Life around zero

The Effect of Low Interest Rates on the Performance of Banks

Bachelor thesis Economics and Business Economics
School of Business and Economics
VU University Amsterdam

Student: Hidde Sevinga
Student number: 2622684
Email: hidde.sevinga@student.vu.nl

Supervisor: Prof. dr. W. Boonstra
Second Assessor: dr. M. Mastrogiacomo

Date: August 2, 2020

ACKNOWLEDGEMENT

I would like to express my sincere gratitude to my supervisor Wim Boonstra and his companion Bruno de Cleen for their support. I have learned a lot about banks, monetary policy, and many other topics, sometimes far beyond the scope of my thesis, but always insightful and entertaining. One of my takeaways from them is that you can always learn and develop knowledge on a subject by just taking a point of view, and then start arguing it.

I also want to thank Hugo Erken for allowing me to join his team at RaboResearch. In addition, I want to say special thanks to Erik-Jan van Harn for answering all my questions on the mathematical part of this thesis, and assuring me that there is 'no such thing as a stupid question'. Next, I want to thank Jeroen Kreijkamp, Koen de Man, Maartje Wijffelaars, and Marijn Heijmerikx, all being part of the Rabobank-team, and Ivanca Zwinkels for their much-appreciated contribution to this thesis.

Finally, I would like to thank my special friend, Tamar den Besten, for being my sparring partner and sounding board during the process of researching and writing.

ABSTRACT

Several studies have examined the effect of interest rates on the performance of banks. Yet, previous research has failed to explore the extremely low and even negative interest rates as witnessed in the euro area. Hence, this study investigates the effect of interest rates on banks in the Eurozone in a negative and low interest environment by means of an extensive empirical analysis over the years 2006 to 2019. Employing a panel data analysis, this study suggests that interest rates significantly predict the net interest margins of banks within the Eurozone. Furthermore, this effect is more extensive in a low interest rate environment. Limited evidence is found however, that the net interest margins are substantially more eroded when interest rates turn negative. The relationship between interest rates and the net interest margins can be explained by the fact that the interest income margins fall more substantially than the interest expense margins in response to an interest rate cut. In line with previous research, this paper finds that banks, hitherto, have been able to offset this loss through an increase of non-interest income and lower impairments to keep the banks' profitability unaffected.

Keywords: interest rates, monetary policy, interest rate margins

TABLE OF CONTENTS

1. INTRODUCTION 5
2. THEORY, LITERATURE OVERVIEW AND DERIVED HYPOTHESES 8
2.1 Theory: Explanation of how banks are affected by interest rates 8
2.2 Literature overview 13
2.3 Derived hypotheses for this study 14
3. DATA AND METHODOLOGY 16
3.1 Data Collection 16
3.2 Variables and measurement 19
3.3 The endogeneity problem of monetary policy 21
3.4 Empirical strategy 22
3.5 Performed tests 23
3.5.1 Test for stationarity 24
3.5.2 The Hausman specification test 24
3.5.3 Tests for heteroscedasticity and autocorrelation 26
4. RESULTS & DISCUSSION 27
4.1 Testing hypotheses 27
4.1.1 Testing hypothesis 1: A lower interest rate lowers the NIMs of banks significantly 27
4.1.2 Testing hypothesis 2: A lower interest rate does not lower the ROAs necessarily 28
4.1.3 Testing hypothesis 3: An interest rate cut in a low interest rate environment affects the NIMs more significantly 29
4.1.4 Testing hypothesis 4: A lower interest rate affects the interest income margin more significantly than the interest expense margin 31
4.1.5 Summary of results 32
4.2 Limitations 33
5. CONCLUSION 34
REFERENCES 35
APPENDIX 38
Appendix A. The effect of the interest rate on impairments of financial assets 38
Appendix B. Identification of countries witnessing a negative, low or high interest rate environment 39
Appendix C. Outcomes of performed statistical tests 40
Appendix D. Additional tables 44

1. INTRODUCTION

In the summer of 2015, the interest rate on Dutch government bonds turned negative for the first time in history. As a result, a current-day investor who is lending his money to the Dutch government or to other euro countries has to pay them interest for the privilege of doing so.

The primary reason for the interest rates to be low, or even negative, is the unconventional monetary policy measures taken by the European Central Bank (ECB). First, the ECB set one of its policy rates, i.e. the deposit facility rate (DFR), below zero. This happened for the first time in 2014 when Mario Draghi, former President of the ECB, announced that the DFR was lowered from 0% to -0.1% to support price stability, which is defined as inflation of below, but close to 2% (DNB, 2014; Draghi, 2014). Since the euro area is facing structural downward pressures on inflation, the ECB tries to prevent the economy from diving into an environment of deflation through lower/negative policy rates. Second, alongside the introduction of negative interest rates, the ECB implemented the so-called longer-term refinancing operations (TLROs). The program is set up in a way that banks can borrow money at the ECB against very favourable conditions. The introduction of TLROs explains why interest rates have fallen more extensively in the euro area than anywhere else in the world (Eggertsson, Juelsrud & Wold, 2017). The actual effects of these measurements on the performance of banks and the broader financial system has not been fully resolved in literature given their novelty.

Commercial banks have been reluctant to pass on low and negative policy rates to their depositors (Eggertsson et al., 2017). At the same time, they are often obligated to pass on the lower rates to borrowers due to reciprocal lending contracts (Claessens, Coleman & Donelly, 2018). Besides the fact that not fully passing on the interest rates by banks impedes the monetary policy transmission, it also puts the banks' principal source of income under pressure as lower interest rates result in lower net interest margins (NIMs)[1] (Altavilla et al., 2018; Claessens et al., 2018; Brunnermeier & Koby, 2018; Kayshap & Stein, 2000). Ultimately, this could adversely impact financial stability in the long run as banks are no longer in the position to fulfil their profession as a lending facilitator to the best of their ability (Claessens, et al., 2018). However, there is no clear relationship derived between the interest rates and the profitability of banks (Altavilla, et al. 2018; Claessens, et al. 2018). This is caused by the facts that banks have been able to reduce their operational costs, that their assets have become more valuable in

[1] $Net\ interest\ margins\ = \frac{Net\ interest\ income\ (NII)}{Average\ earning\ assets}\%$

response to the low interest rates (capital gains), and that they have the ability to lower impairments on financial assets.

A few academic papers examine the effect of varying interest rates on NIMs of banks and confirm that lower interest rates exert a negative influence on NIMs (Altavilla et al., 2018; Busch & Memmel, 2015; Claessens, et al., 2018; Genay & Podjasek, 2014). Furthermore, Claessens et al. find that NIMs of banks are substantially more eroded during an interest rate cut in a low interest rate environment than in a high interest rate environment.

Yet, literature which examines the NIMs of banks when interest rates turned negative, finds no significant effect (Jobst & Lin, 2017; Tan, 2019). This could be explained by the theory of Brunnermeier and Koby, who argue that the tipping point to problematic interest rates is not necessarily equal to zero. As suggested by the Swiss National Bank: *"the laws of economics do not change when interest rates turn negative"* (Eggertsson et al., 2017).

This paper seeks to expand the literature alongside three ways. First, it examines a high-quality dataset of banks within the euro area over a long time period of 2006 to 2019. Second, the use of the most recent figures enables this study to obtain the most relevant results and the ability to distinguish for a negative and low interest environment. Third, it improves the models utilized in previous literature through a different proxy for banks' marginal funding and extensive econometric analyses of the explanatory variables, which has been largely underdeveloped in literature.

Accordingly, the main research question is: *"What is the impact of varying interest rates on the performance (NIMs and ROAs) of banks?".* After having established this relationship, the second question follows*: "Is this effect different in a negative or low interest rate environment?"*. Finally, this paper aims to explain the relationship between interest rates and NIMs through the following question*: "Is the effect of varying interest rates on interest income margins larger than on interest expense margins?"*.

Employing a panel data analysis over the period of 2006 to 2019 while controlling for bank-specific characteristics, the output gap, and fixed effects, in order to mitigate the endogeneity problems, validate the following results. First, lower interest rates lower the NIMs of banks significantly. Second, the effect is substantially more pronounced in a low interest environment; however, limited evidence is found that the effect is more substantial when interest rates turn negative. Third, the interest income margins seems to be more sensitive to varying interest rates than interest expense margins, which would explain the positive relationship between the NIMs and interest rates. Yet, this proof is not conclusive and should be examined in more detail by further research. Fourth, the slope of the yield curve (defined as

the 10-year and 2-year interest rate spread) has not impacted the NIMs of banks significantly. Fifth, the interest rates have not affected the profitability (ROAs) of banks significantly as lower NIMs are offset by lower impairments and capital gains (more valuable assets).

Although this paper mainly focusses on the empirical implications of the above-mentioned questions, in order to provide an answer to the research questions, it is fundamental to comprehend how the sources of profitability are affected by interest rates. Therefore, this paper will start by shedding light on this. Next, it provides an overview of contemporary literature, before drawing the hypotheses for this study. The following chapter will explain the methodology utilized and how the data is collected. Subsequently, the results will be presented, and the limitations of this study scrutinized. The remainder of this paper consists of the conclusion and the Appendix.

2. THEORY, LITERATURE OVERVIEW AND DERIVED HYPOTHESES

This chapter discusses the theory behind how banks are impacted by interest rates. Next, this chapter will give an overview of contemporary literature about the effect of interest rates on the NIMs and ROAs of banks. The remainder of this chapter outlines the hypotheses which are derived from the theory and literature overview.

2.1 Theory: Explanation of how banks are affected by interest rates

As short-term interest rates closely follow the policy rates set by a central bank, the policy rate that drives all other interest rates in the euro area is the DFR. (Bernanke & Gertler, 1995; DNB, 2014). The DFR works either directly or indirectly through the result of banks via five channels, which will be described in detail. This section provides background knowledge on the channels through which banks are affected by a lower/negative DFR, and ultimately by lower/negative interest rates.[2] When examining the empirical effect of interest rates on several aspects of the banks' sources of income, it is paramount to understand how banks operate and how these channels work. [3]

The interest rates set by the ECB impacts banks in five different ways:

(i) The excess reserves channel
(ii) The retail deposit channel
(iii) The capital revaluation channel
(iv) The lower impairments channel
(v) The lower funding costs channel

The five channels are explained in more detail below. Figure 1 displays a simplified bank balance sheet to provide some guidance on what is where at the balance sheet of banks, as this is fundamentally different from 'normal' companies. Figure 2 provides a graphical representation of how the interest rates go through the results of banks. These relationships will be delineated in the following section of this chapter.

