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The impact of negative interest rates on Nordic banks' riskiness

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Abstract:

This thesis examines if the negative interest rates increased Nordic banks' risk-taking and whether there are specific factors that have affected to the overall riskiness of Nordic banks. The prolonged period of negative interest rate policy (NIRP) have raised concerns about the health of European banking sector and how negative deposit rates affect banks' net worth and profitability. It is found that funding structure could affect banks' risk appetite and especially banks with higher share of deposits and traditional business models, tend to increase their credit risk by lending to riskier borrowers.

Previous literature find that the transmission of negative interest rates is not unambiguous and depends on the various bank specific characteristics and country specific factors. In order to measure banks' risk taking behavior, the development of banks' risky assets to total assets need to be examined. By using non-traditional difference-in-differences setup, Nordic banks' risk-taking behavior can be assessed and compared to the non-NIRP-adopter countries. This paper focuses mainly on comparing differences in monetary policy across in broadly comparable countries.

As found in the previous literature, it is expected that banks affected by NIRP reduce their loan prices, increase debt financing and by increasing their lending activity, banks are aiming to maintain their profitability. The empirical findings reported in this thesis suggest that after the implementation of negative interest rates, Nordic banks have had relatively healthy balance sheets and there has not been a clear shift to riskier lending to help the weak profitability. Furthermore, NIRP has had relatively similar effect on both treatment (Nordic banks) and control (non-NIRP-adopter banks) groups.

To conclude, this thesis does not support the previous findings where negative interest rates have increased banks' risk-taking significantly. However, the actual consequences of the ECB's negative interest rate policy are still unknown. It will be difficult to predict will the banks' stability be disturbed, when the record-high inflation rate is pushing the ECB to increase the policy rates at a rapid pace. When the interest rates take a steep upward turn, the maturity risk realizes and banks' ability to pay interest to customers deposits endangers. Therefore, the spillover effects of the ECB's expansionary monetary policy and the racing inflation might have long-lasting impact on the stability of the global banking sector.

KEYWORDS: negative interest rates, monetary policy, Nordic banking sector, risk factors

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1 Introduction

In 2014 the European Central Bank (ECB) became the first central bank to introduce negative interest rates as part of their many other unconventional monetary policy tools in their fight against deflationary risks and dragging growth rates. Since 2014, the ECB cut its deposit facility rate four more times reaching an all-time low of -0.50% in September 2019. The prolonged period of negative interest rate policy (NIRP) raised concerns about the health of the European banking sector and how negative deposit rates affect banks' net worth and profitability. Furthermore, researchers found that funding structure could affect banks' risk appetite to compensate for the negative-yielding deposits held in their balance sheets (Demiralp, Eisenschmidt, & Vlassoupoulous, 2021).

Heider, Saidi, and Schepens (2019) have found that banks with a higher share of deposits and traditional business models tend to increase their credit risk by lending to riskier borrowers to maintain profitability. Therefore, banks' squeezing net interest margins and increasing funding costs continued to raise concerns about the riskiness of the European banks. However, Molyneux, Reghezza, and Xie's (2019) prove that the transmission of negative interest rates is not unambiguous and depends on bank-specific characteristics such as size, funding structure and business model. Moreover, they find that country-specific factors such as inflation and GDP growth can affect the pass-through of NIRP. Thus, considering the Euro area's heterogeneity, euro banks' responsiveness to NIRP might vary greatly. It is necessary to research the impact of NIRP on different banking sectors in the Euro area.

In this thesis, Nordic banks' riskiness and responsiveness to NIRP are taken into closer inspection. In order to measure banks' risk-taking behavior, the development of banks' risky assets to total assets needs to be examined. By using the difference-in-differences methodology, Nordic banks' risk-taking behavior can be assessed and compared to the non-NIRP-adopter countries. This paper closely follows Bongiovanni, Reghezza, Santamaria, and Williams' (2021) research, where it is found that, against the previous

findings, banks that adopted negative interest rates reduced the share of risky assets after the implementation of NIRP. Whereas the previous literature has focused on the Euro area, the purpose of this thesis is to evaluate whether the Nordic banking sector has reacted in a similar way to the uncertainty and risk factors as the whole Euro area and what are the differences in Nordic banks' risk-taking behavior in comparison to non-NIRP-adopter banks.

1.1 Purpose of the study

The purpose of this study is to examine if the negative interest rates increased Nordic banks' risk-taking and examine whether there are specific factors that have affected to the overall riskiness of Nordic banks. According to the existing literature on the NIRP effect on the euro area banks, NIRP-adopter banks increased their lending, and well-capitalized banks increased bank risk in less competitive markets during the NIRP-era. The Nordic banking sector is smaller and less competitive compared to the rest of Europe. By investigating the characteristics of the Nordic banking sector, useful information can be found regarding the NIRP-effect on Nordic banks as a part of the Euro area. Furthermore, it is interesting to learn if Nordic banks' risk-taking behavior follows a similar path to other euro area banks in the previous studies or if there are deviating country-specific characteristics that affect Nordic banks' response to NIRP.

