THE EFFECT OF NEGATIVE INTEREST RATE POLICY'S IMPLEMENTATION ON BANKS' PROFITABILITY

Jyväskylä University
School of Business and Economics

Master's Thesis

2024

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Subject: Business Administration
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ABSTRACT

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Title
The effect of negative interest rate policy's implementation on banks' profitability

Subject	Type of work
Business Administration	Master's Thesis
Date	Number of pages
17/06/2024	50

Abstract

Negative interest rate policy (NIRP) denotes the practice adopted by central banks wherein deposit rates, representing the interest rates at which banks hold their reserves in the central bank, are set below zero. Originating as an unconventional monetary policy response to the aftermath of the global financial crisis in 2009, NIRP aimed to incentivize banks to lend out their reserves, thereby stimulating economic activity. However, banks refrained from setting their own deposit rates below zero, apprehensive of potential deposit withdrawals by customers. As loan rates were reduced, banks experienced a diminution in interest income, which is a significant component of their overall profitability. This thesis explores the effects of NIRP and short-term interest rates during the era of negative policy rates on profitability of banks. Leveraging a panel dataset spanning 1467 banks across the eurozone, Denmark, Japan, Sweden, and Switzerland from 2010 to 2022, and employing a static modelling framework, the analysis reveals nuanced effects. Implementation of NIRP is found to decrease return on average equity, while concurrently increasing share of impaired loans among the sampled banks. In addition, short-term interest rates are associated with lowered return on average equity. Interpreting these findings suggests that as intended by central banks, negative policy rates incentivized banks to increase their lending activities. This increase in lending led to higher share of impaired loans, subsequently reducing profit, equity, and assets of the banks. The reduction in equity was particularly pronounced, leading to a significant decline in ROAE. While it has been argued that loan rates decreased more than deposit rates during the era of negative policy rates, it seems that the reduction in loan rates was not significantly greater than that of deposit rates to substantially impact the banks' interest income. Instead, the observed decrease in profitability can be attributed to the consequences of increased lending.

Key words
Negative interest rates, monetary policy, bank profitability

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TIIVISTELMÄ

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Petra Pohjanrinne

Työn nimi
Negatiivisen korkopolitiikan käyttöönoton vaikutus pankkien kannattavuuteen

Oppiaine	Työn laji
Kauppatieteet	Pro gradu -tutkielma
Päivämäärä	Sivumäärä
17.6.2024	50

Tiivistelmä

Negatiivinen korkopolitiikka viittaa keskuspankkien käytäntöön, jossa viitekorot asetetaan alle nollan. Käytännöllä pyrittiin kiihdyttämään talouskasvua vuoden 2009 finanssikriisin jälkeen rohkaisemalla pankkeja lainaaman keskuspankeissa pitämiään varojaan asiakkaille. Negatiivisen korkopolitiikan käyttöönotosta huolimatta pankit eivät asettaneet omia talletuskorkojaan alle nollan, koska pelättiin, että asiakkaat nostaisivat talletuksensa pois pankeista. Lainakorkojen lasku ja lisääntyneet korkokulut johtivat pankkien korkotuottojen vähenemiseen. Tässä pro gradu -tutkielmassa tarkastellaan negatiivisen korkopolitiikan käyttöönoton ja lyhyiden korkojen vaikutusta pankkien kannattavuuteen. Hyödyntäen laajaa paneelidataa, joka kattaa 1467 pankkia euroalueella, Tanskassa, Japanissa, Ruotsissa ja Sveitsissä vuosilta 2010–2022, ja laskemalla vaikutukset staattisella regressiomallilla, analyysi paljastaa moniulotteisia vaikutuksia. Negatiivisen korkopolitiikan käyttöönoton havaitaan laskevan oman pääoman tuottoa, samalla kun se kasvattaa järjestämättömien lainojen osuutta tutkittujen pankkien keskuudessa. Myös lyhyet korot negatiivisten viitekorkojen aikana laskevat oman pääoman tuottoa. Täten voidaan tulkita, että keskuspankkien suunnitelmien mukaisesti negatiivinen korkopolitiikka kannusti pankkeja lisäämään lainanantoaan. Lainanannon lisääntyminen kasvatti järjestämättömien lainojen osuutta, mikä puolestaan pienensi pankkien tulosta, pääomaa ja varallisuutta. Pääomaan kohdistuva vähennys oli erityisen merkittävä ja johti huomattavaan oman pääoman tuoton laskuun. Vaikka on esitetty, että negatiivisen korkopolitiikan aikana lainakorot laskivat enemmän kuin talletuskorot, näyttää siltä, että lainakorkojen lasku ei ollut merkittävästi suurempi kuin talletuskorkojen lasku, jotta se olisi vaikuttanut pankkien korkotuottoihin. Sen sijaan havaittu kannattavuuden lasku johtuu lisääntyneen lainanannon seurauksista.

Asiasanat
Negatiiviset korot, rahapolitiikka, pankkien kannattavuus

Säilytyspaikka
Jyväskylän yliopiston kirjasto

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1 INTRODUCTION

1.1 Background

Global financial crisis (GFC) between 2007 and 2009 was the worst financial crisis the world had faced since the Great Depression in the 1920's and it led to a devastating recession. In June 2014 central banks adopted an unconventional monetary policy tool, the negative interest rate policy (NIRP) to boost the economy (Junttila, 2022). They set deposit rates, at which other banks can earn interest on their reserves held at the central bank, below zero (Junttila, 2022). As banks were now charged for holding their reserves at the central bank, these negative deposit rates were meant to encourage banks to lend out the reserves and thus, encourage customers to borrow and invest money with low costs and therefore stimulate the economy (Junttila, 2022).

For the NIRP to fully work, negative deposit rates were expected to pass through banks to their depositors (Beckmann et al., 2021). This pass-through is called the interest rate channel (Beckmann et al., 2021). However, banks hesitated to charge interests from their depositors because they were afraid of customers liquidating their deposits (Beckmann et al., 2021). Fear is not proved groundless: according to survey by ING (2006) conducted in Australia, Europe, and the United States of America (USA), 77 percent out of 13 000 bank customers said they would withdraw their deposits if the interest rates were negative. Therefore, these deposit rates were strictly tied to the zero lower bound (ZLB), that is interest rates being exactly zero (Mishkin, 2016, p. 425).

Significant part of banks' profitability consists of net interest margin (NIM), that is the difference between bank's interest income, provided by borrowers in the form of interest rates on loans, that is, loan rates, and expenses from the depositors in the form of deposit rates. Because banks were charged for holding their deposits in the central bank but were not able to pass these costs to their depositors due to the fear of bank run, to protect their interest income, banks

were less likely to reduce loan rates either (Beckmann et al., 2021). Thus, the pass-through of NIRP was incomplete. However, loan rates were reduced relatively more than deposit rates (Beckmann et al., 2021). This led to a loss of income, especially in banks, which were mostly deposit-funded (Heider et al., 2019).

1.2 Motivation and research questions

At this point it seems that implementation of NIRP affected banks' profitability negatively by decreasing NIM of banks. Profitability of banks is one of the main factors in the global financial stability and it ensures the efficiency of financial system and therefore the whole economy. Thus, the effects that implementation of NIRP had on the profitability of banks is a great concern among scholars. After closer inspection, it seems that banks were able to offset the interest income losses by increasing their non-interest income (NII), such as fees (Lopez et al., 2020). Nonetheless, these results are driven by small banks, which do not rely their funding that much on deposits (Lopez et al., 2020), and even though the existing literature has not found negative effects of NIRP on banks' profitability, actions to offset lower interest income do affect banks' health, so the effects must be closely monitored (Turk-Ariss, 2016, as cited in Junttila et al., 2021).

Additionally, studies regarding the effects of NIRP cover only the beginning of the era of negative policy rates, which was not exited until recently, in September 2022 (Beckmann et al., 2021; John & Ranasinghe, 2022). Therefore, this thesis contributes to the existing literature by studying the effects that implementation of NIRP had on banks' profitability from data covering the whole era of negative policy rates, from 2014 to 2022. The relationship between implementation of NIRP and profitability of banks is analysed comprehensively, based on all the main components of banks' balance sheets. Aim is to answer the following research question:

1. How implementation of NIRP affected profitability of banks?

As mentioned, pass-through of NIRP was incomplete. Short-term interest rates are a common method to characterize interest rate environment of a region (see for example López-Penabad et al., 2022) and thus, these rates reflect more appropriately the actual interest rates used by the banks, so in addition to the first research question, I aim to answer the following:

2. How short-term interest rates affected profitability of banks during NIRP?

Thus, this thesis provides policy makers insight into the effectiveness of this tool and banks suggestions how to survive negative interest rate era if it ever happens again.

1.3 Data, methodology, results, and structure

Profitability of banks is proxied by five different profitability measures: NIM, NII, return on average assets (ROAA), return on average equity (ROAE), and impaired loans. ROAA refers to a company's, in this case bank's profit divided by its total assets and it indicates how much of the total assets is turned into profit. The profit consists of interest and non-interest income, loan loss provisions, operating expenses, and taxes. Assets of a bank mostly consist of cash, interest-earning loans, and securities (Mishkin, 2016, p. 233). Impaired loans are loans, of which the borrower is facing difficulties in meeting their contractual obligations (Kenton, 2023).

ROAE is the bank's profit divided by its total equity and indicates how much of the total equity is turned into profit. Total equity of a bank is the bank capital, that is the difference between bank's assets and liabilities (Mishkin, 2016, p. 232). Liabilities consist of borrowings and deposits (Mishkin, 2016, p. 233). In the previous literature (see for example Junttila et al., 2021 and López-Penabad et al., 2022) return on assets (ROA) and return on equity (ROE) are common measures to characterize the overall profitability of a bank.

To study the effects of NIRP and short-term interest rates on these profitability measures, two statistical fixed effects models are constructed. As data, I use an unbalanced panel dataset of 1467 bank groups consisting of 13 029 observations from the eurozone, Denmark, Japan, Switzerland, and Sweden over the period from 2010 to 2022. Data, models, and limitations are presented in detail in section 4. To mitigate potential endogeneity bias, short-term interest rate, NIRP, and control variables are lagged by one period, which is a systematically used lag length in previous literature, and individual-specific and time-fixed effects are included in the models.

The main findings in this research are the positive relationship between implementation of NIRP and share of impaired loans of the respective banks, and the negative relationship between implementation of NIRP and ROAE of the respective banks, as well as between short-term interest rates and ROAE of the respective banks. These results are connected to each other. As intended by the central banks, negative policy rates encouraged banks to increase lending. This led to increased loan loss provisions and impaired loans, which in turn decreased profit, equity, and assets. The decrease in equity was relatively high compared to the others and thus led to decreased ROAE.