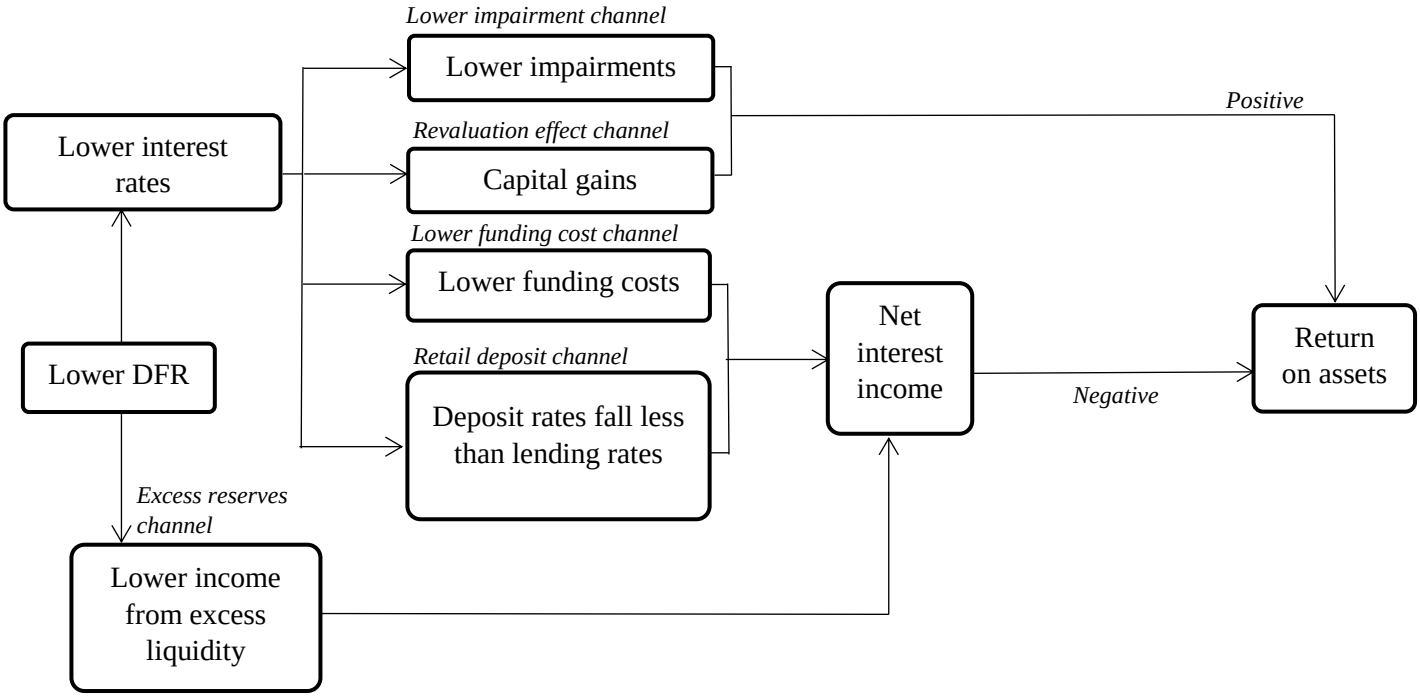
[2] The interest rate is in this paper defined as the 2-year sovereign rate in a country, see for the explanation why section 2.2

[3] Note that although the empirical part of this research primary investigates the effect on NIMs, this section describes the effect on the profitability rather than NIMs.

Figure 1. Simplified bank balance sheet

Assets	**Liabilities**
Liquidity reserves	Sight deposits (non-interest bearing)
Other interest earning assets	Savings deposits
Other assets	Other debt
	Equity
Total assets	**Total liabilities and equity**

Figure 2. Graphical representation on how interest rates go through the banks' results



(i) The excess reserves channel

The negative DFR imposed on the excess liquidity held at the ECB affects the banks' profitability via the NIMs (see Figure 2). A negative DFR constitutes a charge for holding liquidity reserves, which the banks hold at the ECB. Yet, the impact of this channel on profitability is assumed to be limited compared to the other channels (Jobst & Lin, 2016).

Before elaborating further on the other channels, it is essential to understand why and how the ECB uses this channel. Banks are obligated to hold an amount of minimum reserves at the ECB, which is calculated by the required reserves. The reason for this is that it enables banks to make large transfers with other banks as transfers between banks are always settled via the ECB. Note that banks have to meet the minimum reserve requirement not on a daily basis but on average over the maintenance period.[4] The latter enables banks to react to short-term changes in the financial system, which helps to stabilize interbank interest rates (ECB, 2016). The ultimate purpose is to promote financial stability. The other reason for mandatory minimum reserves is that it can be used as a transmission channel to influence the real economy. To clarify, the interest rate that banks impose on their clients are partly based on the DFR, as lower interest rates stimulate loan demand, and therefore investments, the ECB can stimulate the economy via the DFR (DNB, 2014).

Next to the minimum reserves required, banks often choose to exceed this amount, which is referred to as excess reserves. These excess reserves have increased over the past decade. In 2018, this amounted to 17 percent of the Eurozone's GDP (Darvis & Pichler, 2018).[5] There are two primary reasons for the increasing excess liquidity, according to the paper of Darvis and Pichler.[6] First, the financial crisis brought the interbank loan system to a halt. Since banks did not lend money to each other anymore, the banks which otherwise would have been a lender in this market, i.e. provided liquidity, deposited these amounts at their current account at the ECB. Second, the banks' reserves increased because of the Asset Purchase Programmes (APP) of the ECB.[7] The ECB bought bonds and loans from the banks and other investors through this programme which increased the liquidity of banks (Dunne, et al., 2015). Baldo et al. (2017) suggest that it are mainly banks from northern European countries such as Germany and The Netherlands, which have excess reserves at the ECB. The latter is the result of the fact that counterparties of the APP are often situated in these euro-countries, according to Baldo et al. This would suggests that banks from northern European countries are more substantially affected by the DFR than banks from other euro-countries.

[4] The maintenance period is defined to be six weeks in the Eurozone (ECB, 2016).

[5] The ECB has three channels through which banks can deposit their reserves (Darvis & Pichler, 2018):
(i) The current account, i.e. the account at which the minima required reserves are held;
(ii) The regular deposit facility;
(iii) The fixed-term deposit where banks can acquire bonds purchased under the Securities Markets Programme (SMP). The SMP is the acquisition of bonds of several euro-countries by the ECB.

[6] Excess liquidity is referred to as the minimum requirements plus the excess reserves.

[7] The ECB's APP is a bundle of extraordinary monetary policy measures such as long-term refinancing operations to boost inflation within the Eurozone (ECB, 2020).

(ii) The retail deposit channel

The second and most important channel through which lower interest rates impact the banks' performance is through the retail deposit channel. This channel affects the profitability of banks via the NIMs. Note that one of the primary sources of income for banks is the net interest income (NII), which represents to the difference in interest paid to depositors and other capital providers (the liability side of the bank balance sheet) and interest received on outstanding loans and other financial assets, such as excess liquidity held at the ECB (the asset side of the bank balance sheet). The NIMs, therefore, depends on the interest paid and received.

The way this channel adversely impacts bank profitability is rather intuitive. Next to the adverse impact on the interest rate received on the excess reserves, as described in the first channel, a lower DFR decreases the interest rates received on other outstanding loans as banks pass on a lower DFR to customers. To clarify, a lower DFR forces banks to pass on the lower rates to both existing and new loans at the asset side of the banks' balance sheet, as these contracts are often based on contractual repricing (Claessens et al., 2018). In addition, due to the competitive environment, banks are forced to lower their interest rate on loans if the DFR is set lower. However, banks are reluctant to impose their depositors at the liability side of the balance sheet with a lower or even negative interest rate as they are faced by the risk that customers can easily withdraw their deposits and transfer it into cash, due to the zero interest rate of cash (Brunnermeier & Koby, 2018; Claessens et al., 2018; Heider et al., 2019; Jobst & Lin, 2016; Tan, 2019). Eggertsson et al. provide empirical evidence that when interest rates turn negative, these interest rates have been passed on to deposit rates in a limited manner. Thus, deposit rates seem to fall less than the lending rates. As a result, banks see their profits shrink because the margins are smaller.

(iii) The capital revaluation channel

Next to the above mentioned adverse effects, it can be argued that lower interest rates also exert a positive influence on banks' profitability prices (Altavilla et al., 2018; Brunnermeier & Koby, 2018). The capital revaluation channel impacts the banks' profitability directly as these effects are not incorporated in the NIMs but are reported directly in the results (see Figure 2). The capital revaluation materializes after an interest rate cut as lower interest rates mean a lower discount rate for assets and thus higher. Besides, falling interest rates are associated with higher bond prices.

However, this effect depends on whether the assets are part of the banking book or trading book. The banking book exists out of assets related to the core business of the

commercial bank, such as loans (both retail and wholesale), and other financial assets such as deposits and bonds that are part of the investment portfolio (Dermine & Bissada, 2007). Since this portfolio is booked based on book value instead of market value at the balance sheet of a bank, this effect only materializes when banks unwind their positions (Boonstra & De Cleen, 2020).

The impact on the trading book is different. The trading book consists of assets held by banks that are available for sale and hence regularly traded, this is referred to as the treasury portfolio (Dermine & Bissada, 2007).[8] The trading book is based on market value (Boonstra & De Cleen, 2020). Hence, lower interest rates lead to a higher value of the trading book, which is directly recorded in the results. However, this effect is assumed to be temporary as the gains fade away when these assets have matured (Brunnermeier & Koby, 2018).