1.2 Formulation of hypotheses

The research hypotheses are introduced in this chapter. In this thesis, we focus on the Nordic banking sector and its ability to endure the uncertainty caused by NIRP. According to the previous findings, low and negative interest rates increase banks' risk-taking and lending activity. However, the results are not unambiguous and are mainly related to the country- and bank-specific characteristics, as presented in this thesis. We are interested in finding characteristics that determine Nordic banks' risk-taking behavior and their

ability to battle against low profitability during ultra-low interest rates. Thus, the following hypotheses are formulated:

H0: Negative interest rates did not have an impact on Nordic banks' riskiness

H1: Negative interest rates increased Nordic banks' risk-taking

1.3 Structure of the study

This thesis focuses on the Nordic banking sector and banks' capability to respond to the ongoing uncertainty in the economic environment during the NIRP era. Before looking into the Nordic banks' risk taking behavior, chapter 2 covers previous literature that examines other Euro banks and their responsiveness to NIRP. To understand better the complete picture of the functionality of the banking sector, chapter 3 discusses banking related risks and the characteristics Nordic banking sector in more detail. The ECB's implementation of negative interest rates and the different transmission channels of monetary policy are introduced in chapter 4. Data and methodology are covered in chapter 5. Finally, results are introduced in chapter 6 and chapter 7 concludes.

2 Previous literature

Plenty of literature researches negative interest rates and how they have affected different economies across Europe. Researchers have studied how negative interest rates were implemented through different channels, how the unconventional monetary policy has changed banks' lending activity and profitability, and how NIRP has served its purpose on increasing the inflation. Many of these studies touch on bank risk and measure the development of banks' risk appetite.

Demiralp et al. (2021) investigate how NIRP has affected banks in the euro area and evaluate banks' reactions to rate cuts during NIRP in comparison to standard rate cuts. They have found that high-deposit banks with excess liquidity have greater exposure to NIRP, thus increasing risk-taking by lending to riskier counterparties and patching up the lost income from deposits. Demiralp et al. (2021) find that rate cuts in the negative rate environment are not comparable to standard rate cuts due to the fact that banks are hesitant to charge negative rates from retail customers' deposits. Thus, the costs from retail deposits are a burden that cannot be erased with rate cuts, increasing banks' willingness to seek more profitable and riskier funding sources. (Demiralp et al., 2021).

Heider et al. (2019) argue that high-deposit banks' net worth decreases due to higher funding costs caused by NIRP. Consequently, high-deposit banks in the euro area reduce their lending and increase risk-taking. This is a highly unusual phenomenon, as banks with more deposits are usually perceived as more stable and reliable than low-deposit banks. In addition, Heider et al. (2019) suggest that NIRP has an inverse effect on the euro area's inflation, as their findings show that ECB's unconventional monetary policy has caused limited monetary stimulus and financial instability for euro banks.

Similarly to this thesis, Molyneux et al. (2019) paper focus on country and bank-specific factors that define the banks' responsiveness to the NIRP effect. According to their study, Molyneux et al. (2019) find that after the implementation of NIRP, NIRP-adopter banks' profits and margins fell compared to those banks that did not adopt the policy. This

response can be explained by the factors such as banks' size, liquidity and business models. Moreover, the pass-through of any monetary policy is mainly determined by the size of the banking system and the level of competition.

Another study that this thesis closely follows is the paper constructed by Bongiovanni, Reghezza, Santamaria, and Williams (2021). Their paper investigates whether the negative interest rates have affected the risk-taking behavior of euro banks. Again, country- and bank-specific variables are used to measure the development of risky assets and lending. The authors utilize the difference-in-differences methodology and thus compares euro banks to non-NIRP-adopter banks, which is very similar to Molyneux et al. (2019) study. The results point out that the NIRP-adopter banks become less risky by reducing their risky assets compared to non-NIRP-adopter banks. Bongiovanni et al. (2021) elaborate that the unexpected outcome results from decreased loan growth, loan prices and increased amount of safer assets.

On the other hand, as stated in this thesis, the measured NIRP effect is heterogeneous across the euro banks and determined by bank-specific characteristics. For example, Bongiovanni et al. (2021) find that strongly capitalized banks operating in a less competitive environment tend to take more risk and seek greater margins. These findings support the "less skin in the game" hypothesis.

3 The banking sector

Banking sector is one of the key elements of the current society. Banking sectors' principle duty is to solve market imperfections and enable sufficient flow of funds from different counterparties to another (Buckle and Beccalli, 2011). Banks are the intermediaries between lenders and borrowers and they facilitate economy's liquidity in order to enable the financing of counterparties taking their preferences, needs and riskiness into account. Due to the fact that countries' economies and cultures are different, also the banking sectors all around the world vary substantially and aim to respond to the needs of the current economy (Buckle & Beccalli, 2011).

However, Nordic banking sectors are relatively similar and share plenty of similar characteristics and the Nordic banking region is heavily concentrated. Rapidly developed digital banking services, customer behavior and the changes in demographic factors, such as the aging population, are all similar qualities that Nordic banking sectors have. Nordic banking employs approximately 123 000 people, and economics and business are among the most common education in Nordic countries (Finanssiala, 2019). Thus, in this thesis the Nordic banking region is treated as one counterparty rather than examined Nordic countries individually.

In the following subchapters Nordic banking sector is taken into more close inspection. First, banks role as financial intermediaries as a whole is presented and later banking related risks and the main characteristics of the Nordic banking sector are introduced.

3.1 Banks as financial intermediaries

Casu, Girardone & Molyneux (2006) explain that banks' core task is to transmit funds between savers and borrowers. Therefore, banks can be associated as financial intermediaries, and their main function is to connect the needs of different counterparties and allocate the funds to the most profitable areas. Banks transform

small, low-risk and liquid deposits into larger, higher risk and illiquid loans. In other words, banks enhance economic efficiency by productively allocating resources (Casu, Girardone & Molyneux, 2006).