So, even though Beckmann et al. (2021) argued that loan rates were decreased relatively more than deposit rates, Lopez et al. (2020) suspected that the drop of loan rates was not that much larger than of deposit rates, that it would have affected the interest income of banks. Instead, the decrease in profitability is caused by the consequences of increased lending. This theory of maintaining sustainable loan rates and increasing lending is supported by Borio et al. (2017) who pointed out that as the short-term interest rates fall, the demand for loans increases. This phenomenon might also cause the concave, negative relationship

between the short-term interest rate and ROAE of the respective banks. Another possible explanation for this non-linearity could be caused by the retail deposits endowment effect, that is the more the short-term interest rates fall, the less the deposit rates fall. Therefore, the effect of short-term interest rates on profitability diminishes as the rates keep falling.

The remainder of the thesis is organized as follows. Section 2 sets the theoretical framework for the thesis by walking the reader through what is monetary policy, for what it is used and how it is conducted. Section 3 reviews previous literature regarding the effect of NIRP and interest rates on profitability of banks as well as other factors affecting the profitability, such as different characteristics of banks and macroeconomics. Section 4 describes the data and methods used in the estimation of the effects in detail. Results from the estimations are reported in section 5 and in section 6, the results are discussed. In section 7, concluding thoughts are drawn.

2 THEORETICAL FRAMEWORK

2.1 Monetary policy

Policy refers to rules established by an authority to achieve specific goals (Cambridge University Press & Assessment, n.d.). Monetary policy is the rules established by a monetary authority. The goal of monetary policy is to control inflation by controlling interest rates (Mishkin, 2016, p. 623) and thus, to maintain high employment, price stability, economic stability, and predictable exchange rates with other currencies. Monetary authority is the institution of the country or a monetary union, that manages the respective currency and monetary policy. An example of such an institution is a central bank (Mishkin, 2016, p. 56).

2.2 Inflation and interest rates

Inflation is continual increase in the price level and stable inflation between one and three percent is the primary goal of monetary authorities (Mishkin, 2016, p. 54 & 623). To control inflation, monetary authorities use different monetary policy tools (Mishkin, 2016, p. 411). Most of these tools are aimed at controlling interest rates (Mishkin, 2016, p. 564). The interest rate is the cost of borrowing money (Mishkin, 2016, p. 49). There are two types of interest rates in discussion: nominal and real interest rates (Mishkin, 2016, p. 125). In the nominal interest rate, the effect of inflation has not been considered (Mishkin, 2016, p. 125). Real interest rate is defined from the Fisher equation, which states that nominal interest rate is the sum of real interest rate and expected inflation rate (Mishkin, 2016, p. 125). In other words, interest rates and inflation are directly connected to each other, and there is a positive relationship between them. Therefore, monetary authorities typically use monetary policy tools to affect interest rates

and thus, to affect inflation. While they cannot directly control the inflation rate, which is affected by many factors such as supply and demand dynamics, economic growth, and external shocks, they can adjust interest rates to do the job.

2.3 Conventional monetary policy tools

Monetary policy tools are divided into conventional and unconventional tools (Mishkin, 2016, p. 418-425). Conventional tools are open market operations, loan and deposit rates, and reserve requirement rate (Mishkin, 2016, p. 431-432). Central banks implement open market operations by buying or selling short-term government bonds from banks (Mishkin, 2016, p. 418-419). When central banks buy short-term government bonds, demand for these bonds increases and thus, their price (Mishkin, 2016, p. 135). As the price, or in other words present value of these bonds, increases, there is no need to pay such high interest at the maturity date of the bonds (Mishkin, 2016, p. 118). Therefore, these government bond purchases decrease interest rates and inflation.

In addition, government bond purchases by central banks increase money supply: there is more money for the banks to lend to customers (Mishkin, 2016, p. 393). Now, when customers have more money, they want to buy more bonds, which increases the demand for bonds even further and thus, the price of the bonds, and decreases interest rates and inflation (Mishkin, 2016, p. 149). Government bond sales by the central bank decrease the demand for the bonds and thus, their price (Mishkin, 2016, p. 418). With these lower prices, interest rates need to be increased and as a result, inflation rises as well (Mishkin, 2016, p. 418). There is less money in the hands of the public, so customers do not buy as many bonds as previously, so the price of bonds decreases even further. As a result, interest rates and inflation increase.

The European Central Bank sets a target financing rate, which determines the marginal lending rate for the loans taken by the banks and the deposit rate for their deposits at the central bank (Mishkin, 2016, p. 432). Central banks have an important role as lenders of last resort in financial crises, as they provide loans to banks when no one else would, thereby preventing bank failures (Mishkin, 2016, p. 421). Another way of controlling inflation is via the required reserve ratio (Mishkin, 2016, p. 388). Required reserve ratio indicates the proportion of reserves obligated to be held by banks at the central bank (Mishkin, 2016, p. 388). The required reserve ratio affects the money supply, because the lower the ratio, the more reserves banks can lend out (Mishkin, 2016, p. 400). As described previously, increased money supply leads to decreased interest rates and inflation, and vice versa (Mishkin, 2016, p. 149 & 418).

2.4 Unconventional monetary policy tools

Unconventional monetary policy tools are used during and after a financial crisis, when the conventional tools are not enough for the economy to recover from the crisis (Mishkin, 2016, p. 425). Unconventional tools are expanded lending operations, asset purchase programs, forward guidance, and negative interest rate policy (Bank for International Settlements, 2019). Central banks conduct expanded lending operations by increasing their lending to banks to provide liquidity (Mishkin, 2016, p. 425). Lending was increased by allowing lower-quality collateral for longer horizons at lower costs (Bank for International Settlements, 2019). During crises, central banks expand their loan clientele and in addition to banking institutions, lend funds for example investment banks (Mishkin, 2016, p. 426; Bank for International Settlements, 2019).

Asset purchase programs are open market purchases, but in addition to short-term government bonds, central banks buy other types of securities (Mishkin, 2016, p. 426). During the GFC, central banks bought private sector assets and long-term government bonds to decrease a wide range of different interest rates (Mishkin, 2016, p. 426; Bank for International Settlements, 2019). Forward guidance refers to the commitment by the central bank to keep the interest rates at the same, low level for a longer period and thus, affecting the expectations of the future interest rates and therefore lowering the actual interest rates (Mishkin, 2016, p. 430). Negative interest rate policy refers to central banks setting their policy deposit rate, at which other banks can earn interest on their reserves held at the central bank, below zero (Junttila, 2022; European Central Bank, 2024). Negative interest rate policy is a direct way to decrease interest rates and thus, to keep inflation low.

3 PREVIOUS LITERATURE

3.1 The effect of NIRP on banks' profitability

López-Penabad et al. (2022) studied the effect of NIRP and short-term interest rates on 2596 European banks' profitability between 2011 and 2019, and the role business model of the bank had in the effect. Their profitability measures were NIM, ROA, net fees and commissions, net trading income, other operating revenues, and loan loss provisions. Loan loss provisions are an allocation for uncollected loans and loan payments in the income statement of the bank (Alpert, 2021). There is a positive relationship between them and impaired loans: as the share of impaired loans increases, loan loss provisions need to be increased as well. López-Penabad et al. (2022) found that if the country that the bank was based had implemented NIRP, it statistically significantly decreased NIM, ROA, and net trading income, and statistically significantly increased net fees and commissions and loan loss provisions. In the research by López-Penabad et al. (2022), the mean short-term interest rate was -0.3 percent during the research period. They observed a statistically significant negative relationship between the interest rate and ROA, and a statistically significant positive relationship between the interest rate and loan loss provisions, but the rate did not have significant effects on other profitability measures.

Molyneux et al. (2019) studied the effect of NIRP on 7359 banks' NIM, ROA, and NII from 33 OECD-countries covering Asia, Europe, Middle East, North America, Oceania, and South America. In line with the research by López-Penabad et al. (2022), they found that implementation of NIRP lowered NIM statistically significantly by 16.4 basis points and ROA statistically significantly by three basis points. In addition, they found that the effect of NIRP depends on the size of the bank: the smaller the bank, the greater the effect. It seems like bigger banks were more resilient towards the negative policy rates because there was a statistically significant positive relationship between implementation of

NIRP and NII in big banks. However, these size-related results are inconsistent with the research by Lopez et al. (2020), who found that especially in small banks, the interest income loss was compensated with profitable NII. Nevertheless, both agreed that there is a statistically significant positive relationship between implementation of NIRP and NII of the respective banks.

3.2 The effect of short-term interest rate on banks' profitability

Claessens et al. (2018) studied the effect of low interest rates on NIM and ROA of respective 3385 banks globally between 2005 and 2018. In the research the mean short-term interest rate was 1.94 percent, and in line with the research by López-Penabad et al. (2022), one percent drop in the short-term interest rate led to a significant nine basis points drop in the NIM of the respective bank. The effect of short-term interest rate on NIM was even more pronounced the lower the interest rates were. There was no relationship observed between the short-term interest rate and ROA of the respective banks.

Similarly, Bikker and Vervliet (2017) studied the effect of low interest rate on 3582 American banks' NIM, profit, ROA, and ROE between 2001 and 2015. Like Claessens et al. (2018), Bikker and Vervliet (2017) found that one percent drop in the short-term interest rate led to a significant two basis points drop in the NIM of the respective bank, and again, the lower the rates were, the more pronounced was the effect. Low interest rates did not affect the overall profitability, and like López-Penabad et al. (2022), Bikker and Vervliet (2017) proposed decrease in the loan loss provisions as the reason for the non-existent relationship between interest rates and overall profitability due to decreased credit risk of borrowers followed by decreased loan rates.

Borio et al. (2017) studied the effect of interest rates on NIM, NII, loan loss provisions and ROA of 109 banks between 1995 and 2012 in 14 major advanced economies. In the research the average short-term interest rate was 4.21 percent. Like Bikker and Vervliet (2017) and Claessens et al. (2018), Borio et al. (2017) discovered a positive relationship between the short-term interest rate and NIM of the banks. In addition, there was a statistically significant positive relationship between the short-term interest rate and loan loss provisions of the respective banks as well as between the short-term interest rate and ROA of the respective banks. The latter result is inconsistent with the research by Bikker and Vervliet (2017), Claessens et al. (2018) and López-Penabad et al. (2022).

In addition, Borio et al. (2017) found a statistically significant negative relationship between the short-term interest rate and NII of the respective banks. An interesting observation was that all the relationships in the research were concave rather than linear. In practice this implies that the effect of short-term interest rate on profitability diminishes the more the interest rate increases.