(iv) The lower impairments channel

The low interest rate environment ensures that banks can lower their impairment on losses from loans (Altavilla et al., 2018; Brunnermeier & Koby, 2018). This effect impacts the profitability of banks directly. Gertler and Karadi (2011) provide evidence that monetary policy interventions can foster the credit position of borrowers. Besides, lower interest rates stimulate loan demand (Beranke & Gertler, 1995). Finally, at the moment of default, the assets which often becomes the ownership of the banks, are more valuable in a low interest rate environment (see the revaluation channel). Hence, as lower interest rates stimulate loan demand, which enhances the prospects of the economy, and due to the more favourable borrowing conditions, banks can lower their impairments on losses from loans. Yet, these effects are strongly related to overall economic improvement and more favourable prospects (Claessens et al., 2018).

(v) The lower funding costs channel

The retail deposit channel explains how deposit rates seem to fall less than lending rates. However, deposits are not the only source of funding banks have. Banks can also obtain funding at the capital market. Lower funding costs impact the banks via the NIMs and have, therefore, an indirect effect on the profitability. In order to understand how this channel works, it is essential to understand how the interest rate paid at the liability side of the balance sheet is established. This interest rate paid on liabilities exists out of the interest rate banks have to pay in the capital market, and the interest rate banks have to pay to their deposits. Two constituents

[8] In most cases, banks are trading to hedge the risks arising from business activities imposed by clients in the form of foreign exchange- and interest rate risks (Boonstra & de Cleen, 2020).

determine the interest banks have to pay in the capital market, i.e. the risk-free-rate and the liquidity premium. The liquidity premium is affiliated to the liquidity available in the market and what the market's perception is on the credit risk of the banks, i.e. the risk associated with the total assets of the bank.

Due to the stickiness on the deposit rate on the liability side, banks choose to obtain funding in the capital market instead, as lower interest rates are more likely to be incorporated in the interest rates they have to pay in the capital market (Jobst & Lin, 2016). The latter would partly offset their losses on these imposed by the deposits. Yet, Jobst and Lin argue that this effect is limited because banks are contingent on the deposits they already have, and the benefit of funding new loans with lower interest rates is dependent on the demand for loans.

2.2 Literature overview

Whether the interest rate set by the ECB influences the banks' profitability and overall performance has been examined in several academic papers. Claessens et al. investigate the effect of low interest rate environments on the profitability of banks via a cross-country and time-series panel analysis while controlling for bank-fixed effects and bank characteristics. The sample of this study consists of 3,385 banks divided over 47 countries during the period of 2005 to 2013. The paper finds that an interest rate cut depresses the NIMs of banks significantly. Moreover, the authors find that this effect is more substantial in a low interest rate environment and that interest income margins are more substantially affected than the interest expense margins. Yet, they find a smaller effect on the profitability, which can be explained by the lower impairments and the revaluation effect, as these effects run in the opposite direction.

In line with this, Altavilla et al. examine the impact of low interest rates in the euro area over the period of 2000 to 2016. The paper concludes that in the long run low interest rates may have a negative impact on banks' profitability via the NIMs. Yet, in line with other papers, they do not find an effect on the profitability of banks when controlling for overall economic conditions.

Moving on to negative interest rates, Tan does not find a significant effect on the impact of NIMs and banks' profitability when investigating the period shortly before and after the introduction of negative DFR, i.e. January 2013 to December 2015. He suggests that the NIMs are not affected since banks increase their lending volume to compensate for the smaller margin. This result is in line with the research of Jobst and Lin. Jobst and Lin argue that banks have been able to compensate lower margins through more lending volumes and cost reductions from higher operational efficiencies.

Moreover, literature provides evidence that the effect of interest rates on NIMs and profitability is dependent on bank characteristics. Genay and Podjasek study the impact of the interest rates and the slope of the yield curve on the performance of banks in the United States over a time period of 2003 to 2013. They find that in the United States, the impact is more significant for smaller banks compared to larger banks. They explain that smaller banks have a lack of ability to manage interest rate risks, repricing their assets, and are more dependent on retail deposits.

Furthermore, previous research suggests that the relationship between interest rates and NIMs is nonlinear (Borio, Gambacorta & Hoffmann, 2017; Claessens et al., 2018). Both papers show that the NIMs are substantially more eroded at the time of an interest rate cut in a low interest rate environment. Hence, it is both paramount and interesting to distinguish the effect in a low and negative interest rate environment.

Finally, the slope of the yield curve is quintessential to examine since banks transform their short-term liabilities into long-term assets. Consequently, a less steep yield curve does adversely impact the NIMs (Claessens et al., 2018). However, English (2002) does not find empirical evidence that the steepness of the yield curve has a significant impact on the NIMs.[9]

2.3 Derived hypotheses for this study

This paper examines the effect of interest rates on all the channels together via the ROAs. Moreover, this paper examines the excess reserves channel, retail deposit channel, and the lower funding costs via the effect of the interest rates on NIMs. The capital revaluations are not examined as this goes beyond the scope of this study. Finally, relationship between interest rates and the impairments is investigated (see Appendix A).

Drawing on the literature described above and the findings discussed in the explanations provided in the previous sections, the following hypothesises can be developed:

$H1$: *A lower interest rate lowers the NIMs of banks*
$H2$: *A lower interest rate does not lower the ROAs necessarily*

Next, the literature suggests that the effect of the interest rates on the NIMs and ROAs of banks is different in different interest rates environments. Hence, the following hypothesis can be developed:

[9] The United States was the only exception in the study, videlicet, he found an effect for banks in this country.

H3: An interest rate cut affects the NIMs more significantly in a low interest rate environment

Besides, it is interesting to distinguish between the effect of interest rates on the interest income margins and interest expense margins to decide whether the reason for the positive relationship between interest rates and the NIMs is that assets and liabilities adjust differently after an interest rate cut. This would confirm the theory about the retail deposit channel and the lack of ability of banks to offset this through lower funding costs.

H4: An interest rate cut affects the interest income margins more signfianclty than interest expense margins

3. DATA AND METHODOLOGY

This chapter describes the data collection process and the methodology used. First, this chapter will discuss how the sample of banks is constructed and what their sources are. Second, this chapter will discuss how the variables are modified and measured. Third, this chapter will shed light on the endogeneity problem of analysing monetary policy in the broader economy. Fourth, the empirical strategy will be delineated. This strategy explains why certain control variables are included and which fixed effects are used. The final section will discuss the tests which are performed and how the outcomes of these tests are utilized in the model.

3.1 Data Collection

In order to investigate the effect of interest rates on NIMs, this study constructs a unique dataset of 100 banks from 10 countries over a time period of 2006 to 2019. Table 1 displays all the variables used in the analysis and their sources. To start, it extracted the bank-specific data from S&P Global, which enables this study to obtain standardized data. Hence, the data is subject to same accounting principles. The objective is to get a group of banks that is representative for the broader euro area. Therefore, this study includes banks that either have a more than €50 billion in assets or are reported in the dataset as *diversified commercial banks.* This way, one will obtain a dataset with banks that have high reporting quality and which represent a sample that indicates how monetary policy impacts the broader European banking system. The data is trimmed through the exclusion of banks which reported to have a higher value of deposits than liabilities or did not report their results in the year 2018. Due to data availability constraints, this study was forced to use annual data instead of quarterly data.

The data concerning the macroeconomic variables, i.e. interest rates and GDP growth, are obtained from Macrobond for the years 2006 to 2019 on an annual basis. The sample consists of the countries which started the euro, i.e. Austria, Belgium, Finland, France, Greece, Ireland, Italy, Luxemburg, Portugal, Spain, and the Netherlands. Yet, due to the lack of available macroeconomic data from Greece and Luxembourg, these countries are excluded from the sample.

Table 2 represents the summary statistics of the variables used in the regression models. The standard deviation of the ROAs is higher than of the NIMs relative to their means. This difference is in line with the expectations as the ROAs include all the banking activities, and are therefore subject to more various factors. The standard deviation of the interest income margins is much higher than the standard deviation of the interest expense margins suggesting

that interest income margins are way more variable than interest expense margins. The variation in the deposit over liabilities ratio confirms the fact that the data consists of both more traditional banks (retail banking) with a higher deposit to liabilities ratios and banks that are more engaged to wholesale banking activities that tend to have a lower deposit to liabilities ratios. The high output gap of over 9 percent represents Ireland in 2018 and 2019. Because of the fact, a number of businesses are only registered in Ireland on paper; there can be quite some volatility in the GDP data due to accounting effects.

Table 1. Definitions

Term	Definition	Data source
Panel A: Variables of interest		
2yr sovereign yield	The annual average of a country's 2yr sovereign bond yield.	Macrobond
Spread: 10yr – 2yr yield	The difference between a country's 10yr sovereign yield and the 2yr sovereign yield in a certain year.	Macrobond and author's calculations
Negative, low and high interest rate environments	A country is classified as a negative interest rate environment if its sovereign yield for that year was below zero. A country is classified as a low interest rate environment if its sovereign yield for that was lower than the median 2-year sovereign rate, which is equal to 1.41 and being in a high interest environment otherwise.	Macrobond
Net interest margin	This ratio is defined as the net interest income expressed as a percentage of average earning assets.	S&P Global
Return on assets	This ratio is defined as the net income expressed as a percentage of average total assets	S&P Global
Interest income margin	This ratio is defined as the interest income expressed as a percentage of average total assets.	S&P Global and author's calculations.
Interest expense margin	This ratio is defined as the interest expense expressed as a percentage of average total liabilities.	S&P Global and author's calculations
Panel B: Macro controls		
Output Gap	This is defined as the GDP growth minus the potential GDP growth (derived through the Hodrick-Prescott filter).	S&P Global and author's calculations

Panel C: Bank-level controls		
Deposits over liabilities	This ratio is defined as the total customer deposits expressed as a percentage of total liabilities.	S&P Global and author's calculations
Equity over assets	This ratio is defined as total equity expressed as a percentage of total assets.	S&P Global
Securities over assets	This ratio is defined as total securities expressed as a percentage of total assets.	S&P Global

Table 2. Summary statistics

Panel A: Summary statistics – observation level – all countries					
Variable	Obs	Mean	Std.Dev.	Min	Max
Bank variables					
Net interest margin	1011	1.649	0.924	0.005	10.147
Return on assets	1015	0.622	0.956	0.005	14.07
Interest income margin	1088	3.299	2.072	0.404	21.623
Interest expense margin	1088	1.649	0.926	0.005	10.147
Deposit over liabilities ratio	1113	55.445	20.159	0.039	98.468
Equity over assets ratio	1113	7.893	5.457	0.078	70.859
Securities over assets ratio	1114	24.474	14.608	0.000	86.916
Country variables					
2yr sovereign yield	1400	1.409	1.831	-0.738	12.269
Spread: 10yr –2yr sovereign yield	1400	1.455	0.736	0.039	2.899
Output Gap	1400	0.953	1.163	-0.542	9.315

Figure 3 represents the development of the interest rates and the spread (slope of the yield curve) over time, based on yearly averages. Figure 4 represents the development of the NIMs and the interest rates over time, based on yearly averages. Figure 4 shows that the development of the interest rates and NIMs seem to go in the same direction. This gives an indication of the existence of a relationship. In contrast, the spread seems to be relatively stable. Therefore, it would not be a surprise if no clear relationship can be derived between the spread and the NIMs. The ROAs, which are represented in Figure 5, seems to fluctuate over time but not in the exact same direction as the interest rates, which would give an indication that there is a weaker relationship between them. Appendix B contains the identification of countries to be in a negative, low, or high interest environment in the years 2006, 2012, and 2018.

