other activities such as assisting companies in raising financing capital or providing financial advice during mergers and acquisitions. This results in a more stable income structure and consequently lowers the degree of interest rate exposure (Mergaerts & Vander Vennet, 2015). Following this theory, Memmel (2011) compares savings with private commercial banks and measures the impact of a change in the earnings from term transformation on the interest margin of these two groups. The results for the first group's NIM (29.2 basis points) are much higher than for the second group's NIM (6.9 basis points), implying that small banks have greater difficulty to shield their NIMs from low interest rates and hence take the greatest hit. After all, larger banks have the advantage of hedging their exposure to interest rate risk in various ways such as increasing their operational efficiency, switching to trading and fee-based revenues, reducing maturity mismatches by selecting assets and liabilities or attracting other funding sources than deposits. We can therefore conclude that a viable business model in times of low interest rates is characterized by income diversification (CGFS, 2018; Klein, 2020).

Thirdly, the intensity of the relationship between interest rates and NIMs also depend on the nature of the banking market. We distinguish banking markets with low and high concentration. The results illustrate that banks operating in the former environment are more prone to changes in interest rates than banks in the latter environment. Two elements are responsible for this larger impact. On the one hand, banks in a low-concentration market have little power to set their prices (Naceur, 2003). As a result, they are obliged to pass on interest rate drops to their loan customers. On the other hand, a low-concentration market is also characterized by strong competitive pressure, which leaves banks with less latitude to adjust deposit rates (CGFS, 2018).

Fourthly, it might be interesting to consider the economic environment in which banks operate as this largely determines the supply and demand of banking services in the economy (Gros, 2016). Using GDP growth as a proxy, one expects to notice substantial effects on the NIM. However, opinions about the direction of the impact are divided. Altavilla et al. (2018) find that a low economic growth only strengthens the relationship between the NIM and the interest rates. In other words, a low GDP growth creates additional pressure on the NIM in a low interest rate environment. Conversely, Claessens et al. (2018) and Bikker & Vervliet (2017) argue that low economic growth damages debt servicing capacity of borrowers. As a result, banks will charge a higher risk premium which, in turn, will lead to an upward pressure on the banks' interest margins.

Last but not least, several studies claim that there is a relationship between inflation and banks' interest margin. But as for the sign of this relationship, there is a disagreement among the authors. Perry (1992) argues that inflation has a differential impact on the NIM depending on whether it is anticipated or not. If inflation is anticipated and borrowers' real incomes are sticky, we observe a positive association between inflation and banks' NIM. A rise in inflation will then lead to a deterioration in borrowers' net worth and creditworthiness, thereby increasing the risk of default. In response to this, banks will charge higher lending rates which will in turn widen the margin (Tarus, Chekol, & Mutwol, 2012). This theory is consistent with empirical evidence provided by Claessens, Demirgüç-Kunt & Huizinga (2001), Honohan (2003), Gelos (2009) and Angori et al. (2019). However, if inflation is not anticipated, the inflation shock cannot be passed through to borrowing and lending rates equally rapidly. In other words, bank costs may increase faster than bank revenues, thereby impairing banks' NIM (Naceur and Kandil, 2009; Tarus et al., 2012).

5

Econometric panel study

The previous section provided a broad overview of the studies conducted with regard to the relationship between interest rates and banks' NIM. The mixed results regarding the direction of the impact raise the following questions: If UMP of central banks has left its mark on banks' NIM, does this mean that the components of the NIM - the interest rate spread, the loan spread and the deposit spread - are equally affected? Or is there some kind of compensation going on between loan and deposit spreads to limit the damage?

We aim to answer the above-mentioned questions by performing a cross-country panel data analysis. In the following subsections, the methodology will first be explained in detail. Then the data will be discussed in order to proceed to the results of this research.

5.1. Methodology

This section presents the estimation strategy employed to scrutinize the link between interest rates and banks' NIM. Therefore, we first compile a panel dataset that contains repeated observations over the same units (in our case: countries) collected over several periods (Verbeek, 2007; Gujarati & Porter, 2009). Usually, a distinction is made in the literature between micro and macro panels, depending on the number of units and periods. A micro panel, for instance, is characterized by data where the number of units is much larger than the number of periods ($n >> T$). However, if the situation reverses and the number of units is smaller than the number of periods ($n << T$), then we speak of a macro panel. Obviously, the former includes more information on a unit-level, making it more suitable to investigate unit heterogeneity. The latter, on the other hand, rather focuses on the time dimension of the data, capturing the dynamics of adjustment (Baltagi, 2008). Altogether, we construct a balanced[2] macro panel of 10 countries with

[2] Balanced panels are defined as complete panels without randomly missing observations (Baltagi, 2008)

observations collected over 204 time periods. In this way, we gain insight into the extent to which banks' NIM adjust to monetary policy changes.

Furthermore, several other advantages are linked to the use of panel data, also known as longitudinal data. For example, it provides a more informative dataset as the sample size is significantly larger compared to cross-sectional or time-series data. As a result, there will be more variability and less collinearity among variables, but more importantly it will yield more efficient and accurate estimates. Especially the combination of cross-sectional and time series data will allow us to specify richer econometric models to identify and measure effects that are otherwise simply undetectable (Kennedy, 2008; Verbeek, 2007).

Finally, a panel study also makes it possible to control for individual heterogeneity, thereby implicitly acknowledging the fact that all units are different from each other. This further entails that the behaviour of each unit is affected by multiple unmeasured, state- and time-invariant explanatory variables, which in turn could alter the relationship in question. A pure cross-sectional or time series analysis, by contrast, does not account for these variables, causing serious misspecifications and leading to biased results. Consequently, panel data considerably reduce the omitted variable problem and allow us to consider country-specific characteristics that influence the impact of monetary policy on banks' NIM (Hsiao, 2005; Baltagi, 2008).

Although there are a lot of benefits associated with the use of panel data, it does not solve all problems faced by a cross-sectional or time series study. The disadvantages are more of a practical nature such as design and data collection problems, distortions of measurement errors, selectivity problems and cross-section dependence. Despite these limitations, Baltagi (2008) and Verbeek (2007) still argue that it's worth using panel data as the benefits outweigh the disadvantages.

A general panel data model can be written as follows:

$$y_{it} = \alpha_{it} + x_{it}'\beta_{it} + \varepsilon_{it} \qquad \text{with} \quad i = 1, \dots, n \quad \text{and} \quad t = 1, \dots, T \qquad [1]$$

where the double subscripts (i and t) are indices for units and time, x_{it} represents a K-dimensional vector of explanatory variables for unit i in period t, β_{it} quantifies the partial effect of x_{it} on y_{it} for unit i in period t and ε_{it} captures the unobservable factors that influences y_{it}. This model is undoubtedly too general to estimate and to provide useful results. As a result, we'll have to put some structure on the coefficients, α_{it} and β_{it}, by imposing several assumptions on them. In what follows, we will distinguish two estimation techniques, namely the pooled ordinary least square (OLS) model and the individual effects model.

5.1.1. Pooled OLS model

The pooled OLS model is considered to be the most stringent of all panel estimation models as it restricts the coefficients (α and β) to be constant across time and units. Moreover, it imposes two strong assumptions regarding the explanatory variables and error terms. On the one hand, all explanatory variables are assumed to be independent of all error terms. On the other hand, error terms are treated as identically and independently distributed disturbances. Consequently, specification [1] turns into

$$y_{it} = \alpha + x'_{it}\beta + \varepsilon_{it} \quad \text{with} \quad \varepsilon_{it} \sim \text{iid}(0, \sigma_\varepsilon^2) \qquad [2]$$

The pooled estimator is characterized by a number of properties. First, it exploits both the within and between dimensions of the data. Second, the estimator is consistent for $n \rightarrow \infty$ or $T \rightarrow \infty$ as long as the explanatory variables are weakly exogenous and uncorrelated with the individual effects. However, we cannot conclude that this model provides efficient estimators as it simply stacks the data and ignores the panel structure. Moreover, due to the nature of our data, the above-mentioned assumptions will no longer be satisfied (see infra section 5.3.1). For instance, we can no longer presume that errors terms from different periods are uncorrelated. Or, it is no longer appropriate to suppose that different observations of the same units are independent from each other. Hence, this approach does not allow for individual country heterogeneity and time effects. Therefore, the pooled OLS method is likely to yield inefficient estimators relative to the other methods and is thus often considered to be impractical.

5.1.2. Individual effects estimators: fixed vs. random effects model

The individual effects estimators are more appropriate models as they do take the panel structure of the data into account by letting the intercept (α) vary across units. The slope coefficients (β), by contrast, are still considered to be constant for all i and t. Within this category, we speak of fixed effects (FE) or random effects (RE) models depending on the assumptions about the error term. Before going deeper into these models, it is important to mention that both have the ability to control for unobserved country-specific and time-specific effects. In other words, these models pay attention to the unobserved heterogeneity that may not be captured by the explanatory variables included in the model. Subsequently, the omitted variable bias will be significantly reduced, yielding consistent and unbiased estimators (Leyaro, 2015).

The fixed effects model regards unobserved differences between units as a set of fixed parameters and changes equation [1] into

$$y_{it} = \alpha_i + x'_{it}\beta + \varepsilon_{it} \quad \text{with} \quad \varepsilon_{it} \sim \text{iid}(0, \sigma_\varepsilon^2) \qquad [3]$$

where the individual-specific intercept (α_i) represents those (un)observable time-invariant differences across units. Characteristic for this model is that it does not

impose any restrictions upon the relationship between α_i and the explanatory variables, thereby allowing for any correlations between them. As for the relationship between α_i and the error terms, statistical independence is assumed (Baltagi, 2008; Verbeek, 2008).
Nevertheless, the fixed effects model has some disadvantages. First, this approach will not produce estimates for the variables that do not change over time. Second, fixed effects estimators exploit the within dimension of the data, causing them to ignore any information about differences between individuals. So, if the explanatory variables vary widely across units, but fluctuate only slightly over time for each unit, the estimators will be rather imprecise. This will be reflected in larger standard errors, higher p-values and wider confidence intervals (Allison, 2005; Nwakuya & Ijomah, 2017).

In contrast to the fixed effects model, the random effects model assumes the individual-specific effect to be a random variable that is uncorrelated with the explanatory variables. The model can therefore be written as

$$y_{it} = \mu + x'_{it}\beta + \epsilon_{it} \qquad [4]$$

$$\epsilon_{it} = \alpha_i + \varepsilon_{it} \qquad \text{with} \qquad \varepsilon_{it} \sim \text{iid}(0, \sigma^2_{\varepsilon}) \quad \text{and} \quad \alpha_i \sim \text{iid}(0, \sigma^2_{\alpha}) \qquad [5]$$

The main difference is that the error term $(\alpha_i + \varepsilon_{it})$ now consists of two components. On the one hand, it contains the individual specific component (α_i), which is time invariant and homoscedastic across units. The inclusion of this element in the error term explains the assumption above; any correlation between the two variables, α_i en x_{it}, would lead to biased and inconsistent estimators. On the other hand, the error term also includes an erratic component (ε_{it}) that is uncorrelated over time and homoscedastic. Unlike the fixed effects model, the random effects model use information both within and between individuals, resulting in more efficient estimates.

5.2. Data and sample

The data used in this dissertation is obtained from Eurostat, Thomson Reuters Datastream and Statistical Data Warehouse (SDW), a database maintained by the ECB. Our sample consist of 2550 bank observations and covers 17 years from 2003 to 2019. Within this time interval, we consider both the years before and after the Global Financial Crisis, which allows us to fully capture the evolution of a low interest rate environment. The 10 countries in study include: Austria, Belgium, Germany, Spain, Finland, France, Ireland, Italy, The Netherlands and Portugal. These countries represent core (6) and periphery countries (4) and are considered due to data availability. In addition, we refer to the appendix A for a list of all countries and a table describing all the variables included in the empirical analyses of this paper.

5.2.1. Dependent variables

As mentioned in section 2, the objective of our study is to determine whether the components of banks NIM are affected by the changes in the interest rate structure. Therefore, we'll consider three dependent variables.

Our first and main dependent variable is the interest rate spread, which is obtained by taking the difference between lending rates charged by banks on loans to households and deposit rates offered by banks to households. We focus specifically on households because they are the counterparty to most bank loans and deposits in the countries under consideration, except for Austria and Italy (Appendix B). Although the volume of loans to NFCs is roughly the same as that of households, we cannot include this group in our study due to a lack of bank balance sheet data on the liabilities side.

In addition to the main component of the NIM, we are also interested in the evolution of the commercial margins. By taking these into account, we gain insight into how banks' credit and deposit policy adapts to a changing interest environment.

- On the asset side, we define the loan spread as the wedge between lending rates and the 5-year Credit Default Swap (CDS) rate. The price of a CDS provides a direct measure of the compensation required by the market for insuring credit risk (Norden, & Wagner, 2008).
- The deposit spread on the liability side is computed by subtracting the deposit rates from the 3-month Euro OverNight Index Average (EONIA).

5.2.2. Explanatory variables

Considering the existing literature on the association between interest rates and banks' interest margins, we decided to use the following set of explanatory variables. In addition to the description of the variables, we also provide a hypothesis for each variable regarding its expected impact on the NIM and its components.

5.2.2.1. Financial market characteristics

So far, we know that the banks' traditional business is particularly influenced by monetary policy measures. This implicitly means that money market interest rates are the most critical drivers of banks' NIM (Angori et al., 2019). In accordance with the above-mentioned studies, we therefore introduce two monetary policy indicators that will reflect the financial market, in particular the interest rate environment.

On the one hand, we use the 3-month EURIBOR rate to proxy the short-term interest rate. The EURIBOR indicates the average interest rate at which Eurozone banks offer to grant loans to each other. The relevant data has been retrieved from Eurostat and contains monthly based information. Following the evidence from various studies, we expect a positive sign for this variable. In other words, an increase (a decrease) in short-term interest rate is expected to move banks' NIMs upwards (downwards).

On the other hand, the long-term interest rate is represented by the yields of government bonds with maturities of close to 10 years. This variable is, in turn, used to determine the slope of the yield curve, which is approximated by the difference between the long- and short-term interest rates. Once again, monthly data are collected over the period 2003-2019 from SDW. We assume that this variable will have a positive sign as an increase in the slope of the yield curve implies a bigger difference between the interest rate on loans and that on deposits (Cruz-Garcia et al., 2019).

5.2.2.2. Bank-specific characteristics

Assuming that each bank is affected in a different way by monetary policy shocks, we include a set of bank-specific indicators, namely cash, capital and the loans-to-total-assets-ratio and the deposit-to-total-liabilities-ratio. Our first two variables shed light on banks' liquidity and capital dimension as the financial crisis has shown that insufficient buffers had been built up in these areas. The two other variables refer to the structure of the balance sheet, which will give us some insight into the banks' business model. Although there are many other bank-related variables, we'll limit ourselves to these four variables to maintain an overview in this dissertation.

To begin with, cash is considered the most important liquid and safest asset for two reasons. On the one hand, banks need cash to fund their day-to-day operations and to fulfill short-term payment obligations (Borio et al., 2015). On the other hand, cash creates a buffer in times of financial emergencies as it can be used immediately to pay for the essentials and stay on top of the bills (Angbazo, 1997). However, holding excess cash is not the best strategy to follow since it involves an opportunity cost. By maintaining high levels of cash, banks may miss the opportunity to invest in potentially high-yielding assets. To make up for this situation, they tend to pass this cost on to their customers by increasing their interest rates (Garza-Garcia, 2010; López-Espinosa et al., 2011; Angori et al., 2019; Cruz-Garcia et al., 2019). In this vein, a higher amount of cash is associated with higher NIMs. We approximate this variable in the analyses by the ratio of cash to total assets.

A second bank-specific factor is bank capital (CAP) that serves as a buffer against unexpected losses (Yeh, Twaddle, & Frith, 2005). A solid capital cushion does duty as a safety net in difficult times, making it a proxy of bank solvency (Athanasoglou, Brissimis, & Delis, 2008). Alternatively, bank capital also sheds light on banks' degree of risk aversion. Typically, risk averse banks tend to hold more capital than regulatory imposed to ensure they are fully hedged against credit-risk exposure. However, this choice comes at a price. Such banks prefer equity financing over debt financing, which is obviously more expensive. Consequently, they are inclined to impose higher rates to cover these higher costs, which will eventually lead to higher NIMs (Saunders & Schumacher, 2000; Borio et al., 2015; CFGS, 2018). Bank capital is represented by the ratio of capital to total assets and is thus expected to show a positive sign.

In order to complete the analysis with regard to banks' attitude towards risk, we include the ratio of loans to total assets (LTA). This variable indicates the extent to which banks are specialized in converting liquid deposits into illiquid loans and is therefore considered a good approximation of banks' credit risk. Several studies (Dell'Ariccia & Marquez, 2006; Delis & Kouretas, 2011; Maddaloni & Peydró, 2011) have already shown that low interest rates have significantly influenced banks' credit policy. For example, monetary policy accommodation has contributed to a softening of lending standards, a reduction in bank screening, which, in turn, increased the probability of granting loans to more risky debtors. That being the case, banks were obliged to hold a higher amount of provisions, forcing them eventually to charge higher rates. Moreover, loans have the highest operational costs as they must be originated, serviced and monitored (Claeys & Vander Vennet, 2008). Assuming that these two elements will be reflected in banks' loan pricing behavior, we expect that banks primarily active in lending will have higher interest margins (Tarus et al., 2012).

With respect to the funding composition, we add the ratio of deposits to total liabilities (DEP). In general, it is preferable to rely more heavily on deposits than on other non-deposit sources as the availability and the price of the latter are much more sensitive to changes in the economic and/or financial environment. However, when interest rates are low, households may be indifferent between holding cash and deposits, which means that banks may experience a large outflow of deposits (Drechsler, Savov, & Schnabl, 2017; Boucinha & Burlon, 2020). In order to avoid cash hoarding, retail deposit rates have become much stickier, limiting the scope to improve the NIMs in a low interest rate environment. As a result, banks will either grant more loans, invest in riskier assets or increase their mortgage rates in response to lower interest rates. The impact on NIM therefore varies from bank to bank (Demiralp, Eisenschmidt, & Vlassopoulos, 2017; Amzallag, Calza, Georgarakos, & Sousa, 2019, Heider et al., 2019).

5.2.2.3. Macroeconomic characteristics

Several studies (Valverdie, Humphrey, & Fernandez, 2003; Laeven & Levine, 2009; CGFS, 2018; Zhang, Li, Li & Xu, 2018) prove that macroeconomic and structural conditions matter when analyzing bank margins across countries (supra section 4.3). These factors are able to capture differences that are not directly related to a bank’s business model but are nonetheless important in sketching the relationship between interest rates and banks’ NIMs (Mergaerts & Vander Vennet, 2015). As a result, we consider four country-level indicators as control variables, namely economic growth, inflation, market concentration of banking business and the stock market volatility.

As mentioned earlier, it is important to have an idea of the economic environment in which banks operate. To take this element into account, we consult quarterly published data on gross domestic product (GDP) at market prices of each country. Based on this data, we compute the monthly GDP growth rate as this is an essential indicator of economic health. After all, a growing or shrinking economy will have repercussions on the banking sector. In the former case, for example, improved economic conditions will lower loan default rates, thereby reducing banks’ interest rates. In the latter case, low economic growth will adversely affect the debt servicing capacity of borrowers and will thus contribute to an increase in interest rates. Although opinions are divided regarding the impact of this variable (supra section 4.3), we hypothesize that economic growth is positively related to banks' NIM.

Another vital environmental condition we incorporate is the inflation rate. In the eurozone, the Harmonised Index of Consumer Prices (HICP) is considered as a high-quality indicator of inflation. It represents the changes over time in the prices of consumer goods and services acquired, used or paid for by households (ECB, s.d.). Another advantage of using the HICP is that these indices are immediately comparable between countries. In our analyses, we use the monthly rate of change of the HICP for each country. Looking at the empirical evidence, we find no consensus about the impact. Yet, we hypothesize that a higher rate of inflation goes along with higher bank margins.

Our third country-level control variable, the Herfindahl-Hirschman Index (HHI), captures the degree of market concentration in the banking industry. The index is calculated by summing the squares of the market shares of all the credit institutions in a country. So, it will provide us insight into the competition among banks on a national scale. Furthermore, it is worth mentioning that although the HHI is a very frequently used measure, it makes abstraction of the complexities of various markets. An index of 0 denotes perfect competition whereas an index of 1 indicates an absolute monopoly. Finally, in line with the literature, we presume that a more competitive banking environment (i.e. a low HHI) is characterized by lower interest margins.

To finalize the list of control variables, we pay regard to the stock market volatility as this affects each and every player of the economy. It follows that price fluctuations are therefore not only monitored by investors but also by banks (Rashid, & Ilyas, 2018). If markets start to panic and volatility increases, this will have a dual effect. On the one hand, the prevailing uncertainty will prompt banks to increase their lending rate due to the higher risks (Angbazo, 1997; Levy & Hennessy, 2007; Albertazzi & Gambacorta, 2009). On the other hand, households and firms are not willing to pay such high rates, which will shrink the amount of bank lending. More specifically, in times of macroeconomic uncertainty, firms will be more reluctant to finance themselves with debt. In particular, they will review their leverage decisions to reduce the proportion of debt in their capital structure. Eventually, banks will be prevented from using their deposits effectively to widen their margins (Rashid, 2013; Rashid, 2004). Based on these theories, we believe that the NIM and the stock market volatility are positively related. We proxy the volatility of the stock market by using monthly volatility indices based on the EURO STOXX 50.

VARIABLE	EXPECTED SIGN ON I_SPREAD	EXPECTED SIGN ON L_SPREAD	EXPECTED SIGN ON D_SPREAD
Short-term interest rate	+	+/-	+
Slope of the yield curve (YC)	+	-	+
Cash	+	+	+/-
Deposits-to-total liabilities (DEP)	+/-	+/-	+/-
Capital	+	+	+/-
Loans-to-total assets (LTA)	+	+	+/-
GDP growth	+	-	+
Inflation (HICP)	+	+	+/-
Market concentration (HHI)	+	+	+
Stock market volatility (VSTOXX)	+	+	+/-

Note: The symbols +, -, +/- represent respectively an expected positive, negative or a priori unclear on the dependent variables.

Table 1: Expected impact of each variable on bank spreads

5.2.3. Descriptive statistics

Before performing the regressions, it may be useful to analyse our data. It is worth mentioning that we'll adjust the data with the aim of reducing the influence of outliers in the analyses. This means that the observations are trimmed or winsorized in cases they report extreme and implausible values, making the data seem logically inconsistent. Table 2 provides the descriptive statistics for the full sample and table 3 records the evolution over time of each variable. The corresponding correlation matrix and scatterplots are presented in appendix C. These figures will be briefly discussed below.