3.3 The effect of bank characteristics on banks' profitability

According to Goddard et al. (2004), bank's size affects its ROE positively due to economies of scale. However, Demirgüç-Kunt and Huizinga (2013) suggest that large banks could have lowered their loan rates during the era of low interest rates more than small banks because of the cost efficiency provided by their size, which in turn would imply that negative interest rates affected large banks' profitability even more than small banks. Indeed, Alessandri and Nelson (2015) found that even when hedged against the interest rate risk, large banks are more exposed to the risk than small banks. In addition, Lopez et al. (2020) suggest that lower deposit expenses from the central banks compensate for the decrease in the interest income in small banks. Nevertheless, large banks might have been able to boost their other business to cover for the loss more than small banks. Therefore, the effect of the size of the bank is not robust and for example, neither Athanasoglou et al. (2008) nor Junttila and Viitala (2023) found size having any effect on banks' profitability. Still, though controversial, or perhaps because of that, size is considered as one of the profitability factors in this thesis.

Business model of a bank is defined by the funding structure of the bank (López-Penabad et al., 2022). According to Farné and Vouldis (2020), in general, business model affects the profitability of a bank: wholesale-funded banks earn higher profits than deposit-funded banks, because they can take higher risks in the financial markets. As NIRP hit directly deposit rates, supposedly negative interest rates affected more deposit-funded banks. Indeed, Heider et al. (2019) confirmed that deposit-funded banks suffered more losses due to NIRP than wholesale-funded banks. Similarly, López-Penabad et al. (2022) found that the business model of the bank affected profitability in such a way that retail-oriented banks were more negatively affected by NIRP than other banks. In the light of previous literature, this result does make sense, as retail-oriented banks are mostly funded by deposits (Cernov & Urbano, 2018). Therefore, business model is considered as one of the profitability factors in this thesis.

Ekpu and Paloni (2015) studied the effect of corporate and commercial lending on ROAE of 83 banks from the United Kingdom (UK) between 2005 and 2009. According to Turati (2002, as cited in Ekpu & Paloni, 2015), loans provided by banks account for about 55 percent of assets of a bank. This suggests that lending is a very important source of profit for a bank. Indeed, Ekpu and Paloni (2015) found that the more loans a bank provides, the higher the ROAE. In addition, Bikker and Vervliet (2017) used lending as one of their control variables and found that as anticipated lending increased NIM, ROA and ROE of the respective banks. Lending was a control variable in the study by López-Penabad et al. (2022) as well, and following Bikker and Vervliet (2017), they discovered the positive relationship between lending and NIM of the respective banks, but also between lending and loan loss provisions of the respective banks. Interestingly, in the study of López-Penabad et al. (2022), lending seemed to

decrease ROA and net trading income. However, in general lending is considered as an increasing factor of profitability.

Nguyen (2012) studied the effect of NII on NIM of 3593 banks in 28 financially liberalized countries between 1997 and 2004 and found a negative relationship between these two. Ratio of equity to total assets is used as a proxy for level of risk aversion because the more equity financed the bank is, the higher profit investors require. Buying equity is riskier than buying debt, as in bankruptcy, debtors are the ones to receive their investments first. So, to address the level of risk aversion, Nguyen (2012) used a ratio of equity to total assets as an independent variable in the model, and this ratio seemed to have a positive effect on NIM. The same result was discovered by Maudos and Guevara (2004), who studied the factors of NIM of 1826 banks in Germany, France, UK, Italy, and Spain between 1993 and 2000.

3.4 The effect of macroeconomic variables on banks' profitability

Albertazzi and Gambacorta (2009) studied the effects of different macroeconomic variables, such as gross domestic product (GDP), inflation, and short- and long-term interest rates, on net interest income, NII, operating costs, loan loss provisions, and profit before taxes of European and North American banks between 1981 and 2003. They found a statistically significant positive relationship between GDP and net interest income, and a statistically significant negative relationship between GDP and loan loss provisions. The following interpretation is simple: in the expansionary phase of the business cycle, the financial conditions of customers are improved and therefore, they demand more loans, which increases the profitability of banks.

Salas and Saurina (2002) studied the effects of multiple macroeconomic and bank-specific factors, such as GDP, indebtedness, regulatory changes, loans, inefficiency, and size, on 1381 Spanish banks' loan losses between 1985 and 1997. They found a statistically significant negative relationship between GDP and loan losses. Expectedly, this implies that when the economy is booming, there are less loan losses, because customers can keep up with their loan payments. Thus, loan loss provisions do not need to be so high when GDP is growing fast.

Albertazzi and Gambacorta (2009) found a statistically significant positive relationship between inflation and NII of the respective banks. The result implies that as the aggregate price level increases, so do the fees of banks. A statistically significant positive relationship was found also between inflation and loan loss provisions of the respective banks. Similarly, as the prices increase, customers may struggle to pay back their loans, and thus, the provisions need to be increased to cover possible losses.

Tan and Floros (2012) studied the effects of GDP and inflation on 101 Chinese banks' profitability between 2003 and 2009. Contrary to the results obtained by Albertazzi and Gambacorta (2009), according to Tan and Floros (2012b), there is a negative relationship between the growth of GDP and

profitability of banks. Economic growth improves the business environment and new banks are established, which in turn increases competition among banks and thus lowers their profits. In line with results obtained by Albertazzi and Gambacorta (2009), Tan and Floros (2012a) found a positive relationship between inflation and profitability of banks. Whenever an increase in inflation is expected or experienced, banks adjust their interest rates accordingly and thus earn higher profits.

3.5 Models and methodologies

Studies about the effects of NIRP and short-term interest rate on the profitability of banks are usually a combination of different statistical techniques. Already the objective of the studies, to research the effect of NIRP and short-term interest rate on the profitability of banks, suggest that they are regression analyses, which is a technique used to estimate relationships between different variables (Freedman, 2009, p. 1). In addition, most studies used as a baseline in this thesis are panel data analyses, that is the data has been collected from multiple individuals in multiple points of time (Stock & Watson, 2020, p. 52).

The ever-evolving nature of banks' profitability is broadly recognized in the existing literature (see for example Athanasoglou et al., 2008). Representing the relationship between interest rates and profitability of banks with a dynamic regression model is then a legitimate starting point for estimation of this relationship (Bikker & Vervliet, 2017). Therefore, both Borio et al. (2017) and Claessens et al. (2018) estimated the effects of interest rates on profitability of banks with this dynamic regression model by including a lagged response variable as one of the explanatory variables. To estimate the parameters of the model they use the system generalized method of moments (S-GMM), which is the most suitable estimator for dynamic panel data models (Bikker & Vervliet, 2017). S-GMM estimator instruments the response variable by its lagged value.

However, if the Hansen-Sargan test of the dynamic regression model returns p-value under five percent, the instrumented, lagged response variable is not valid and the consistency of S-GMM estimator depends on this validity (Bikker & Vervliet, 2017). Instrument is a variable in a regression model, which correlates with the explanatory variable but not with the response variable (Bobbitt, 2020). It is added into the model to address endogeneity (Imbens & Angrist, 1994). Due to the rejection of null hypothesis in the Hansen-Sargan test, Bikker and Vervliet (2017) decided to represent the relationship between interest rates and profitability as well as NIRP and profitability with a static regression model to avoid inconsistent estimates. Similar modelling was conducted by Molyneux et al. (2019), Lopez et al. (2020), and López-Penapad et al. (2022). In the static model the relationship between interest rates and profitability is assumed not to evolve over time. The estimator of the parameters in this model is a fixed effects estimator.

3.6 Hypotheses

The research objective is to estimate the effect of NIRP and short-term interest rates on profitability of banks. Molyneux et al. (2019) and López-Penabad et al. (2022) found a statistically significant, negative relationship between implementation of NIRP in a region and NIM of the respective banks as well as between implementation of NIRP in a region and ROA of the respective banks by studying data between 2012 and 2016 globally and between 2011 and 2019 in Europe. In this thesis, I expect to observe similar results by studying data between 2010 and 2022 from the eurozone, Denmark, Japan, Sweden, and Switzerland and thus to construct a comprehensive picture of the relationship between implementation of NIRP in a region and NIM/ROA of the respective banks during NIRP (2014-2022) in countries that implemented NIRP. Therefore, the hypothesis 1 of the thesis goes:

Hypothesis 1. There is a statistically significant negative relationship between implementation of NIRP in a region and NIM and ROAA of the respective banks.

Molyneux et al. (2019) and Lopez et al. (2020) found a statistically significant positive relationship between implementation of NIRP in a region and NII of the respective banks by studying data between 2012 and 2016 globally and 2010 and 2017 in Europe and Asia. Results formulate hypothesis 2 for the data of this thesis that goes:

Hypothesis 2. There is a statistically significant positive relationship between implementation of NIRP in a region and NII of the respective banks.

Bikker and Vervliet (2017), Borio et al. (2017) and Claessens et al. (2018) found a statistically significant positive relationship between a short-term interest rate and NIM of the respective banks by studying data between 2001 and 2015 in USA, and 1995 and 2018 globally. Relying on their findings, hypothesis 3 of the thesis is formulated as follows:

Hypothesis 3. There is a statistically significant positive relationship between the short-term interest rate in a region and NIM of the respective banks.

Bikker and Vervliet (2017) suggested that there is a positive relationship between short-term interest rates in a region and loan loss provisions of the respective banks, which would be the reason why low interest rates do not affect ROA. Both Borio et al. (2017) and López-Penabad et al. (2022) found this relationship by studying data between 1995 and 2012 globally and between 2011 and 2019 in Europe. As loan loss provisions and impaired loans are tightly connected, in this thesis, I expect the following:

Hypothesis 4. There is a statistically significant positive relationship between the short-term interest rate in a region and impaired loans of the respective banks.

4 DATA AND METHODOLOGY

4.1 Geographical limitation

Dataset of central bank policy rates from Bank for International Settlements (BIS) (2024) discloses that policy rates of central banks were lowered below zero in the eurozone, Denmark, Croatia, Japan, Sweden, and Switzerland. Croatia did not join the eurozone before the beginning of 2023 (Williams, 2023). However, BIS does not have sufficient coverage of the policy rates from the central bank of Croatia, so therefore Croatia is excluded from this research. Thus, this thesis focuses on the effects of NIRP on banks' profitability in the eurozone, Denmark, Japan, Sweden, and Switzerland.