Financial intermediaries are not necessarily needed, but banks help to ease the information asymmetries and additional costs that might occur while practicing direct lending (Casu, Girardone & Molyneux, 2006: s. 6). Such transaction costs and information asymmetries are examples of market insufficiencies, that banks are trying to mitigate. Banks charge fees from borrowers and lenders by acting as financial intermediaries to maintain organized and efficient financial markets. In order to gain profit, banks charge higher interest on loans than the interest they pay to their depositors. Thus, banks need to evaluate their fees so that their services outweigh the customers' costs and are more profitable for everyone compared to direct finance.

In today's banking system, financial intermediation has become more complex and banking activities include more counterparties with more complex needs than just borrowing or depositing money (Casu, Girardone & Molyneux, 2006). Therefore, more banking related risks arise and need to be considered when balancing the needs of customers and other financial intermediaries.

3.2 Banking related risks

Banks are often the first counterparties to face the challenges of changing political or economic environments. Banks' primary objective is to maximize profits and shareholder value like any other business. In addition, banks manage loans and other financing instruments that enable companies to function and develop globally and allow regular people to buy homes. Therefore, risk management is in a crucial role in the banking sectors' everyday function. (Buckle & Beccalli, 2011)

Bank regulation managed by financial supervisory authorities requires transparency and careful weighting of different banking related risks, as banks are responsible for preserving funds safely and reliably. Most importantly, banks operate as financial intermediaries that should help to increase returns to shareholders without unnecessary risks. Due to the nature of today's banking sectors, which are globally linked and thus more affected by cross-border risks, the need for extra cautiousness and transparency has increased remarkably.

3.2.1 Credit risk

Credit risk is the most profound risk in banking, and it is the most critical risk linked with the assets held by a bank (Choudhry, 2022; Buckle & Beccalli, 2011). The definition of credit risk is the risk that a customer will default on a loan (Choudhry, 2022). Thus, expected cash flows from loans and securities may not be paid in full or in time and this negatively affects the present value of the bank's assets as well (Buckle & Beccalli, 2011). Thus, the financial solidity of a bank deteriorates.

The state of the economy is one of the most important measures for credit risk (Buckle & Beccalli, 2011). For example, in 2007, the significant credit quality decline was caused by the subprime mortgage crisis, which later expanded to the global banking crisis. In the 2007 crisis, a large amount of mortgage loans defaulted, which further assisted the collapse of Lehman Brothers – one of the largest banks in the world (Buckle & Beccalli, 2011). Buckle and Beccalli (2011) suggest multiple solutions to control credit risk such as screening, monitoring, credit rationing and diversification. By screening the customers, banks can estimate borrowers' probability of default. Banks gather information about their customers internally or from external credit agencies, and in this way they can screen out the poor credit risks from their credit pool.

Banks can write covenants into loans to monitor customers' future actions. In this way, banks can improve the probability of the repayment of loans. Credit rationing can be

done in two ways: banks grant a lower loan amount than the borrower has applied and banks refuse to grant loans with a higher interest rate. In the first case, banks aim to avoid the possibility of borrowers' increasing incentives to engage in high-risk activities with a greater loan amount. In the second case, if the borrower is willing to pay a higher interest rate on a loan they are considered a higher-risk borrower and a high-interest rate might increase the probability of default. (Buckle & Beccalli, 2011).

Lastly, diversifying the loan portfolio is the most common way to mitigate credit risk. This means that banks grant loans to different kinds of borrowers and avoid focusing on certain target customers. Thus, the group of risky assets is merged into a larger, more diversified and less risky loan portfolio.

3.2.2 Liquidity risk

Liquidity risk is a result of multiple factors. Bank's liquidity risk includes the balance sheet's both sides, assets and liabilities. On the assets side, it comes from the ability of a bank to sell securities to raise funding; on the other hand, the liabilities side of the balance sheet liquidity risk comes from a loss of funding. Banks can manage their liquidity risk by diversifying the funding sources and increasing the number of good-quality assets. (Buckle & Beccalli, 2011)

Buckle and Beccalli (2011) highlight that one of the key strategies to mitigate liquidity risk is to keep a stable deposit base. This is achieved by extending the pool of depositors and attracting deposits from different depositors. With a greater variety of depositors, the probability of withdrawals simultaneously is less likely. Another solution to liquidity risk management is hoarding a large amount of highly liquid assets and in need of cash, they can be sold at any time. However, this strategy causes greater costs for banks, as safe and liquid assets generate lower returns than riskier ones. Eventually, maintaining such a liquidity buffer becomes a burden for a bank. Therefore, most banks gather more deposits to manage their liquidity risk.

3.2.3 Interest rate risk

Interest rate risk realizes when the maturities of assets and liabilities are mismatched and there are changes in the market interest rates. Buckle and Beccalli (2011) explain that the primary reason for interest rate risk is that the average maturity of liabilities are shorter than assets.