To begin with, table 2 and 3 confirm conventional wisdom about the three spreads. On average, the interest rate spread is the largest source of income for banks. More specifically, when performing maturity transformations, an average spread of 2.10% is used between lending rates and deposit rates (Appendix D). Looking at the evolution over time, we notice a steady decline in the lending and deposit margins in consequence of an easing policy environment. Furthermore, income is also earned on the asset side with an average lending spread of 1.69%. This implies that banks manage to price their loans at a higher rate than the market reference rate. On the liability side, however, the tide turned in 2010. The deposit spread becomes negative and averages -0.12%. Also, the opposite trend in commercial margins is remarkable (Appendix D). When the lending spread reaches its peak (2.81%) at the time of the European sovereign debt crisis, the deposit spread reaches its lowest point (-1.18%). This may already indicate the existence of a compensation effect. We'll further discuss this in the next section.

The average short- and long-term interest rates result in an upward sloping yield curve. However, this has not always been the case as we can clearly observe a transition period in table 3 and figure 3. The greater change in short-term rates first flattened the yield curve in 2007 and then reversed it in 2008. Since this is perceived as a predictor of a pending economic recession, investors gradually lost their confidence in the near-term economy and flocked to long-term investment. As a result of the massive switch to long-term maturities, yields fell below short-term rates. In addition, central banks have taken various standard and non-standard measures to address the challenges posed by the financial crisis. Interest rates (short and long) are pushed down, thereby resulting in a slightly upward sloping yield curve.

With regard to the bank-specific variables, cash and capital ratios are on average 9.26% and 7.23% respectively. Those variables have been on an upward trend with the pace of the increase accelerating from 2010 onwards. This is due to a set of international rules, drawn up by the Basel Committee on Banking Supervision, designed to mitigate risk within the international banking sector. One of the objectives of these rules was to ensure funding stability. In particular, banks had to maintain a stable funding profile in relation to the composition of their assets and off-balance sheet activities (BIS, 2014). For example, under the Basel III regulation, loans are considered the riskiest assets and are therefore recommended to be financed with retail deposits, the most stable funding sources. After all, excessive reliance on unstable funding of core assets may increase the risk of failure and potentially lead to broader systemic stress (BIS, 2014). In this vein, the DEP-ratio gradually increases. Finally, the LTA-ratio reveals that loans vis-à-vis the non-financial private sector account for around 34% of total assets of banks in our sample. The relatively small numbers for DEP and LTA indicate that our data includes both banks engaged in traditional intermediation activities as well as those that are more involved in capital market transactions. So, we have a heterogeneous sample that doesn't just include pure retail banks.

Last but not least, we take a look at the country-specific variables. The GDP grows at an average monthly rate of 0.13%. In the first years (2003-2007), this percentage rose to 0.26% and 0.28%, but the economic downturn caused a sharp drop and even pushed the growth rate into the negative area. Furthermore, if we compare the monthly rate of growth of 2003 and 2019, we notice that the GDP growth has not fully recovered after the crisis. The month over month change in the price of goods and services is on average 0.13%. We further observe a strong volatility in HICP throughout the years due to factors such as the economic crisis, declining consumer confidence and declining demand for goods. Next, we have the HHI index with an average value of 0.11%. This points to the presence of a large number of banks, creating a non-concentrated competitive market. Lastly, stock market volatility varies between 15.91 and 63.27. Table 3 shows us that as soon as unrest and panic arise in the markets, volatility increases.

2003-2019	MEAN	STD.DEV.	MIN.	25% PERC.	MEDIAN	75% PERC.	MAX.
I_SPREAD	2,10	0,63	0,66	1,70	2,11	2,53	4,18
L_SPREAD	1,69	1,02	-0,76	0,93	1,61	2,23	6,02
D_SPREAD	-0,12	0,93	-2,65	-0,74	-0,44	0,63	2,75
ST_RATE	1,28	1,58	-0,42	-0,04	0,76	2,15	5,11
LT_RATE	2,99	1,89	-0,65	1,43	3,40	4,17	13,85
CASH	9,26	5,28	2,02	5,26	8,55	11,26	38,13
CAPITAL	7,23	2,50	3,37	5,17	6,85	8,75	15,34
DEP	26,81	8,19	7,57	22,76	26,88	31,47	51,41
LTA	33,75	10,68	12,15	24,79	33,75	40,83	60,56
GDPGROWTH	0,13	0,32	-1,03	0,00	0,13	0,25	3,66
HICP	0,13	0.64	-2.49	-0.16	0.12	0.42	2.51
HHI	0,11	0,09	0,02	0,05	0,07	0,14	0.39
VSTOXX	22,37	8,71	12,17	15,91	20,19	24,96	63,27

Table 2: Descriptive statistics of the (in)dependent and control variables

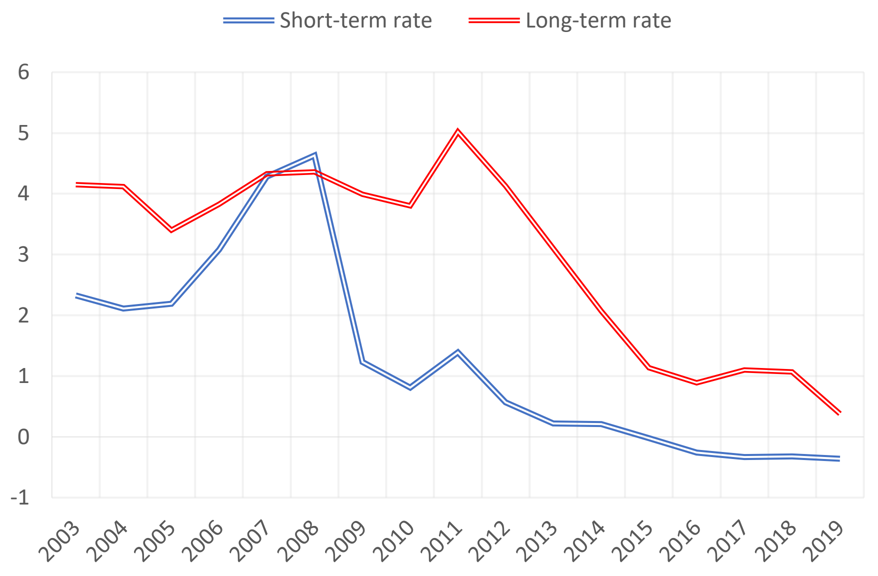

Figure 3: Evolution of the average short- and long-term interest rates

	I_SPREAD	L_SPREAD	D_SPREAD	ST_RATE	LT_RATE	CASH	DEP	CAPITAL	LTA	GDP GROWTH	HICP	HHI	VSTOXX
2003	2,60	0,97	0,75	2,33	4,15	6,30	27,42	6,46	36,00	0,14	0,16	0,099	32,11
2004	2,42	0,80	0,63	2,11	4,12	6,73	26,52	6,25	35,56	0,20	0,17	0,104	18,90
2005	2,16	1,03	0,68	2,19	3,40	7,57	25,52	6,09	35,57	0,21	0,18	0,107	14,03
2006	2,37	0,59	1,12	3,08	3,83	7,18	24,74	6,22	36,23	0,28	0,17	0,110	16,52
2007	2,53	0,65	1,52	4,28	4,33	7,49	23,73	6,14	35,50	0,26	0,24	0,107	19,63
2008	2,50	1,19	1,08	4,63	4,36	8,55	22,99	5,99	34,20	-0,16	0,14	0,110	33,84
2009	2,26	1,39	-0,75	1,23	3,99	9,70	23,36	6,11	33,32	-0,02	0,04	0,114	33,71
2010	1,97	1,60	-0,73	0,81	3,80	10,45	23,47	6,41	32,27	0,20	0,18	0,110	26,49
2011	2,03	1,73	-0,62	1,39	5,02	11,03	23,60	6,87	31,94	0,01	0,23	0,115	29,89
2012	1,99	2,81	-1,18	0,57	4,13	13,05	23,30	7,21	30,32	-0,10	0,20	0,114	24,54
2013	2,11	2,70	-0,89	0,22	3,10	11,18	25,89	8,10	31,92	0,07	0,08	0,105	18,58
2014	2,14	2,75	-0,65	0,21	2,07	11,07	27,40	8,55	32,25	0,16	0,00	0,107	18,25
2015	1,87	2,43	-0,59	-0,02	1,14	12,12	28,44	8,32	32,24	0,17	0,03	0,111	23,98
2016	1,74	2,33	-0,64	-0,26	0,89	11,49	29,91	8,44	32,75	0,26	0,09	0,107	23,63
2017	1,73	1,93	-0,58	-0,33	1,10	8,35	32,07	8,59	34,56	0,28	0,11	0,098	14,79
2018	1,67	1,72	-0,56	-0,32	1,07	6,92	33,55	8,70	35,22	0,13	0,12	0,094	16,40
2019	1,55	2,03	-0,56	-0,36	0,38	8,31	33,78	8,49	34,02	0,07	0,11	0,094	15,05

Table 3: Evolution of the averages per variable for 2003-2019

5.3. Empirical results

5.3.1. Pooled OLS method

We start by applying the pooled OLS method to our variables in levels. The benchmark specifications take the following form:

$$\begin{aligned}\text{Bank spread}_{it} = {} & \alpha + \beta_1 ST_{RATE_{it}} + \beta_2 ST_{RATE}{}_{it}^{2} + \beta_3 YC_{it} + \beta_4 YC_{it}^2 + \\ & \gamma_1 CASH_{it} + \gamma_2 DEP_{it} + \gamma_3 CAP_{it} + \gamma_4 LTA_{it} + \delta_1 GDPGrowth_{it} \\ & + \delta_2 HICP_{it} + \delta_3 HHI_{it} + \delta_4 VSTOXX_{it} + \varepsilon_{it}\end{aligned}$$

The regressions have a similar structure for all dependent variables of interest (interest rate spread, lending spread and deposit spread). Each model explains the dependent variable as a function of the three-month short-term interest rate and the slope of the yield curve (difference between the 10-year bond yield and the three-month rate). Quadratic terms of these monetary policy indicators are also included to capture a certain form of non-linearity, which has been described in the literature. Furthermore, several bank-specific and macroeconomic variables are added as control variables (see section 5.2.2 for a more detailed description).

Table 4 reports the panel estimation results for the interest rate spread, the lending spread and the deposit spread as dependent variables, respectively. The first column of the table shows that, in the absence of additional controls, monetary policy has a significant impact on banks' interest rate spread by influencing either the short-term rate or the slope of the yield curve. More specifically, a one percentage point decrease in the level of short-term interest rate is associated with a 0.27 percentage point decrease in the interest rate spread, ceteris paribus. Similarly, a one percentage point decrease in the slope of the yield curve contributes to a 0.15 percentage point drop in the interest rate spread. This effect was to be expected since maturity transformation belongs to one of the core activities of banks. Also in line with previous studies (Angori et al., 2019; Cruz-Garcia et al., 2019), the results reveal an inverted U-shaped relationship between the two monetary policy indicators and banks' interest rate spread. This implies that the impact of changes in the short-term interest rate and in the slope of the yield curve are more pronounced when the levels of the two explanatory variables are low. Furthermore, column 2 shows that these results are robust (and even slightly amplified) against including several bank-specific and macroeconomic control variables.

Next to our main explanatory variables, most bank-specific control variables also seem to exert a small but statistically significant impact on the interest rate spread, except for the capital ratio. For example, the coefficient of LTA is negatively and significantly related to the interest rate spread. This finding contradicts with our hypothesis, but a possible explanation could be that when banks are specialized in lending, they may benefit from informative advantages and lower intermediation

cost. This, in turn, could lead to narrower interest rate spreads (Petersen and Rajan, 1995; Berlin and Mester, 1999; Boot, 2000).
In terms of macro-economic control variables, our results regarding economic growth are in line with Altavilla et al. (2018); banks operating in countries characterized by a weak economy suffer from lower interest rate spreads. The reasoning behind this is that slow GDP growth adversely impacts loan demand, thereby discouraging investment. Taking into account that the latter are usually funded via bank intermediation, reduced demand may threaten financial stability. Therefore, banks tend to lower their lending rate in order to attract customers and avoid problems. The HHI-index, which captures the degree of market concentration, exhibits the largest impact among the control variables. Contrary to our expectations, the coefficient suggests that countries, whose banking industry is taken over by a number of dominant players, are more likely to have lower interest rate spreads. According to De Haan & Poghosyan (2012), this result reflects strong supervisory power. More specifically, banks in a concentrated banking system can be monitored more closely than banks in a diffuse banking system, which means that exorbitantly high and low rates on loans and deposits cannot be applied. Our empirical evidence further shows that market volatility has a small, but statistically significant effect on the interest rate spread. From the magnitude of this result, it could be inferred that stock market turmoil will not immediately lead to major changes in bank interest rates. Finally, in contrast with the empirical literature, we find no significant impact of inflation on our dependent variable.

Analogously, we next consider the impact on banks' lending and deposit spread in columns 3 to 6 of table 4. To compare the magnitudes of the impact on both spreads, we will discuss the results together. The first thing to notice is the asymmetric impact of the short-term interest rate on both spreads; while the lending spread increases along with the short-term rate, the deposit spread seems to be decreasing. These results therefore immediately support our hypothesis that some form of compensation exists between both spreads. The reasoning could be as follows: when policy and market interest rates are very low, banks' scope to reduce their deposit rates is limited, thereby compressing the deposit margin. The magnitude of the coefficient may thus reflect the immediate and full pass-through of lower policy rates on the money market rate (EONIA) and the stickiness of deposit rates (Heider et al., 2019). To compensate for this negative effect, banks widen their lending spread by increasing their mark-up on the reference rate. In addition, lending rates also take longer to adjust compared to deposit rates, which could also contribute to higher lending spreads in times of falling interest rates (Raknerud, Vatne, & Rakkestad, 2011). The opposite trend also continues in the squared term of this explanatory variable, creating a U-shaped relationship with banks' lending spread on the one hand and an inverted U-shaped relationship with the deposit spread on the other. The slope of the yield curve significantly and negatively affects both spreads. On the asset side, this can be interpreted as a portfolio-allocation effect: when the yield curve flattens, banks may be tempted to

reallocate their portfolio into higher-yielding but riskier assets, widening their lending margin (King & Yu, 2018).
Our regression results further show that banks with few deposits are characterized by higher lending spreads. This might refer to the greater risk associated with wholesale funding, since banks' lending rates are mainly determined by the marginal cost of funding (Borio & Fritz, 1995). In line with our expectations, better capitalized banks tend to have higher spreads as they can use the excess capital to engage in riskier activities. This finding is, in turn, consistent with our hypothesis and aforecited studies (Ho & Saunders, 1981; Claeys & Vander Vennet, 2009).
Turning to the role of country-level macroeconomic factors, the sign of the coefficient of GDP growth seems to prove the opposite of what we have argued above. While we assumed that banks applied lower rates to attract customers, this result suggests that banks in countries with low economic growth appear to have higher lending spreads. Bikker & Vervliet (2017) and Claessens et al. (2018) obtain the same results and explain it as follows: as soon as the debt servicing capacity of borrowers is damaged, banks are inclined to increase their risk premia in view of higher credit default, which in turn leads to wider lending margins. In contrast to column 2, the HHI-coefficients are now found to be significant and positively related to both spreads. These results are thus in line with Naceur (2003) and confirm our hypothesis: in a monopolistic market environment, banks tend to collude in order to obtain higher bank margins. More specifically, they'll set lower deposit rates and higher lending rates to increase their income on both sides of the balance sheet. Regarding the impact of stock market volatility, a positive and significant correlation is found with both bank spreads, which is consistent with our hypothesis. The coefficients have similar magnitude but opposite signs, which could explain the small coefficient in column 2. Distrust in the stock market and the ensuing uncertainty seem to influence bank rates to the same extent, offsetting any major drawbacks. Finally, no clear relationships for cash and inflation are found in our models as these are insignificant in any case.

In order to consider the estimated parameters and the associated significance as reliable, they must meet a number of conditions. In the following paragraphs, we provide evidence for the violation of two important assumptions (serial correlation and heteroscedasticity) in our pooled OLS models. As a result, our regressions may produce biased estimates, which implies that we need a better estimation technique.

According to the pooled OLS method, error terms are not allowed to be serially correlated (across individuals and time) as they are supposed to be independent and identically distributed. This implicitly means that no systematic pattern should be found in the error terms. Otherwise, we'll obtain standard errors smaller than they actually are and higher R^2. We use the Breusch-Godfrey and the Durbin-Watson test for serial correlation in panel models to verify this. The null hypothesis of these tests state that there is no serial correlation while the alternative hypothesis provides support for it. The test results can be found in appendix E.

Both tests indicate that the null hypothesis is rejected in all three regressions as we find p-values that are less than the 5% significance level.

Furthermore, it is expected in the pooled OLS method that error terms are homoscedastic i.e. have a constant variance. If the error terms do not meet this requirement, the estimates will remain biased (but consistent). To detect whether we can speak of homoscedasticity or not, we use the Breusch-Pagan test (Appendix E). The null hypothesis assumes homoscedasticity in our models while the alternative hypothesis indicates the presence of heteroskedasticity. Again, we find smaller p-values than the 5% significance level, which provides evidence in favour of the alternative hypothesis. Our models are therefore characterized by a certain degree of heterogeneity, which we already expected due to the nature of our data.

	Dependent variable:					
	I_Spread		L_Spread		D_Spread	
	(1)	(2)	(3)	(4)	(5)	(6)
Short-term rate	0.268***	0.282***	-0.695***	-0.654***	0.499***	0.736***
	(0.024)	(0.027)	(0.033)	(0.038)	(0.022)	(0.023)
Short-term rate²	-0.018***	-0.015**	0.099***	0.068***	-0.017***	-0.057***
	(0.006)	(0.007)	(0.009)	(0.010)	(0.006)	(0.006)
Slope YC	0.146***	0.166***	0.055*	-0.125***	-0.074***	-0.150***
	(0.022)	(0.023)	(0.031)	(0.032)	(0.020)	(0.020)
Slope YC²	-0.021***	-0.021***	0.023***	0.033***	-0.012***	-0.003
	(0.002)	(0.002)	(0.003)	(0.003)	(0.002)	(0.002)
Cash		-0.006**		-0.006		0.003
		(0.003)		(0.004)		(0.002)
DEP		0.010***		-0.032***		0.010***
		(0.002)		(0.003)		(0.002)
LTA		-0.019***		0.008***		-0.007***
		(0.002)		(0.002)		(0.001)
Capital		0.000		0.093***		0.074***
		(0.007)		(0.010)		(0.006)
GDP Growth		0.183***		-0.143***		0.170***
		(0.039)		(0.055)		(0.034)
HICP		-0.009		-0.008		0.017
		(0.019)		(0.027)		(0.017)
HHI		-0.837***		0.701***		0.471***
		(0.162)		(0.228)		(0.140)
VSTOXX		0.006***		0.020***		-0.021***
		(0.001)		(0.002)		(0.001)
Constant	1.695***	2.008***	1.946***	1.736***	-0.493***	-0.730***
	(0.033)	(0.075)	(0.046)	(0.105)	(0.031)	(0.065)
Observations	2,040	2,040	2,040	2,040	2,040	2,040
R2	0.237	0.347	0.430	0.510	0.702	0.778
Adjusted R2	0.235	0.343	0.429	0.507	0.702	0.776
F Statistic	157.659*** (df = 4; 2035)	89.705*** (df = 12; 2027)	383.429*** (df = 4; 2035)	175.962*** (df = 12; 2027)	1,199.118*** (df = 4; 2035)	591.142*** (df = 12; 2027)
Note:						*p<0.1; **p<0.05; ***p<0.01

Table 4: Static model for bank spreads estimated with pooled OLS

5.3.2. Fixed effects method

Given that the results of the pooled OLS method may be biased, we decide to apply the individual effects method. In order to select the most appropriate model for our study, we'll perform the Hausman test on each of our baseline specifications. This test states under the null hypothesis that the estimated coefficients of both methods (FE and RE) do not differ substantially from each other, which implies that preference should be given to the random effects model. The Hausman tests display p-values that are less than the 5% significance level allowing the null hypothesis to be rejected. In other words, the Hausman test confirms the presence of unobserved heterogeneity as there exists some form of correlation between the individual effects and the explanatory variables. The use of the random effects would therefore lead to inconsistent estimators in our study.
Additionally, we perform the F-test between the pooled OLS estimator and the FE estimator to check the joint significance of individual effects (Appendix F). We obtain a very small p-value, indicating that not all individual effects are simultaneously zero. Based on this test, we determine that the null hypothesis can be rejected and that the fixed-effects estimator is preferred over the pooled OLS estimator.

Table 5 reports the results of the specifications below:

$$\begin{aligned}\text{Bank spread}_{it} = {} & \alpha_i + \beta_1 \text{ST}_{\text{RATE}_{it}} + \beta_2 \text{ST}_{\text{RATE}_{it}}^{2} + \beta_3 \text{YC}_{it} + \beta_4 \text{YC}_{it}^2 + \\ & \gamma_1 \text{CASH}_{it} + \gamma_2 \text{DEP}_{it} + \gamma_3 \text{CAP}_{it} + \gamma_4 \text{LTA}_{it} + \delta_1 \text{GDPGrowth}_{it} \\ & + \delta_2 \text{HICP}_{it} + \delta_3 \text{HHI}_{it} + \delta_4 \text{VSTOXX}_{it} + \varepsilon_{it}\end{aligned}$$

Before discussing the regression results, we note that the R^2 of each specification has increased significantly using the fixed effects method, pointing out that this choice contributes to the predictive ability of the equations. Analogous to the pooled OLS estimates, first the most general case without controls is estimated for the interest rate spread (columns 1). Next, control variables are included to estimate the full model (columns 2). As we control for bank-specific and macroeconomic characteristics (see appendix H for robustness of the results), we see the impact of the short-term rate rising as opposed to the impact of the slope of the yield curve. The short-term interest rate is significantly positive: a one percentage point decrease in the level of short-term interest rate is associated with a 0.41 percentage point decrease in the interest rate spread. Again, this relationship is found to be stronger when interest rates are low. These results are consistent with previous empirical evidence (see, for instance, Borio et al. (2015), Angori et al. (2019); Brei et al. (2019), Cruz-García et al. (2019)). As for the long-term interest rate, we do not find a significant impact on the interest rate spread. While this may seem strange at first sight, it is not inconsistent with the study of English (2002) and Klein (2020) (supra section 4.1). They argue that this can occur if the degree of maturity mismatches between loans and deposits is low. However, in line with many other studies (Genay & Podjasek, 2014; Borio et al., 2015; Bikker & Vervliet, 2017; CGFS, 2018; Claessens et al., 2018; Angori et al., 2019; Brei et al., 2019; Cruz-García et al., 2019), we expected to find a significant positive impact. Looking at the regression results with only 1 control variable at a time (Appendix H), we note that the inclusion of the capital ratio is responsible for the loss of significance. To see whether this result is robust, we estimate the same model in first differences. If we obtain the same results, this provides evidence of the existence of multicollinearity in our model. Estimation results in column 9 of appendix H show that we can reject the presumption of severe multicollinearity as we obtain the expected sign and significance for the slope of the yield curve. In terms of control variables, results confirm the hypothesis that holding excess cash is accompanied by an opportunity cost, which translates into higher retail lending rates. Furthermore, our results provide evidence that is consistent with Demirgüç-Kunt and Huizinga (1999), Saunders & Schumacher (2000) and Bikker & Vervliet (2017); banks with a high capital ratio (for regulatory or credit reasons) cover this cost by charging an extra premium over the pure spread for interest-rate risk. Deposit- and loan-ratios, by contrast, do not significantly affect the interest rate spread. Hence, our analysis finds no support for the presumption that traditional banks, specialized in converting liquid deposits into illiquid loans, suffer the most in a declining interest rate environment.