4.2 Profitability measures

Based on the previous literature, to analyse the effects of NIRP and short-term interest rates on profitability of banks comprehensively, the main components of banks' balance sheets are considered as profitability measures: non-interest income divided by average total assets (NII), difference between bank's interest income and expenses divided by average total assets (NIM), impaired loans divided by average risk weighted assets (IMP), return on average assets (ROAA), and return on average equity (ROAE). These ratios are obtained from Moody's Analytics BankFocus -database, which includes consolidated financial statements of 1467 bank groups from the eurozone, Denmark, Japan, Sweden, and Switzerland. The data in the database covers period from 2010 to 2022, so each ratio each year from all the banks is considered. TABLE 1 below presents the number of observations of each profitability ratios, mean ratio, standard

deviation of the ratio, and maximum and minimum values. Definitions and sources of the variables are listed in Appendix 1.

TABLE 1 Descriptive statistics of annual profitability measures from bank groups in the eurozone, Denmark, Japan, Sweden, and Switzerland between 2010 and 2022.

Variable	Obs.	Average	SD	Max.	Min.
NII	12 672	2.868	5.631	40.103	-10.112
NIM	12 783	1.411	1.847	39.701	-10.654
IMP	5 765	5.851	6.368	39.766	0.000
ROAA	12 947	0.692	2.365	39.850	-14.920
ROAE	12 354	6.261	6.785	40.262	-15.277

4.3 Statistical models

From the previous literature, the first choice regarding the model was whether to use a dynamic or static model. As mentioned previously, due to the dynamic nature of the banks' profitability measures, representing the effect of NIRP and short-term interest rates on the profitability of banks, a dynamic regression model is a legitimate starting point for the analysis (Bikker & Vervliet, 2017). For a dynamic regression model and panel data, S-GMM estimator works the best (Bikker & Vervliet, 2017). However, the Hansen-Sargan tests returned p-values below five percent, so the instruments in the model were not valid. Therefore, I needed to choose a static model.

So, following the footsteps of Bikker and Vervliet (2017), Molyneux et al. (2019), Lopez et al. (2020) and López-Penapad et al. (2022), to study the effects of NIRP and short-term interest rate on banks' profitability, the following statistical models are considered:

$$\gamma_{it} = \alpha_0 + \alpha_1 * NIRP_{t-1} + \alpha_2 * W_{t-1} + \alpha_3 * X_{t-1} + \delta_i + \theta_t + \varepsilon_{it} \quad (1)$$

$$\gamma_{it} = \beta_0 + \beta_1 * ir_{t-1} + \beta_2 * W_{t-1} + \beta_3 * X_{t-1} + \delta_i + \theta_t + \varepsilon_{it} \quad (2)$$

Models consist of intercept term, explanatory variables, control variables, individual-specific and time-fixed effects, and error term. For bank i and year t, γ represents bank's profitability measure; NIRP takes value of one if the region where the bank is based implemented NIRP in year t, and zero otherwise; ir represents annual, average three-month interbank money market interest rate; W and X represent vectors of bank-specific and macroeconomic control variables, respectively, δ represents individual-specific effects of bank i, and θ represents time-fixed effects in year t. To mitigate potential endogeneity bias, explanatory and control variables are lagged by one period, which is a systematically used lag length in previous literature, and individual-specific and time-fixed effects are included in the models (see for example López-Penabad et al., 2022).

4.4 Explanatory variables

In the model 1, I consider a binary variable taking the value of one or zero to reflect whether the central bank of the region where the bank is based implemented NIRP or not, respectively. The implementation of NIRP is based on central bank's annual averages of month-end policy rates between January 2010 and December 2022: if the average is negative, NIRP was implemented, and the variable takes value of one. Annual averages are calculated from the month-end deposit rates obtained from the data portals of European Central Bank (2024) for the eurozone, Danmarks Nationalbank (2024) for Denmark, CEIC Data (2024) for Japan, and Sveriges Riksbank (2024) for Sweden. Due to lack of information, the rates from Switzerland are their target rates for the three-month LIBOR provided by BIS (2024). Definition and sources of the variable are listed in APPENDIX 1.

The evolution of these policy rates throughout the research period is illustrated in FIGURE 1. Since 2011 all the policy rates excluding the one of Bank of Japan have been gradually decreasing to finally drop below zero around 2014, Denmark being the first to show an example already in 2012, and Japan following as the last in 2015. Except for Sweden, none of the rates were dropped below minus one percent, and all the rates were gradually increased from 2021 onwards, except for Japan. Number of the policy rates, mean policy rate, standard deviation in them, and maximum and minimum rates are presented in TABLE 2.

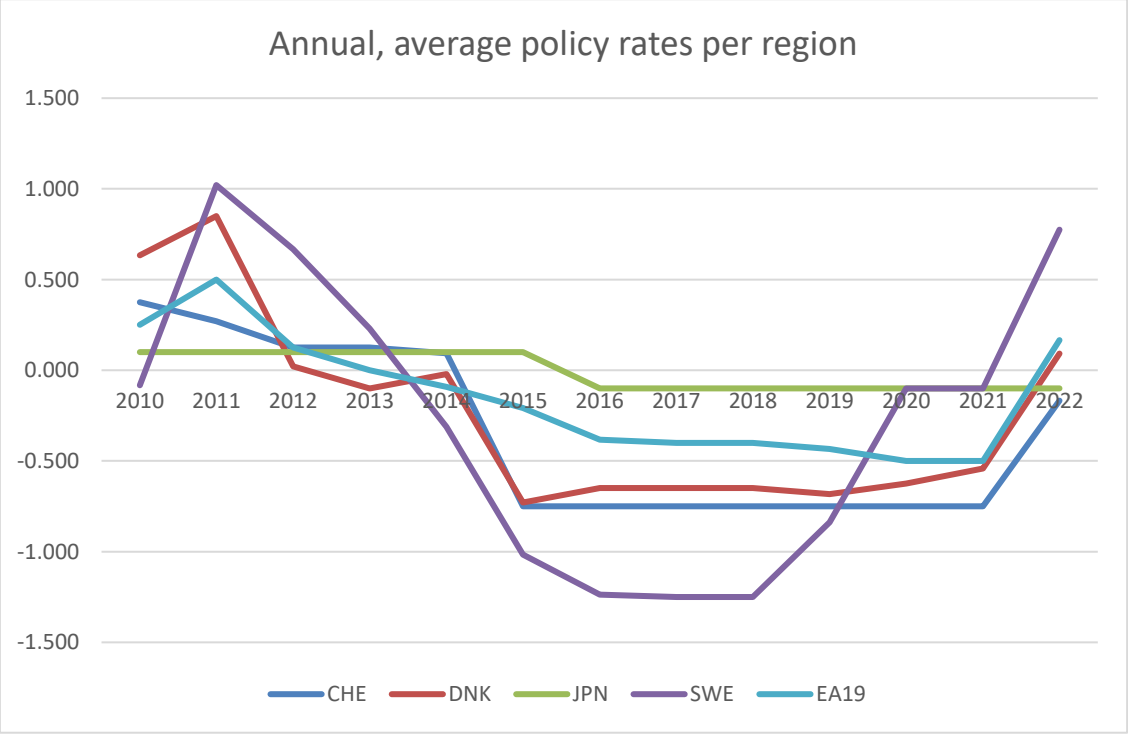

FIGURE 1 Evolution of annual, average month-end policy rate of central banks in the eurozone, Denmark, Japan, Sweden, and Switzerland between 2010 and 2022.

The annual, average three-month interbank money market interest rate from the eurozone, Denmark, Japan, Sweden, and Switzerland between 2010 and 2022 provided by Organization for Economic Co-operation and Development (OECD) (2024) is considered as an explanatory variable in the model 2. Definition and source of the interest rate are listed in APPENDIX 1. This interest rate reflects more appropriately the actual interest rates used by banks, because due to the fear of bank run, the pass-through of unconventional monetary policy via the interest rate channel is incomplete (Beckmann et al., 2021). In the previous literature, this short-term interest rate is a common method to characterize the interest rate environment of a region (see for example López-Penabad et al., 2022). Number of the short-term interest rates, the mean, standard deviation in the rates, and maximum and minimum rates are presented in TABLE 2.

The evolution of the short-term interest rates throughout the research period is illustrated in FIGURE 2. Just like the policy rates, all the short-term interest rates have been gradually decreasing since 2011 (including Japan) and despite the incomplete pass-through of NIRP, the annual, average short-term interest rates have dropped below zero. However, from FIGURE 3, it can be observed that even though the average short-term interest rate across all the regions in the research follows quite accurately the average policy rate across all the regions, there is a clear gap caused by the incomplete pass-through of NIRP. FIGURE 4 illustrates the evolution of the profitability ratios and policy and short-term interest rates throughout the research period. Since 2014 and 2015 all the ratios have slightly decreased, except for ROAA, which suggests that implementation of NIRP and the following low short-term interest rates did harm the profitability of banks.

TABLE 2 Descriptive statistics of annual, average month-end policy rate of central banks (NIRP) and annual, average three-month interbank money market rate (IR) of the eurozone, Denmark, Japan, Sweden, and Switzerland between 2010 and 2022.

Variable	Obs.	Mean	SD	Max.	Min.
NIRP	65	-0.199	0.501	1.021	-1.250
IR	65	0.044	0.576	1.658	-0.819

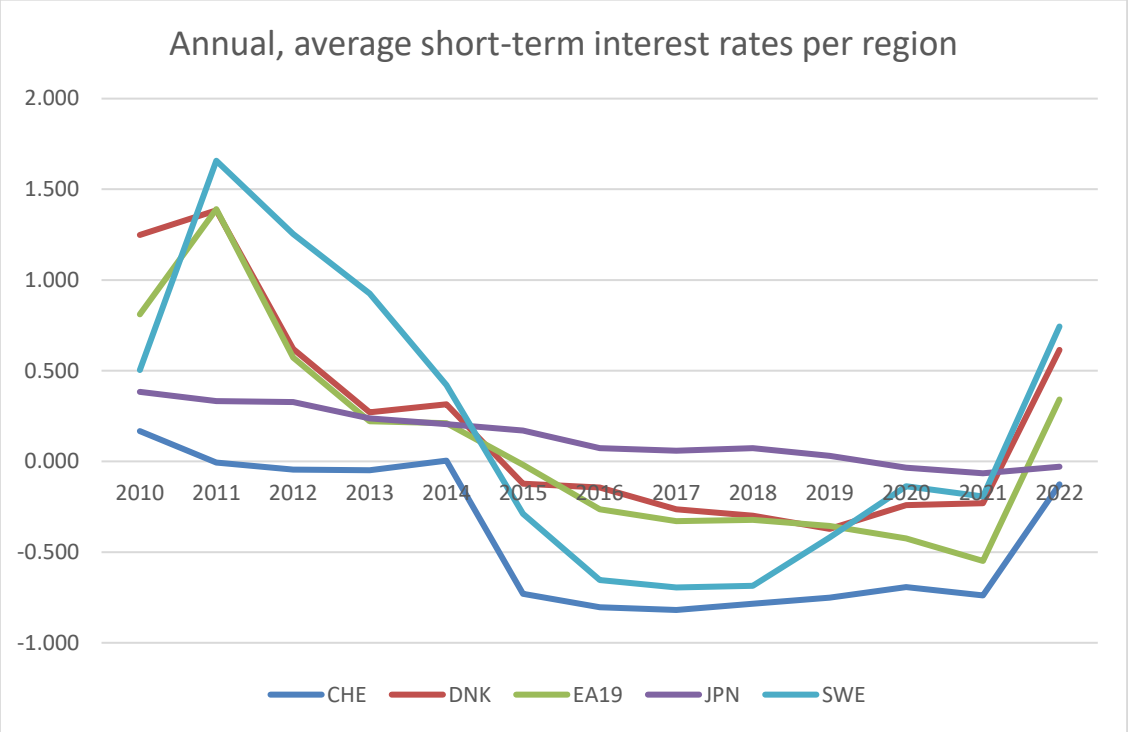

FIGURE 2 Evolution of annual, average three-month interbank money market interest rates in the eurozone, Denmark, Japan, Sweden, and Switzerland between 2010 and 2022.