When there are changes in market interest rates, two risks arise – income effect and market value effect. The income effect can be divided into reinvestment risk and refinancing risk. Refinancing risk is the scenario where the cost of reborrowing funds is higher than the returns earned on the investments, whereas the reinvestment risk occurs when the cost of funds is higher than the returns on funds to be reinvested. Compared to the income effect, the market value effect refers to the change in the present value of cash flows on assets and liabilities. Whenever interest rates move up, the discount rate on cash flows increases and the prices of assets and liabilities are reduced. (Buckle & Beccalli, 2011)

Interest rate risk is avoided by matching the maturities of liabilities and assets. However, this is not always possible; for example, it is unprofitable for banks to match their short-term liabilities to long-term assets. Therefore, banks will keep their balance sheet unmatched at a certain level to keep the business productive and risk tolerable. (Buckle & Beccalli, 2011)

3.2.4 Market risk

Banks face uncertainties regarding their loan and trading portfolios when market rates change. This is called market risk. Buckle and Beccalli (2011) elaborate that the market risk is a combination of interest rate risk, equity price risk, commodity price risk and

foreign exchange risk. Thus, market risk is a complex set of factors that can be difficult to control.

An important note is that assets held for trading are held in a bank's trading book, distinct from the loans held in a bank's banking book. Riskier securities are put in the trading books, and banks benefit from lower capital requirements. Buckle and Beccalli (2011) show that banks' trading activities have grown significantly and the income generated from these activities has become more prominent than traditional banking activities. Due to the beforementioned features, some critics have argued that banks that collect deposits should not practice asset trading.

3.3 The Nordic banking sector

The Nordic banks in Norway, Denmark, Sweden and Finland have a lot of common features. Therefore Nordics should be treated as one region rather than examine each country's banking sector as its own. The Nordic banking sector has shown strong profitability and capital adequacy in European comparisons. The main factors for better-than-average profitability in Nordic countries are the low levels of non-performing loans and loan losses. However, heavy concentration in the Nordic banking sector also creates many common threats. For example, Nordic banks are heavily interconnected to each other via their assets and funding. Thus, they share the same risks related to bank stability. In addition, their systemic risks relate mainly to lending to the residential and commercial real estate markets. (Savolainen & Tölö, 2017)

Cross-border banking has a strong presence in the Nordic region. Nordea is the largest bank in the Nordics, resulting of a merger of two large banks in 1997, the Finnish Merita Bank and the Swedish Nordbanken. Another large Nordic bank, the Danish Danske Bank, merged with Sampo Bank in 2006. Amongst others, there are multiple other Nordic banks operating in Finland in more focused and smaller business areas. (Savolainen & Tölö, 2017)

Generally, the Nordic banks are stable and well-rated in the international stress tests. In measuring asset quality, most of the risks on banks' balance sheets are a lending-related credit risk. Banks grant loans to households and non-financial corporations, whereas many household loans are housing loans. Due to the real-estate collateral, they are lower risk than most of the other loans. On the other hand, the relatively high loans-to-deposits ratio should be considered a possible risk factor that should be measured carefully. Some researchers propose that Nordic banks should pay attention to the high levels of household debt together with the substantial rise in house prices. Households are highly indebted in the Nordic countries and previous research papers have shown a strong link between household debt accumulation and financial crises. (Savolainen & Tölö, 2017)

In recent years, ultra-low interest rates have pressured the Nordic banking sector's net interest income downward. Despite the highly unusual economic environment, the development in bank profitability has been good. Regarding return on equity and cost-to-income ratio, Norway and Sweden are the most successful in the Nordics. The Danish banks have been improving their profitability steadily over the years after the financial crisis, despite being the most affected by it. Unlike other Nordic countries, the Finnish banking sector bears a high share of net income from trading and investment activities in total profits while suffering a decrease in the share of net interest income. (Savolainen & Tölö, 2017)

The Finnish banking sector is highly concentrated as the Nordic banks in general. In 2021 Finnish banking sector consisted of 208 credit institutions, and due to several mergers, the amount is 20 fewer than in 2020. Banks have a significant role as an employer, as Finnish banks employed 19 695 people in 2021. To highlight the Finnish banking sector's concentration, most banks belong to a banking group or amalgamation. Three of the largest banks operating in Finland (OP, Nordea & Danske Bank) dominate the share of granted loans and deposits, holding 68,9% and 76,9%, respectively. Like other Nordic

countries, Finnish banks' profitability has been at a good level for several years and a significant share of granted loans are housing loans. In addition, the amount of non-performing assets has remained low. In general, the Finnish banking sector's loss-absorbing capacity has proven to be secure and solid. (Finance Finland, 2021)

In December 2020, there were in total of 121 banks operating in Sweden. The Swedish banking sector employs over 41 000 people and there were 1231 bank branches in the country in 2020. The Swedish banking industry accounts for 4,5% of the GDP and has an important role in the Swedish economy. Due to rapid change to cashless and more electronic everyday banking, Sweden is the leading country in non-cash payments in European measures. The Swedish banking sector also has a lot of business outside of Nordics, such as in Baltics. (EBF Sweden, 2021)

In line with other Nordics, in 2020, Swedish household lending increased to 5,7% compared to 5,2% in the previous year. This can be explained due to increasing house prices, a trend in the Nordic countries during Covid-19. In addition, perhaps due to the uncertainties created by the coronavirus, household deposits increased by 11% in 2020 from the previous year's 5%. Deposits account for 35% of household financial assets, which is Sweden's most common household financial asset. According to the financial stability reports, Swedish banks have high capital and strong profit-ability and the banks' performing loan ratio is the lowest in Europe. (EBF Sweden, 2021)