Figure 3

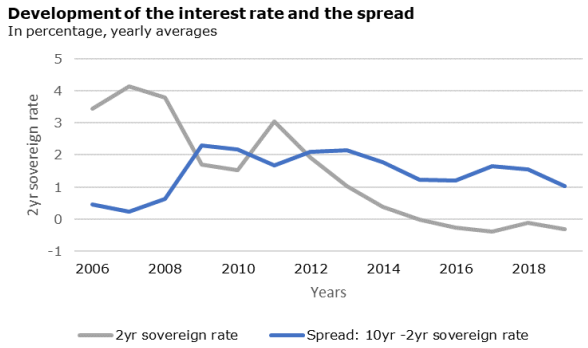


Figure 4

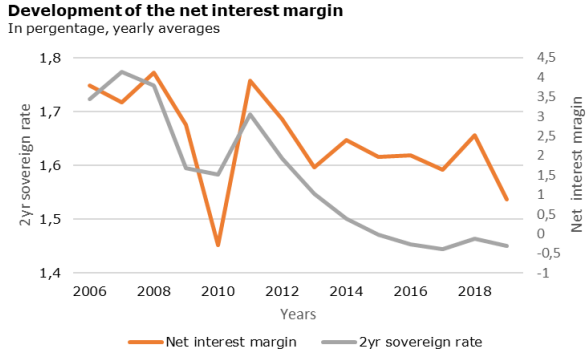
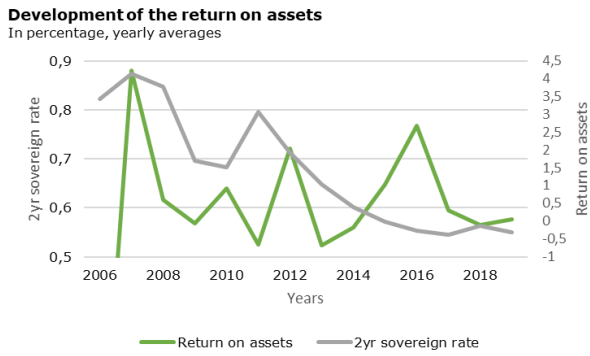


Figure 5



3.2 Variables and measurement

The leading independent variable of this study is the interest rate, which is defined as the 2-year sovereign yield. After consultation with some bankers from Rabobank with considerable experience in this field, this study decided that the 2-year sovereign yield is the best proxy for the marginal cost of funding of banks. An alternative would be to take a proxy for the risk-free rate, such as the Overnight Interest Swap (OIS), as done in the study of Altavilla et al. However, since the OIS is not country specific, one should add a risk premium in order to distinguish for a bank in a particular country. To clarify, if one would consider the OIS as the 'risk-free rate',

the same rate applies for banks in Germany and Italy, which is certainly not true. Hence, the sovereign yield is the preferred proxy, as the risk-free rate does not represent the banks' actual funding rate. Nevertheless, this study acknowledges that this proxy is subject to a certain degree of arbitrariness. The reasons for this are that banks are likely to have a worse rating than countries, and it ignores the difference in the creditworthiness of banks in a country itself.

In contrast to Claessens et al., this study uses the 2-year sovereign yield instead of the 3-month sovereign yield. The reason for this is that banks do not fund their assets with funding with a maturity of three months as most lending consists of loans with a maturity which is significantly longer than three months. Moreover, a substantial part of the banks' funding is retail deposits. Without elaborating further on the specific technical features of the determination of the maturity of retail deposits, the duration can be estimated.[10] A practical study of Konings and Ducuroir (2014) finds that Belgian banks assume a two-year duration on their non-maturing assets and liabilities, i.e. retail saving accounts. Konings and Ducuroir investigate this by using a replicating portfolio approach. The latter means that they compounded a portfolio of fixed income securities to replicate the cash-flows of the non-maturing liabilities that minimizes the variability of the modelled interest margin. The duration of this replicating portfolio is then assumed to be the duration of the non-maturing liabilities. Hence, the 2-year sovereign yield is the better proxy for the banks' marginal funding costs.

In order to clarify the relationship between interest rates and NIMs, the NIMs are decomposed into the interest income margins and the interest expense margins, which are defined respectively as the interest income divided by the earning assets, and the interest expense divided by the interest-bearing liabilities. Yet, after calculating the earning assets and interest-bearing liabilities, this study found detrimental data problems. Hence, it took the total assets and total liabilities as a proxy for respectively the earning assets and interest-bearing liabilities. The latter is justified by the fact that the factor earning assets/total assets and interest-bearing liabilities/total liabilities is relatively stable over time.

The spread, which is calculated as the difference between the 2-year and 10-year sovereign yield, provides a proxy for the slope of the yield curve, in line with the research of Claessens et al.

To avoid the cyclical element in the GDP growth, this study uses the output gap instead. In order to derive the output gap for all countries every year, the Hodrick-Prescott filter is used. The Hodrick-Prescott filter decomposes GDP growth into a trend component, cyclical

[10] The duration is defined as the average maturity of an asset (Dermine & Bissada, 2007).

component, and an error component. Hodrick and Prescott (1997) specify the objective of the model as follows:

$$y_t = min_\tau \left(\sum_{t=1}^{T} C_t^2 + \lambda \sum_{t=2}^{T-1} [(T_{t+1} - T_t) - (T_{t+1} - T_{t-1})]^2 \right)$$

To clarify, the time series value of y_t is decomposed into a trend component T_t and a cyclical component C_t, and λ is the smoothing parameter. [11] The solution is derived by minimizing the objective. This is done by minimizing the difference between the trend component (T_t) and the time series value (y_t) to get the cyclical component (C_t), and minimizing the second derivate of the trend component (T_t) (Hodrick & Prescott, 1997). Subsequently, one will obtain the potential GDP growth for every entity in time. Next, the output gap will be derived through subtracting the potential GDP growth from the actual GDP growth.

3.3 The endogeneity problem of monetary policy

Analysing the effect of monetary policy on the broader economy is associated with endogeneity problems (Bernanke & Getler, 1995; Claessens et al., 2019; Heider et al. 2019; Tan, 2019). The reason for this is that monetary policy, by definition, is endogenous (Bernanke & Getler, 1995). To clarify, central banks usually set lower policy rates when the economy is slowing down or because of other economic conditions such as low inflation. At the same time, deteriorating economic conditions are associated with lower loan demand resulting in lower NIMs (Heider et al., 2019). Besides, when the economy slows down, households are likely to save less resulting in fewer deposits.[12] Therefore, one cannot obtain clear results using a regular regression model as the effect of lower interest rates (monetary policy) is not exogenous.

Tan and Heider et al. attempt to counter this problem via the difference-in-difference method. Both papers used this method based on how much banks lend to households relative to their assets. The idea is that the impact of a negative DFR has a more substantial effect on banks with a higher degree of household deposits. Because it is less complicated for households than for corporations to withdraw their deposits, banks will be more hesitant to pass on lower interest rates to households. The hypothesis of Tan is that if a negative DFR impacts the NIMs of banks, the effect must be significantly larger for banks with more household deposits. Yet, as discussed previously, he does not find a result.

[11] λ is set equal to 100, which is common for annual data.
[12] Note that this effect is arguable as uncertainty could also lead to more savings by households.

Unfortunately, the difference-in-difference method used by Tan and Heider et al., forces the research to examine a short period due to econometric reasons. However, studying a more prolonged period seems to be more appropriate. Claessens et al. point out that banks have a limited ability to compensate for the declining NIMs (for instance, through increasing lending as suggested by Tan) since the range of expanding non-interest income for banks is confined in the long run. Besides, it is unlikely that the effect of the negative DFR was directly incorporated in the deposit rates after the introduction of the negative DFR in 2014. Trying to observe the effect in the exact period in which the interest rate change has been implemented is likely to render an insignificant result.

Therefore, doing this type of research is a trade-off between isolating the effect of interest rates over a short period (which is required by the difference-in-difference method) or obtaining less strong causal effects over a more extended period of time. This study follows the methodology used in the paper of Claessens et al. Nevertheless, this research acknowledges the limitation imposed by the endogeneity of monetary policy. Therefore, one should be reluctant to claim causal effects.

3.4 Empirical strategy

This study seeks to isolate the effect of the interest rates on the NIMs and ROAs of banks. Moreover, it aims to provide an answer on if this relationship is different in a negative and low environment. The empirical strategy of this paper is constructed to enable this.

The NIMs represent the banks' primary source of income, which is assumed to be under pressure due to the low or negative interest rates, and the ROAs represent the banks' profitability. When regressing the ROAs, this study took the first differences. The lagged NIM and ROA are included as a control variable in order to reduce the autocorrelation to which the model is subject (see paragraph 3.5.3). The slope of the yield curve is vital to include since this study assumes that a shallower yield curve leads to lower NIMs. The bank's characteristics are added as implicated by other bank literature (Claessens et al., 2018; Heider et al. 2018; Tan, 2019). Although the endogeneity of monetary policy is difficult to captivate, the output gap controls for overall economic conditions, which is essential to isolate the effect of interest rates.