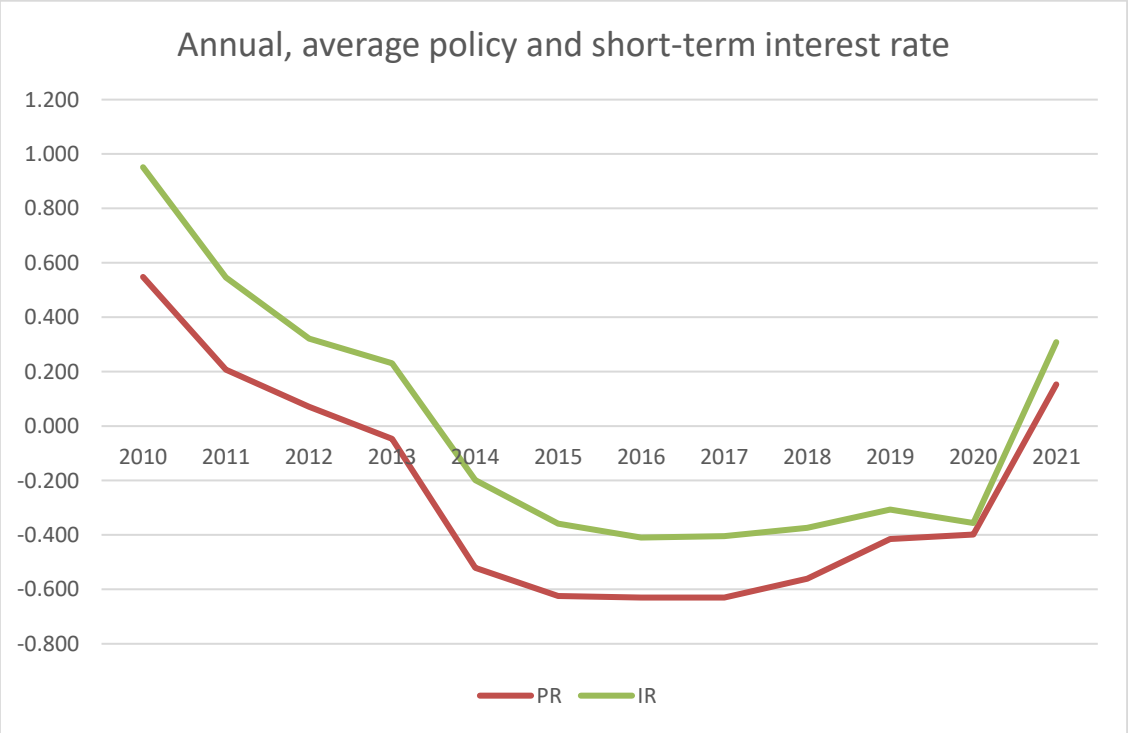

FIGURE 3 Evolution of annual, average month-end policy rate of central banks (PR) and annual, average three-month interbank money market rate (IR) of the eurozone, Denmark, Japan, Sweden, and Switzerland between 2010 and 2022.

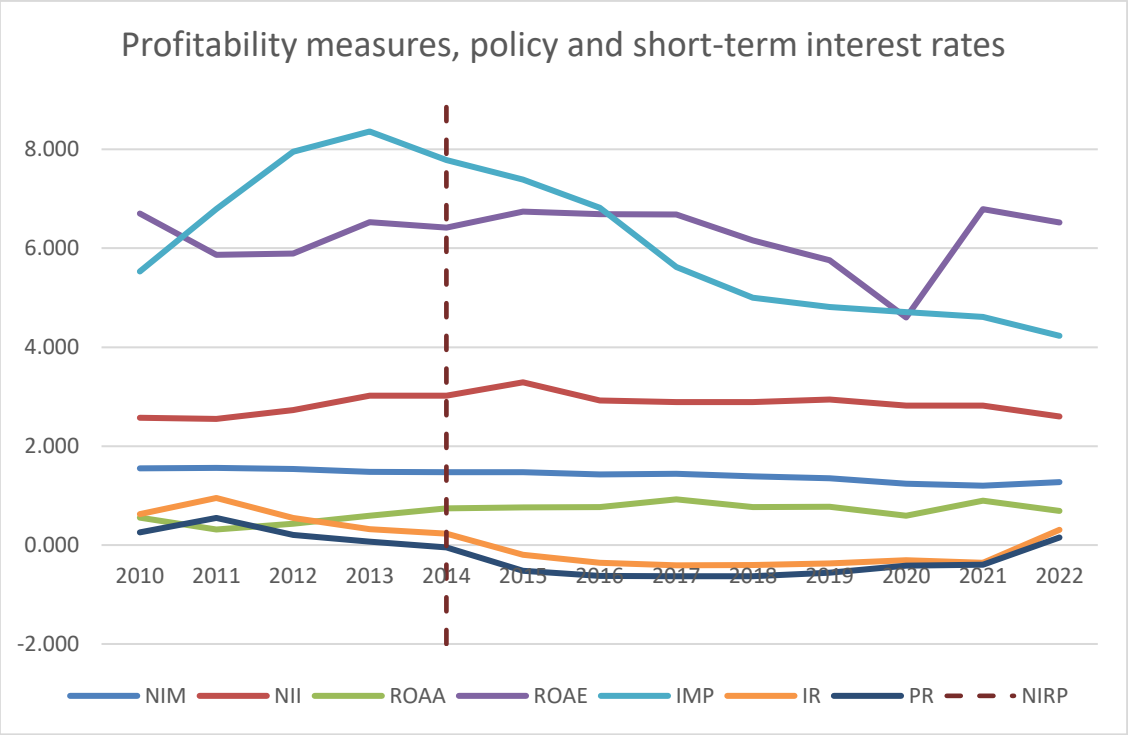

FIGURE 4 Evolution of annual, average profitability measures of banks, month-end policy rate of central banks (PR) and three-month interbank money market rate (IR) in the eurozone, Denmark, Japan, Sweden, and Switzerland between 2010 and 2022. Vertical dashed line in 2014 represents the implementation of NIRP.

4.5 Control variables

Control variables in the models 1 and 2 are collected from the previous literature regarding factors of banks' profitability. Demirgüç-Kunt and Huizinga (2013), Alessandri and Nelson (2015) and Lopez et al. (2020) suggested that the negative interest rates harmed large banks more than small banks. Heider et al. (2019), Farné and Vouldis (2020) and López-Penabad et al. (2022) found that business model of the bank affects profitability: wholesale-funded banks are more profitable than deposit-funded banks, especially when the interest rates are low or even negative. In addition, Maudos and Guevara (2004) and Nguyen (2012) discovered positive relationship between share of equity-funding and profitability, because more equity-funded banks require higher profit due to the risky nature of equity-funding. Ekpu and Paloni (2015), Bikker and Vervliet (2017) and López-Penabad et al. (2022) considered lending as an increasing factor of profitability of banks.

Therefore, in the statistical models of this thesis, vector W represents bank-specific control variables, and it consists of the size of the bank, that is the natural logarithm of total assets (Assets), lending, that is the loans and advances to customers divided by total assets (Loans), share of wholesale-funding, that is the wholesale-funding divided by total funding excluding derivatives (WSF) and

share of equity, that is the total equity divided by total assets (Equity). These ratios are obtained from Moody's Analytics BankFocus -database, which includes consolidated financial statements of 1467 bank groups from the eurozone, Denmark, Japan, Sweden, and Switzerland. Definitions and sources of these bank-specific control variables are listed in APPENDIX 1. The data in the database covers period from 2010 to 2022, so each ratio each year from all the banks is considered. TABLE 3 presents the number of each of the variables, the mean of each of the variables, standard deviation in each of the variables, and maximum and minimum values.

Following Salas and Saurina (2002), Albertazzi and Gambacorta (2009) and Tan and Floros (2012), vector X in the statistical models of this thesis represents macroeconomic control variables, and it consists of annual growth of the real gross domestic product (GDP) and annual growth of inflation, that is measured as the growth of the consumer price index (CPI). Annual growths of GDP and CPI each year between 2010 and 2022 in the eurozone, Denmark, Japan, Sweden, and Switzerland are obtained from the database of the World Bank (2024). Definitions and sources of these macroeconomic control variables are listed in APPENDIX 1.

TABLE 3 presents the number of the two macroeconomic control variables, the mean of both variables, standard deviation in both variables, and maximum and minimum values. FIGURE 4 illustrates the evolution of these macroeconomic control variables in relation to the evolution of policy and short-term interest rates. TABLE 4 is the correlation matrix. Correlation of 0.80 and higher is considered as a sign of multicollinearity (Gujarati & Porter, 2009, as cited in Ekpu & Paloni, 2015) and here, it can be observed that there is no multicollinearity between the explanatory and control variables. Only exception is the correlation of 0.92 between the two explanatory variables, policy and short-term interest rates, which for the sake of the research does not matter as these two variables are not used in the same model.

TABLE 3 Descriptive statistics of annual bank-specific and macroeconomic variables from bank groups in the eurozone, Denmark, Japan, Sweden, and Switzerland between 2010 and 2022.