The coefficient of GDP growth is statistically significant, with the positive sign indicating that banks operating in countries with a sluggish economy are confronted with lower rates, which in turn compresses their interest rate spread. Also consistent with our expectations: stock market volatility affects the interest rate spread positively. The magnitude of this coefficient can be explained in the same way as in the pooled OLS model: the VSTOXX coefficients for the lending and deposit spread are of the same order with opposite sign, so that the effect is largely neutralized. Finally, in contrast with the empirical literature of, for example, Tarus et al. (2012) and CGFS (2018), no clear-cut effect of inflation (HICP) and market concentration (HHI) on banks' interest rate spread are found in our model. Nevertheless, the latter finding is in line with Valverde & Fernández (2007) as they also found no significant impact of market concentration on interest rate spread.

Columns 3 to 6 of table 5 presents the estimation results for the two commercial margins, the lending and deposit spread. In accordance with above, the basic specifications for the lending and deposit spread can be found in columns 1 and 3, respectively. Columns 2 and 4 show the model with controls. The compensation effect is again clearly visible in our results. More specifically, a decline in the level of short-term interest rate has a positive impact on the lending spread, therefore partially offsetting the negative effect on the deposit spread. Moreover, when squares are taken into account, we find a convex relationship for the lending spread and a concave relationship for the deposit spread. The slope of the yield curve, by contrast, exhibits a convex relationship with respect to both spreads.

The sign and the coefficient of cash in column 4 confirms our reasoning above for banks interest rate spread: banks with large amounts of cash on their balance sheets make up for the missed opportunities by imposing higher rates on their loans, increasing their lending spread on the one hand and the interest rate spread on the other hand. In the same vein as cash, better capitalized banks seem to enjoy higher lending and deposit spreads. These findings are thus consistent with our hypothesis. From the negative sign of the deposit-ratio in column 4, it could be inferred that non-retail banks have wider lending spreads, as they may rely on non-deposit sources to fund their loans (Disalvo & Johnston, 2017). Furthermore, the ratio of loans to total assets plays a significant role in banks' lending spread, confirming our hypothesis: banks' loan pricing behaviour is influenced by the higher costs and risks associated with a higher proportion of loans. This result is also consistent with López-Espinosa et al. (2011).

Turning to the role of country-level macroeconomic factors, we obtain the same mixed results for GDP growth rate as in the pooled OLS model. Whereas the coefficient in column 2 implies lower bank rates during an economic downturn, column 4 shows that it is more likely to be associated with higher lending spreads due to higher risk premiums on loans (Bikker & Vervliet, 2017; Claessens et al., 2018). We find a similar inverse effect for the HHI-index. Banks in highly concentrated markets appear to have lower lending spreads, but higher deposit spreads. A possible reason could be the greater competition between the dominant market players, which lowers lending and deposit rates. However, the coefficient in column 2 does not confirm this presumption. Again, no clear evidence is found for the effect of inflation on the lending spread. Nonetheless, it does have a small but positive effect on the deposit spread at a significance level of 10%. This outcome is in line with Naceur & Kandil (2009) and Tarus et al. (2012) as they argued that if inflation is not anticipated, bank costs may increase faster than bank revenues if a rise in inflation occurs.

Finally, we note that, based on our analysis, the spread on the liability side seems to be more prone to changes in interest rates, while the spread on the asset side exhibits greater sensitivity to changes in structural (bank-specific and macroeconomic) factors.

	Dependent variable:					
	I_Spread		L_Spread		D_Spread	
	(1)	(2)	(3)	(4)	(5)	(6)
Short-term rate	0.321***	0.409***	-0.596***	-0.586***	0.611***	0.758***
	(0.019)	(0.023)	(0.031)	(0.033)	(0.018)	(0.018)
Short-term rate²	-0.038***	-0.054***	0.063***	0.035***	-0.058***	-0.072***
	(0.005)	(0.006)	(0.009)	(0.008)	(0.005)	(0.004)
Slope YC	0.040**	-0.002	-0.083***	-0.296***	-0.274***	-0.225***
	(0.019)	(0.020)	(0.031)	(0.029)	(0.019)	(0.016)
Slope YC²	-0.011***	-0.006***	0.026***	0.039***	0.003	0.004***
	(0.002)	(0.002)	(0.003)	(0.003)	(0.002)	(0.002)
Cash		0.008***		0.023***		-0.009***
		(0.003)		(0.005)		(0.003)
DEP		-0.002		-0.094***		0.036***
		(0.003)		(0.005)		(0.003)
LTA		0.002		0.019***		0.006**
		(0.004)		(0.005)		(0.003)
Capital		0.070***		0.195***		0.016**
		(0.008)		(0.012)		(0.006)
GDP Growth		0.142***		-0.154***		0.128***
		(0.031)		(0.045)		(0.025)
HICP		-0.003		-0.001		0.023*
		(0.015)		(0.022)		(0.012)
HHI		-0.298		-2.767***		1.310***
		(0.424)		(0.615)		(0.338)
VSTOXX		0.006***		0.017***		-0.017***
		(0.001)		(0.002)		(0.001)
Observations	2,040	2,040	2,040	2,040	2,040	2,040
R2	0.339	0.383	0.440	0.593	0.795	0.872
Adjusted R2	0.334	0.377	0.437	0.589	0.793	0.871
F Statistic	259.460*** (df = 4; 2026)	104.355*** (df = 12; 2018)	398.486*** (df = 4; 2026)	245.188*** (df = 12; 2018)	1,958.763*** (df = 4; 2026)	1,144.407*** (df = 12; 2018)
Note:						*p<0.1; **p<0.05; ***p<0.01

Table 5: Static model for bank spreads estimated with FE

5.3.3. Heterogeneous effects of monetary policy

In our literature review, we have observed that the relationship between interest rates and banks' NIM varies over time and is especially more prominent in a low and negative interest rate environment. Accordingly, we would like to investigate how different interest rate environments affect the components of banks' NIM. In principle, there are various methods to capture this heterogeneous effect. For instance, Claessens et al. (2018) define a low interest rate environment as a period in which the 3-month interest rate is at or below a fixed threshold value of 1,25%. Altavilla et al. (2018) applies a similar approach but take the rate on marginal refinancing operations (MRO) and the interbank overnight rate (EONIA) into consideration with threshold values of 1,5% and 1,25%, respectively. In these cases, however, the results will depend on the arbitrarily chosen values for the thresholds. Therefore, we decided to include year dummies in the estimation of our empirical models with a view to representing certain defining moments.

First, we construct a dummy variable CRISIS that captures the years of the financial crisis (2007-2009). This timeframe is based on figure 3 and Appendix D where a clear drop in interest rates is visible. Hence, the dummy takes the value of 1 in 2007-2009 and 0 for the other years.

Second, it is no longer a secret that interest rates are at an all-time low and have already reached their zero lower bound. In order to find out the effect of a low, but positive interest rate environment on bank spreads, we introduce a dummy ZLB. We set the value of ZLB to 1 for the period 2011-2013 and to 0 otherwise. This period also includes the moment at which the deposit facility rate (DFR) was reduced to zero in 2012.

Finally, we also add a dummy to identify the NIRP. Following Boungou (2019) and given that the majority of countries have adopted this policy of negative rates since 2014, NIRP takes the value 1 from the year of implementation (2014-2019) onwards and the value 0 before this period.

Initially, we will only include the dummies in our regressions. Since the three dummies do not overlap over time, we decide to include them together in one regression. Afterwards, we'll further enrich our models by including interactions between the dummy variables and the financial market variables. Specifically, we estimate the following models:

$$\begin{aligned}\text{Bank spread}_{it} = {} & \alpha_i + \beta_1 \text{ST}_{\text{RATE}_{it}} + \beta_2 \text{ST}_{\text{RATE}_{it}}^{2} + \beta_3 \text{YC}_{it} + \beta_4 \text{YC}_{it}^2 + \\ & \gamma_1 \text{CASH}_{it} + \gamma_2 \text{DEP}_{it} + \gamma_3 \text{CAP}_{it} + \gamma_4 \text{LTA}_{it} + \delta_1 \text{GDPGrowth}_{it} \\ & + \delta_2 \text{HICP}_{it} + \delta_3 \text{HHI}_{it} + \delta_4 \text{VSTOXX}_{it} + \tau_1 \text{CRISIS} + \tau_2 \text{ZLB} + \\ & \tau_3 \text{NIRP} + \varepsilon_{it}\end{aligned}$$

The regression results are presented in table 6. In column 1, we note the same concave relationship between the short-term interest rate and banks’ interest rate spread as in table 5. Surprisingly, including the dummy variables into our specifications seems to reverse the impact of the slope of the yield curve. This outcome is somewhat surprising as it contradicts with our expectations and the aforecited studies. Looking at the coefficients of the dummies, we note that CRISIS significantly and positively affects the interest rate spread. This may indicate the fact that during the crisis and post-crisis years, banks have reoriented their business strategies and models away from trading and more complex activities towards less capital-intensive activities, including retail businesses. The reliance on interest income has therefore increased, even for the larger banks, allowing us to consider the financial crisis as a watershed for the banking sector (CGFS, 2018a; CFGS, 2018b, King & Yu, 2018). Remarkably, our empirical evidence further suggests that short-term nominal interest rates, approaching the zero lower bound, exert no impact on the interest rate spread. Although this outcome is unexpected, the graph in Appendix C shows that the interest rate spread remained more or less constant over the period considered. Finally, in line with our expectations, banks experience a deterioration of 0.17 percentage point in their interest rate spread as a result of the NIRP. Several authors (Jobst & Lin, 2016; Boungou & Mawusi, 2019; Eisenshmidt & Smets, 2019; Stráský & Hwang, 2019) state that this outcome stems from banks' decision not to apply negative interest rates to household deposits. So, while the yield on loans gradually declined, the funding costs remained unchanged, thereby compressing the interest rate spread.

In the same vein, columns 2 and 3 provide the results for the lending and deposit spread. The results in column 2 show that the inclusion of several dummies does not change the relationship between the financial market variables and the lending spread. In particular, a reduction in short-term interest rate and a flattening of the yield curve still contribute to an increase in banks’ lending spread. Moreover, the sign and the significance of the quadratic terms indicate that these relationships are convex.
As for the dummy variables, we find that the period of the financial crisis does not appear to have a significant impact on the lending spread. This outcome is somewhat surprising as lending rates have fallen following the crisis, putting pressure on banks’ lending spread (Gambacorta, Illes, & Lombardi, 2014). Conversely, the coefficient of ZLB is found to be statistically significant, with the positive sign indicating a rise in the lending spread. Usually, bank lending rates display a strong co-movement with policy rates, but this relationship seems to break down due to the strong repricing of risk from 2010 (the sovereign debt crisis) onwards. Credit risk has progressively increased in Europe, reaching higher levels than before the crisis. As a result, banks required higher risk premia to compensate for the deteriorating financial conditions. During these years, lending rates were therefore at a relatively higher level compared to the policy rates, which then reached their zero lower bound (Gambacorta et al., 2014; Hennecke, 2017;

Eisenshmidt & Smets, 2019). Moreover, banks' loan pricing behaviour doesn't seem to change once interest rates are cut into negative territory. Although the coefficient of NIRP is slightly smaller, banks are still inclined to widen their lending spreads. Two possible explanations are put forward. Either, banks face a considerable opportunity cost for holding deposits at non-negative rates as they can easily switch to wholesale funding that declines in lockstep with the marginal policy rate. Or, corporate deposit rates cannot be sufficiently reduced to compensate for the sticky retail deposit rates. In both cases, banks tend to offset their disadvantage by increasing their lending rates, and thereby widening their lending spread (Jobst & Lin, 2016). It should be noted that this finding contradicts with our presumption above that falling lending rates have narrowed the interest rate spread during NIRP.

For the effects of the dummies on banks' deposit spread, we'll look at the third column of Table 6. Although the impact of the market variables is slightly smaller with the addition of the dummies, they still exert a significant impact on the deposit spread. Furthermore, the financial crisis is found to compress banks' deposit spread. Since late 2008, banks have been operating in an easing policy environment, characterized by declining policy rates and short-term money market interest rates. Considering that banks usually set their deposit rates slightly below a reference market rate to obtain a positive spread, the downward trend in market interest rates inevitably narrowed the deposit spreads. In addition, this compression was even reinforced by competition for more stable deposit funding as banks' access to market funding was constrained at the time (ECB, 2011; Brunnermeier and Koby, 2018). Moreover, the coefficient of ZLB shows that this negative impact of falling interest rates due to loose monetary policy persists over time until they reach the zero lower bound. However, once central banks cut interest rates into negative territory, the transmission to deposit spreads ceases, as the coefficient is found to be insignificant.

	I_Spread	L_Spread	D_Spread
	Dependent variable:		
	(1)	(2)	(3)
Short-term rate	0.367***	-0.477***	0.710***
	(0.034)	(0.048)	(0.026)
Short-term rate²	-0.060***	0.031***	-0.045***
	(0.007)	(0.010)	(0.005)
Slope YC	-0.069***	-0.262***	-0.139***
	(0.023)	(0.033)	(0.018)
Slope YC²	-0.002	0.031***	-0.000
	(0.002)	(0.003)	(0.002)
Crisis	0.136***	-0.084	-0.323***
	(0.039)	(0.054)	(0.029)
ZLB	0.050	0.619***	-0.301***
	(0.040)	(0.057)	(0.031)
NIRP	-0.175***	0.382***	0.029
	(0.058)	(0.082)	(0.044)
Cash	0.003	0.005	0.004
	(0.003)	(0.005)	(0.003)
DEP	0.003	-0.085***	0.026***
	(0.003)	(0.005)	(0.003)
LTA	0.000	0.021***	0.009***
	(0.004)	(0.005)	(0.003)
Capital	0.074***	0.151***	0.024***
	(0.008)	(0.012)	(0.006)
GDP Growth	0.155***	-0.083*	0.083***
	(0.031)	(0.044)	(0.024)
HICP	-0.003	-0.005	0.022*
	(0.015)	(0.021)	(0.011)
HHI	-0.049	-1.605***	0.692**
	(0.428)	(0.603)	(0.324)
VSTOXX	0.005***	0.019***	-0.015***
	(0.001)	(0.002)	(0.001)
Observations	2,040	2,040	2,040
R2	0.599	0.697	0.895
Adjusted R2	0.595	0.693	0.894
F Statistic	125.5745***	192.8821***	716.4692***
Note:	*p<0.1; **p<0.05; ***p<0.01		

Table 6: Static model with dummy variables estimated with FE

However, these dummies do not allow us to define the role played by these different time periods in the impact of our market variables on bank margins. Therefore, we introduce several interaction terms to determine whether the impact of the interest rate structure on bank margins varies during these specific time periods. Table 7 reports the estimation results. For the sake of convenience, we only present the coefficients for the main explanatory variables, the dummies and the interaction terms. Before proceeding to the results, it is worth mentioning that adding interaction terms to the model drastically changes the interpretation of all the coefficients in our regressions. While the coefficient for short-term interest rates in the previous regressions could be interpreted as the unique effect on bank margins, in this case, the effect of short-term rate also depends on the coefficients of CRISIS, ZLB and NIRP. With the presence of interaction terms, the coefficient of short-term rate can now only be interpreted as the unique effect on bank margins when the dummy variables (CRISIS, ZLB and NIRP) equal zero.

The first thing we notice in table 7 is that R^2 is again greater for all specifications with interactions than without interaction terms. Hence, we conclude that these extra terms contribute to the predictive ability of our model.
Column 1 shows that when CRISIS equals 1 (and ZLB = NIRP = 0), the relationship between short-term interest rate and interest rate spread reverses: results indicate a convex relationship instead of a concave relationship that we have found in our FE model (table 5). Earlier in this thesis, it was mentioned that interest rate changes reach bank assets and liabilities at a different pace due to the existence of maturity mismatches and repricing frictions (English, 2002; Andreasen et al. 2013, Heider et al., 2019). Considering that banks have never been as mismatched as in the run-up to and during the financial crisis due to their unprecedented expansion in mortgage lending and in the presence of repricing frictions, these results might support this view (Jordà, Schularick, & Taylor, 2015). Unlike the financial crisis, our results further suggest that the period in which interest rates approach the zero lower bound does not significantly alter the relationship between short-term rates and banks interest rate spread. In other words, a decrease in the former is still associated with a decrease in the latter. However, once we set NIRP equal to 1 and take into account a negative interest rate environment, the relationship in question becomes stronger compared to a positive interest rate environment as the associated coefficients are 1.141[3] vs. 0.222, respectively.

Regarding our second monetary policy indicator, we document that the impact of the slope of the yield curve on banks interest rate spread does not change during the financial crisis. A decrease in the slope of the yield curve therefore leads to lower interest rate spreads. According to our results, this relationship does not seem to last in a low (ZLB) and negative (NIRP) interest rate environment. The coefficient of the main variables and the interaction terms represent an U-shaped relationship between the slope of the yield curve and banks interest rate spread,

[3] 1.141 = 0.222 + 0.919

which is somewhat surprising as it contradicts the bulk of the literature that provides evidence for the compression of banks spreads caused by the flattening of the yield curve.

The second column reports the effects on the lending spread. We note that the short-term interest rate is still negatively correlated with banks' lending spread. Moreover, taking into account the specific time periods, CRISIS and ZLB, the relationship in question has intensified. More specifically, banks try to keep their lending spread as high as possible while the downward pressure on the interest rates increases due to additional UMP measures. As previously mentioned, the increase in the lending spread during the ZLB-period is mainly due to a significant increase in credit risk, leading to a strong repricing of the latter. However, this compensatory behaviour appears to cease once central banks adopt the NIRP. We find a significant coefficient, with the positive sign indicating that lower negative short-term rates are transmitted to lower lending rates, thereby compressing the lending spread (Heider et al., 2019).
In the FE model in table 5, we found a U-shaped relationship between the slope of the yield curve and the lending spread. After performing the different interactions, our results show that this relationship does not change over time.

Finally, we examine the role of our market variables in different interest rate environments on banks' deposit spread. In line with the bulk of the literature, we find that bank deposit rates broadly tracked the downward adjustments in policy rates and market reference rates during the financial crisis. As we have noted before, banks were hit particularly hard by funding stresses as their access to market funding was curtailed. This, in turn, amplified competition for deposits, pushing deposit rates down. However, the interest rate pass-through of monetary policy appears to be interrupted once interest rates approach the zero lower bound. We find a significant coefficient, with the negative sign indicating that deposit margins widen as short-term rates drop. According to the Financial stability review of the ECB (2011), this finding holds for banks operating in countries that were less affected by the sovereign debt crisis at the time. Finally, our regression results also show that in a negative interest rate environment, deposit margins decline along with lower short-term rates. More specifically, a drop of one percentage point in short-term rate would induce a decline of 0.211[4] percentage point in the deposit spread. If we compare this coefficient with the impact on the lending spread (1.421), these findings support the hypothesis of a limited pass-through of negative rates as lending spreads are affected to a larger extent than deposit spreads, thereby exerting a negative effect on interest rate margins (Carbó-Valverde, Cuadros-Solas & Rodríguez-Fernández, 2019). This observation follows from the fact that a lower negative policy rate feeds through to lower negative market rates, but not to lower retail deposit rates. The latter are in fact bounded and stuck at levels close to zero because of legal constraints, fear of losing the

[4] 0.211 = 1.331 – 1.120

core funding base, or fear of hitting a psychological threshold[5] (Alsterlind, Armelius, Forsman, Jönsson, & Wretman, 2015; Eggertsson et al., 2019, Heider et al., 2019).
As for the slope of the yield curve, the interaction terms for the financial crisis are found not to be significant, suggesting that this particular period didn't change the impact on banks deposit margins. A low and negative interest rate environment, by contrast, reversed the relationship in question.

Altogether, the analysis in this section has shown that changes in interest rates, attributable to accommodative monetary policy measures, weigh on banks interest rate margins, especially during the ZLB and NIRP periods. Regarding the spreads on both sides of the balance sheet, we found that banks managed to offset the reduced deposit margins to some extent with wider lending spreads until the implementation of the NIRP. Afterwards, we observe an imperfect pass-through of negative rates on retail deposit rates, indicating the existence of their zero lower bound and thereby limiting the banks' scope to preserve their interest rate spread.

[5] Households may view the negative rates as 'abnormal' or 'theft' and react more instinctively by withdrawing their money from the bank (Alsterlind et al., 2015).