Additionally, the regression model includes fixed effects to control for economic conditions as well. The bank fixed effects control for bank-specific factors that are not observable and time-invariant. In order to control for country-specific factors, i.e. changes in the macroeconomic environment and loan demand, country fixed effects are included. Without country-time fixed effects, changes in the NIMs or ROAs could be the result of other effects

rather than the interest rates, such as loan demand (Tan, 2019). Tan mentions that one concern regarding the use of country fixed effects is the risk of contagion as the result of cross-border lending activities. To clarify, if a great part of banks' lending activities are cross-border, country fixed effects are not sufficient to control for loan demand. Yet, only 5% of total loans were cross-border, according to the study of Tan. Finally, time-fixed effects are not included. Although time fixed effects control for regulatory changes over time, the inclusion seems to lead to overfitting. Moreover, the bank-specific control variables and the fixed effects on both countries and banks already control for most information which is time-sensitive. Specifically, the most extensive model of this study can be specified as follows:

$$y_{ijt} = \beta_0 + \beta_1 y_{ijt-1} + \beta_2 2Yearrate_{jt} + \beta_3 RateSpread_{jt} + \beta_4 Low_{jt} + \beta_6 2YearrateXLow_{jt} + \beta_7 RateSpreadXLow_{jt} + \beta_{10} OutputGap_{jt} + \beta_{11} X_{it} + \delta_i + \omega_j + \varepsilon_{ijt}$$

Where:

- y_{ijt} is the NIM or ROA of bank *i* in country *j* in year t,
- y_{ijt-1} is the lagged NIM or ROA,
- $2Yearrate_{jt}$ is the rate on the 2-year sovereign yield,
- $RateSpreadXLow_{jt}$ is the spread between the 10-year sovereign yield and 2-year sovereign yield,
- Low_{jt} is a dummy equal to 1 if the country *j* in specific year *t* is in a "low/negative interest rate environment" which is respectively defined as a country where the 2-year yield is either below zero or lower than 1.41,
- $OutputGap_{jt}$ controls for the country's economic conditions,
- X_i level characteristics controls, i.e. deposit over liabilities, total equity capital over total assets, and total securities over total assets,
- δ_i is a bank fixed effect,
- ω_j is a country fixed effect,
- ε_{ijt} is an error term.

3.5 Performed tests

This study performed several tests to make sure that the data is reliable, unbiased, and consistent. These steps are done for every regression performed in this research, which can be

found in Appendix C, but the following section will only focus on the principal regression, i.e. the effect of interest rates on the NIMs of banks.

3.5.1 Test for stationarity

Before performing the regression, the data is tested, whether it is stationary or nonstationary. Stationarity means that the statistical properties of the variables do not change over time (Enders, 2010). Testing on stationarity is necessary because all nonstationary variables can have a specific trend, which could lead to a detrimental co-linearity, i.e. one derives a correlation between two variables that actually do not have a relationship whatsoever. Hence, the results are way less reliable if data is nonstationary. Stata provides several *xunitroot* tests to check whether data is stationary. Since the data of this study is not strongly balanced, i.e. some entities have more data available than others, this research is forced to perform the Fisher-type test. The Fisher-type test is ultimately based on the famous augmented Dickey-Fuller test (a commonly performed test but which cannot be performed on panel data). The tests provide three statistical outcomes. As suggested by Choi (2001), this study took the outcome of the Z statistic to make the decision of whether the data is stationary or not. The outcome of Z statistic outperforms the other considering the trade-off between power and size, and is moreover the most conservative (Choi, 2001). A time-lag of one year is included, as this is common for annual data (Woolridge, 2016).

The tests show that the deposit over liabilities ratios, equity over assets ratios, and securities over assets ratios are nonstationary (see Appendix C). This can be explained by the fact that the ECB has tightened the liquidity and solvency requirements for banks over the past decade. In order to circumvent this problem, this study took the first differences of the variables. In this way the data is considered to be stationary (see Appendix C).

3.5.2 The Hausman specification test

This study performed the Hausman test to decide whether to use fixed or random effects. Both models can be used to circumvent endogeneity problems, i.e. a correlation between the error term and the explanatory variables (Dougherty, 2016). The latter leads to biased results, and are either caused by:

(i) Measurement errors;

(ii) Inverse causality;

(iii) Omitted variables (Dougherty, 2016).

Measurement errors occur when the proxy of an unobservable variable is not fully reflecting what is sought to measure. Inverse causality occurs when the explanatory variables depend on the dependent variable. Omitted variables are the variables that should be in the regression equation but are left out (Dougherty, 2016).

Through the use of fixed effects, which means that there is a dummy included for every bank and country, the dummies account for confounding variables that similarly impact all banks or countries. Therefore, due to the inclusion of bank and country fixed effects, the coefficients in the analysis are identified by the variation in the strength of the interest rates and NIMs across banks and countries. There are two assumptions to make, according to Torres-Reyna. First, it assumes that some unobserved element within the entity impacts the outcome of the dependent variable. Second, it assumes that the disturbance term has a different impact on the dependent variable across the different entities (banks and countries), and are not correlated with each other. This, in contrast to the random effects model, which assumes that the differences across countries and banks do impact the outcome of the dependent variable (Torres-Reyna, 2007).

Hausman (1978) defined the null hypothesis for this decision as follows:

$$H0 = (\hat{\beta}_{RE} - \hat{\beta}_{FE})' \left(\mathrm{Var}\left((\hat{\beta}_{RE}\right) - \mathrm{Var}\left(\hat{\beta}_{FE}\right)\right)^{-1} (\hat{\beta}_{RE} - \hat{\beta}_{FE})$$

$\hat{\beta}_{RE}$ is defined as the estimated value using the random effects model and $\hat{\beta}_{FE}$ is defined as the estimated value using the fixed effects model. As discussed previously, the null hypothesis (no correlation) is:

$$H0: E(u_{it} \intercal X_{it}) = 0$$

Hausman explains that if the correlation is actually equal to zero (under the null hypothesis), both specifications are consistent as they will both provide the same estimated value, however, $\hat{\beta}_{RE}$ is more efficient. Yet, if they differ, the fixed effects model is the only consistent model (Hausman, 1978). The p value of the Hausman test is smaller than the conventional 5% significant level. Hence, the null hypothesis is rejected which means the fixed effects model is more appropriate. The results of this test and for all the other regression models can be found in Appendix C.

3.5.3 Tests for heteroscedasticity and autocorrelation

The data is also tested on the presence of heteroscedasticity through the modified Wald test. Heteroscedasticity means that the standard errors are non-constant, e.g., the variation of the standard errors increases over time (Dougherty, 2016). The latter leads to biased results. The test shows that the model is indeed suffering from heteroscedasticity (see Appendix C). Finally, this study performed a Woolridge test for autocorrelation. Autocorrelation signifies that the unique error terms are not distributed independently. To clarify, a positive value of the disturbance term is followed by a positive value of the next disturbance term, an vice versa (Dougherty, 2016). The latter leads to smaller standard errors and a higher R-squared (Torres-Reyna, 2007). Autocorrelation is a common problem in panel data analysis as the data contains multiple time periods per entity, hence, the assumption that the standard error terms are distributed independently is likely to be violated within entities. Accordingly, the Wooldridge test shows that the model is suffering from autocorrelation (see Appendix C).

To circumvent the above-mentioned problems of autocorrelation and heteroscedasticity, this study included clustered standard errors on bank and country level, as suggested by Dougherty. These clustered standard errors allow heteroscedasticity and any correlation within the specified cluster (Dougherty, 2016). By means of these clustered standard errors, the problems concerning the standard errors are solved. Also, as mentioned previously, the lagged NIM and ROA are included to reduce the impact of autocorrelation on the estimated values of the explanatory variables.

4. RESULTS & DISCUSSION

This chapter will discuss the results derived from testing the hypotheses, which are constructed in this research in section 2.3. Next, it will provide a summary of these findings, and how these findings relate to the results of Claessens et al. The last section of this chapter delineates the limitations of this study.

4.1 Testing hypotheses

4.1.1 Testing hypothesis 1: A lower interest rate lowers the NIMs of banks significantly

Table 3 reports the results from the panel regression that represents the effect of interest rates on the NIMs of banks. Columns 1 to 4 display how the model is built up concerning the fixed effects and control variables; this helps to observe how the effect of the interest rates on the NIMs changes after extending the model. The results in column 4 indicate that interest rates have a significant positive effect on the NIMs of banks at 1 percent confidence. Hence, the null hypothesis of no effect of the interest rates on the NIMs can be rejected, confirming hypothesis 1. More specifically, if the interest rate decreases with one percentage point, the NIMs decreases with 2.5 basis points, ceteris paribus. The two remaining significant variables are the lagged dependent variable and the output gap. The directions are in line with expectations, higher NIMs in the previous year, result in higher NIMs this year. A higher output gap is associated with more demand for loans and higher margins, which result in higher NIMs. Even though the effect of the spread is not significant, the direction of the estimated value is surprising. The negative estimated value suggests that a shallower slope of the yield curve (spread) results in higher NIMs, which is in contrast to what the literature suggests, and in contrast to what one would expect considering the maturity transformation role that banks have. However, Figure 3 displays that the slope of the yield curve has been relatively stable. Furthermore, comparing Figures 3 and 4, one can observe that during the euro crisis (around 2010), the spread was increasing, whereas the NIMs were shrinking. Hence, it seems plausible that there can be no apparent effect derived.

The other explanatory variables are not significant, but most directions are still in line with the expectations. First, higher deposit over liabilities ratios result in lower NIMs. Second, higher equity to assets ratios results in slightly lower NIMs, which is surprising as the literature suggests that banks that are better capitalized tend to have higher NIMs (Claessens et al., 2018).

Third, higher securities to assets ratios are associated with lower NIMs. Banks that have higher securities to assets ratios tend to have lower NIMs because they are less attached to lending. Note that for panel regression analysis, the R-Squared is not informative.