Variable	Obs.	Mean	SD	Max.	Min.
Bank-specific control variables					
Assets	12 755	9.152	2.115	14.854	0.045
Loans	12 465	51.988	23.781	99.097	-68.984
WSF	12 325	36.023	32.723	100.291	0.000
Equity	12 755	11.739	12.907	88.757	1.525
Macroeconomic control variables					
GDP	65	1.706	2.179	6.845	-6.096
CPI	65	1.214	1.856	8.395	-1.144

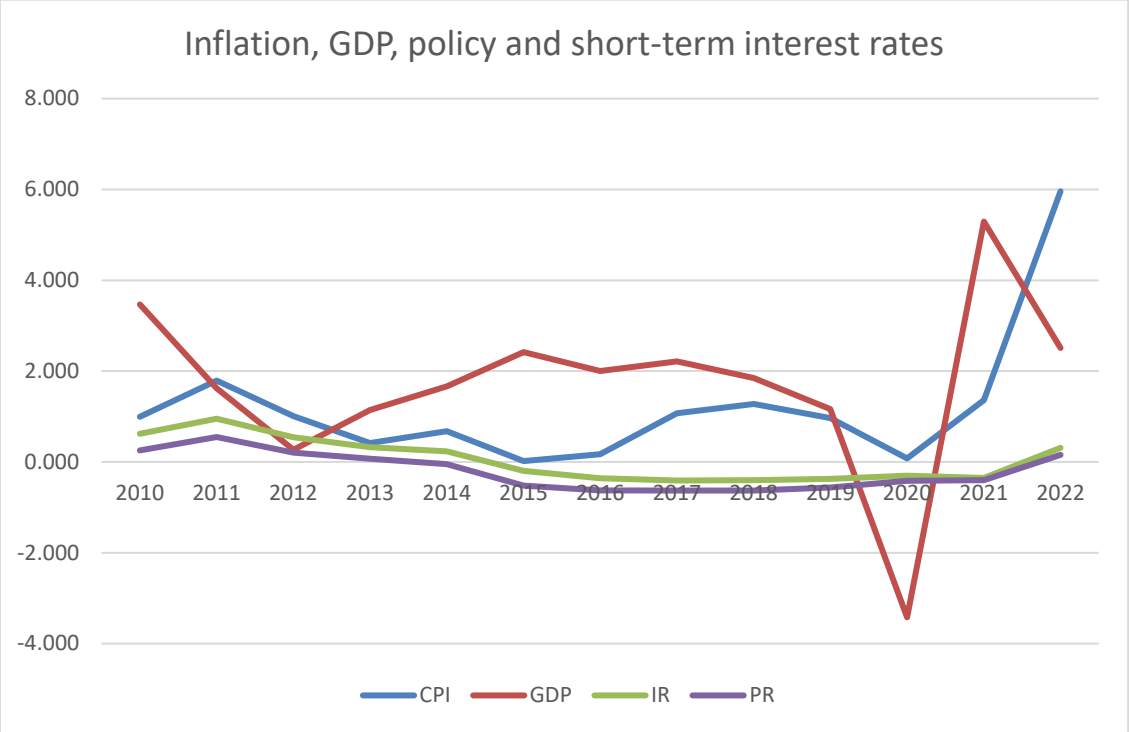

FIGURE 5 Evolution of annual, average growth of consumer price index (CPI), growth of real gross domestic product (GDP), month-end policy rate of central banks (PR) and annual, average three-month interbank money market rate (IR) of the eurozone, Denmark, Japan, Sweden, and Switzerland between 2010 and 2022.

TABLE 4 Correlation matrix of the correlations between the response, explanatory, and control variables.

	NIM	NII	ROAA	ROAE	IMP	Assets	WSF	Loans	Equity	IR	NIRP	GDP	CPI
Response variables													
NIM	1												
NII	-0.1	1											
ROAA	0.03	0.36	1										
ROAE	0.12	0.22	0.59	1									
IMP	0.25	-0.06	-0.20	-0.13	1								
Bank-specific control variables													
Assets	-0.10	-0.34	-0.17	-0.04	-0.09	1							
WSF	-0.01	0.28	0.16	0.09	0.05	0.05	1						
Loans	0.34	-0.30	-0.15	-0.07	0.22	0.16	-0.01	1					
Equity	-0.01	0.52	0.39	0.06	0.05	-0.46	0.32	-0.29	1				
Explanatory variables													
IR	0.04	-0.05	-0.07	-0.02	0.11	0.07	0.09	0.04	0.01	1			
NIRP	-0.01	-0.05	-0.07	-0.05	0.05	0.09	0.04	0.01	0.01	0.92	1		
Macroeconomic control variables													
GDP	0.02	0.02	0.05	0.12	0	-0.01	0.01	0.01	-0.01	0	0.01	1	
CPI	0.03	-0.02	0.01	0.05	-0.02	0.02	0.06	0.05	-0.02	0.30	0.32	0.29	1

4.6 Endogeneity

Endogeneity means that an explanatory variable of a model correlates with the error term of the model (Jeffrey, 2016, p. 88). Endogeneity could be caused by causal loop, that is, the profitability measures of banks might affect the balance sheet items and

monetary policy used in the research (Bikker & Vervliet, 2017; Borio et al., 2017). Another potential cause for endogeneity could be the omitted variable bias (OVB) (Bikker & Vervliet, 2017). OVB occurs when model leaves one or more relevant variables out (Jeffrey, 2016, p. 89-93).

In this research, the potential endogeneity is addressed by lagging explanatory and control variables with one period and including individual-specific and time-fixed effects (López-Penabad et al., 2022). In addition, Borio et al. (2017) suggest that with these types of sample characteristics, endogeneity is not necessarily a serious problem. While the profitability of all the banks might affect monetary policy, the effect of an individual bank on monetary policy is not that strong. The same applies to the short-term interest rate in a region: profitability of a bank in a certain region is important for the macroeconomic conditions in that region but does not affect macroeconomic conditions in other regions.

4.7 Data transformation and modification

The coefficients of NIRP and short-term interest rate were estimated with R software (later referred to as R) and written in R programming language itself. Data from Moody's Analytics BankFocus (later referred to as BF), OECD, central banks, BIS, and World Bank were divided into three excels before imported into the software: one containing the profitability measures from BF, one containing the bank-specific control variables from BF, and one containing the different policy and short-term interest rates and macroeconomic control variables from the other above-mentioned sources. While still in Excel, order number column as well as names of the banks were removed from the BF-datasets as useless for the sake of the research, the names of the ratios were converted into symbols used in the research, and cells containing values denoted as "n.a.", not available, were turned into empty cells, so that R would be able to read them correctly.

After importing all three datasets into R, natural logarithms of total assets of each bank each year were calculated and used onwards. In both datasets from BF, all the ratios from each year were in their own columns. In R, the data was converted from this wide format into long format. At this point, the outliers of the profitability measures and bank-specific control variables, that is the values smaller than first percentile or bigger than 99th percentile, excluding missing values, were defined, and filtered away from the data. Then, BF-datasets were converted into a wider format again, but this time only the ratios were divided into separate columns. Years were left in one column, so that the datasets were still in a long, panel format. At this point, mean profitability measures were calculated to draw FIGURE 4. Now, these two datasets from BF were combined by matching identification numbers of the banks, years, and countries. At this point, descriptive statistics from all the datasets were calculated. Then, BF-data and rest of the variables were combined by matching years and countries, and correlation matrix was built. The different policy rates were turned into a binary

variable, which takes value of one, if the policy rate was negative and value of zero, if positive, and year dummies were defined.

Lagged short-term interest rates and policy rates were plotted separately against each of the profitability rates. As no linearity was observed, I had to choose either a fixed or random effects model (Greene & Zhang, n.d.). To decide between these two, Chi-squared test statistics were calculated for each of the five profitability measures with both models 1 and 2, that is ten models in total, with Hausman test. All the p-values, except in the estimation of the effect of short-term interest rates on NIM, were below the significance level of five percent, which implies that the individual-specific effects in the data do correlate with the explanatory variables. Thus, to estimate the effects of both NIRP and short-term interest rate on the profitability measures, fixed effects models would be more suitable than random effects models. The results from these models are presented in section 5.

4.8 Autocorrelation and heteroscedasticity

After running the estimations, autocorrelation and heteroscedasticity were checked. Autocorrelation occurs when the error terms in a regression model are correlated with each other over time (Smith, 2023). Heteroscedasticity occurs when the variance of the error terms in a model is not the same (Hayes, 2022). To check for autocorrelation, I calculated the Chi-squared test statistics for each of the ten models with Breusch-Godfrey -test and one lag, as this specific test is suitable for data structured in panel format and allows to choose the lag length (Millo, n.d.). All the p-values were below the significance level of five percent, so there was autocorrelation in the models. To check for heteroscedasticity, I calculated the Chi-squared test statistics for each of the ten models with Breusch-Pagan -test, which is suitable for panel models (Shah, 2023). Heteroscedasticity, that is p-values below the significance level of five percent, was observed in all the estimations.

Autocorrelation and heteroscedasticity needed to be considered when interpreting the estimated coefficients from the model. Therefore, following the footsteps of Molyneux et al. (2019) and López-Penabad et al. (2022), I calculated clustered, robust standard errors for each of the ten models by building each of them a Newey-West -covariance matrix. For this I used the vcovHC-function in R. The method was defined as "arellano" which allows a fully general structure with respect to autocorrelation and heteroscedasticity (Millo & Croissant, n.d.). HC1 was used as the covariance matrix estimator. The number of observations in each of the ten models to the number of explanatory variables (1) is way over 50 and thus, considered as very high (MacKinnon & White, 1985). Therefore, all the covariance matrix estimators address heteroscedasticity accurately enough, so the choice of the estimator did not make any change (MacKinnon & White, 1985). Data was not pre-whitened beforehand, that is the data was not transformed to remove autocorrelation before calculating the heteroscedasticity-

consistent matrix, so the matrix was calculated from the original residuals of the model (Andrews & Monahan, 1992).

Finally, at this point, summary of the model and the covariance matrix in R returned estimated coefficients along with clustered, robust standard errors, that address autocorrelation and heteroscedasticity.

5 RESULTS

In this section, I present the estimation results of the statistical models 1 and 2 that allow to evaluate the effects of NIRP and short-term interest rate on profitability measures of the respective banks. TABLE 5 shows the results for the profitability measures NIM, NII, ROAA, ROAE, and impaired loans. The panels have not been balanced, that is the missing values have not been removed, because regression leaves them automatically out of the estimations. Thus, the number of observations and banks varies depending on the response variable in question.