Together with Sweden, the Danish banking sector has been efficient in its digitalization efforts in retail banking. For example, the number of branches of Danish banks has decreased in five years from 1004 (2015) to 740 (2020). In addition, the total number of banks decreased due to the mergers from 109 in 2015 to 90 in 2020. These numbers include foreign and Faroese banks. The Danish banks employed 35 555 people in 2020 and the financial sector plays a pivotal role in the Danish economy as a value creator and employer. According to the figures of 2017, the financial sector contributes to the welfare of Denmark by paying around 6,8 billion kroner in taxes. (Finance Denmark, 2021)

Among its peers in the Nordics, mortgage loans is an essential part of the Danish financial sector. The total amount of granted mortgage loans accounts for 80% of the total lending in the country. The bank profitability is also good, but there have been challenges due to covid restrictions and negative interest rates. Denmark was one of the first countries to introduce a negative interest rate policy in 2012 and ever since that the banking sector has had to find ways to fill in the gaps in bank profitability. (Finance Denmark, 2021)

Unlike other Nordics, Norway's banking sector is relatively small and banks do not have such a prominent role concerning GDP. This is due to a smaller amount of cross-border banking activities. Domestic banks dominate the banking sector, as in 2020 118 of 134 banks were Norwegian. However, foreign banks hold a higher corporate market share, accounting for 33% of the total market. For example, Finnish Nordea Bank is the second largest bank in Norway and Danske Bank and Handelsbanken also have a great share of the Norwegian market. Again, loans cover most of the Norwegian banks' assets, and the most significant shares are mortgage loans and real estate loans. (Norges Bank, 2022; EBF Norway, 2021)

The funding for Norwegian banks comes mainly from deposits and bonds. Deposits account for 40% and long-term wholesale funding 30% of the total funding. The total banking sector assets were 669 billion euros in 2020. What is worth mentioning is that the majority of the Norwegian banks' wholesale funding is raised in foreign currency. This exposes Norwegian banks to foreign exchange risks in addition to the beforementioned banking-related risks. On the other hand, like the rest of the Nordics, Norwegian banks have good capital adequacy and the capability to handle financial turbulence. (EBF Norway, 2021)

As mentioned in this section, the Nordic banking sector is considered stable and relatively risk-tolerant compared to its European peers. Despite the challenging times of Covid-19, Nordic banks have managed to keep their profitability at a tolerable level and

the losses have not reached the magnitude that was expected at the beginning of the pandemic. While the European Union's GDP suffered severely from the virus, contracting by -5,9%, the Nordics managed to dodge the most intense economic hit (Tapia & Tragotsis, 2021). The average contraction of GDP in the Nordic region was -3.0% in 2020. The economic outcomes of Covid-19 in the Nordic countries varied to some extent. Norway was the least affected with a GDP contraction of -0.7%, while Denmark shrunk around -2.1%, Finland -2,3% and Sweden -2,9%. (Tapia & Tragotsis, 2021).

4 ECB's negative interest rate policy

Since 2014, several central banks have implemented the negative interest rate policy both in and outside Europe. These banks include the European Central Bank (ECB), Danmarks Nationalbank (DNB), the Swiss National Bank (SNB), the Swedish Riksbank, the Bank of Japan (BOJ), and the Central Bank of Hungary (MNB) (European Central Bank, 2020). This unconventional monetary policy tool is due to the global financial crisis and its radical and far-reaching effects on economic growth and soundness. According to Arteta, Kose, Stocker and Taskin (2018), by utilizing NIRP, both the ECB and Riksbank aimed to stabilize inflation expectations and increase growth, whereas SNB and DNB tried to tackle currency appreciation and capital inflow pressures. With these unique methods, central banks have been fighting against the zero-lower bound constraints to further their monetary easing actions (Arteta et al., 2018).

Negative interest rates are a highly unusual phenomenon. The general assumption before the global financial crisis was that policy interest rates are bounded at zero and further reductions into negative territory could lead to severe problems, such as impaired effectiveness of monetary policy in inducing inflation and limited ability to increase economic activity (Inhoffen, Pekanov & Url, 2021). Thus, negative interest rates were expected to cripple traditional monetary policy channels. There are only a few events in the past when negative rates have been introduced briefly. For example, in 2009 due to the financial crisis, Riksbank briefly lowered its deposit facility rate below zero in order to ease the biggest shock (Arteta et al., 2018).

Arteta et al. (2018) explain that at the beginning of the NIRP era, the main reasons behind the unconventional monetary policy were weakened demand, fear of deflation and dragging growth. Therefore, the ECB lowered its deposit facility rate below zero down to -0.10% for the first time in June 2014 to increase lending activity amongst banks in the euro area, assist economic recovery and halt low inflation and increase the inflation rates to a little under 2%. After implementing the NIRP, central banks have charged commercial banks for keeping their excess reserves in their accounts. Usually,

banks would avoid holding large excess cash reserves as the deposit policy rates normally are in the positive territory and below money market rates. However, commercial banks are more eager to maintain higher balances in central bank deposit facilities during these uncertain times. (Arteta et al., 2018)

According to the European Central Bank (2020), by charging for banks' excess liquidity, central banks in NIRP-adopter countries encourage commercial banks to increase their lending activity. The negative interest rates on excess liquidity reduce banks' profitability and increase costs on their liabilities since the fees are bounded at zero. To avoid this unusual problem, banks have to reallocate their portfolios toward credit expansion and purchasing more securities. Similar to standard rate cuts, easing measures through NIRP operate through the bank lending channel of monetary policy. (European Central Bank, 2020)