	Dependent variable:		
	I_Spread	L_Spread	D_Spread
	(1)	(2)	(3)
Short-term rate	0.222**	-0.496***	1.331***
	(0.092)	(0.121)	(0.067)
Short-term rate²	-0.005	-0.065**	-0.122**
	(0.023)	(0.031)	(0.017)
Slope YC	0.221***	-0.912***	0.243***
	(0.070)	(0.092)	(0.051)
Slope YC²	-0.051***	0.103***	-0.039***
	(0.009)	(0.012)	(0.007)
Crisis	1.185***	-0.012	-0.144
	(0.272)	(0.358)	(0.199)
ZLB	0.67***	-0.277	1.202***
	(0.171)	(0.225)	(0.125)
NIRP	0.283*	-0.575***	1.580***
	(0.160)	(0.210)	(0.117)
Short-term rate * Crisis	-0.661***	-0.428**	-0.209***
	(0.139)	(0.183)	(0.101)
Short-term rate² * Crisis	0.090***	0.127***	0.050**
	(0.030)	(0.039)	(0.022)
Slope YC * Crisis	0.167	0.592***	-0.010
	(0.112)	(0.148)	(0.082)
Slope YC² * Crisis	-0.114***	-0.187***	0.007
	(0.020)	(0.027)	(0.015)
Short-term rate * ZLB	-0.111	-1.152***	-1.458***
	(0.227)	(0.299)	(0.167)
Short-term rate² * ZLB	-0.058	0.386**	0.514***
	(0.123)	(0.163)	(0.091)
Slope YC * ZLB	-0.367***	0.802***	-0.342***
	(0.075)	(0.099)	(0.055)
Slope YC² * ZLB	0.057***	-0.084***	0.036***
	(0.010)	(0.013)	(0.007)
Short-term rate * NIRP	0.919***	1.917***	-1.120***
	(0.137)	(0.180)	(0.101)
Short-term rate² * NIRP	0.512	2.075***	-0.406
	(0.406)	(0.535)	(0.298)
Slope YC * NIRP	-0.360***	0.461***	-0.632***
	(0.089)	(0.117)	(0.065)
Slope YC² * NIRP	0.055***	-0.046**	0.094***
	(0.016)	(0.021)	(0.012)
Bank-specific controls	YES	YES	YES
Macroeconomic controls	YES	YES	YES
Observations	2,040	2,040	2,040
R2	0.645	0.766	0.913
Adjusted R2	0.639	0.761	0.911
F Statistic	101.239***	181.688***	582.651***
Note:			*p<0.1; **p<0.05; ***p<0.01

Table 7: Static model with dummies and interaction terms estimated with FE

5.3.3.1. <u>Bank business model</u>

The last section of this thesis examines whether bank-specific characteristics amplify or weaken the impact of interest rate changes on bank spreads in a low and negative interest rate environment. More specifically, various studies (Eggertson, Juelsrud, & Wold, 2017; Boungou & Mawusi, 2019; Carbó-Valverde, Cuadros-Solas, & Rodríguez-Fernández, 2019; Schelling & Towbin, 2020) argue that UMP, in particular quantitative easing (QE) and NIRP, have a differential effect on less-diversified, lending-and-deposit focused banks (Bindseil, 2018). Within this framework, the funding structure of banks especially receives a lot of attention. Banks with a large deposit base are expected to face more financial burdens in a low and especially negative interest rate environment than low-deposit funded banks. The reasoning has already been discussed several times in this thesis: once bank deposit rates decouple from movements in policy rate and money market interest rate for aforementioned reasons, the decline in lending rates will be stronger than in deposit rates, thereby causing a significant decrease in their interest margins. However, Eisenschmidt & Smets (2019) and Heider et al. (2019) state that banks with higher deposit shares don’t just throw in the towel. Once interest rates go negative, the likelihood of those banks lowering their lending rates decreases. To ease the pressure on their margins and to compensate for the penalty of holding excess liquidity under NIRP, they will either restrict loan supply and/or start lending to riskier borrowers at higher rates. This ultimately results in higher lending spreads for banks that are highly reliant on retail deposits. Low-deposit funded banks, by contrast, will be able to mitigate the adverse effects associated with UMP by, for instance, investing in non-interest income activities (Weistroffer, 2013).

In order to test whether the spreads of banks with low and high deposit shares are differently affected, we start with our baseline specifications from section 5.3.2 and add various dummies (QE[6] and NIRP) and interactions. Table 8 reports the results[7]. We are mainly interested in the triple interaction terms as these will tell us whether high-deposit funded banks are more prone to interest changes during the QE or NIRP-period. Unfortunately, the first three columns display that the triple interaction term containing QE is not found to be significant. In other words, our results do not provide evidence that high-deposit funded banks are affected to a greater extent by interest rate changes during QE than low-deposit funded banks. However, when we decompose the three-way interaction into two-way interactions, we do find some important coefficients. First, (short-term rate * DEP) significantly and positively affects the interest rate spread and lending spread. This implies that a cut in short-term interest rate is expected to lower the spreads of high-deposit funded banks more than for low-deposit funded banks. Second, the

[6] QE takes the value 1 from 2015M03 – 2017M12 and 0 otherwise.

[7] The marginal effect of interest rate changes on banks with high and low deposits before and after the introduction of QE can be found in appendix I.

results (DEP * QE) reveal that lending spreads of the former are compressed during QE (ECB, 2000).

Turning to columns 4 to 6, we perform the same analysis after NIRP is adopted. The first thing to notice is that the triple interaction terms are significant. While this results for the interest rate spread complies with literature, the findings for the deposit spread is somewhat surprising as most studies state that deposit margins are expected to be less responsive to policy rate cuts in negative territory. Contrary to our expectations, we find no significant impact on the lending spread. Looking at the double interaction terms, similar results are found as for the QE-period. Although the coefficient is smaller, we find that the interest rate spread of banks with higher deposit shares are more interest sensitive. Furthermore, results also point out that the lending spread of banks with more deposits is experiencing a smaller downward impact during NIRP than QE as the coefficients are -0,059 vs. -0,108. This may confirm banks' reluctance to reduce spreads even more in a negative interest rate environment as suggested Eisenschmidt & Smets (2019) and Heider et al. (2019).

	Dependent variable:					
	I_Spread (1)	L_Spread (2)	D_Spread (3)	I_Spread (4)	L_Spread (5)	D_Spread (6)
Short-term rate	-0.010 (0.035)	-0.910*** (0.052)	0.777*** (0.092)	-0.041 (0.043)	-1.034*** (0.062)	1.041*** (0.362)
Short-term rate²	-0.031*** (0.006)	0.060*** (0.008)	-0.077*** (0.005)	-0.005 (0.006)	0.113*** (0.008)	-0.102*** (0.005)
Slope YC	0.030 (0.019)	-0.257*** (0.029)	-0.208*** (0.016)	-0.035 (0.021)	-0.382*** (0.031)	-0.098*** (0.018)
Slope YC²	-0.008*** (0.001)	0.036*** (0.003)	0.003** (0.002)	-0.003 (0.002)	0.046*** (0.003)	-0.005*** (0.002)
QE	-0.023 (0.001)	0.616** (0.241)	-0.039 (0.134)			
Short-term rate * DEP	0.014*** (0.001)	0.010*** (0.001)	0.001 (0.001)			
Short-term rate * QE	-0.127 (0.593)	0.893 (0.894)	-0.159 (0.498)			
DEP * QE	-0.003 (0.005)	-0.024*** (0.008)	0.009* (0.005)			
Short-term rate * DEP * QE	-0.001 (0.019)	-0.018 (0.029)	0.101 (0.005)			
DEP	0.004 (0.003)	-0.084*** (0.005)	0.036*** (0.003)	0.041*** (0.008)	-0.015** (0.006)	0.028*** (0.004)
NIRP				0.157 (0.109)	0.742*** (0.158)	0.504*** (0.092)
Short-term rate * DEP				0.007*** (0.001)	-0.001 (0.002)	-0.001 (0.001)
Short-term rate * NIRP				-0.233 (0.247)	1.677*** (0.357)	-1.337*** (0.209)
DEP * NIRP				-0.017*** (0.004)	-0.044*** (0.005)	-0.004 (0.003)
Short-term rate * DEP * NIRP				0.036*** (0.008)	0.013 (0.012)	0.021*** (0.007)
Bank-specific controls	YES	YES	YES	YES	YES	YES
Macroeconomic controls	YES	YES	YES	YES	YES	YES
Observations	2,040	2,040	2,040	2,040	2,040	2,040
R2	0.645	0.694	0.886	0.672	0.739	0.893
Adjusted R2	0.641	0.690	0.885	0.667	0.735	0.892
F Statistic	141.051***	175.875***	602.780***	158.344***	218.891***	646.338***
Note:					*p<0.1; **p<0.05; ***p<0.01	

Table 8: Static model for bank business model (DEP) estimated with FE

We'll perform the same analysis on the asset side by including the LTA-variable instead of the DEP-variable. The findings are shown in table 9[8]. Similar to the above results, the relationship between short-term interest rate and bank spreads does not appear to depend on the share of loans and QE at the same time as the triple interaction in each specification is found to be insignificant. The double interaction term (Short-term rate * LTA), by contrast, enters each equation significantly. From these results, it could be inferred that the compensation effect between lending and deposit spreads decreases as banks issue more loans, making interest rate spreads more sensitive to changes in interest rates. In addition, we find that banks primarily active in lending experience a deterioration in their lending spread during QE.

In columns 4 to 6, the same study is repeated, except that rates are now being pushed into the negative area. The three-way interaction term is found to be significant, indicating that the relationship between short-term rates and bank lending spreads are stronger for banks specialized in lending during NIRP. Furthermore, 3 other conclusions can be drawn. First, all spreads are affected downward by a decrease in short-term rates once NIRP is adopted. The biggest impact is found on the deposit spread, which is at odds with our previous finding and the bulk of the literature as the zero lower bound on retail deposits limits large decreases of the deposit spread. Second, the more loans a bank issues, the more their interest rate and lending spread are compressed in a negative interest rate environment. Finally, short-term interest rate seems to exert a considerably larger impact on the interest rate spread of banks with a higher share of loans.

Bringing the asset and liability side together, the impact of UMP (QE + NIRP) on the spreads of lending-and-deposit focused banks turns out to be not clear-cut. On the one hand, our analysis provides no support on the interest rate sensitivity of banks with a large deposit or loan base during QE. Regarding the period after the implementation of NIRP, on the other hand, we find mixed results. The research on the liabilities side indicates that the interest rate spread and deposit spread of high-deposit funded banks are more sensitive to interest changes, whereas on the asset side the lending spread is found to be more sensitive.

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[8] The marginal effect of interest rate changes on banks with high and low deposits before and after the introduction of NIRP can be found in appendix J.

	Dependent variable:					
	I_Spread (1)	L_Spread (2)	D_Spread (3)	I_Spread (4)	L_Spread (5)	D_Spread (6)
Short-term rate	0.070**	-0.861***	0.865***	-0.113***	-1.092***	1.044***
	(0.029)	(0.044)	(0.025)	(0.036)	(0.052)	(0.030)
Short-term rate²	-0.047***	0.051***	-0.079***	-0.023***	0.108***	-0.104***
	(0.005)	(0.008)	(0.005)	(0.006)	(0.008)	(0.005)
Slope YC	0.029	-0.255***	-0.217***	-0.047**	-0.381***	-0.122***
	(0.019)	(0.029)	(0.016)	(0.022)	(0.031)	(0.018)
Slope YC²	-0.009***	0.036***	0.004**	-0.003	0.044***	-0.003**
	(0.002)	(0.003)	(0.002)	(0.002)	(0.003)	(0.002)
QE	-0.098	0.615***	0.096			
	(0.151)	(0.228)	(0.127)			
Short-term rate * LTA	0.010***	0.006***	-0.002***			
	(0.001)	(0.001)	(0.000)			
Short-term rate * QE	0.197	0.841	0.273			
	(0.565)	(0.853)	(0.475)			
LTA * QE	0.001	-0.024***	0.004			
	(0.004)	(0.007)	(0.004)			
Short-term rate * LTA * QE	-0.009	-0.011	-0.004			
	(0.017)	(0.025)	(0.014)			
LTA	-0.031***	-0.001	0.010***	-0.034***	0.005	0.013***
	(0.004)	(0.006)	(0.003)	(0.004)	(0.006)	(0.003)
NIRP				-0.435***	0.457***	0.321***
				(0.098)	(0.141)	(0.083)
Short-term rate * LTA				0.009***	0.001	-0.001
				(0.001)	(0.001)	(0.000)
Short-term rate * NIRP				0.475*	1.425***	-0.560**
				(0.253)	(0.363)	(0.213)
LTA * NIRP				0.006**	-0.026***	0.002
				(0.003)	(0.004)	(0.002)
Short-term rate * LTA * NIRP				0.010	0.021**	-0.005
				(0.007)	(0.011)	(0.006)
Bank-specific controls	YES	YES	YES	YES	YES	YES
Macroeconomic controls	YES	YES	YES	YES	YES	YES
Observations	2,040	2,040	2,040	2,040	2,040	2,040
R2	0.650	0.696	0.887	0.666	0.739	0.893
Adjusted R2	0.645	0.693	0.885	0.662	0.736	0.891
F Statistic	143.701***	177.671***	609.796***	154.393***	219.733***	645.121***

Note: *p<0.1; **p<0.05; ***p<0.01

Table 9: Static model for bank business model (LTA) estimated with FE

6

Conclusion

In the wake of the Global Financial Crisis, monetary policy has faced major challenges in safeguarding financial stability, boosting inflation and stimulating growth. In order to cope with these problems, central banks have taken several conventional and unconventional monetary policy measures. In the following years, both short and long-term interest rates were driven down, with the former even reaching (below) the zero lower bound. Considering that the health of the banking sector is closely tied to monetary policy, today's interest-rate environment poses enormous challenges to growth in the banking sector. After all, low and negative interest rates hurt profitability over time by eroding banks' net-interest margins.

In this paper, we have examined two variables reflecting the impact of monetary policy (the level of the short-term rates and the slope of the yield curve) on the components of banks' NIM, in particular the interest rate spread, lending spread and deposit spread. More specifically, we focused on two main questions: '*If falling interest rates have left their mark on banks' NIM, how and to what extent are the separate components of the NIM impacted?' 'Furthermore, can we observe any compensation between the loan and deposit spread?'* These relationships are analysed for approximately 2550 banks operating in the 10 countries of the European Union using a large set of panel data composed of interest rate variables, bank-specific variables and macroeconomic variables. Our empirical approach is based on a static panel framework (FE estimation technique) that takes into account the heterogeneity across different countries.

The main conclusion concerning the first part of this paper is that monetary policy considerably affects the different components of banks' NIM and that bank lending spread and deposit spread respond differently to interest rate cuts. Our empirical analysis shows that monetary policy easing (a reduction in short-term interest rates and a flattening of the yield curve) is associated with narrower interest rate and deposit spreads, but wider lending spreads. These results therefore provide strong evidence for the presumption that the components of the NIM on both sides of the balance sheet are asymmetrically affected. Hence, we can infer that banks succeed in partially offsetting the decline in deposit spreads with an increase in lending spreads. Moreover, in all cases the impact is found to be quadratic, such that the spreads are more sensitive to changes in the two monetary policy indicators when interest rates are low. These findings hold and resist the inclusion of several bank-specific and macroeconomic control variables.

In the second part of this thesis, we examined to what extent the interest rate pass-through of monetary policy is influenced by different interest rate environments. We have analysed three time periods, namely the financial crisis with declining interest rates, a period of low, but positive rates fluctuating around the zero lower bound and eventually a negative interest rate environment. The results revealed that accommodative monetary policy measures weigh on banks interest rate spreads, especially in a negative interest rate environment. In addition, the implementation of NIRP gives rise to an imperfect pass-through of negative rates on retail deposit rates, thereby compressing banks' NIM. Finally, our analysis provides no clear-cut results regarding the hypothesis that traditional banks take the largest hit from low rates caused by QE or NIRP.

To conclude this thesis, I would like to offer a proposition for future research. As mentioned earlier, we have compiled a balanced sample consisting of both core and periphery countries. Both country groups have been affected in different ways by the conventional and unconventional monetary policy measures. It might therefore be interesting to consider them separately and track the impact of those measures on the particular behaviour of bank spreads. This sub-sample analysis could in turn shed light on the effectiveness of the monetary policy transmission mechanism in those country groups and on the need of revising the side effects of UMP.

7

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8

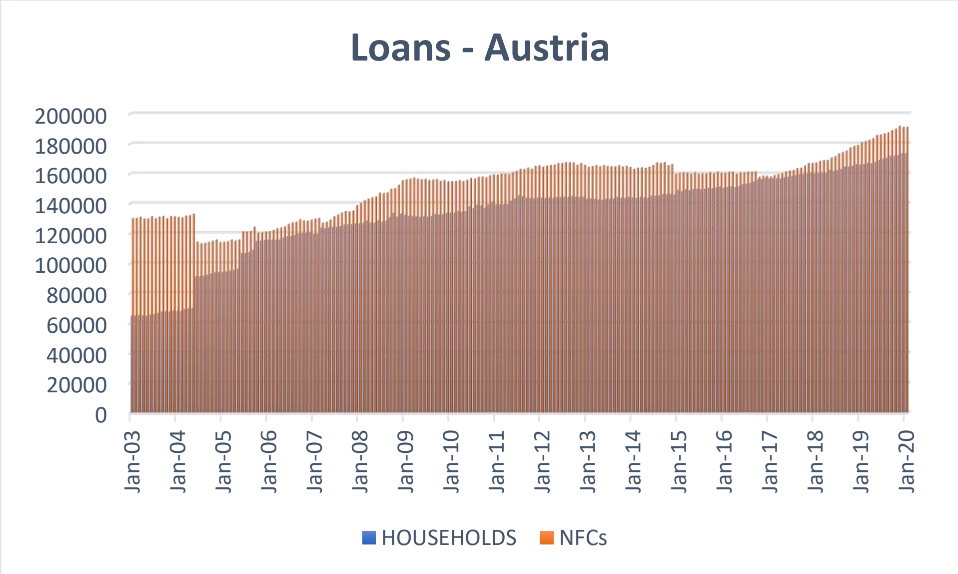
Appendix

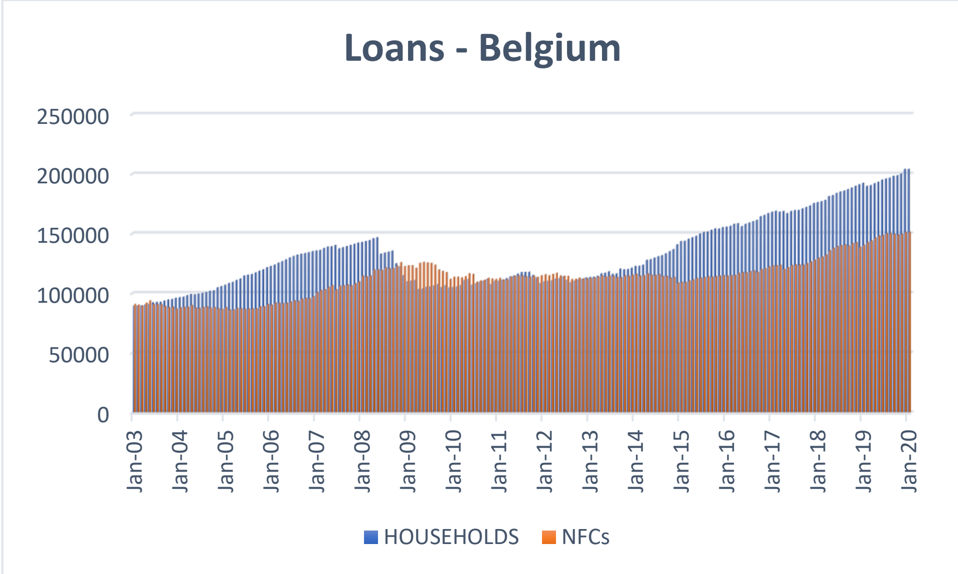
A. List of all countries and all variables of interest

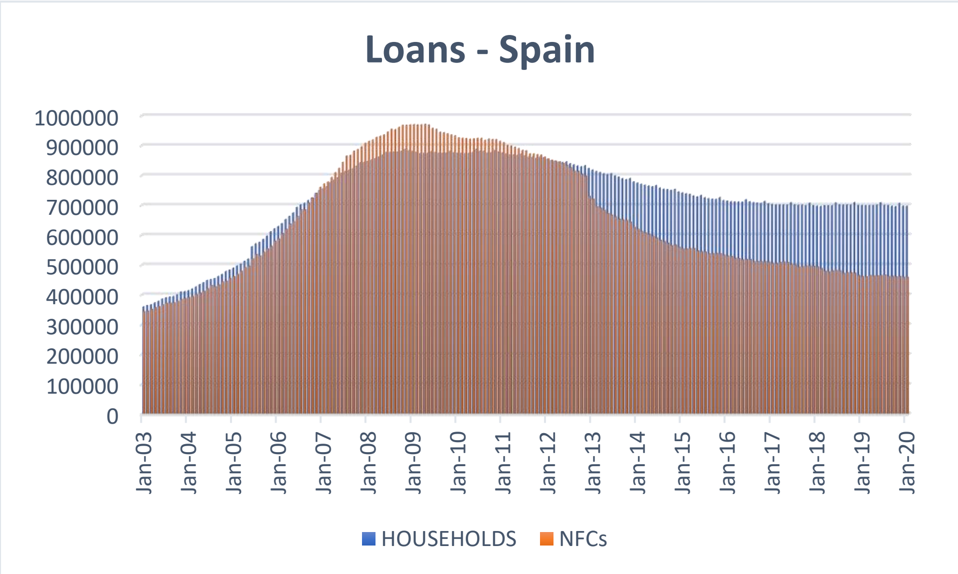
COUNTRIES	ABBREVIATION
Austria	AU
Belgium	BE
Germany	DE
Spain	ES
Finland	FI
France	FR
Ireland	IR
Italy	IT
The Netherlands	NL
Portugal	PT

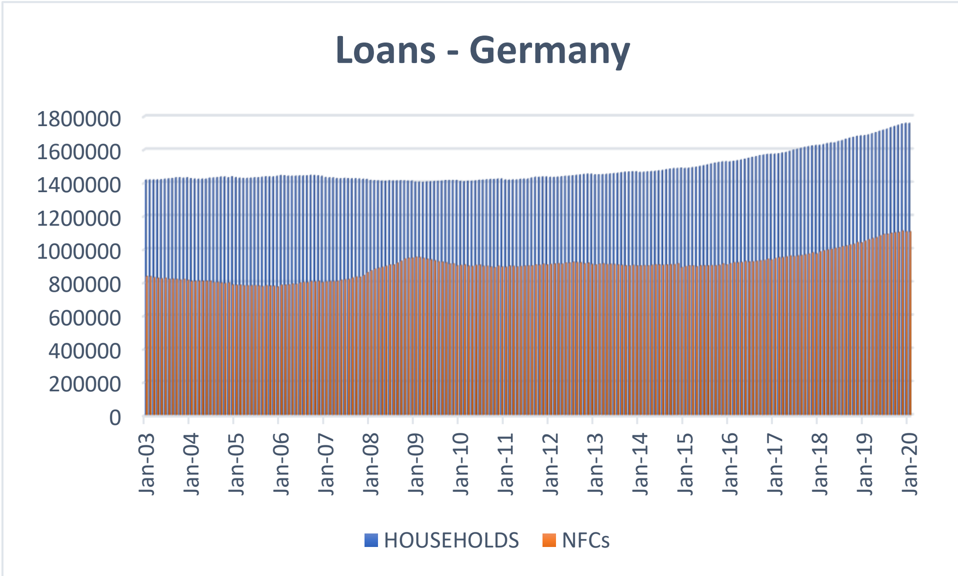
PANEL A: Variables of interest	DEFINITION
Interest spread (I_SPREAD)	The difference between retail lending and borrowing rates
Loan spread (L_SPREAD)	The difference between retail lending rates and 5-year CDS swap rate
Deposit spread (D_SPREAD)	The difference between 3-month EONIA rate and retail deposit rates
PANEL B: Financial market characteristics	**DEFINITION**
Short-term interest rate (ST_RATE)	The 3-month EURIBOR on a monthly basis
Long-term interest rate (LT_RATE)	The 10-year government bond yield on a monthly basis
Yield curve (YC)	The difference between the 10-year government bond yield and 3-month EURIBOR
PANEL C: Bank-specific characteristics	**DEFINITION**
Cash	The ratio of cash to total assets
Deposits-to-total Labilities (DEP)	The ratio of deposits to total assets
Capital (CAP)	The ratio of capital to total assets
Loans-to-total assets (LTA)	The ratio of loans to total assets
PANEL D: Country-specific characteristics	**DEFINITION**
GDP growth rate (GDP growth)	The GDP growth rate per country per month
Harmonized index of consumer prices (HICP)	A comparable measure of inflation per country per month
Herfindahl-Hirschman Index (HHI)	Market concentration per country per month
Stock market volatility (VSTOXX)	Monthly volatility indices based on the EURO STOXX 50