Results obtained for the parameter α_1 suggest that in the eurozone, Denmark, Japan, Sweden, and Switzerland, when NIRP was implemented between 2010 and 2022, it decreased ROAE and increased the share of impaired loans of the respective banks statistically significantly by 84.5 and 101.4 basis points, respectively. Hypotheses 1 and 2 must be rejected because no statistically significant relationship was observed between implementation of NIRP and NIM, ROAA, and NII of the respective banks.

Results obtained for the parameter β_1 suggest that there is a statistically significant, negative relationship between short-term interest rate and ROAE of the respective banks. In the eurozone, Denmark, Japan, Sweden, and Switzerland between 2010 and 2022, the short-term interest rate decreased ROAE of the respective banks on average by 107.2 basis points. Hypotheses 3 and 4 must be rejected because no statistically significant relationship was observed between short-term interest rate and NIM of the respective banks nor between short-term interest rate and share of impaired loans of the respective banks.

Regarding the bank-specific control variables, there is a statistically significant negative relationship between size of the bank measured by natural logarithm of total assets and NIM of the respective bank. The result is in line with those obtained by López-Penabad et al. (2022). Statistically significant negative relationship was observed also between size of the bank and NII of the respective bank, and the result follows the same path as those obtained by Lopez et al. (2020), but it is contrary to results by Molyneux et al. (2019). ROAE size seems to affect

positively, which in turn is in line with the results obtained by Goddard et al. (2004). Size affects positively also ROAA and share of impaired loans.

Share of wholesale-funding affects positively the impaired loans of the respective banks. The result is in line with those obtained by López-Penabad et al. (2022). Lending of the bank affects positively both NIM and impaired loans of the bank. Risk aversion of the bank affects positively NII and ROAA of the respective banks. Regarding the macroeconomic control variables, there seems to be statistically significant positive relationship between growth of GDP and NII, ROAA and ROAE of the respective banks. Growth of CPI seems to affect negatively impaired loans of the respective banks and positively ROAE of the respective banks.

TABLE 5 Estimation results of the statistical models 1 and 2. ', *, **, and *** indicate statistical significance at five, one, 0.1, and zero percent levels, respectively. Robust standard errors clustered at the bank level are reported below the estimations.

Response variable	NIM		NII		ROAA		ROAE		IMP	
Model	1	2	1	2	1	2	1	2	1	2
NIRP/IR	0.060	-0.089	0.014	-0.191	-0.004	-0.003	-0.845**	-1.072***	1.014*	-0.214
	(0.053)	(0.061)	(0.146)	(0.142)	(0.083)	(0.009)	(0.325)	(0.319)	(0.409)	(0.274)
Bank-specific control variables										
Assets	-0.172'	-0.177*	-0.621***	-0.628***	0.304*	0.304*	1.513***	1.484***	1.388**	1.395**
	(0.089)	(0.090)	(0.172)	(0.172)	(0.119)	(0.119)	(0.440)	(0.440)	(0.474)	(0.475)
WSF	0.001	0.001	-0.002	-0.002	-0.002	-0.002	0.001	0.003	0.033*	0.036*
	(0.003)	(0.003)	(0.006)	(0.006)	(0.003)	(0.003)	(0.010)	(0.010)	(0.016)	(0.016)
Loans	0.021***	0.021***	-0.008	-0.008	0.004	0.004	0.016	0.016	0.060***	0.059**
	(0.004)	(0.004)	(0.007)	(0.007)	(0.003)	(0.003)	(0.012)	(0.012)	(0.018)	(0.018)
Equity	0.000	0.000	0.025'	0.024'	0.053***	0.053***	0.027	0.024	-0.001	-0.002
	(0.005)	(0.005)	(0.015)	(0.015)	(0.011)	(0.011)	(0.029)	(0.029)	(0.040)	(0.040)
Macroeconomic control variables										
GDP	-0.005	-0.006	0.049'	0.043'	0.061***	0.061***	0.417***	0.362***	0.036	0.058
	(0.009)	(0.007)	(0.027)	(0.022)	(0.015)	(0.014)	(0.055)	(0.051)	(0.045)	(0.038)
CPI	0.009	0.007	0.007	0.025	-0.001	0.000	-0.029	0.258***	-0.246*	-0.438***
	(0.018)	(0.009)	(0.040)	(0.023)	(0.021)	(0.015)	(0.089)	(0.061)	(0.114)	(0.067)
No. of observations	11 929	11 929	11 872	11 872	12 049	12 049	11 580	11 580	5 559	5 559
No. of banks	1374	1374	1369	1369	1384	1384	1374	1374	817	817

6 DISCUSSION

6.1 The effect of NIRP and short-term interest rates

This thesis makes three new contributions to existing literature. The first one is the observation of a positive relationship between implementation of NIRP and impaired loans of the respective banks. When the interest rates decrease, banks increase their lending to use their reserves held at the central bank and thus avoid paying negative deposit rates on them, and to cover the interest income loss, just as central banks intended. So, banks allow lower-quality collateral for longer horizons at lower costs, which would then increase the share of impaired loans in their loan portfolio (Lopez et al., 2020; Lauritzen, 2022).

The second contribution is that implementation of NIRP decreases the ROAE of the respective banks. As implementation of NIRP increases the share of impaired loans, the profit, total assets, and equity of the respective banks decrease, which leads to decreased ROAE, so these two results are connected to each other. When the share of impaired loans and lending in general increases, loan loss provisions should be increased as well and indeed, this positive relationship between implementation of NIRP and loan loss provisions of the respective banks as well as between short-term interest rates and loan loss provisions of the respective banks was discovered by López-Penabad et al. (2022) and Borio et al. (2017), respectively. Therefore, it can be assumed, that when the share of impaired loans increases, the loan loss provisions increase as well, which decreases profit, assets, and equity of the respective banks even further, and thus, the ROAE.

The third contribution of this thesis is the interesting observation that there seems to be a negative relationship also between the short-term interest rate and ROAE of the respective banks. In other words, if the short-term interest rate was to rise, it would decrease ROAE even further. Similar result was obtained by Borio et al. (2017), who discovered that relationship between short-term interest

rate and profitability of banks was concave rather than linear. In practice this implies that the effect of short-term interest rate on profitability diminishes the more the interest rate changes. Borio et al. (2017) suspected that this puzzling behavior could stem from the retail deposits endowment effect. This effect means that banks tend to price their deposits rates below short-term interest rates to enhance their profitability by investing and lending with higher rates. However, when NIRP was implemented and short-term interest rates fell, deposit rates did not fall as quickly. Indeed, Beckmann et al. (2021) highlighted that due to the fear of bank run, deposit rates were strictly tied to the ZLB. Another possible explanation for the concave relationship between short-term interest rates and profitability introduced by Borio et al. (2017) is that demand for loans is more sensitive to short-term interest rates than demand for deposits. So, when interest rates fell, demand for loans increased and even though the decreased interest rates harmed profitability, the increased demand for loans compensated for it. Vice versa, when interest rates increase, the demand for loans decreases and might affect profitability of banks negatively.

Increased share of impaired loans suggests that the goal of the central banks was reached, and banks did increase their lending, which is in line with the results obtained by Lopez et al. (2020) and Lauritzen (2022). In addition, the negative relationship between short-term interest rates and ROAE of the respective banks suggests that demand for loans increased (Borio et al., 2017). However, contrary to the results obtained by Molyneux et al. (2019) and López-Penabad et al. (2022) but in line with the results obtained by Lopez et al. (2020) and Junttila et al. (2021), it seems that implementation of NIRP did not decrease NIM of the respective banks. Lopez et al. (2020) suggest that the loan rates were not decreased that much more than the deposit rates, so the effect on NIM is not significant. But by expanding their loan clientele and allowing lower-quality collaterals for longer horizons at lower costs, the share of impaired loans increases and instead of interest income loss, the increased share of impaired loans is what harms the overall profitability of banks measured as ROAE. This alarming development must be closely monitored in the future. However, the overall profitability measured as ROAA is not harmed, because the change in the equity is relatively bigger than the change in the assets.

In this situation, to maintain the level of ROAE without increasing lending even further, and thus, the share of impaired loans, banks could increase their NII. This positive relationship between implementation of NIRP and NII of the respective banks was discovered by Molyneux et al. (2019) and Lopez et al. (2020), but the fact that the relationship was not found in this thesis, suggests that this possibility was not as widely exploited as it could be. In addition to NIRP, other unconventional monetary policy tools of the central bank, such as asset purchase programs and expanded lending operations could be exploited to balance out the effects that extensive lending has on ROAE. For example, a sale of securities to the central bank decreases assets of the bank which in turn maintains both ROAA and ROAE of the bank. Alternatively, by taking a loan from the central bank with low costs enough, equity could be increased and thus, the ROAE.

6.2 The effect of bank characteristics and macroeconomics

According to Turati (2002, as cited in Ekpu & Paloni, 2015), loans provided by banks account for about 55 percent of assets of a bank. This suggests that lending is a very important source of profit for a bank. Therefore, lending measured as the share of loans from total assets was one of the control variables in this research and the more loans were provided by the bank, the higher the NIM and share of impaired loans of the bank. Results are obvious because the more loans the bank provides, the more interest income it receives, which leads to higher NIM. Naturally, increased lending leads to increased impaired loans as well, when lower-quality collaterals for longer horizons at lower costs are allowed.

An important factor in the profitability of banks seems to be the size of the bank. In this thesis, I observed that the larger the bank, the worse the NIM. Findings are supported by the previous literature. Demirgüç-Kunt and Huizinga (2013) suggest that large banks could have lowered their loan rates during NIRP more than small banks because of the cost efficiency provided by their size, which in turn would imply that negative interest rates affected large banks' interest income even more than small banks. Alessandri and Nelson (2015) found that even when hedged against the interest rate risk, large banks are more exposed to it than small banks.

Contrary to the findings of Molyneux et al. (2019) and Junttila et al. (2021) but in line with the findings of Lopez et al. (2020), it seems that the larger the bank, the worse the NII. Lopez et al. (2020) suggested that especially small banks increased their NII, because they had fewer options to compensate for the interest income loss caused by implementation of NIRP. For example, again due to the cost efficiency provided by their size, larger banks appeared to be more capable to reduce deposit and other interest expenses than their smaller counterparts.

In this research, there is a positive relationship between size and ROAA of a bank which is in accordance with the results obtained by Molyneux et al. (2019), who found that implementation of NIRP decreased ROA of especially small banks. In addition, size seems to be an improving factor of ROAE of the respective banks. Result is in line with those obtained by Junttila et al. (2021), who found that the effect of short-term interest rates on ROE of the respective banks varied with size: strongest positive relationship was observed between the short-term interest rates and ROE of large banks.