Table 3. The effect of the interest Rate on the NIMs of banks

VARIABLES	(1) NIM	(2) NIM	(3) NIM	(4) NIM
Lagged Dependent Variable			0.909***	0.642***
			(0.023)	(0.096)
2yr Sovereign Yield	0.043**	0.043**	0.005	0.025***
	(0.021)	(0.021)	(0.005)	(0.008)
Spread: 10yr – 2yr Yield			-0.015	-0.009
			(0.014)	(0.019)
Output Gap			0.023***	0.065***
			(0.006)	(0.017)
Deposit Ratio (f.d)[13]			-0.05	-0.009
			(0.008)	(0.010)
Equity Ratio (f.d.)			-0.013*	-0.005
			(0.008)	(0.011)
Securities Ratio (f.d.)			-0.004**	-0.001
			(0.002)	(0.002)
Constant	1.692***	1.604***	0.139**	0.508***
	(0.083)	(0.022)	(0.054)	(0.167)
Observations	1,011	1,011	907	907
R-squared		0.026		0.488
Number of Banks	100	100	100	100
Fixed Effects	NO	YES	NO	YES
Clustered Standard Errors	YES	YES	YES	YES

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

4.1.2 Testing hypothesis 2: A lower interest rate does not lower the ROAs necessarily

Table D1 reports the results from the panel regression that represents the effect of the interest rate on ROAs (see Appendix D).[14] In line with the research of Claessens et al., and due to the variety of reasons discussed previously, it was not expected to find significant results, confirming hypothesis 2.

[13] f.d. means "first differences"
[14] All tables which do not present significant results can be found in Appendix D.

4.1.3 Testing hypothesis 3: An interest rate cut in a low interest rate environment affects the NIMs more significantly

Table 4 reports the results from the panel regression that represents the effect of interest rates on NIMs in a negative and low interest rate environment. Column 1 represents the full sample; column 2 represents the results when identifying the negative interest rate environment as the 2-year sovereign yield being lower than 0 percent, and column 3 represents the results when identifying the low interest rate environment as the 2-year sovereign yield being lower than 1.41 percent.

In the case of the negative interest rate environment (column 2), the results indicate that there is no significant evidence that an interest rate cut in a negative interest environment affects the banks' NIMs differently than in a positive interest rate environment. Hence, the null hypothesis of no significant different effect in a negative interest rate environment cannot be rejected, and hypothesis 3 cannot be confirmed. Nevertheless, the estimated effect is quite large as it suggests that at the time of an interest rate cut of one percentage point, the NIMs decrease with 15.2 basis points, ceteris paribus. The latter is much larger than estimated in a low interest rate environment.

The results of column 3 indicate that an interest rate cut in a low interest environment affects the banks' NIMs differently at 6 percent confidence. Hence, the null hypothesis of no significant different effect in a low interest rate environment can be rejected. Discussing column 3 more specifically, in a low interest rate environment, the NIMs of banks are 17 basis points lower than in a high interest rate environment, ceteris paribus. Moreover, an interest rate cut of one percentage point in a low interest rate environment lowers the NIMs with 7.6 basis points, ceteris paribus.

Comparing the latter to the result of the full sample (2.5 basis points), it can be argued that in a low interest rate environment, the NIMs are substantially more eroded by an interest rate cut, confirming hypothesis 3.

Table 4. The effect of the interest rate on the NIMs in a negative and low interest rate environment

VARIABLES	(1) NIM	(2) NIM	(3) NIM
Lagged Dependent Variable	0.642***	0.646***	0.643***
	(0.096)	(0.095)	(0.096)
2yr Sovereign Yield	0.025***	0.010	-0.002
	(0.008)	(0.010)	(0.012)
Spread	-0.009	-0.043*	-0.064**
	(0.019)	(0.024)	(0.028)
Output Gap	0.065***	0.066***	0.064***
	(0.016)	(0.018)	(0.019)
Deposit Ratio (f.d.)	-0.009	-0.010	-0.009
	(0.010)	(0.010)	(0.010)
Equity Ratio (f.d.)	-0.005	-0.005	-0.005
	(0.011)	(0.011)	(0.011)
Securities Ratio (f.d.)	-0.001	-0.001	-0.001
	(0.002)	(0.002)	(0.002)
Dummy: Sovereign Yield < 0.00		-0.075	
		(0.105)	
2yr Sovereign Yield * Dummy		0.152	
		(0.100)	
Spread * Dummy		0.041	
		(0.053)	
Dummy: Sovereign Yield < 1.42			-0.170**
			(0.080)
2yr Sovereign Yield * Dummy			0.076*
			(0.035)
Spread * Dummy			0.054
			(0.058)
Constant	0.508***	0.600***	0.678***
	(0.167)	(0.147)	(0.162)
Observations	907	907	907
R-squared	0.488	0.495	0.495
Number of Bank	100	100	100
Fixed Effects	YES	YES	YES
Clustered Standard Errors	YES	YES	YES

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table D2 represents the results of the relationship between the ROAs and the interest rates when distinguishing for a negative and low interest environment (see Appendix D). There can be no clear results derived considering the interest rates in a low or negative interest rate

environment, i.e. hypothesis 3 cannot be confirmed at the conventional 5 or 10 percent significance levels regarding the banks' ROAs.

4.1.4 Testing hypothesis 4: A lower interest rate affects the interest income margin more significantly than the interest expense margin

This study decomposes the NIMs into the interest income margin and the interest expense margin. This analysis is paramount because a difference in repricing assets and liabilities can explain the relationship between the interest rates and the NIMs.

Table 5 displays the effect of the interest rates on the interest income margin and the interest expense margin of the full sample, respectively. The results indicate that the interest income margin and interest expense margin are significantly predicted by the interest rate of a country at 1 percent confidence. Moreover, the effect of the interest rates is generally larger for the interest income margin, confirming hypothesis 4. This difference is equal to 3.4 basis points. To clarify, banks pass on lower interest rates to both borrowers and lenders; however, banks are not able to pass on lower interest rates on both sides of the balance sheet equally, explaining the relationship between the NIMs and the interest rates (see Table 3).

Next, one would expect that the difference between the effect of the interest rates on the interest income margin and interest expense margin to be larger in a low interest rate environment as it is known that in a low interest rate environment an interest rate cut has a more significant impact on the NIMs (see Table 4). However, this study cannot confirm the latter as displayed in Table D3 (see Appendix D). There is no significant result obtained from this regression model, and the estimated values seem to contradict that one would expect.

Table 5. The effect of the interest rate on the interest income and interest expense margin of banks

VARIABLES	(1) Interest Income Margin	(2) Interest Expense Margin
Lagged Dependent Variable	0.714***	0.740***
	(0.063)	(0.053)
2yr Sovereign Yield	0.246***	0.212***
	(0.037)	(0.028)
Spread	-0.316***	-0.340***
	(0.085)	(0.083)
Output Gap	0.136***	0.080**
	(0.043)	(0.038)
Deposit Ratio (f.d.)	-0.028	0.017
	(0.017)	(0.015)
Equity Ratio (f.d.)	-0.031	-0.019
	(0.024)	(0.012)
Securities Ratio (f.d.)	0.007	-0.007
	(0.006)	(0.005)
Constant	0.891***	0.579***
	(0.174)	(0.096)
Observations	985	985
R-squared	0.717	0.769
Number Banks	98	98
Fixed Effects	YES	YES
Clustered Standard Errors	YES	YES

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

4.1.5 Summary of results

As this study broadly applies the methodology of Claessens et al., one would expect similar results. Note that this study improves the model of Claessens et al. by taking the 2-year sovereign yield as a proxy for the banks' marginal funding and by controlling for country fixed effects. Besides, it extends the model through examining a longer time period and distinguishing between a negative interest rate environment and a low interest rate environment. In line with Claessens et al., this study finds that the interest rates significantly predict the NIMs of banks and that this effect is larger in a low interest rate environment. This study expected that this effect would be even more extensive in a negative interest rate environment. However, this cannot be confirmed. The result that the effect of interest rates on the interest income margins is larger than on interest expense margins is line with the research of Claessens et al.

Yet, in contrast to Claessens et al., this study cannot confirm that this effect is more abundant in a low interest rate environment.

4.2 Limitations

The first limitation is the endogeneity of monetary policy as monetary policy is considered to be endogenous. This endogenous character of monetary policy makes it rather difficult to examine. Therefore, no causal relationship can be revealed by definition.

Second, some limits appeal to the way this study set up the model. There could be disruptions in the model due to the potential nonlinear relationship between NIMs and the interest rates. This study sought to circumvent this problem through the specification of a negative and low interest rate environment. However, the actual non-linearity may not be captured within this specification.

Third, another caveat could be that some regulatory changes may have had a larger impact on banks than as specified in the model used in this research. This study tried to capture regulatory changes through the inclusion of bank and country fixed effects and control variables, i.e. the bank-specific characteristics, which are firmly related to regulatory changes, such as Basel III. Nevertheless, this study does acknowledge that this is not easy to captivate.

Besides, this study does not include any time-lags between interest rates and the dependent variables, which could have been more appropriate. However, the latter is very difficult to model accurately as these time-lags vary for different type of banks (Claessens et al., 2018).

Finally, there are some data limitations as the selection of banks may be subject to a certain degree of arbitrariness, and because many banks did not report their results in a consistent manner.

5. CONCLUSION

In conclusion, this study examines how interest rates impact the NIMs and profitability of banks within the Eurozone. This research shows that interest rates significantly predict the NIMs of banks. This effect is significantly more pronounced in a low interest rate environment. Yet, limited evidence is found that this effect is also significantly different when interest rates turn negative. The effect of interest rates on NIMs can be explained by the fact that interest income margins tend to be more sensitive to varying interest rates than interest expense margins. This evidence suggests that banks have to reprice their assets more aggressively than their liabilities, resulting in lower NIMs. This research finds no clear relationship between the interest rates and the profitability of banks. This can be explained by the fact that, hitherto, banks have been able to offset lower NIMs through capital revaluation gains and lower impairments. However, the adverse effect of low interest rates on NIMs is permanent. In contrast, the beneficial effects of low interest rates on capital revaluations and impairments, are considered to be non-permanent and dependent on economic conditions. Hence, the adverse impact of interest rates on the profitability is expected to materialize in the future. This would negatively impact the financial system as banks cannot support the real economy to the best of their ability, and it impedes the monetary policy transmission into the bargain. Further research is necessary to dive into the exact implications of low interest rates for banks and to what degree not entirely passing on interest rates to customers impedes the effectiveness of the monetary policy.