Thus far, Heider et al. (2019) and other researchers have argued that modestly negative interest rates affect lending and inflation similarly to rate cuts in positive territory. However, concerns have been about a prolonged period of significantly negative interest rates. Some researchers claim that NIRP has served its purpose, increased lending, and created economic soundness during the current environment (Arteta et al., 2018). On the contrary, several researchers argue that these unconventional monetary policy tools have increased financial stability risks and decreased banks' willingness to lend (Arteta et al., 2018). The total outcome of NIRP is still debatable and highly uncertain, as the ECB has launched other monetary policy easing tools, such as TLTROs and quantitative easing. Due to these additional unconventional monetary policy tools, it is difficult to distinguish which effects are caused by NIRP or other easing methods (Heider et al., 2019).

Monetary policy's role in preserving financial stability is still debated. Smets (2018) argues that the central banks should consider financial stability concerns when deciding on the optimal adjustment path for inflation. This preventive role for monetary policy is justified because the monetary stance affects the general attitude towards risk, the

allocation of credit and the strength of the financial cycle. These factors, in turn, influence the ability to maintain price stability (Smets, 2018). Due to this discussion, central banks are more responsible for maintaining financial stability and making price stability efficient (Smets, 2018).

Even though the overall outcome of a prolonged period of negative interest rates is still unknown, the ECB argues that the current policy has reached its goals regarding price stability and increasing economic activity (ECB, 2022). Due to the negative interest rate policy, the overall lending activity has increased and the creditworthiness of borrowers has improved, which has, in turn, helped to limit the negative impact of negative interest rates on bank profitability (Smets, 2018). In addition, ECB's unconventional methods have improved inflation expectations, which have been the primary concern in the past years and the euro area's GDP has increased between 2,5 and 3,0 percentage points (Smets, 2018).

According to Inhoffen et al. (2021), negative interest rate policy may generate risks such as cash hoarding, impacting the bank profitability by decreasing the interest rate income and creating asset price bubbles. However, the expected adverse outcomes have not materialized and the effective lower bound on interest rates are proven to be well below zero. Furthermore, Bongiovanni et al. (2021) find that after the implementation of NIRP, NIRP-adopter banks reduced their holdings of risky assets. During the NIRP period, banks in the euro area acquired safer and more liquid assets to strengthen their balance sheets and become more alert to uncertain market conditions (Bongiovanni et al., 2021). Thus, according to Inhoffen et al. (2021) and Bongiovanni et al. (2021) the unconventional monetary policy seems to have served its purpose of stabilizing the economic environment after the financial crisis.

4.1 Monetary policy transmission under NIRP

The monetary policy transmission is a mechanism that represents how monetary policy changes in nominal interest rates affect the real economy and, for example, employment. Monetary policy transmission mechanisms can be divided into different channels that work through such operations as bank lending, interest rates and company balance sheets. (Ireland, 2006)

In the transmission of monetary policy, the banking sector plays a significant role, which is highlighted in bank-centered financial systems such as the euro area (Demiralp et al., 2021). Monetary policy operates through different channels, later introduced in the following chapters. The global financial crisis displays an example of the importance of banks in the monetary policy transmission to the real economy since the instability and riskiness of some of the biggest banks shook the whole global economy (Albertazzi et al., 2020).

Demiralp et al. (2021) explain that changes in monetary policy and how they affect bank behavior are largely researched in cases where the policy rates have remained above zero. Therefore, it is unknown whether previous results apply to negative territory (Demiralp et al., 2021). The link between monetary policy and bank stability is remarkable, taking the size of the banking sector in the euro area into account (Albertazzi et al., 2020). In addition, countries inside the euro area are highly heterogeneous in terms of using fixed or adjustable rate mortgages. As mortgages are the most common liability of households in the euro area, this feature impacts monetary policy transmission (Albertazzi et al., 2020).

Prior to the introduction of negative rates, economists did not believe in the efficiency of negative interest rates, as it was assumed that the banks were hesitant to pass on the rate cuts below zero while the deposit facility rate was about to be decreased into the

negative territory (Albertazzi et al., 2020). Banks' reluctance to follow the unconventional monetary policy can be explained by multiple factors, such as legal restrictions and fear of customers moving their funds to cash or interest-bearing investments (Albertazzi et al., 2020).

Boucinha et al. (2020) argue that the policy rate cuts have affected the economy in the same way as regular rate cuts, thus easing the financial conditions in the euro area. Inhoffen et al. (2021) elaborate that the successful pass-through of the unconventional monetary policy interest rate and bank lending channels have played a key role in stabilizing the euro area's economic environment.

4.2 Transmission channels of monetary policy

In this thesis, three different transmission channels of monetary policy are taken into closer inspection: interest rate channel, bank lending channel and risk-taking channel. When examining factors such as banking sector's stability and functionality during negative interest rates, all three channels are linked to each other and together they carry out the ECB's expansionary monetary policy to the real economy.