These positive relationships between size, ROAA, and ROAE imply that during the period of NIRP, the larger the bank, the better the ROAA and ROAE. Both Molyneux et al. (2019) and Junttila et al. (2021) based their findings on the fact, that even though all the banks have had the possibility to increase their share of wholesale-funding, the largest banks have had the greatest interest in doing so and increase their profitability this way. Additionally, Molyneux et al. (2019) suggest that implementation of NIRP enabled large banks to take greater advantage of declining funding costs and that through hedging, lending, and

income diversification, they are better at protecting themselves against interest rate risk.

López-Penabad et al. (2022) found that size affects positively loan loss provisions, and, in this thesis, I discovered a positive relationship between size of the bank and share of impaired loans of the bank. Molyneux et al. (2019) suggested that large banks would lend more than small banks. In this light, it would make sense that the share of impaired loans of large banks and the respective loan loss provisions would then be greater than in small banks.

The share of equity in a bank affects positively NII and ROAA of the respective banks. More equity-funded banks are required to generate higher profit due to the risky nature of equity-funding compared to, for example, more deposit- and wholesale-funded banks, which would explain the higher ROAA. Another explanation could stem from funding structure: less deposit-funded, and more equity-funded banks do not need to pay such high interest expenses, which would then lead to both higher equity to assets -ratio as well as higher profit and thus, higher ROAA. Additionally, if the bank is less deposit-funded and more equity-funded, they could have more sources of NII. However, this interesting relationship does require some further research. The share of wholesale-funding has a positive effect on impaired loans, which implies that banks which were more wholesale-funded increased their lending more than, for example, deposit-funded banks.

Economic growth, measured as the growth rate of GDP, affects positively NII, ROAA and ROAE of the respective banks. This implies that profitability of banks increases during expansionary phase of the economy and decreases during recession. As customers have more money to spend during expansion, banks provide more loans, thus making more interest income and improving their overall profitability measured as ROAA and ROAE of the banks. Increased banking activity affects positively the NII of the banks, such as fees and commissions.

Inflation, measured as the growth rate of CPI, affects ROAE of the respective banks positively, when the explanatory variable is short-term interest rates, and share of the impaired loans of the respective banks negatively. Mishkin (2016, p. 125) illustrated how during normal times, interest rates and inflation go hand in hand. So, when inflation increases, interest rates would increase too, which would then generate more interest income for banks. In addition, as the price level increases, so do the prices of bank and thus, their profit. Even though also bank must pay higher prices, it seems like the increase in price level benefits banks more than decrease. Then again, when the inflation volatility is high, bank managers behave more conservatively (Caglayan & Xu, 2016). They might tighten lending conditions and thus, decrease the share of impaired loans. For example, in the sample data of this thesis, the coefficient of variation in inflation is over one, which is considered as high volatility.

6.3 Future research

The underlying assumption in this thesis was that implementation of NIRP lowered interest rates used by banks, and indeed, by just observing the development of the short-term interest rate during the period of negative policy rates (see FIGURE 3), it can be concluded that the interest rates were lowered. However, due to the incomplete pass-through of the policy rates, the actual extent to which the interest rates were lowered, remains an open question. Analysing this question would require using the actual deposit rates of banks as a response variable, and this type of data is more difficult to attain. Thus, exploring this question is left for the future research.

The increase in the share of impaired loans caused by implementation of NIRP, and the following decrease of ROAE is an alarming observation, which requires closer inspection and monitoring in the future. In addition, the positive effect of equity on NII of the respective banks during the era of negative policy rates suggests that equity-funded banks could have more sources of NII, but this interesting observation requires some further research. The positive effect of inflation on ROAE combined with the negative effect on impaired loans suggests the banks benefit more from the price level increase than decrease, but again, this relationship is left for the future research to be more closely studied.

7 CONCLUSIONS

To boost the economy after GFC, since 2014 central banks of the eurozone, Denmark, Japan, Sweden, and Switzerland have introduced NIRP. This unconventional monetary policy tool did not have as powerful an effect as it was hoped for, because banks hesitated to pass the negative deposit rates on to their customers in the fear of bank run. The incomplete passthrough was expected to lead to a loss of NIM and therefore profitability of banks.

So far, it seems that contrary to the expectations, NIRP did not harm the overall profitability of banks, because banks were able to offset the losses by, for example, increasing their NII. However, as NIRP was exited only recently, in September 2022, there is no research of the effects of NIRP on profitability of banks covering the whole era of negative policy rates. Therefore, this thesis contributes to the existing literature by studying the effects that implementation of NIRP had on profitability of banks from data covering the whole era of negative policy rates, from 2014 to 2022 and thus, form a comprehensive picture of the effects on all the main components of banks' profitability.

Because of the incomplete passthrough of the negative policy rates, short-term interest rates used in the eurozone, Denmark, Japan, Sweden, and Switzerland over the period between 2010 to 2022 reflect more appropriately the actual interest rates used in the banks. Thus, in addition to the effect of NIRP, I studied the effect of short-term interest rates on the profitability of banks. The average short-term interest rate was 0.04 percent during the research period.

The main findings in this research are the positive relationship between implementation of NIRP and share of impaired loans of the respective banks, and the negative relationship between implementation of NIRP and ROAE of the respective banks, as well as between short-term interest rates and ROAE of the respective banks. These results are connected to each other. As intended by the central banks, negative policy rates encouraged banks to increase lending. This led to increased loan loss provisions and impaired loans, which in turn decreased profit, equity, and assets. The decrease in equity was relatively high compared to the others and thus led to decreased ROAE.

So, even though Beckmann et al. (2021) argued that loan rates were decreased relatively more than deposit rates, Lopez et al. (2020) suspected that the drop of loan rates was not that much larger than of deposit rates, that it would have affected the interest income of banks. Instead, the decrease in profitability is caused by the consequences of increased lending. This theory of maintaining sustainable loan rates and increasing lending is supported by Borio et al. (2017) who pointed out that as the short-term interest rates fall, the demand for loans increases. This phenomenon might also cause the concave, negative relationship between the short-term interest rate and ROAE of the respective banks. Another possible explanation for this non-linearity could be caused by the retail deposits endowment effect, that is the more the short-term interest rates fall, the less the deposit rates fall. Therefore, the effect of short-term interest rates on profitability diminishes as the rates keep falling.

Especially size seems to be an important factor in the profitability of banks during the era of negative policy rates. Demirgüç-Kunt and Huizinga (2013) and Lopez et al. (2020) argue that small banks do not have as many options to cover interest income losses as large banks, so they do not lower their loan rates as much as large banks and they rely more on NII sources. However, the overall profitability measured as ROAA and ROAE is higher in large banks. Both Molyneux et al. (2019) and Junttila et al. (2021) believe that large banks have increased their share of wholesale-funding more. They benefited more from the decrease in interest expenses due to economies of scale and increased lending more, which then led to an increased share of impaired loans.

Other important factors of the profitability of banks during the era of negative policy rates are lending of the bank, their share of wholesale-funding, and share of equity. As anticipated, the more loans banks provide, the more they make interest income, which increases their NIM. While expanding their loan clientele, the share of impaired loans increases as well. The share of wholesale-funding has a positive effect on impaired loans, which implies that banks which were more wholesale-funded increased their lending more than, for example, deposit-funded banks. More equity-funded banks are required to earn more profit due to the risky nature of equity-funding, which is observed in this research as a positive effect of equity on ROAA, and they seem to exploit NII sources more than deposit-funded banks. In addition, during expansionary phases of the business cycle, which we have been experiencing since the GFC,

profitability of banks increases. Interestingly, banks seem to benefit also from inflation.

In conclusion, implementation of NIRP increased lending and thus, share of impaired loans, which in turn decreased ROAE of the respective banks. The increased demand for loans resulting from reduced loan rates, coupled with the retail deposits endowment effect, contributed to a negative relationship between short-term interest rate and ROAE. To maintain ROAE, tools such as increased NII or participating in the asset purchase programmes and expanded lending operations conducted by central banks could be exploited by banks even more.

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APPENDICES

APPENDIX 1: Descriptions and sources of model variables

Variable	Symbol	Units	Definition	Database
Banks' profitability measures				
Net interest margin	NIM	percentage	Difference between bank's interest income and expenses, divided by average total assets	Moody's Analytics BankFocus
Non-interest income	NII	percentage	Non-interest income divided by average total assets	Moody's Analytics BankFocus
Impaired loans	IMP	percentage	Impaired loans divided by average risk weighted assets	Moody's Analytics BankFocus
Return on average assets	ROAA	percentage	Profit divided by average total assets	Moody's Analytics BankFocus
Return on average equity	ROAE	percentage	Profit divided by average total equity	Moody's Analytics BankFocus
Interest rate environment measures				
Negative interest rate policy	NIRP	binary	Value of one if annual average of month-end policy rate is negative, value of zero otherwise	Central banks, CEIC, and Bank for International Settlements
Short term interest rate	IR	percentage	Annual, average three-month interbank money market interest rate	Organization for Economic Co-operation and Development
Bank-specific control variables				
Size	Assets	logarithm	Natural logarithm of total assets	Moody's Analytics BankFocus
Share of equity	Equity	percentage	Total equity divided by total assets	Moody's Analytics BankFocus

Lending	Loans	percentage	Loans and advances to customers divided by total assets	Moody's Analytics BankFocus
Share of wholesale-funding	WSF	percentage	Wholesale-funding divided by total funding excluding derivatives	Moody's Analytics BankFocus
Macroeconomic control variables				
Economic growth	GDP	percentage	Annual growth of the real gross domestic product	World Bank
Inflation growth	CPI	percentage	Annual growth of the consumer price index	World Bank

APPENDIX 2: Disclosure on artificial intelligence tools

The work done in this thesis was supported by artificial intelligence tools, more specifically ChatGPT developed by OpenAI. The tool was used for improving the coherence and structure of the language in this thesis mostly through rephrasing and optimizing sentences. Furthermore, AI-tools were utilized in the statistical analysis to check, validate, and improve the code used in R. The usage of ChatGPT in this context aimed to enhance the quality and effectiveness of this master's thesis. The AI tool served as a valuable resource for language improvement, code validation and optimization, and communication clarity within the thesis, all while taking precautions to prevent plagiarism. It is important to note that while ChatGPT played a role in this aspect, the research, analysis, and conclusions presented in this thesis remain the result of human effort and expertise, with ChatGPT serving as a complementary tool to aid in the writing and validation process.