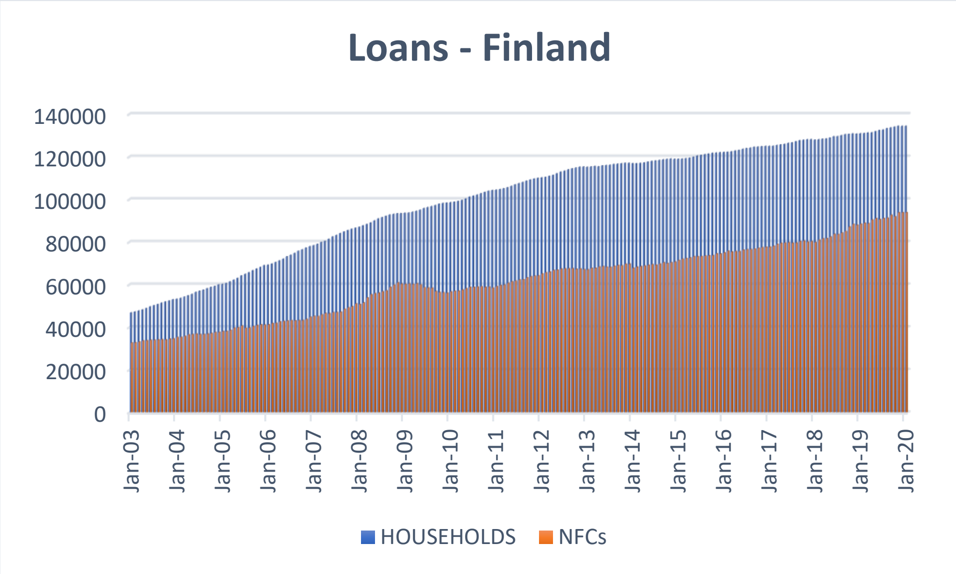
B. Loans and deposits vis-à-vis households and NFCs

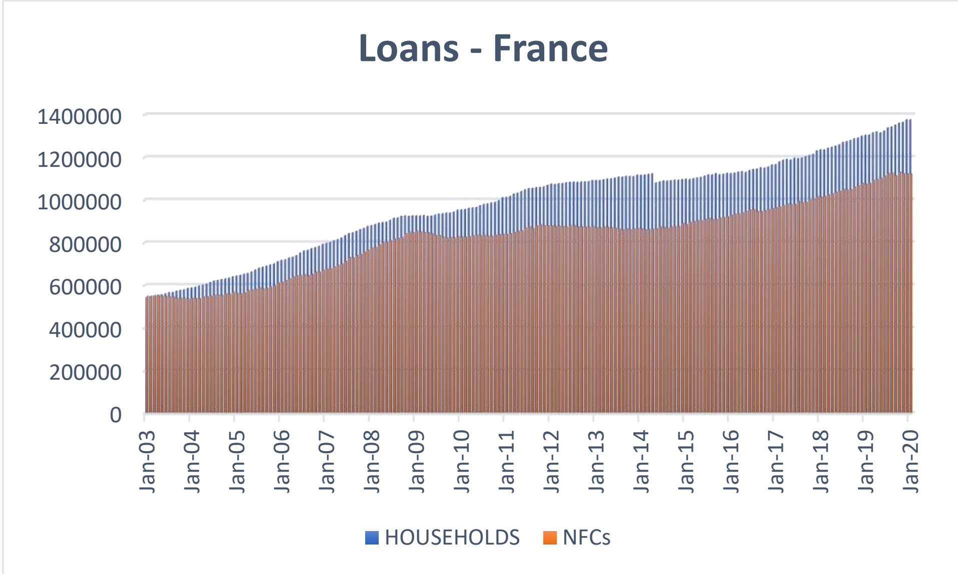


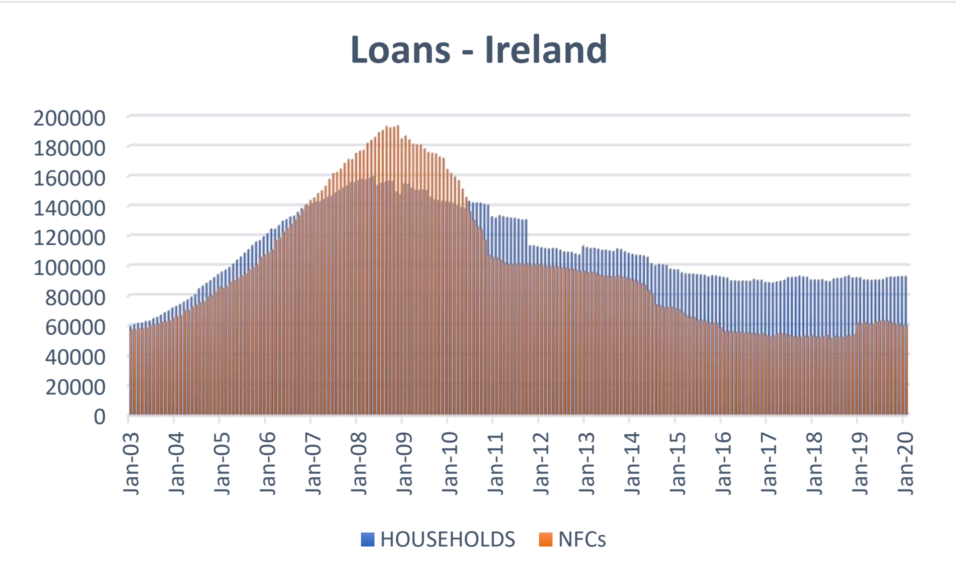


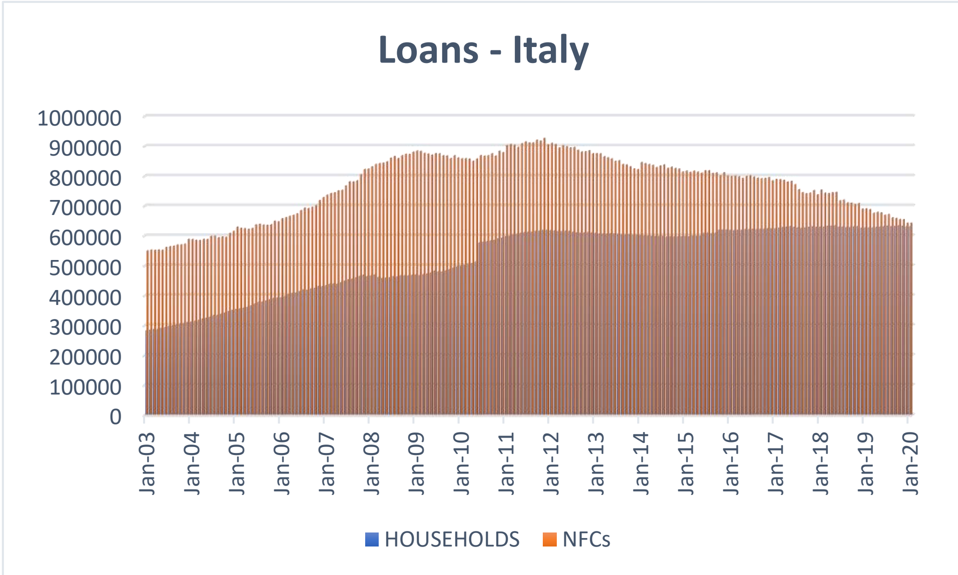





Loans - Finland
140000
120000
100000
80000
60000
40000
20000
0
Jan-03
Jan-04
Jan-05
Jan-06
Jan-07
Jan-08
Jan-09
Jan-10
Jan-11
Jan-12
Jan-13
Jan-14
Jan-15
Jan-16
Jan-17
Jan-18
Jan-19
Jan-20
HOUSEHOLDS
NFCs


Loans - France
1400000
1200000
1000000
800000
600000
400000
200000
0
Jan-03
Jan-04
Jan-05
Jan-06
Jan-07
Jan-08
Jan-09
Jan-10
Jan-11
Jan-12
Jan-13
Jan-14
Jan-15
Jan-16
Jan-17
Jan-18
Jan-19
Jan-20
HOUSEHOLDS
NFCs


Loans - Ireland
200000
180000
160000
140000
120000
100000
80000
60000
40000
20000
0
Jan-03
Jan-04
Jan-05
Jan-06
Jan-07
Jan-08
Jan-09
Jan-10
Jan-11
Jan-12
Jan-13
Jan-14
Jan-15
Jan-16
Jan-17
Jan-18
Jan-19
Jan-20
HOUSEHOLDS
NFCs


Loans - Italy
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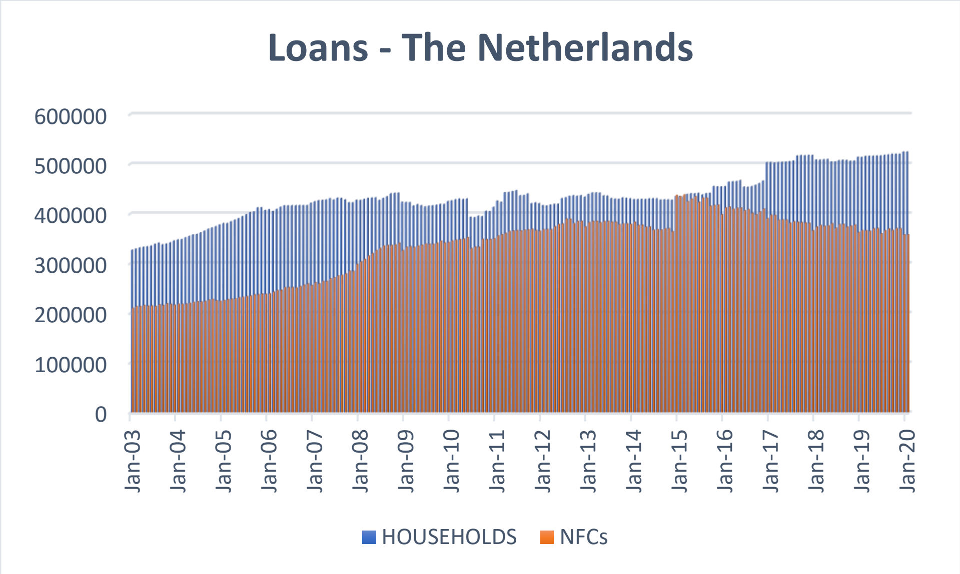
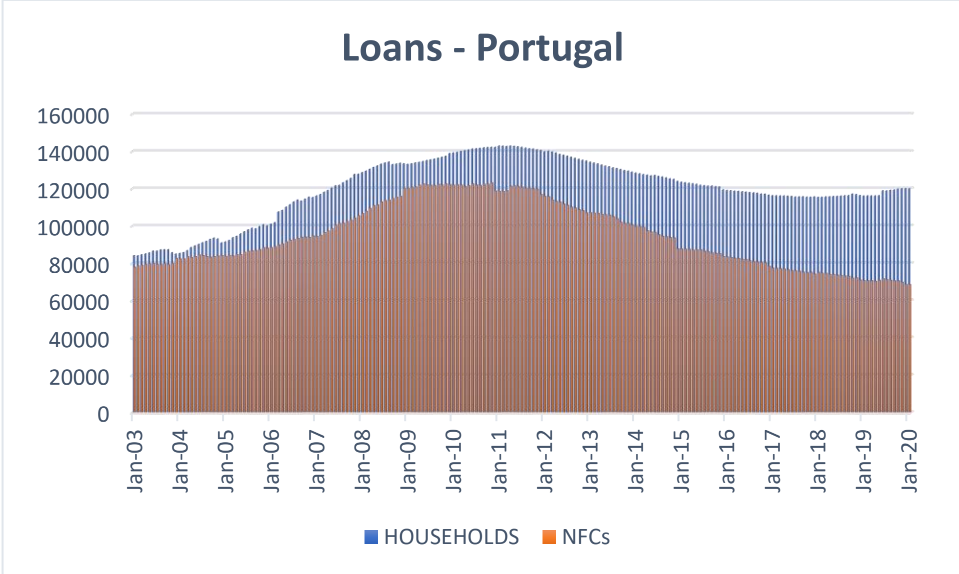
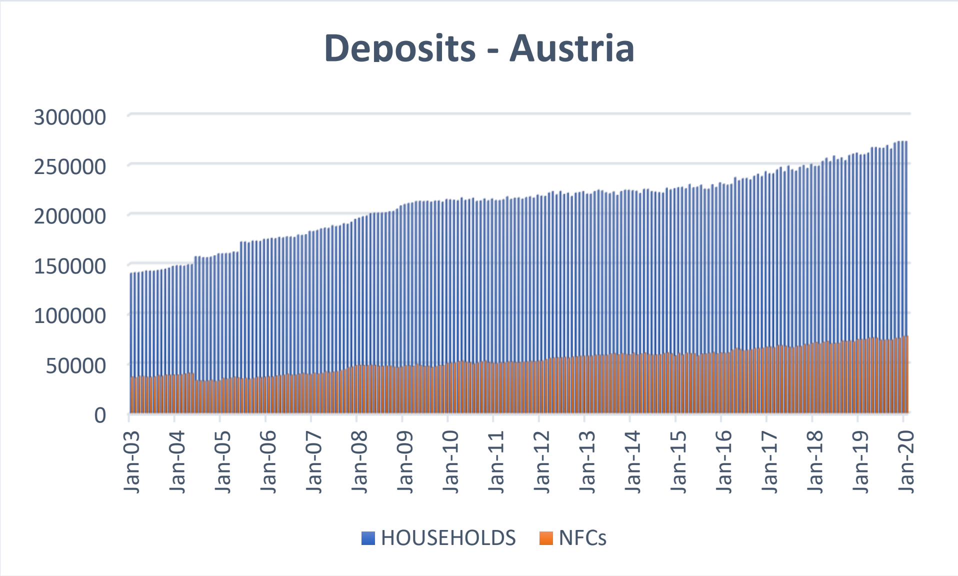
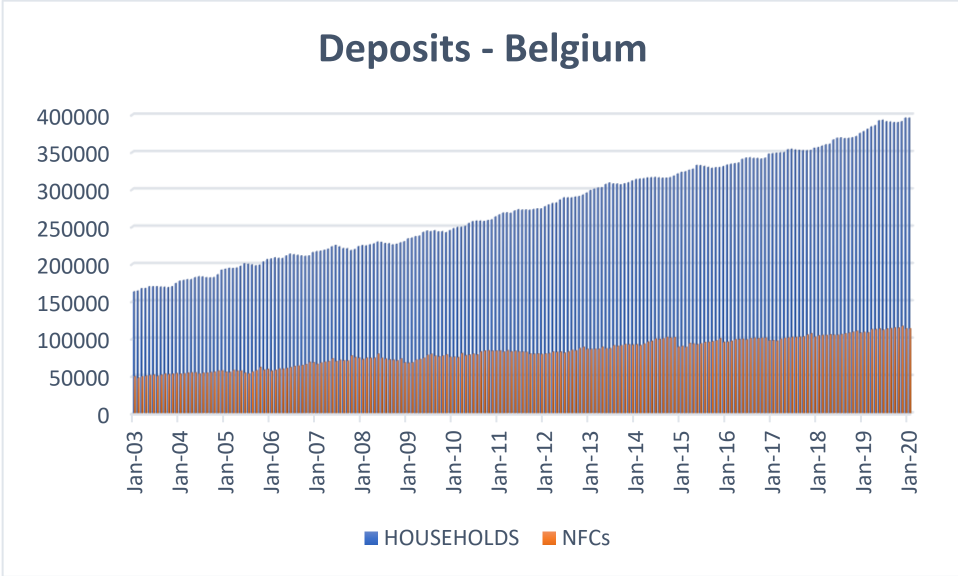
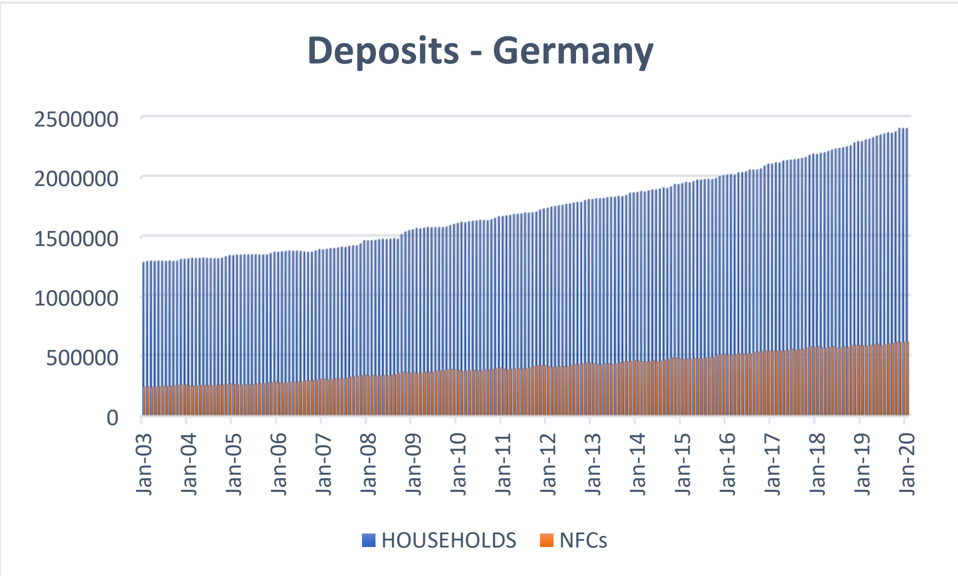
900000
800000
700000
600000
500000
400000
300000
200000
100000
0
Jan-03
Jan-04
Jan-05
Jan-06
Jan-07
Jan-08
Jan-09
Jan-10
Jan-11
Jan-12
Jan-13
Jan-14
Jan-15
Jan-16
Jan-17
Jan-18
Jan-19
Jan-20
HOUSEHOLDS
NFCs

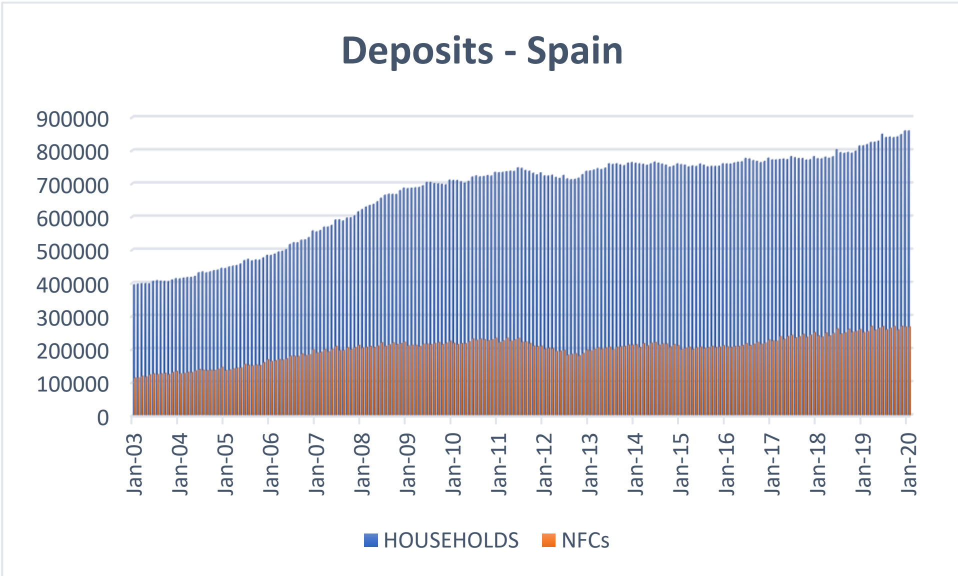

Loans - The Netherlands
600000
500000
400000
300000
200000
100000
0
Jan-03
Jan-04
Jan-05
Jan-06
Jan-07
Jan-08
Jan-09
Jan-10
Jan-11
Jan-12
Jan-13
Jan-14
Jan-15
Jan-16
Jan-17
Jan-18
Jan-19
Jan-20
HOUSEHOLDS
NFCs

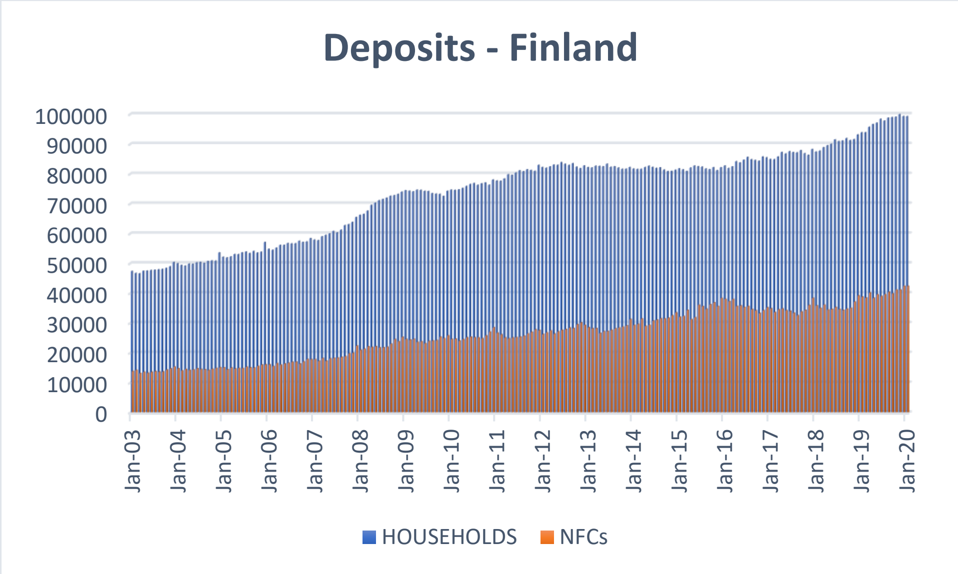

Loans - Portugal
160000
140000
120000
100000
80000
60000
40000
20000
0
Jan-03
Jan-04
Jan-05
Jan-06
Jan-07
Jan-08
Jan-09
Jan-10
Jan-11
Jan-12
Jan-13
Jan-14
Jan-15
Jan-16
Jan-17
Jan-18
Jan-19
Jan-20
HOUSEHOLDS
NFCs