4.2.1 Interest rate channel

A traditional view on interest rate channel explains that the changes in policy rates are transmitted to deposit and loan rates via the banking system. However, negative interest rate policy has shown that this standard view can be challenged, and the ultra-low interest rates have partly impaired the transmission mechanism of monetary policy. Due to the effective zero lower bound on retail deposits, banks' with deposit-based funding are challenged, and higher reliance on deposits creates difficulties in covering their funding costs. This phenomenon creates a lot of uncertainty and heterogeneity amongst the euro area's banks. The hindering zero lower bound squeezes high deposit banks'

profit margins and eventually, banks may increase their loan rates to cover their losses. Normally banks lower their loan rates during times of monetary easing. (Albertazzi et al, 2020)

When discussing the transmission channels of monetary policy, the importance of steering the short-term interest rates and thus affecting the long-term real interest rates are often highlighted. Once the monetary policy changes impact long-term interest rates, the real economy, such as employment and consumption, is affected. Therefore, one of the key monetary policy transmission mechanisms is the interest rate channel. (Albertazzi et al., 2020)

Monetary policy changes lead to an increase in the short-term nominal interest rate and eventually cause an increase in long-term interest rates. More precisely, this results from investors' behavior of arbitraging away differences in risk-adjusted expected returns on debt instruments of various maturities. Eventually, borrowers realize their real cost of debt over all maturities has increased, and they cut back their investment expenditures. As well as companies, households reduce their consumption in the high-interest rate environment, linked with lower aggregate output and employment. (Ireland, 2006)

Researchers have found that in the euro area, the interest rate pass-through is incomplete for some market sectors. For example, Belke, Beckmann and Verheyen (2013) and von Borstel, Eickmeier and Krippner (2016) argue that the interest rate pass-through is complete only for small company loans. The authors suggest that central banks have to practice more aggressive monetary policy activities to overcome this friction in the interest rate channel. In addition, it is found that bank interest rates are higher when the euro area financial markets are more fragmented, and thus, more aggressive measures are required for complete interest rate pass-through for the whole market.

4.2.2 Bank lending channel

As noted before, bank lending channel is another key transmission channel together with the interest rate channel. Expansionary monetary policy such as NIRP often increases banks' willingness to provide loans. There are several research done regarding this view and conflicting results have emerged. For example, Albertazzi et al. (2018) argue that the standard function of bank lending channel remains unchanged during NIRP, whereas Borio and Gambacorta (2017) find that the bank lending channel become less effective in NIRP environment. Demiralp et al. (2021) argue that the bank lending activity have increased during NIRP era.

According to Ireland (2006), banks hold a special position in the economy and the bank lending channel of monetary policy highlights banks role as an intermediary. Whereas companies and households need bank loans and depositary services, banks, especially smaller ones, are heavily reliant on customers' deposits. For smaller local banks, deposits are the main source of funds for lending. Thus, during NIRP-era expansionary monetary policy has led to the reduction in deposit profits and eventually cut back smaller banks' lending activity. If smaller high-deposit banks are not able to provide loans to their customers, companies and households will eventually seek loans from another bank with a broader funding base. In order to tackle the profitability issues, high-deposit banks have had to weight their options and decide whether they want to increase risky lending. (Ireland, 2006)

According to the conventional monetary policy, a monetary tightening raises the cost of issuing deposits, thus decreasing banks' willingness to lend. This traditional view of the bank lending channel relies heavily on the central banks' decisions on the reserve requirements. According to this formulation, if banks were not subject to reserve requirements, the mechanism would not be effective. Nowadays, however, monetary policy implementation targets a level of short-term interest rates, and the traditional bank lending channel is not a valid representation of a monetary policy transmission mechanism via banks. (Albertazzi et al., 2020)

Albertazzi et al. (2020) explain that the bank-specific features determine the ability of banks to grant loans when there are changes in monetary policy. Heider et al. (2019) support this argument by elaborating that during negative interest rate era, banks with greater share of deposits engage to greater risk-taking and grant less loans. On the contrary, banks that rely on market based funding are seen as more reliable lenders during negative interest rates. When the rates are positive, high-deposit banks are seen more stable lenders and therefore the ECB's unconventional monetary policy has turned the bank lending upside down. This is due to the fact that the monetary policy is only partly transmitted to the real economy. Furthermore, banks are hesitant to lower the deposit rates below zero, because they are afraid of large cash withdrawals. High deposit reserves become costly and high-deposit banks need to patch the losses by riskier lending.

4.2.3 Risk-taking channel

What monitors the risk-taking channel, are the changes in monetary policy that could affect banks' "risk appetite" and eventually the stability of the banking sector. High-deposit banks' tendency to move safer assets towards riskier ones supports the view of risk-taking channel of monetary policy. The risk-taking channel describes the banking sector's risk perceptions and risk tolerance whenever policy rates are adjusted. According to Heider et al. (2019), during NIRP era high-deposit banks increased riskier lending activity in order to avoid losses caused by higher retail deposit rates. Demiralp et al. (2021) elaborate that the higher asset prices compared to the low policy rates might increase banks' risk-taking behavior. This can be explained by the higher returns of riskier assets and one of the goals of quantitative easing policy is said to be banks' portfolio rebalancing towards more riskier assets.

However, Brunnermeier and Koby (2018) argue that there could be an ultimate lower bound for policy rates. According to their research, after -1.0% level increased risk-

taking and bank lending become contractionary for banks' profitability and financial stability. Therefore, further reductions in policy rates do not stimulate lending activity and banks do not benefit from increased risk-taking anymore. By reaching the ultimate lower bounds, banks could seek alternative risky funding sources and the ECB's expansionary monetary policy could lead to serious damages to the stability of global banking sector.