REFERENCES

Altavilla, C., Boucinha, M., Peydró, J.-L., and Beck, T. (2018). Monetary policy and bank profitability in a low interest rate environment. *Economic Policy, 33* (96), 531–586. https://doi.org/10.1093/epolic/eiy013

Baldo, L., Hallinger B., Helmus, B., Herrala, N., Martins, D., Mohing, F., Petroulakis, F., Resinek, M., Vergote, O., Usciati, B., and Wang, Y. (2017). *The distribution of excess liquidity in the euro area* (Working papers No 200.). European Central Bank. https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3071551

Bernanke, B.S. and Gertler M. (1995). Inside the black box: the credit channel of monetary policy transmission, *Journal of Economic Perspectives*, 9, 27–48. DOI: 10.1257/jep.9.4.27

Borio, C., Gambacorta, L., & Hofmann, B. (2017). The influence of monetary policy on bank profitability. *International Finance*, *20*(1), 48-63. https://doi.org/10.1111/infi.12104

Brunnermeier, M. K. & Koby, Y. (2018). *The reversal interest rate* (NBER Working Papers No. 25406). National Bureau of Economic Research, Inc. DOI: 10.3386/w25406

Busch, R., and Memmel, C. (2015). *Banks' Net Interest Margin and the Level of Interest Rates* (Research Centre Discussion Papers No. 2015/16). Deutsche Bundesbank. https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2797040

Choi, I. (2001). Unit root tests for panel data. *Journal of international money and Finance*, *20*(2), 249-272. https://doi.org/10.1016/S0261-5606(00)00048-6

Claessens, S., Coleman, N., & Donnelly, M. (2018). "Low-For-Long" interest rates and banks' interest margins and profitability: Cross-country evidence. *Journal of Financial Intermediation*, 35, 1-16. https://doi.org/10.1016/j.jfi.2017.05.004

Darvas, Z., and Pichler, D. (2018). *Excess liquidity and bank lending risks in the euro area* (Working Paper No. 2018/16). Bruegel Policy Contribution. https://www.econstor.eu/handle/10419/208030

De Nederlandsche Bank (2014). *Lage rente.* https://www.dnb.nl/rente-eninflatie/lagerente/index.jsp#:~:text=DNB%20bepaalt%20de%20spaarrente%20niet,op%20dit%20moment%20niet%20negatief.

Dermine J., and Bissada, Y.F. (2007). *Asset and Liability Management: The Banker's Guide to Value Creation and Risk Control.* New York, USA: Financial Times.

Dougherty, C. (2016). *Introduction to Econometrics.* Oxford, UK: Oxford University Press

Draghi, M. (2014, June 5*). Introductory Statement to the Press Conference (with Q&A). Frankfurt, Germany.* https://www.ecb.europa.eu/press/pressconf/2014/html/is140605.en.html

Ducuroir F. & Konings W. (2014). *Replicating portfolio approach to determine the duration of non-maturing liabilities.* (Case study). Reacfin. https://www.reacfin.com/wp-content/uploads/2016/12/140618-Reacfin-White-Paper-Banks-Replicating-Portfolio-Approach-for-N..._0.pdf

Dunne P., Everett M. and Stuart R. (2015). *The Expanded Asset Purchase Programme – What, Why and How of Euro Area QE.* (Quarterly Bulletin 03) Central Bank of Ireland. https://static.rasset.ie/documents/business/cb-qb3-2015.pdf#page=63

Eggertsson, G. B., R. E. Juelsrud, and E. G. Wold (2017). *Are negative nominal interest rates expansionary?* (NBER Working paper 24039). National Bureau of Economic Research, Inc. DOI: 10.3386/w24039

European Central Bank (2020). *Asset Purchase Programme*. https://www.ecb.europa.eu/mopo/implement/omt/html/index.en.html

European Central Bank (2016). *Minimum Reserve Requirements.* https://www.ecb.europa.eu/explainers/tell-me/html/minimum_reserve_req.en.html#:~:text=Euro%20area%20banks%20are%20required,at%20their%20national%20central%20bank.&text=This%20helps%20to%20stabilise%20the,other%20for%20short%2Dterm%20funds.

Enders, Walter (2010). *Applied Econometric Time Series*. New York, USA: Wiley. pp. 53–57.

English, W. B. (2002). *Interest rate risk and bank net interest margins.* (BIS Quarterly Review, 67-82). Bank for International Settlements. https://www.bis.org/publ/qtrpdf/r_qt0212g.pdf

Genay, H, and Podjasek, R.., 2014. *What is the impact of a low interest rate environment on bank profitability*? (Chicago Fed Letter, 324).

https://www.questia.com/library/journal/1P3-3328271831/what-is-the-impact-of-a-low-interest-rate-environment

Gertler, M. and P. Karadi (2011). A model of unconventional monetary policy. *Journal of Monetary Economics*, 58, 17–34. https://doi.org/10.1016/j.jmoneco.2010.10.004

Hausman, J. A. (1978). Specification Tests in Econometrics. *Econometrica*, *46* (6), 1251-1271.

Heider, F., Saidi, F., & Schepens, G. (2019). Life below zero: Bank lending under negative policy rates. *The Review of Financial Studies*, *32*(10), 3728-3761. https://doi.org/10.1093/rfs/hhz016

Hodrick, R. J., and Prescott E.C., (1997). Postwar U.S. Business Cycles: An Empirical Investigation. *Journal of Money, Credit, and Banking*, *29(1),* 1–16. DOI: 10.2307/2953682

Jobst, A. and Lin, H. H. (2016). *Negative interest rate policy (NIRP); Implications for monetary transmission and bank profitability in the euro area.* (IMF Working Papers No. 16/172) International Monetary Fund. https://www.imf.org/external/pubs/ft/wp/2016/wp16172.pdf

Kashyap, A.K., and Stein J.C, 2000. What Do a Million Observations on Banks Say about the Transmission of Monetary Policy? *American Economic Review*, *90,* 407-428. DOI: 10.1257/aer.90.3.407

Tan, G. (2019). *Beyond the zero lower bound: negative policy rates and bank lending.* (DNB Working paper) De Nederlandsche Bank. https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3467618

Torres-Reyna O. (2007). *Panel Data Analysis Fixed and Random Effects using Stata [8-17]*. https://www.princeton.edu/~otorres/Panel101.pdf.

Wooldridge, J. M. (2012). *Introductory econometrics: A modern approach*. Mason, USA: Nelson Education.

APPENDIX

Appendix A. The effect of the interest rate on impairments of financial assets

Table 9 represents the results from the panel regression that represents the 'effect' of interest rates on the amount of impairments on financial assets of banks. This relationship is relevant since literature suggests that banks are able to offset the lower NIMs through lower impairments and, via this, are able to keep their profitability at their level. Yet, this is not a sustainable feature as it is highly dependent on favourable economic prospects and overall economic improvement. As the economy is slowing down as a result of the Covid-19 pandemic in 2020, the impairments are likely to rise again. Based on the above-mentioned reason, one can draw the following hypothesis:

$H0$: *A lower interest rate results in signficantly lower impairments on financial assets*.

The result of column 4 suggests that one can reject the null hypothesis, that there is no significant effect of interest rates on impairments on financial assets, at 0.01 confidence. The latter indicates that there is a relationship between a lower interest rates and the amount of impairments on financial assets of banks. The explanation of why this is the case are described in section 2.1. However, given the complexity of impairments, further research needs to show precisely how this relationship works. After all, the state of the economy seems to have a more substantial influence.

Table A1. The relationship between interest rates and the impairments on financial assets of banks

VARIABLES	(1) Impairments (f.d.)	(2) Impairments (f.d.)	(3) Impairments (f.d.)	(4) Impairments (f.d.)
2yr Sovereign Yield	0.143***	0.143***	0.128***	0.128***
	(0.019)	(0.019)	(0.018)	(0.018)
Spread: 10yr – 2yr Sovereign Yield			-0.149***	-0.149***
			(0.047)	(0.047)
Output Gap			-0.069***	-0.069***
			(0.023)	(0.023)
Deposit Ratio (f.d.)			-1.344	-1.344
			(0.956)	(0.956)
Equity Ratio (f.d.)			0.024	0.024
			(0.026)	(0.026)
Securities Ratio (f.d.)			0.003	0.003
			(0.005)	(0.005)
Constant	-0.122***	-0.122***	0.215**	0.215**
	(0.022)	(0.022)	(0.097)	(0.097)
Observations	1,000	1,000	998	998
Number of Banks	99	99	99	99
Random Effects	NO	YES	NO	YES
Clustered Standard Errors	YES	YES	YES	YES

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Appendix B. Identification of countries witnessing a negative, low or high interest rate environment

Figure B1. Negative, low and high interest rate environment over 2006, 2012, 2018

2006

Negative	Low	High
		Austria Belgium Finland France Germany Ireland Italy Portugal Spain the Netherlands
0	0	10

2012

Negative	Low	High
	Austria Belgium Finland France Germany The Netherlands	Ireland Italy Portugal Spain
0	6	4

2018

Negative	Low	High
Austria Belgium Finland France Germany Ireland Portugal Spain The Netherlands	Italy	
9	1	0

Appendix C. Outcomes of performed statistical tests

Table C1. Fisher test for stationarity based on augmented Dickey-Fuller Test (level)

Nominal Fisher Level	**Z-statistic**	**p-value**	**Lag length**	**Decision**
NIM	-3.5491	0.0002	1	Stationary
Interest income margin	-3.1185	0.0009	1	Stationary
Interest expense margin	-7.1590	0.0000	1	Stationary
2yr sovereign rate	-6.8801	0.0000	1	Stationary
Spread	-18.3208	0.0000	1	Stationary
Deposit-ratio	0.6455	0.0000	1	Nonstationary
Equity-ratio	0.4601	0.6773	1	Nonstationary
Securities-ratio	-1.1347	0.1282	1	Nonstationary

Table C2. Fisher test for stationarity based on augmented Dickey-Fuller Test (1st difference)

Nominal Fisher 1st difference	Z-statistic	p-value	Lag length	Decision
ROA	-.213767	0.0000	1	Stationary
Impairments on financial assets (log)	-17.6426	0.0000	1	Stationary
Deposit-ratio	-17.1641	0.0000	1	Stationary
Equity-ratio	-12.4222	0.0000	1	Stationary
Securities-ratio	-5.0140	0.0000	1	Stationary

Hausman test for choosing Fixed Effect Model or Random Effect Model

- Dependent variable: NIM
  Test: Ho: difference in coefficients not systematic (Random Effect more appropriate)
  chi2(7) = (b-B)'[(V_b-V_B)^(-1)](b-B) = 312.37
  Prob>chi2 = 0.0000
  (V_b-V_B is not positive definite)

P value of Hausman test is smaller than the conventional 5% significant level. Hence, the null hypothesis is rejected which means the Fixed Effect Model is more appropriate.