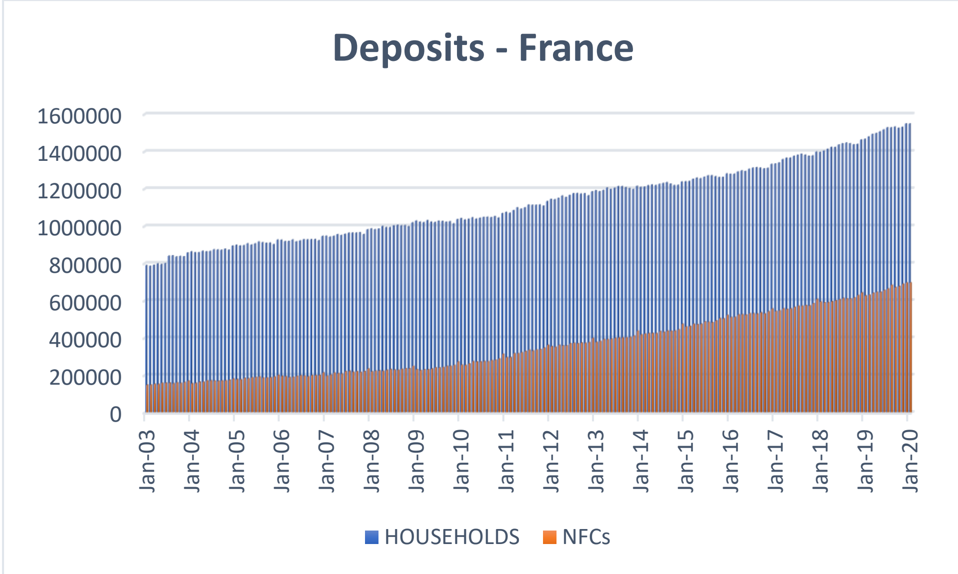

Deposits - Austria
300000
250000
200000
150000
100000
50000
0
Jan-03 Jan-04 Jan-05 Jan-06 Jan-07 Jan-08 Jan-09 Jan-10 Jan-11 Jan-12 Jan-13 Jan-14 Jan-15 Jan-16 Jan-17 Jan-18 Jan-19 Jan-20
HOUSEHOLDS
NFCs

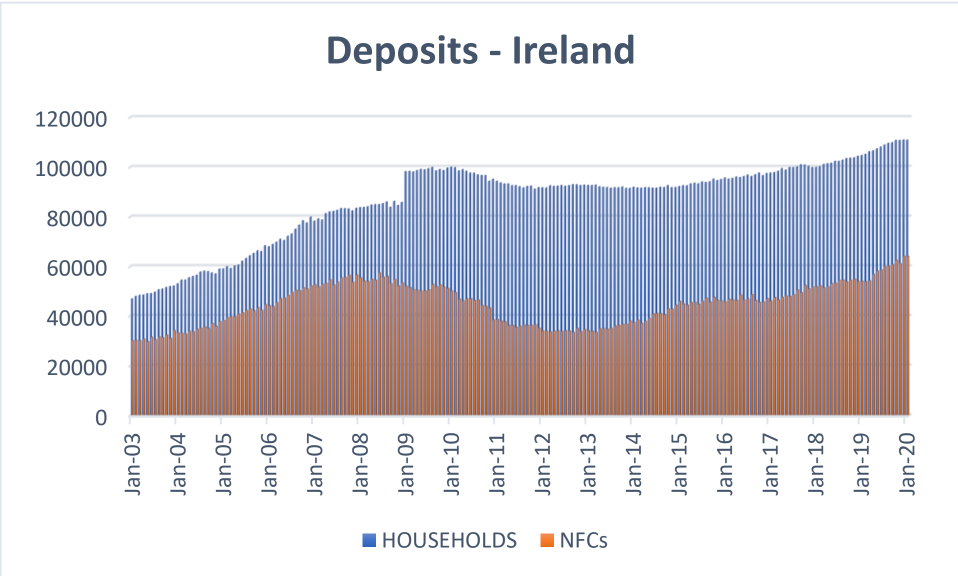

Deposits - Belgium
400000
350000
300000
250000
200000
150000
100000
50000
0
Jan-03 Jan-04 Jan-05 Jan-06 Jan-07 Jan-08 Jan-09 Jan-10 Jan-11 Jan-12 Jan-13 Jan-14 Jan-15 Jan-16 Jan-17 Jan-18 Jan-19 Jan-20
HOUSEHOLDS
NFCs

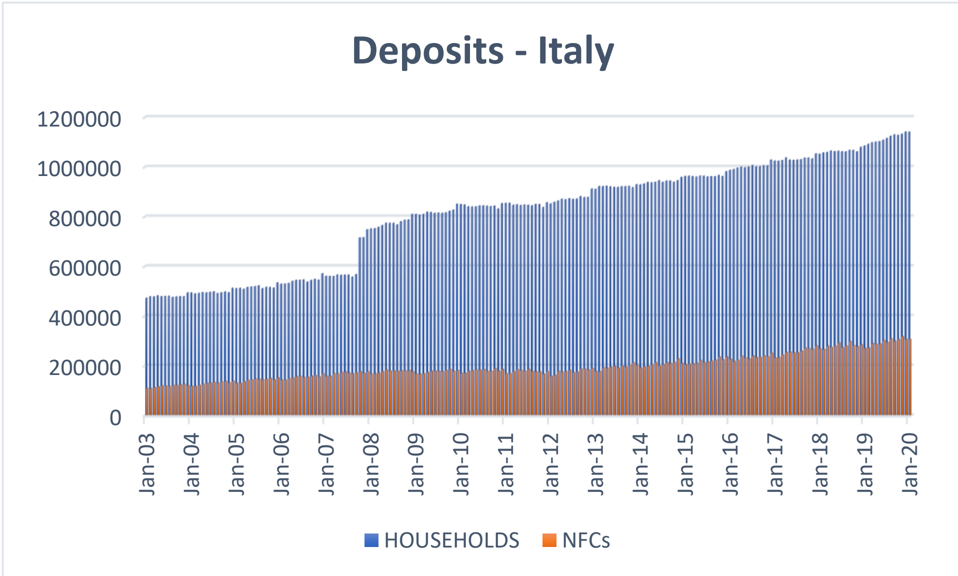

Deposits - Germany
2500000
2000000
1500000
1000000
500000
0
Jan-03 Jan-04 Jan-05 Jan-06 Jan-07 Jan-08 Jan-09 Jan-10 Jan-11 Jan-12 Jan-13 Jan-14 Jan-15 Jan-16 Jan-17 Jan-18 Jan-19 Jan-20
HOUSEHOLDS
NFCs


Deposits - Spain
900000
800000
700000
600000
500000
400000
300000
200000
100000
0
Jan-03 Jan-04 Jan-05 Jan-06 Jan-07 Jan-08 Jan-09 Jan-10 Jan-11 Jan-12 Jan-13 Jan-14 Jan-15 Jan-16 Jan-17 Jan-18 Jan-19 Jan-20
HOUSEHOLDS
NFCs


Deposits - Finland
100000
90000
80000
70000
60000
50000
40000
30000
20000
10000
0
Jan-03
Jan-04
Jan-05
Jan-06
Jan-07
Jan-08
Jan-09
Jan-10
Jan-11
Jan-12
Jan-13
Jan-14
Jan-15
Jan-16
Jan-17
Jan-18
Jan-19
Jan-20
HOUSEHOLDS
NFCs


Deposits - France
1600000
1400000
1200000
1000000
800000
600000
400000
200000
0
Jan-03
Jan-04
Jan-05
Jan-06
Jan-07
Jan-08
Jan-09
Jan-10
Jan-11
Jan-12
Jan-13
Jan-14
Jan-15
Jan-16
Jan-17
Jan-18
Jan-19
Jan-20
HOUSEHOLDS
NFCs


Deposits - Ireland
120000
100000
80000
60000
40000
20000
0
Jan-03
Jan-04
Jan-05
Jan-06
Jan-07
Jan-08
Jan-09
Jan-10
Jan-11
Jan-12
Jan-13
Jan-14
Jan-15
Jan-16
Jan-17
Jan-18
Jan-19
Jan-20
HOUSEHOLDS
NFCs


Deposits - Italy
1200000
1000000
800000
600000
400000
200000
0
Jan-03
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Jan-06
Jan-07
Jan-08
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Jan-11
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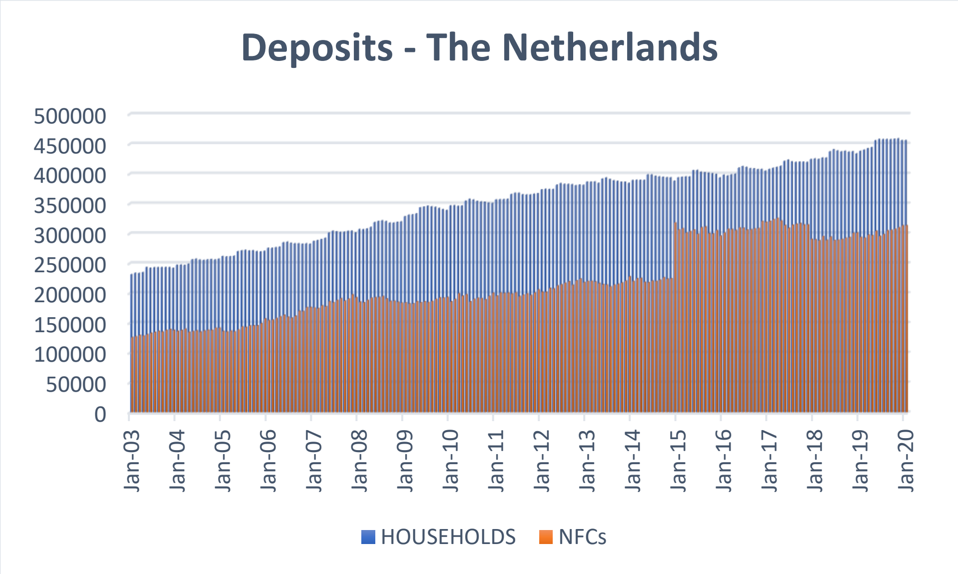
Jan-13
Jan-14
Jan-15
Jan-16
Jan-17
Jan-18
Jan-19
Jan-20
HOUSEHOLDS
NFCs


Deposits - The Netherlands
500000
450000
400000
350000
300000
250000
200000
150000
100000
50000
0
Jan-03
Jan-04
Jan-05
Jan-06
Jan-07
Jan-08
Jan-09
Jan-10
Jan-11
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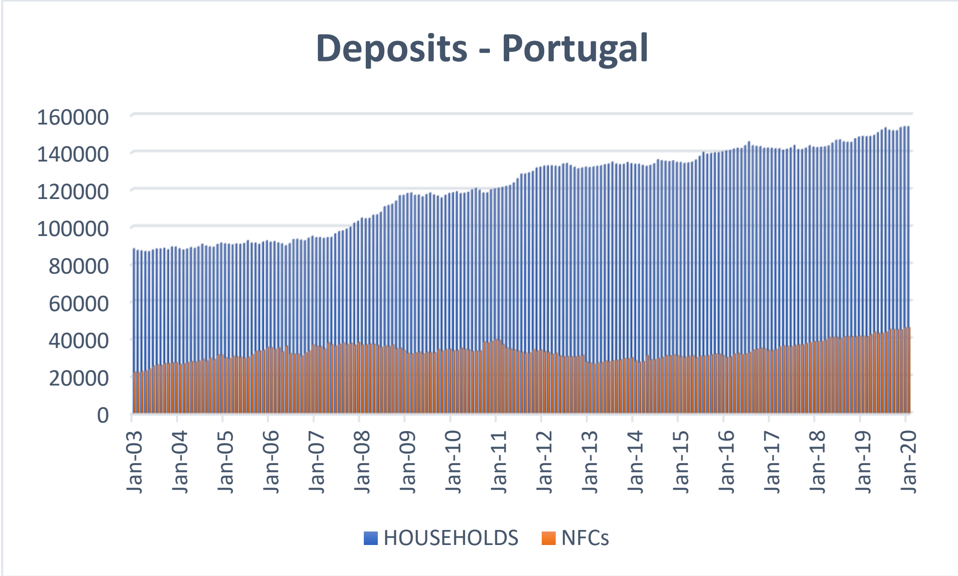
Jan-13
Jan-14
Jan-15
Jan-16
Jan-17
Jan-18
Jan-19
Jan-20
HOUSEHOLDS
NFCs


Deposits - Portugal
160000
140000
120000
100000
80000
60000
40000
20000
0
Jan-03
Jan-04
Jan-05
Jan-06
Jan-07
Jan-08
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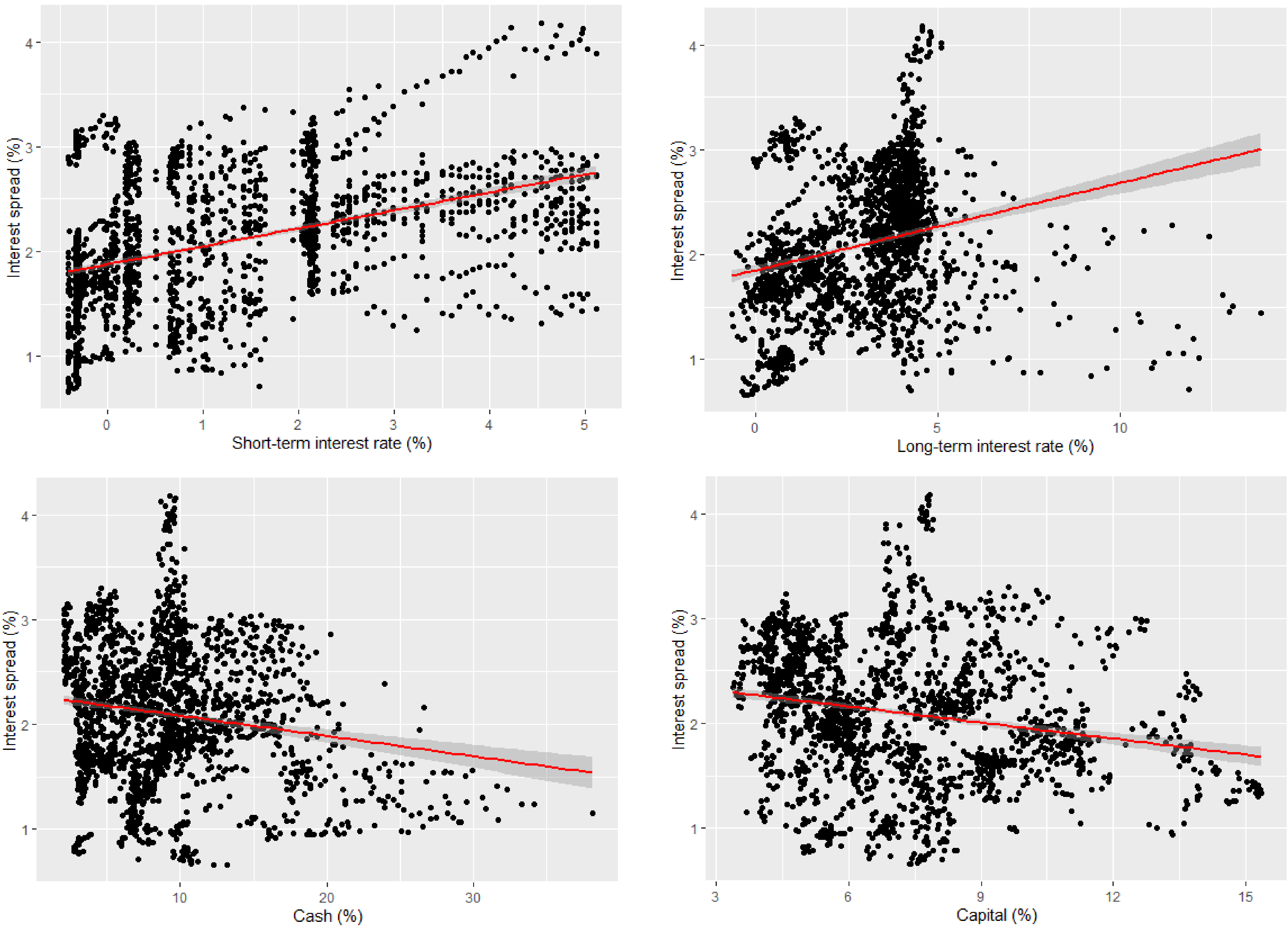
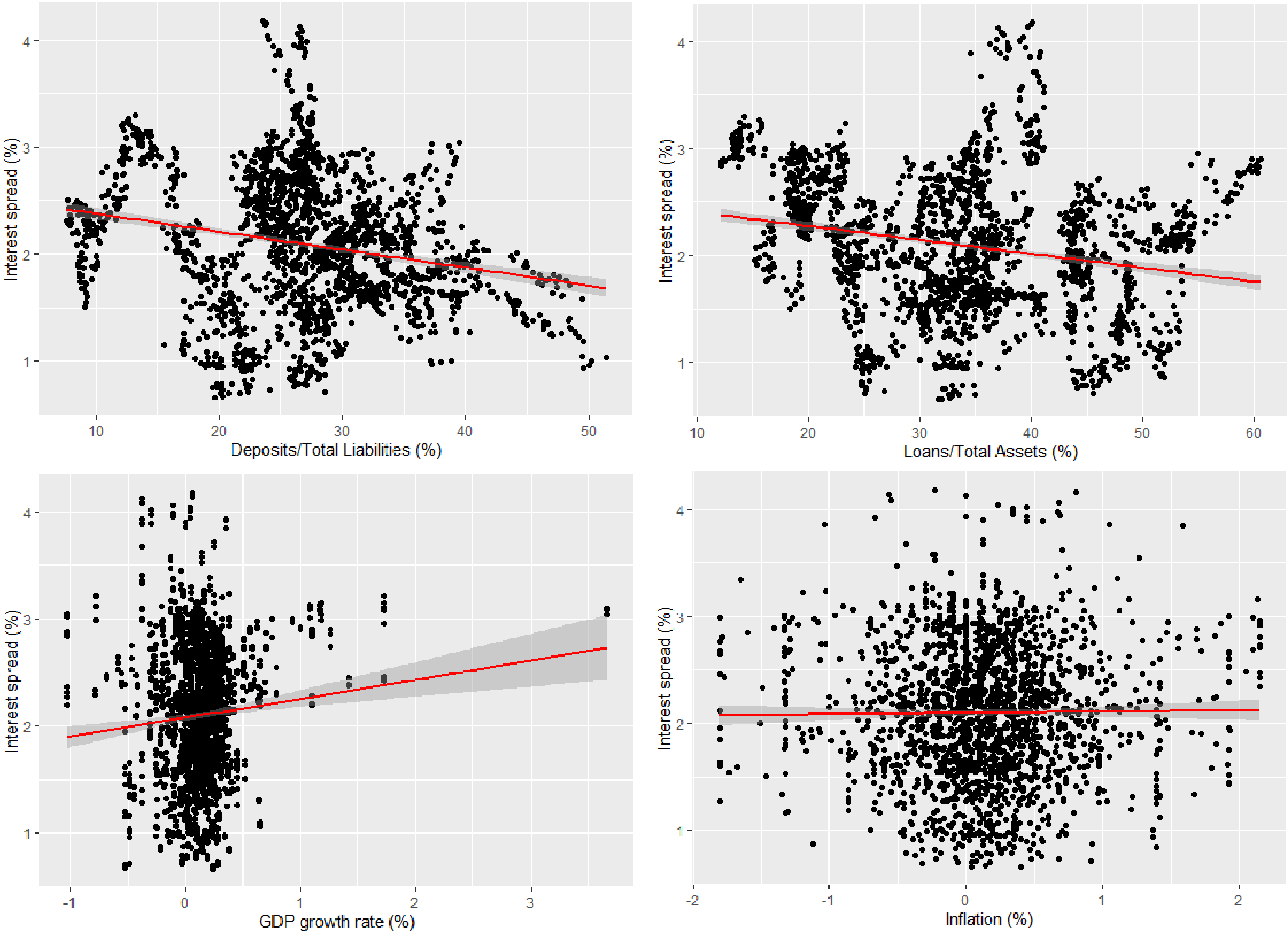
Jan-13
Jan-14
Jan-15
Jan-16
Jan-17
Jan-18
Jan-19
Jan-20
HOUSEHOLDS
NFCs

C. Correlation matrix & scatterplots

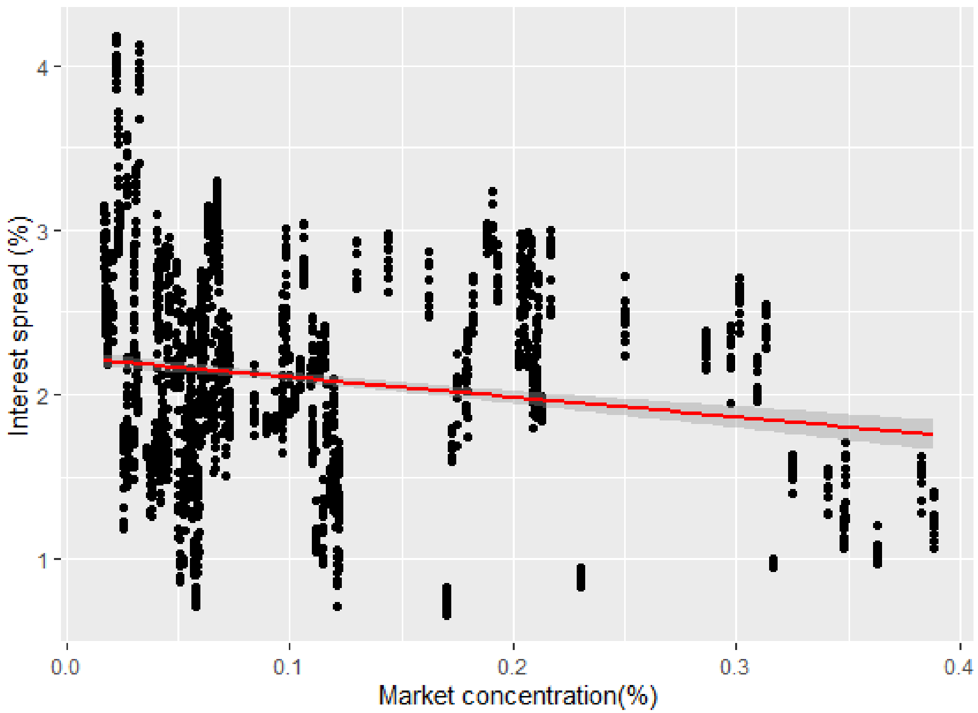
	I_Spread	L_Spread	D_Spread	ShortRate	YC	CASH	DEP	LTA	CAP	GDPGrowth	HICP	HHI	VSTOXX
I_Spread	1												
L_Spread	-0.065	1											
D_Spread	0.479	-0.618	1										
ShortRate	0.429	-0.537	0.793	1									
YC	-0.123	0.386	-0.482	-0.304	1								
CASH	-0.162	0.056	-0.157	-0.180	-0.088	1							
DEP	-0.219	0.029	-0.095	-0.276	-0.038	-0.077	1						
LTA	-0.220	0.0005	0.096	0.079	0.082	-0.151	0.589	1					
CAP	-0.203	0.376	-0.205	-0.358	0.294	-0.243	0.430	0.412	1				
GDPGrowth	0.090	-0.098	0.125	-0.059	-0.153	-0.107	-0.039	-0.105	0.033	1			
HICP	0.011	-0.050	0.059	0.053	-0.007	0.005	0.007	0.013	-0.036	-0.004	1		
HHI	-0.169	-0.020	0.029	0.020	-0.079	0.531	-0.032	0.077	-0.267	-0.005	0.00002	1	
VSTOXX	0.171	0.046	-0.039	0.259	0.091	0.108	-0.191	-0.045	-0.156	-0.290	-0.033	0.028	1



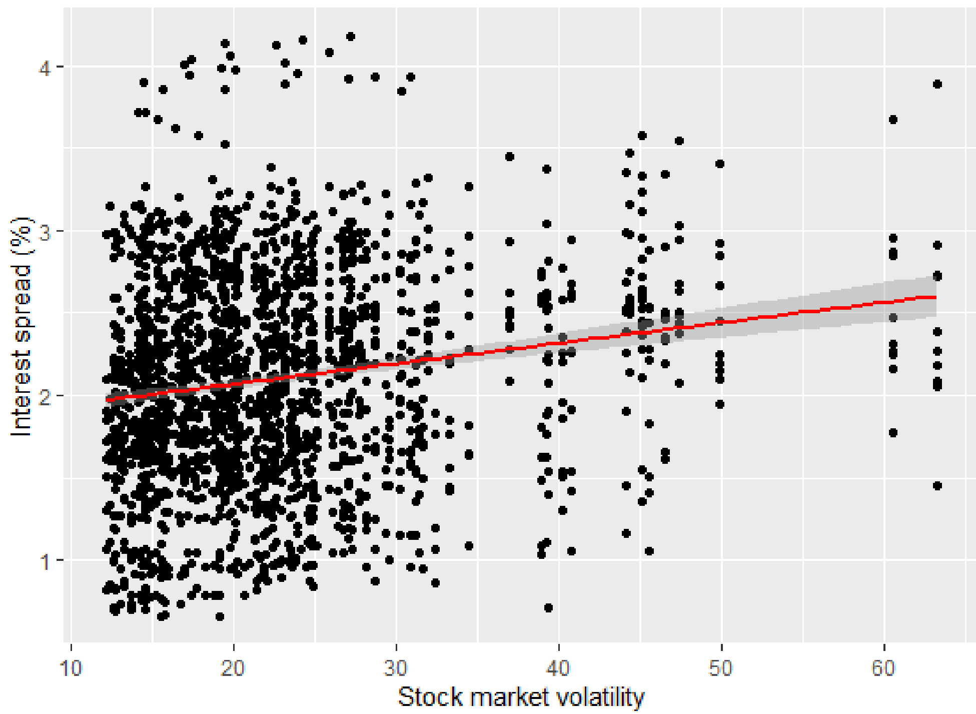
Interest spread (%)
Short-term interest rate (%)
0
1
2
3
4
5
Interest spread (%)
Long-term interest rate (%)
0
5
10
Interest spread (%)
Cash (%)
10
20
30
Interest spread (%)
Capital (%)
3
6
9
12
15
1
2
3
4



Interest spread (%)
Deposits/Total Liabilities (%)
Interest spread (%)
Loans/Total Assets (%)
Interest spread (%)
GDP growth rate (%)
Interest spread (%)
Inflation (%)

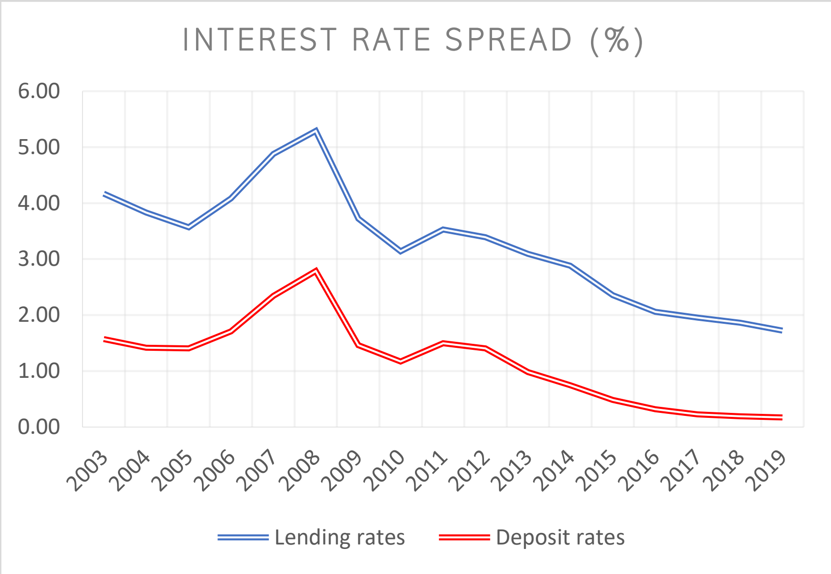


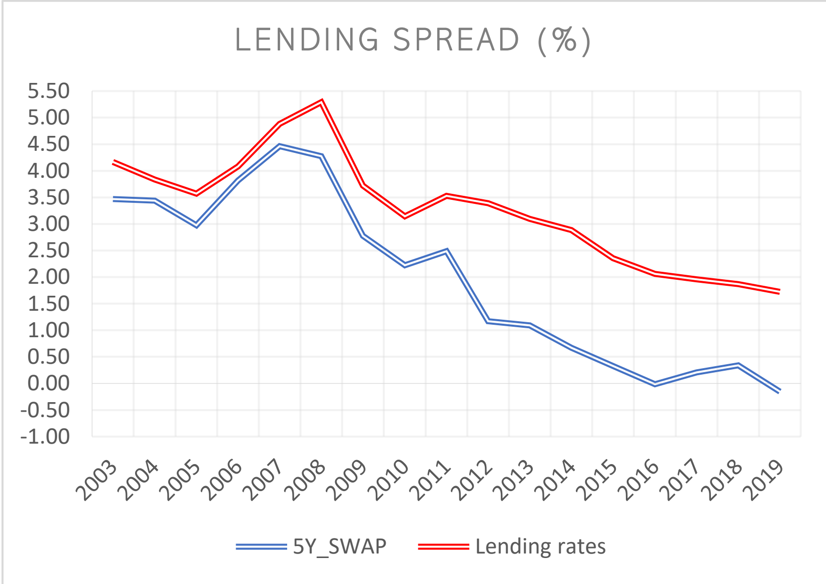
Interest spread (%)
4
3
2
1
0.0
0.1
0.2
0.3
0.4
Market concentration(%)

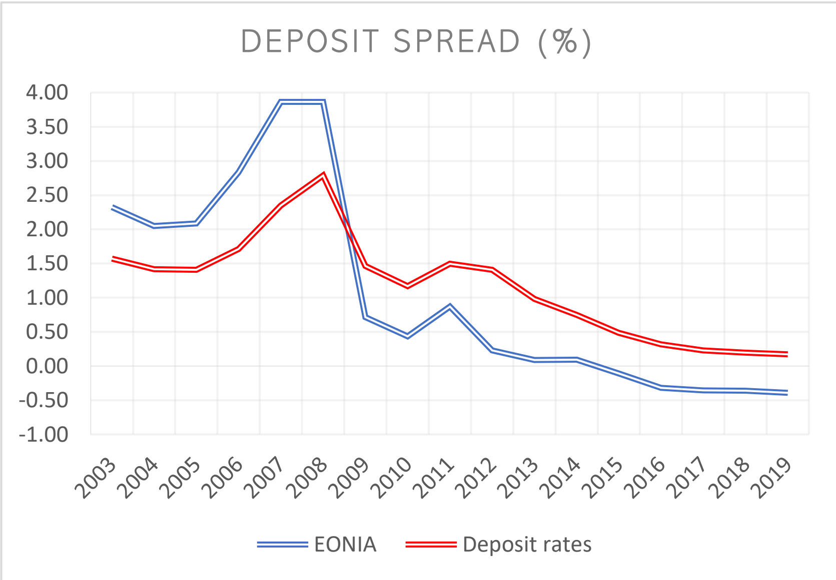


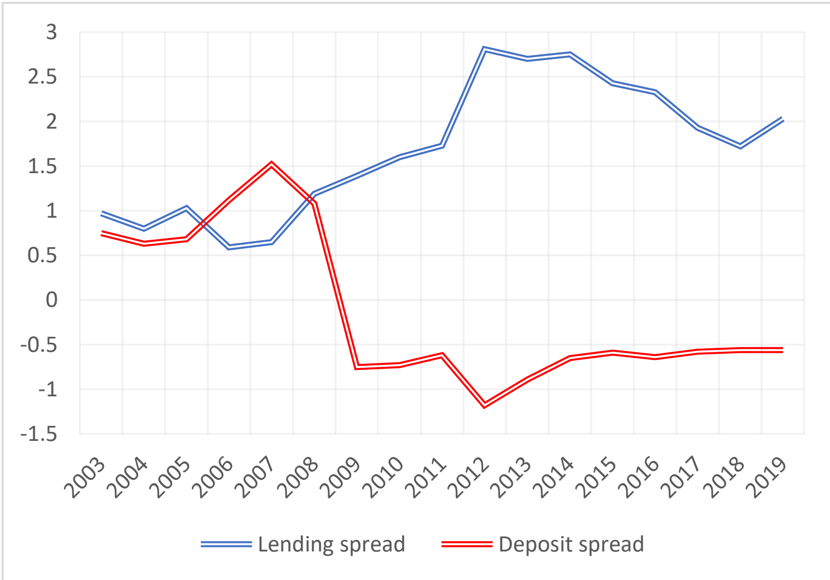
Interest spread (%)
4
3
2
1
10
20
30
40
50
60
Stock market volatility

D. The evolution of the 3 spreads over time









E. Properties pooled OLS regressions

```
	Breusch-Pagan test

data:  Regression1
BP = 344.38, df = 12, p-value < 2.2e-16
```

[9]

```
	Breusch-Pagan test

data:  Regression2
BP = 455.27, df = 12, p-value < 2.2e-16
```

```
	Breusch-Pagan test

data:  Regression3
BP = 305.58, df = 12, p-value < 2.2e-16
```

```
	Durbin-Watson test for serial correlation in panel models

data:  I_Spread ~ ST_RATE + ST_RATE2 + YC + YC2 + Cash_1 + DTL_1 + LTA_1 +     Capital_1 + GDPGrowth + HICP + HHI + MRKTVOL
DW = 0.59013, p-value < 2.2e-16
alternative hypothesis: serial correlation in idiosyncratic errors
```

```
	Durbin-Watson test for serial correlation in panel models

data:  L_Spread ~ ST_RATE + ST_RATE2 + YC + YC2 + Cash_1 + DTL_1 + LTA_1 +     Capital_1 + GDPGrowth + HICP + HHI + MRKTVOL
DW = 0.81489, p-value < 2.2e-16
alternative hypothesis: serial correlation in idiosyncratic errors
```

```
	Durbin-Watson test for serial correlation in panel models

data:  D_Spread ~ ST_RATE + ST_RATE2 + YC + YC2 + Cash_1 + DTL_1 + LTA_1 +     Capital_1 + GDPGrowth + HICP + HHI + MRKTVOL
DW = 0.57656, p-value < 2.2e-16
alternative hypothesis: serial correlation in idiosyncratic errors
```

[9] Critical values: dL = 1,194 and dU = 1.939

```
        Breusch-Godfrey/Wooldridge test for serial correlation in panel models

data:  I_Spread ~ ST_RATE + ST_RATE2 + YC + YC2 + Cash_1 + DTL_1 + LTA_1 +     Capital_1 + GDPGrowth + HICP + HHI + MRKTVOL
chisq = 1695.1, df = 203, p-value < 2.2e-16
alternative hypothesis: serial correlation in idiosyncratic errors
```

```
        Breusch-Godfrey/Wooldridge test for serial correlation in panel models

data:  L_Spread ~ ST_RATE + ST_RATE2 + YC + YC2 + Cash_1 + DTL_1 + LTA_1 +     Capital_1 + GDPGrowth + HICP + HHI + MRKTVOL
chisq = 1445.2, df = 203, p-value < 2.2e-16
alternative hypothesis: serial correlation in idiosyncratic errors
```

```
        Breusch-Godfrey/Wooldridge test for serial correlation in panel models

data:  D_Spread ~ ST_RATE + ST_RATE2 + YC + YC2 + Cash_1 + DTL_1 + LTA_1 +     Capital_1 + GDPGrowth + HICP + HHI + MRKTVOL
chisq = 1699.5, df = 203, p-value < 2.2e-16
alternative hypothesis: serial correlation in idiosyncratic errors
```

F. F-test for individual effects

```
        F test for individual effects

data:  I_Spread ~ ST_RATE + ST_RATE2 + YC + YC2 + CASH + DEP + LTA +  ...
F = 134.67, df1 = 9, df2 = 2018, p-value < 2.2e-16
alternative hypothesis: significant effects


        F test for individual effects

data:  L_Spread ~ ST_RATE + ST_RATE2 + YC + YC2 + CASH + DEP + LTA +  ...
F = 112.31, df1 = 9, df2 = 2018, p-value < 2.2e-16
alternative hypothesis: significant effects

        F test for individual effects

data:  D_Spread ~ ST_RATE + ST_RATE2 + YC + YC2 + CASH + DEP + LTA +  ...
F = 198.01, df1 = 9, df2 = 2018, p-value < 2.2e-16
alternative hypothesis: significant effects
```

G. Empirical results pooled OLS

	Dependent variable: I_Spread							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Short-term rate	0.269***	0.240***	0.256***	0.228***	0.262***	0.268***	0.286***	0.258***
	(0.024)	(0.024)	(0.023)	(0.027)	(0.024)	(0.024)	(0.023)	(0.024)
Short-term rate²	-0.021***	-0.014**	-0.010*	-0.008	-0.015**	-0.018***	-0.024***	-0.017***
	(0.006)	(0.007)	(0.006)	(0.007)	(0.006)	(0.006)	(0.006)	(0.006)
Slope YC	0.133***	0.148***	0.182***	0.176***	0.153***	0.146***	0.123***	0.142***
	(0.022)	(0.022)	(0.021)	(0.024)	(0.022)	(0.022)	(0.022)	(0.022)
Slope YC²	-0.020***	-0.022***	-0.023***	-0.023***	-0.021***	-0.021***	-0.019***	-0.021***
	(0.002)	(0.002)	(0.002)	(0.003)	(0.002)	(0.002)	(0.002)	(0.002)
Cash	-0.011***							
	(0.002)							
DEP		-0.008***						
		(0.002)						
LTA			-0.016***					
			(0.001)					
Capital				-0.018***				
				(0.006)				
GDP Growth					0.198***			
					(0.039)			
HICP						-0.013		
						(0.021)		
HHI							-1.259***	
							(0.137)	
VSTOXX								0.004***
								(0.001)
Constant	1.823***	1.918***	2.160***	1.800***	1.653***	1.697***	1.859***	1.620***
	(0.043)	(0.056)	(0.046)	(0.048)	(0.034)	(0.033)	(0.037)	(0.043)
Observations	2,040	2,040	2,040	2,040	2,040	2,040	2,040	2,040
R2	0.244	0.246	0.305	0.240	0.246	0.237	0.267	0.239
Adjusted R2	0.243	0.244	0.304	0.238	0.244	0.235	0.265	0.237
F Statistic (df = 5; 2034)	131.552***	132.368***	178.701***	128.537***	132.769***	126.167***	148.162***	128.013***

Note: *p<0.1; **p<0.05; ***p<0.01

	Dependent variable:							
	L_Spread							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Short-term rate	-0.695***	-0.754***	-0.694***	-0.580***	-0.689***	-0.694***	-0.698***	-0.750***
	(0.033)	(0.034)	(0.033)	(0.038)	(0.033)	(0.033)	(0.033)	(0.033)
Short-term rate²	0.100***	0.108***	0.099***	0.072***	0.096***	0.099***	0.100***	0.104***
	(0.009)	(0.009)	(0.009)	(0.010)	(0.009)	(0.009)	(0.009)	(0.009)
Slope YC	0.057*	0.060**	0.053*	-0.033	0.049	0.055*	0.059*	0.039
	(0.031)	(0.031)	(0.031)	(0.034)	(0.031)	(0.031)	(0.031)	(0.030)
Slope YC²	0.023***	0.021***	0.023***	0.030***	0.022***	0.023***	0.022***	0.023***
	(0.003)	(0.003)	(0.003)	(0.004)	(0.003)	(0.003)	(0.003)	(0.003)
Cash	0.002							
	(0.003)							
DEP		-0.016***						
		(0.002)						
LTA			0.001					
			(0.002)					
Capital				0.052***				
				(0.008)				
GDP Growth					-0.182***			
					(0.055)			
HICP						-0.039		
						(0.029)		
HHI							0.199	
							(0.196)	
VSTOXX								0.021***
								(0.002)
Constant	1.928***	2.416***	1.918***	1.647***	1.985***	1.950***	1.920***	1.559***
	(0.061)	(0.078)	(0.067)	(0.066)	(0.048)	(0.046)	(0.053)	(0.059)
Observations	2,040	2,040	2,040	2,040	2,040	2,040	2,040	2,040
R2	0.430	0.445	0.430	0.441	0.433	0.430	0.430	0.458
Adjusted R2	0.428	0.444	0.428	0.439	0.431	0.429	0.429	0.457
F Statistic (df = 5; 2034)	306.666***	326.043***	306.712***	320.376***	310.438***	307.238***	306.954***	343.755***
Note:						*p<0.1; **p<0.05; ***p<0.01		

	Dependent variable:							
	D_Spread							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Short-term rate	0.500***	0.544***	0.503***	0.664***	0.487***	0.498***	0.500***	0.563***
	(0.022)	(0.022)	(0.022)	(0.024)	(0.021)	(0.022)	(0.022)	(0.020)
Short-term rate²	-0.019***	-0.024***	-0.019***	-0.056***	-0.011*	-0.017***	-0.017***	-0.023***
	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)
Slope YC	-0.086***	-0.078***	-0.087***	-0.200***	-0.062***	-0.074***	-0.075***	-0.055***
	(0.020)	(0.020)	(0.020)	(0.021)	(0.020)	(0.020)	(0.021)	(0.019)
Slope YC²	-0.011***	-0.011***	-0.011***	-0.002	-0.011***	-0.012***	-0.012***	-0.012***
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Cash	-0.010***							
	(0.002)							
DEP		0.012***						
		(0.001)						
LTA			0.005***					
			(0.001)					
Capital				0.074***				
				(0.005)				
GDP Growth					0.358***			
					(0.036)			
HICP						0.030		
						(0.019)		
HHI							-0.056	
							(0.129)	
VSTOXX								-0.024***
								(0.001)
Constant	-0.373***	-0.853***	-0.655***	-0.920***	-0.570***	-0.496***	-0.486***	-0.039
	(0.040)	(0.051)	(0.044)	(0.042)	(0.031)	(0.031)	(0.035)	(0.037)
Observations	2,040	2,040	2,040	2,040	2,040	2,040	2,040	2,040
R2	0.705	0.713	0.706	0.729	0.716	0.702	0.702	0.748
Adjusted R2	0.704	0.712	0.705	0.728	0.716	0.702	0.701	0.748
F Statistic (df = 5; 2034)	973.114***	1,009.359***	976.455***	1,091.924***	1,026.971***	960.471***	958.948***	1,210.485***
Note:						*p<0.1; **p<0.05; ***p<0.01		

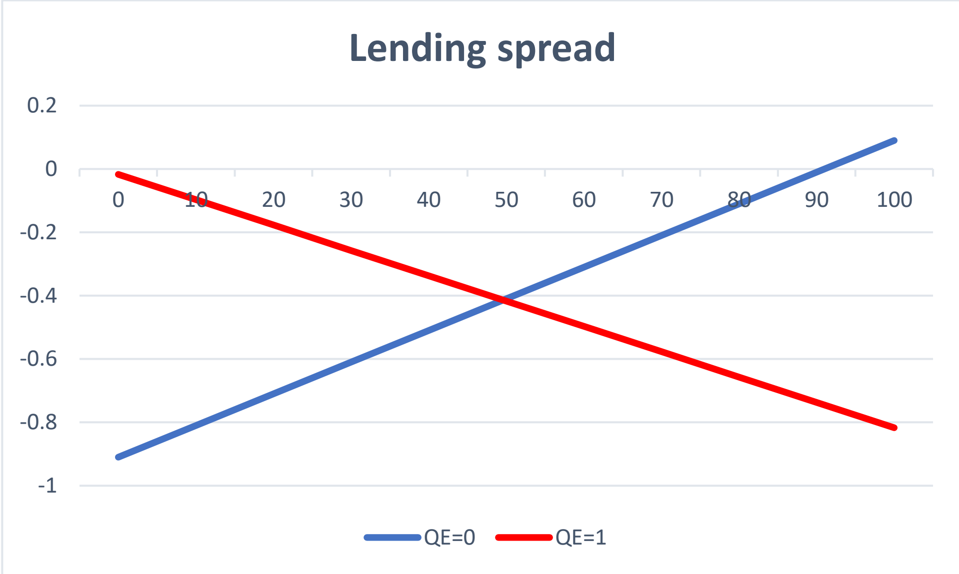
H. Empirical results FE

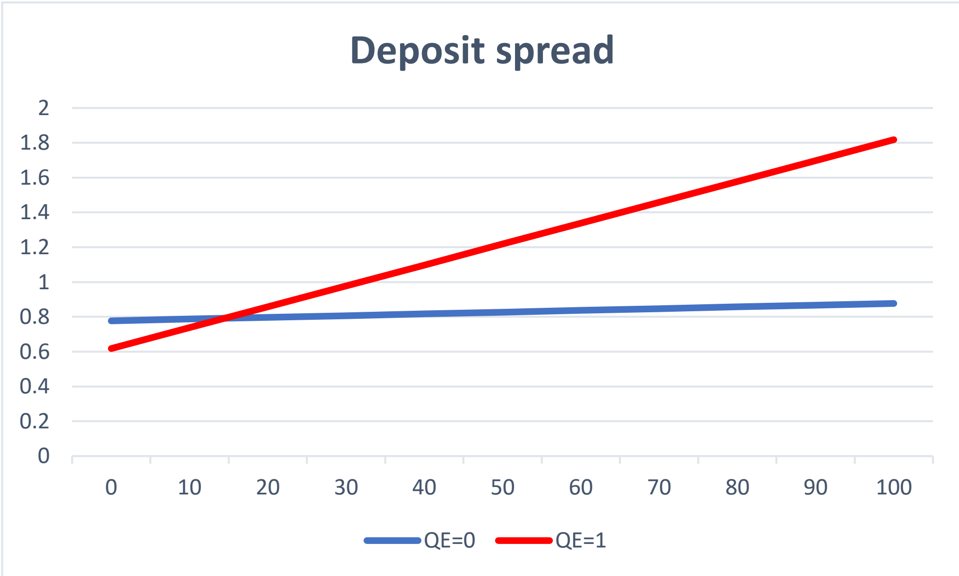
	Dependent variable:								
	I_Spread								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Short-term rate	0.322***	0.342***	0.323***	0.425***	0.316***	0.321***	0.321***	0.311***	0.294***
	(0.019)	(0.020)	(0.019)	(0.021)	(0.019)	(0.019)	(0.019)	(0.019)	(0.021)
Short-term rate^2	-0.037***	-0.040***	-0.038***	-0.058***	-0.036***	-0.038***	-0.038***	-0.037***	-0.029***
	(0.005)	(0.005)	(0.005)	(0.006)	(0.005)	(0.005)	(0.005)	(0.005)	(0.006)
Slope YC	0.042**	0.047**	0.039**	-0.003	0.046**	0.040**	0.039**	0.034*	0.064***
	(0.019)	(0.019)	(0.019)	(0.019)	(0.019)	(0.019)	(0.019)	(0.019)	(0.019)
Slope YC^2	-0.011***	-0.011***	-0.011***	-0.007***	-0.011***	-0.011***	-0.011***	-0.011***	-0.011***
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Cash	0.003								0.004
	(0.003)								(0.003)
DEP		0.007***							0.018***
		(0.003)							(0.004)
LTA			-0.002						0.012***
			(0.003)						(0.005)
Capital				0.065***					-0.075***
				(0.007)					(0.011)
GDP Growth					0.126***				0.162***
					(0.031)				(0.031)
HICP						-0.010			-0.006
						(0.016)			(0.015)
HHI							0.133		1.991***
							(0.353)		(0.593)
VSTOXX								0.005***	0.005***
								(0.001)	(0.001)
Observations	2,040	2,040	2,040	2,040	2,040	2,040	2,040	2,040	2,030
R2	0.339	0.342	0.339	0.367	0.344	0.339	0.339	0.344	0.375
Adjusted R2	0.335	0.337	0.334	0.362	0.340	0.334	0.334	0.340	0.368
F Statistic	207.922*** (df = 5; 2025)	210.045*** (df = 5; 2025)	207.579*** (df = 5; 2025)	234.589*** (df = 5; 2025)	212.560*** (df = 5; 2025)	207.580*** (df = 5; 2025)	207.509*** (df = 5; 2025)	212.572*** (df = 5; 2025)	100.406*** (df = 12; 2008)
Note:									*p<0.1; **p<0.05; ***p<0.01