- Dependent variable: ROA
  Test: Ho: difference in coefficients not systematic (Random Effect more appropriate)
  chi2(7) = (b-B)'[(V_b-V_B)^(-1)](b-B) = 2697.13
  Prob>chi2 = 0.0000
  (V_b-V_B is not positive definite)

P value of Hausman test is smaller than the conventional 5% significant level. Hence, the null hypothesis is rejected which means the Fixed Effect Model is more appropriate.

- Dependent variable: interest income margin (based on total assets)
  Test: Ho: difference in coefficients not systematic (Random Effect more appropriate)
  chi2(7) = (b-B)'[(V_b-V_B)^(-1)](b-B) = 17.90
  Prob>chi2 = 0.0065
  (V_b-V_B is not positive definite)

P value of Hausman test is smaller than the conventional 5% significant level. Hence, the null hypothesis is rejected which means the Fixed Effect Model is more appropriate.

- Dependent variable: interest expense margin (based on total liabilities)
  Test: Ho: difference in coefficients not systematic (Random Effect more appropriate)
  chi2(7) = (b-B)'[(V_b-V_B)^(-1)](b-B) = 13.16
  Prob>chi2 = 0.0405
  (V_b-V_B is not positive definite)

P value of Hausman test is smaller than the conventional 5% significant level. Hence, the null hypothesis is rejected which means the Fixed Effect Model is more appropriate.

- Dependent variable: impairments on financial assets
  Test: Ho: difference in coefficients not systematic (Random Effect more appropriate)
  chi2(7) = (b-B)'[(V_b-V_B)^(-1)](b-B) = 4.75
  Prob>chi2 = 0.5764

(V_b-V_B is not positive definite)
P value of Hausman test is larger than the conventional 5% significant level. Hence, the null hypothesis is not rejected which means the Random Effect Model is more appropriate.

Modified Wald test for heteroscedasticity

- Dependent variable: NIM
  H0: sigma(i)^2 = sigma^2 for all i
  Chi2 (101) = 2.1e+05
  Prob>chi2 = 0.0000

P value of modified Wald test is smaller than the conventional 5% significant level. Hence, the null hypothesis is rejected which means there has been a problem of heteroscedasticity.

- Dependent variable: ROA
  H0: sigma(i)^2 = sigma^2 for all i
  Chi2 (101) = 1.6e+07
  Prob>chi2 = 0.0000

P value of modified Wald test is smaller than the conventional 5% significant level. Hence, the null hypothesis is rejected which means there has been a problem of heteroscedasticity.

- Dependent variable: interest income margin
  H0: sigma(i)^2 = sigma^2 for all i
  Chi2 (101) = 2.2e+35
  Prob>chi2 = 0.0000

P value of modified Wald test is smaller than the conventional 5% significant level. Hence, the null hypothesis is rejected which means there has been a problem of heteroscedasticity.

- Dependent variable: interest expense margin
  H0: sigma(i)^2 = sigma^2 for all i
  Chi2 (101) = 9.9e+06
  Prob>chi2 = 0.0000

P value of modified Wald test is smaller than the conventional 5% significant level. Hence, the null hypothesis is rejected which means there has been a problem of heteroscedasticity.

- Dependent variable: interest income margin (based on total assets)
  H0: sigma(i)^2 = sigma^2 for all i
  Chi2 (101) = 1.4e+06
  Prob>chi2 = 0.0000

P value of modified Wald test is smaller than the conventional 5% significant level. Hence, the null hypothesis is rejected which means there has been a problem of heteroscedasticity.

- Dependent variable: interest expense margin (based on total liabilities)
  H0: sigma(i)^2 = sigma^2 for all i
  Chi2 (101) = 4.7e+06
  Prob>chi2 = 0.0000

P value of modified Wald test is smaller than the conventional 5% significant level. Hence, the null hypothesis is rejected which means there has been a problem of heteroscedasticity.

- Dependent variable: impairments on financial assets
  H0: sigma(i)^2 = sigma^2 for all i

Chi2 (101) = 71181.41
Prob>chi2 = 0.0000

P value of modified Wald test is smaller than the conventional 5% significant level. Hence, the null hypothesis is rejected which means there has been a problem of heteroscedasticity.

Woolridge test for autocorrelation

- Dependent variable: NIM
  H0: no first order autocorrelation
  F(1,100) = 28.137
  Prob > F = 0.0000

P value of Hausman test is smaller than the conventional 5% significant level. Hence, the null hypothesis is rejected which means there has been a problem of autocorrelation.

- Dependent variable: ROA
  H0: no first order autocorrelation
  F(1,100) = 5.365
  Prob > F = 0.0226

P value of Wooldridge test is smaller than the conventional 5% significant level. Hence, the null hypothesis is rejected which means there has been a problem of autocorrelation.

- Dependent variable: interest income margin (based on total assets)
  H0: no first order autocorrelation
  F(1,100) = 52.339
  Prob > F = 0.0000

P value of Wooldridge test is smaller than the conventional 5% significant level. Hence, the null hypothesis is rejected which means there has been a problem of autocorrelation.

- Dependent variable: interest expense margin (based on total liabilities)
  H0: no first order autocorrelation
  F(1,100) = 12.578
  Prob > F = 0.0006

P value of Wooldridge test is smaller than the conventional 5% significant level. Hence, the null hypothesis is rejected which means there has been a problem of autocorrelation.

- Dependent variable: impairments on financial assets
  H0: no first order autocorrelation
  F(1,100) = 2.857
  Prob > F = 0.0941

P value of Wooldridge test is larger than the conventional 5% significant level. Hence, the null hypothesis is cannot be rejected which means there has been no problem of autocorrelation.

Appendix D. Additional tables

Table D1. The Effect of the Interest Rate on ROAs of Banks

VARIABLES	(1) ROA	(2) ROA	(3) ROA	(4) ROA
Lagged Dependent Variable (f.d.)			-0.480***	-0.493***
			(0.052)	(0.046)
2yr Sovereign Yield Rate	-0.013	-0.011	-0.013	-0.048
	(0.027)	(0.033)	(0.032)	(0.049)
Spread			-0.111	-0.104
			(0.079)	(0.068)
Output Gap			-0.052**	-0.127
			(0.024)	(0.078)
Deposit Ratio (f.d.)			-0.039**	-0.039**
			(0.018)	(0.018)
Equity Ratio (f.d.)			0.006	-0.013
			(0.029)	(0.032)
Securities Ratio (f.d.)			-0.015***	-0.016***
			(0.005)	(0.005)
Constant	-0.013	-0.015	0.239**	0.343***
	(0.018)	(0.023)	(0.103)	(0.110)
Observations	914	914	811	811
R-squared		0.000		0.480
Number of Banks	100	100	100	100
Fixed Effects	NO	YES	NO	YES
Clustered Standard Errors	YES	YES	YES	YES

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table D2. The effect of the interest rate on ROAs in a negative, low and high interest rate environment

VARIABLES	(1) ROA	(2) ROA	(3) ROA
Lagged Dependent Variable (f.d.)	-0.493***	-0.493***	-0.493***
	(0.046)	(0.047)	(0.046)
2yr Sovereign Yield	-0.048	-0.044	-0.048
	(0.049)	(0.048)	(0.049)
Spread	-0.104	-0.078	-0.104
	(0.068)	(0.128)	(0.068)
Output Gap	-0.127	-0.120	-0.127
	(0.078)	(0.075)	(0.078)
Deposit Ratio (f.d.)	-0.039**	-0.039**	-0.039**
	(0.018)	(0.018)	(0.018)
Equity Ratio (f.d.)	-0.013	-0.012	-0.013
	(0.032)	(0.032)	(0.032)
Securities Ratio (f.d.)	-0.016***	-0.016***	-0.016***
	(0.005)	(0.005)	(0.005)
Dummy: Sovereign Yield < 0.00		0.326	
		(0.312)	
2yr Sovereign Yield * Dummy		0.485	
		(0.299)	
Spread * Dummy		-0.092	
		(0.164)	
Dummy: Sovereign Yield < 1.41			1.257
			(0.723)
2yr Sovereign Yield * Dummy			0.054
			(0.097)
Spread * Dummy			-0.491
			(0.327)
Constant	0.343***	0.279	0.343***
	(0.110)	(0.200)	(0.617)
Observations	811	811	811
R-squared	0.480	0.484	0.486
Number of Banks	100	100	100
Fixed Effects	YES	YES	YES
Clustered Standard Errors	YES	YES	YES

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table D3. The effect of the interest rate on the interest income margins and interest expense margins of banks in a low interest rate environment

VARIABLES	(1) Interest Income Margin	(2) Interest Expense Margin
Lagged dependent variable	0.675***	0.707***
	(0.076)	(0.066)
2yr sovereign yield	0.119***	0.122***
	(0.036)	(0.029)
Spread	-0.621***	-0.588***
	(0.106)	(0.094)
Output Gap	0.108***	0.048**
	(0.029)	(0.023)
Deposit Ratio (f.d.)	0.028*	0.017
	(0.016)	(0.014)
Equity Ratio (f.d.)	0.033	0.020
	(0.024)	(0.012)
Security Ratio (f.d.)	0.009	0.009*
	(0.006)	(0.005)
Dummy: Sovereign Yield < 1.41	-1.521***	-1.304***
	(0.303)	(0.262)
2yr Sovereign Yield * Dummy	0.064	-0.037
	(0.151)	(0.104)
Spread * Dummy	0.656***	0.617***
	(0.118)	(0.101)
Constant	2.011***	1.403***
	(0.432)	(0.262)
Observations	985	985
R-squared	0.732	0.769
Number of Banks	98	98
Fixed Effects	YES	YES
Clustered Standard Errors	YES	YES

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1