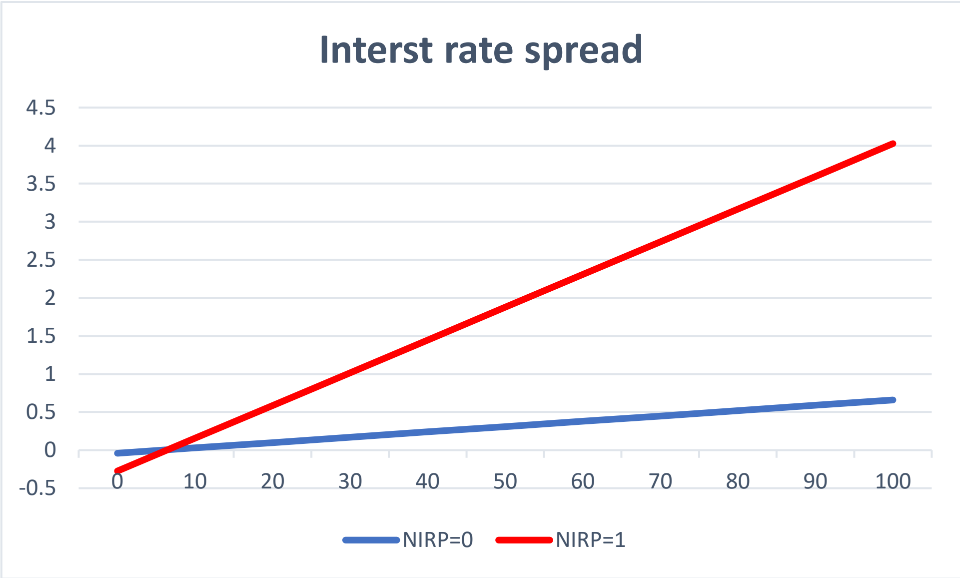
	Dependent variable:							
	L_Spread							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Short-term rate	-0.587***	-0.770***	-0.551***	-0.508***	-0.584***	-0.595***	-0.597***	-0.649***
	(0.030)	(0.031)	(0.030)	(0.036)	(0.031)	(0.031)	(0.031)	(0.030)
Short-term rate²	0.067***	0.080***	0.055***	0.047***	0.058***	0.063***	0.063***	0.066***
	(0.009)	(0.008)	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)	(0.008)
Slope YC	-0.062**	-0.144***	-0.114***	-0.119***	-0.096***	-0.082***	-0.084***	-0.115***
	(0.031)	(0.030)	(0.031)	(0.032)	(0.031)	(0.031)	(0.031)	(0.030)
Slope YC²	0.025***	0.027***	0.027***	0.030***	0.026***	0.026***	0.027***	0.027***
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
Cash	0.030***							
	(0.004)							
DEP		-0.062***						
		(0.004)						
LTA			-0.040***					
			(0.004)					
Capital				0.055***				
				(0.011)				
GDP Growth					-0.291***			
					(0.050)			
HICP						-0.022		
						(0.026)		
HHI							0.504	
							(0.580)	
VSTOXX								0.023***
								(0.002)
Observations	2,040	2,040	2,040	2,040	2,040	2,040	2,040	2,040
R2	0.455	0.503	0.463	0.447	0.450	0.441	0.441	0.485
Adjusted R2	0.451	0.499	0.459	0.443	0.446	0.437	0.437	0.481
F Statistic (df = 5; 2025)	337.517***	409.466***	348.507***	326.939***	330.728***	318.884***	318.901***	381.040***
Note:						*p<0.1; **p<0.05; ***p<0.01		

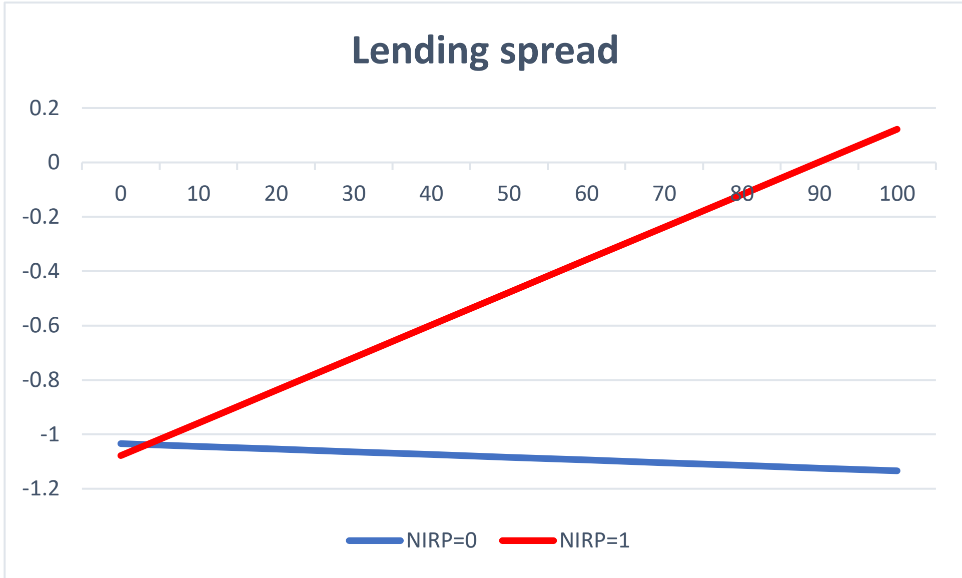
	Dependent variable:							
	D_Spread							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Short-term rate	0.603***	0.752***	0.571***	0.740***	0.598***	0.610***	0.614***	0.663***
	(0.018)	(0.017)	(0.018)	(0.021)	(0.018)	(0.018)	(0.018)	(0.016)
Short-term rate²	-0.062***	-0.072***	-0.051***	-0.082***	-0.052***	-0.058***	-0.058***	-0.061***
	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)
Slope YC	-0.294***	-0.225***	-0.245***	-0.327***	-0.259***	-0.274***	-0.270***	-0.243***
	(0.018)	(0.017)	(0.018)	(0.018)	(0.018)	(0.019)	(0.019)	(0.017)
Slope YC²	0.004**	0.003	0.002	0.009***	0.003*	0.003	0.003	0.002
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Cash	-0.031***							
	(0.002)							
DEP		0.050***						
		(0.002)						
LTA			0.036***					
			(0.003)					
Capital				0.080***				
				(0.007)				
GDP Growth					0.324***			
					(0.029)			
HICP						0.035**		
						(0.015)		
HHI							-1.242***	
							(0.343)	
VSTOXX								-0.023***
								(0.001)
Observations	2,040	2,040	2,040	2,040	2,040	2,040	2,040	2,040
R2	0.810	0.837	0.813	0.809	0.806	0.795	0.796	0.838
Adjusted R2	0.809	0.836	0.812	0.807	0.805	0.794	0.794	0.837
F Statistic (df = 5; 2025)	1,726.032***	2,077.670***	1,765.586***	1,711.467***	1,687.072***	1,571.351***	1,578.988***	2,099.198***
Note:						*p<0.1; **p<0.05; ***p<0.01		

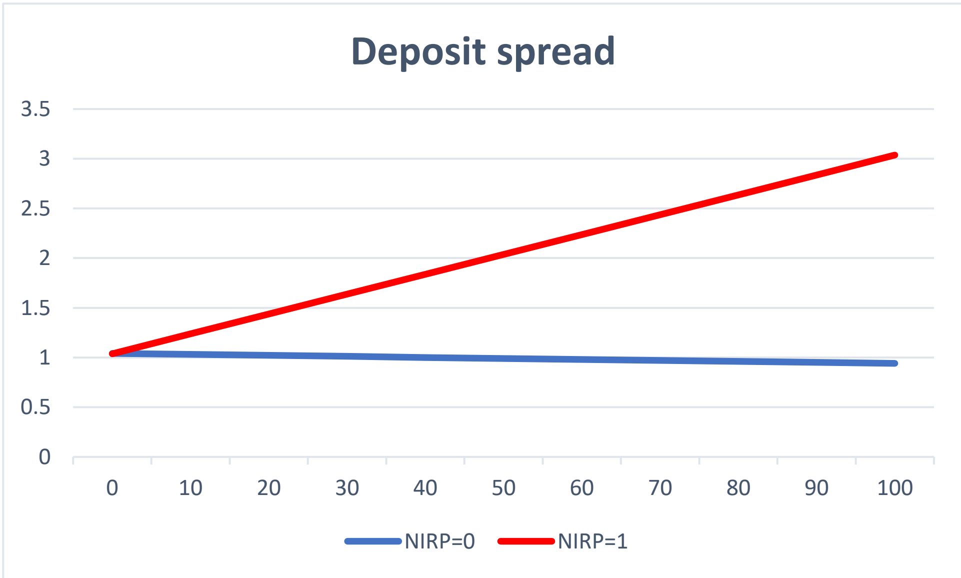
I. Marginal effects liability side: QE + NIRP



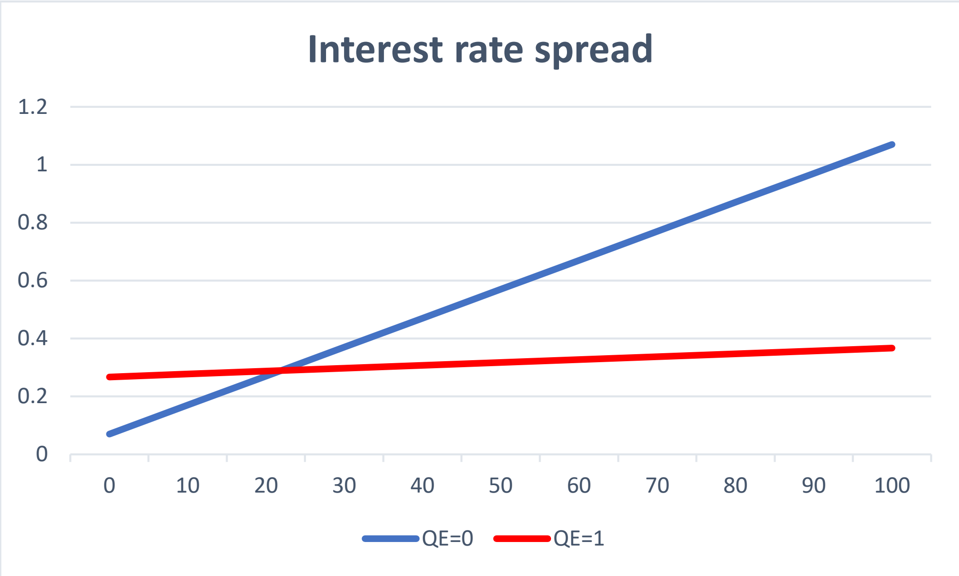


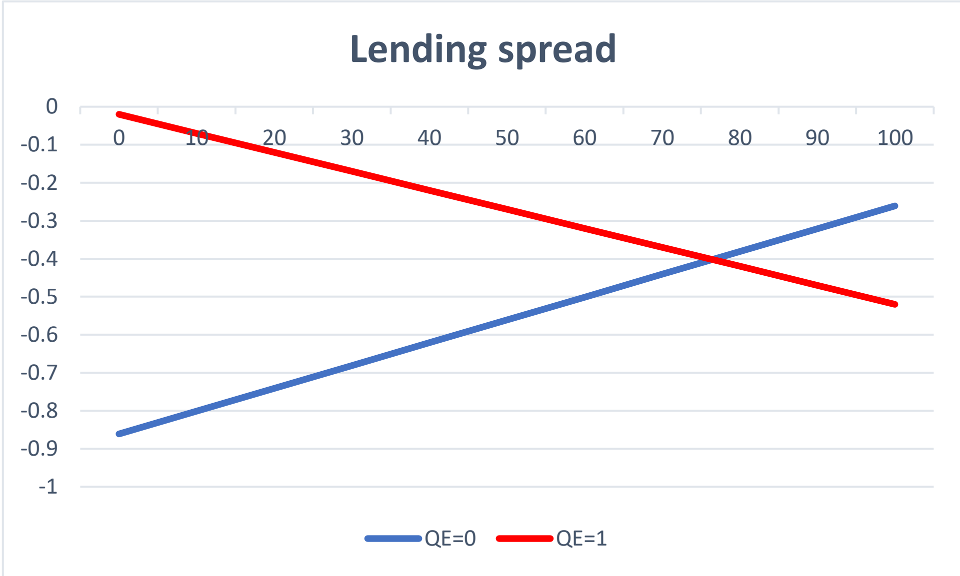

Interst rate spread
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
-0.5
0
10
20
30
40
50
60
70
80
90
100
NIRP=0
NIRP=1

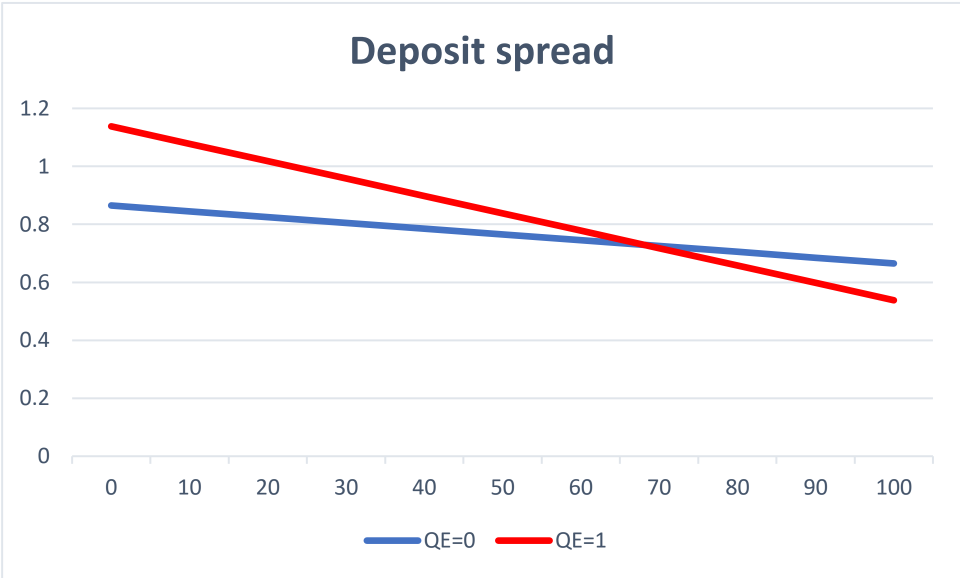

Lending spread
0.2
0
-0.2
-0.4
-0.6
-0.8
-1
-1.2
0
10
20
30
40
50
60
70
80
90
100
NIRP=0
NIRP=1

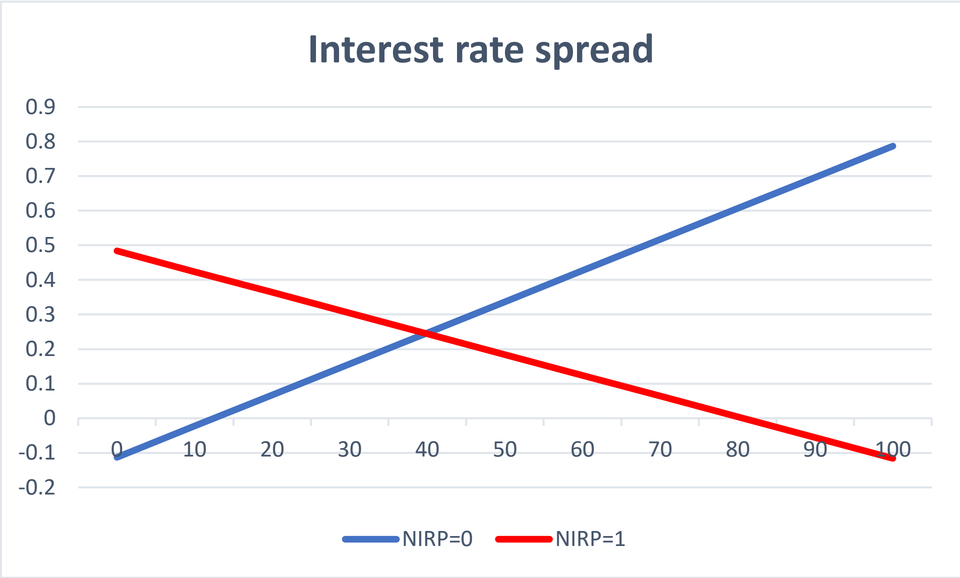

Deposit spread
3.5
3
2.5
2
1.5
1
0.5
0
0
10
20
30
40
50
60
70
80
90
100
NIRP=0
NIRP=1

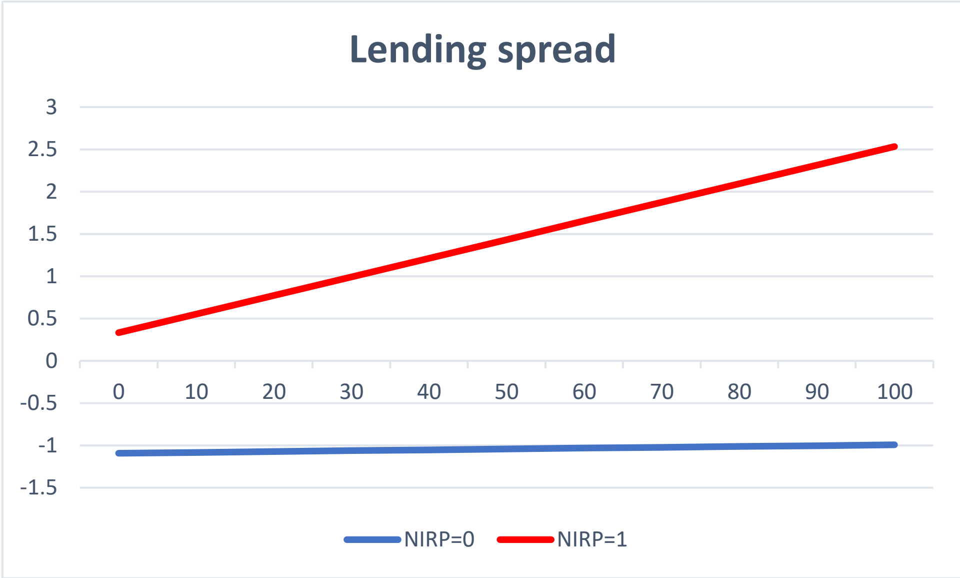
J. Marginal effects asset side: QE + NIRP

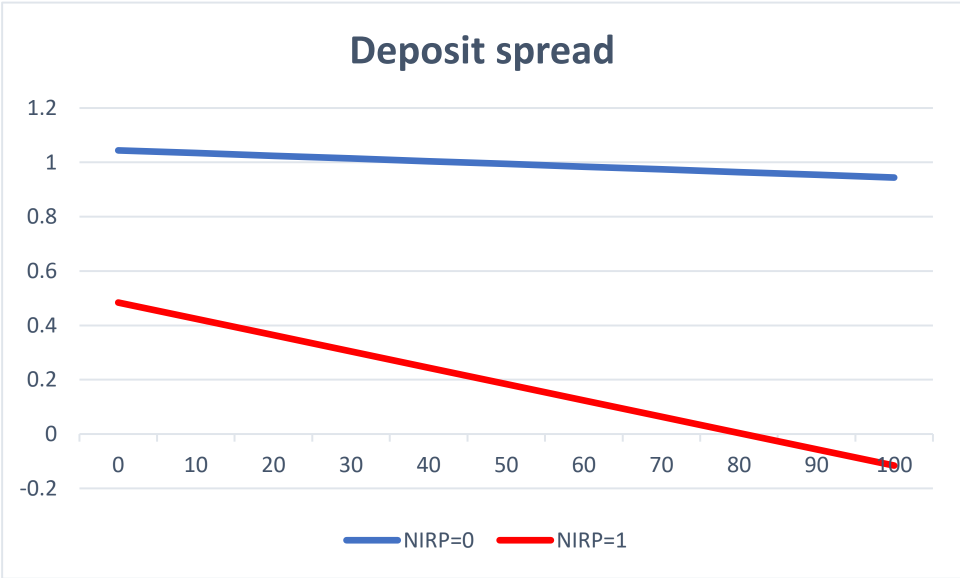







Interest rate spread
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
-0.1
-0.2
0 10 20 30 40 50 60 70 80 90 100
NIRP=0
NIRP=1


Lending spread
3
2.5
2
1.5
1
0.5
0
-0.5
-1
-1.5
0 10 20 30 40 50 60 70 80 90 100
NIRP=0
NIRP=1


Deposit spread
1.2
1
0.8
0.6
0.4
0.2
0
-0.2
0 10 20 30 40 50 60 70 80 90 100
NIRP=0
NIRP=1

The marginal effects are calculated as the derivative of bank spreads with respect to short-term rate for high and low deposit funded banks before and after QE/NIRP.

QE = 0/NIRP=0:

β(shortrate) + β(shortrate*DEP)*DEP

QE = 1/NIRP=1:

β(shortrate) + β(shortrate*DEP)*DEP + β(shortrate*QE)*1 + β(shortrate*QE*DEP)*1*DEP

β(shortrate) + β(shortrate*DEP)*DEP + β(shortrate*NIRP)*1 + β(shortrate*NIRP*DEP)*1*DEP