5 Methodology and data

In order to examine how negative interest rates have affected Nordic banks' riskiness, the banks need to be compared to non-NIRP-adopter countries' banks. Thus, the characteristics of Nordic banks can be highlighted if their risk-taking behavior differs significantly from non-NIRP-adopter banks. Similar to Bongiovanni et al. (2021), a difference-in-differences estimator is the most effective approach to properly determine the discrepancies in risk-taking behavior between Nordic NIRP-adopter and other non-NIRP-adopter countries. Abadie (2003) explains that the difference-in-differences method is a widely used tool for applied economics research, which allows analyses with a panel data regression. It can be used to compare treated banks with untreated banks.

In the difference-in-differences framework the two groups, control and treatment groups, are compared with each other to result in Y , the growth of risky assets for bank i in country j at time t (Bongiovanni et al., 2021). In this framework, the treatment group is Nordic banks and control group includes non-NIRP-adopter banks that are Canadian, Australian, Polish and British banks. The model follows the method used by Molyneux et al. (2019):

$$Y_{i,j,t} = \alpha + \beta_1(Treated_{i,j} * Post_{j,t}) + \beta_2 X_{i,j,t} + \gamma_j + \varphi_i + \varepsilon_{i,j,t} \quad (1)$$

where *Treated* is a variable that is 1 if the Nordic bank is more affected by NIRP than the non-NIRP-adopter banks, 0 otherwise. *Post_{j,t}* is a variable that is 1 after the period that country j decided to implement NIRP and 0 before adopting the policy and γ is a country specific factor that controls time-invariant and unobservable characteristics, and φ controls for time-varying shocks that affect banks' risk taking. The coefficient β_1 measures the difference in the growth of risky assets between banks in Nordic NIRP-adopting countries and other European NIRP-adopting countries. To control for possible heterogeneity between banks, the vector X is added to the equation. X includes bank and country specific variables that can influence banks' risk-taking. (Bongiovanni, 2021)

Using the difference-in-differences estimator, two assumptions need to be considered when testing the differences in the growth of risky assets between the treatment and control groups (Bongiovanni et al., 2021). First, the control group should comprise a proper counterfactual to the treatment group (Bongiovanni, 2021). Second, there should be a parallel trend between both control and treatment groups, which in this case means that both Nordic NIRP-adopter countries and non-NIRP-adopter countries should have similar trend lines before the introduction of NIRP (Bongiovanni, 2021).

5.1 Data

The data used in the empirical analysis is collected from the Fitch database. The bank-specific variables and dependent variable Risk ratio are obtained from Fitch database's bank financials data. Macroeconomic variables GDP and CPI has been gathered from World Bank open dataset for all eight countries used in the analysis. Bank-specific data comprises Nordic banks and their financials from 2013 to 2019 and there are in total of 267 Nordic banks that construct the treatment group. Fitch database covers 763 Nordic banks and the total amount of 1017 non-NIRP adopter banks used in the analysis. Due to a lack of consistent data for the eight-year period, many of the banks were left out, and there were in total 90 Finnish banks, 74 Swedish banks, 46 Norwegian banks and 57 Danish banks in the control group. The control group includes 86 Polish, 74 British, 43 Canadian and 26 Australian banks. Prior NIRP treatment and control groups have 266 and 267 observations and during the NIRP period there were 1049 and 1593 observations, respectively. Due to a lack of data, there are a few inconsistencies in the total observations of bank-specific variables. Loan growth and Liquidity have 10-20 less observations than other variables.

Table 1. Descriptive statistics

Descriptive statistics of treatment and control groups prior and during the NIRP-period												
Variables	Treatment						NIRP Period					
	N	Mean	St. Dev.	Min	Max	Statistic	N	Mean	St. Dev.	Min	Max	
<i>Panel A: Bank risk measure</i>												
RR	266	0,969	***	0,042	0,8	1	1,049	0,956	***	0,05	0,61	1
<i>Panel B: Bank descriptive variables</i>												
ETA	266	0,124	***	0,065	0,004	0,325	1,049	0,117	***	0,054	0,012	0,334
Funding structure	266	1,148		0,092	1,004	1,481	1,049	1,141	*	0,073	1,012	1,501
Loan growth	266	7,112		11,168	-14,46	91,37	1,049	7,231	*	14,121	-66,52	230,7
ROAA	266	0,821	*	0,765	-5,36	2,91	1,049	0,826	***	1,016	-15,22	5,74
Loan rates	266	4,405	***	1,873	0,09	13,53	1,049	3,649	***	1,929	0,07	15,27
NITOI	266	26,747		20,633	-101,46	97,07	1,049	25,249		175,195	-4,575,250	3,000,000
Liquidity	266	16,092	***	12,78	0	64,34	1,047	18,528		15,568	0	71,75
<i>Panel C: Macroeconomic variables</i>												
GDP	266	1,447	***	0,871	-0,902	2,658	1,049	2,187	***	0,912	-0,365	4,489
CPI	266	0,521	***	0,85	-0,18	2,12	1,049	1,343	***	0,899	-0,208	3,55
<i>Panel D: Bank risk measure</i>												
RR	267	0,912	***	0,102	0,114	1	1,593	0,89	***	0,111	0,167	1
<i>Panel E: Bank descriptive variables</i>												
ETA	267	0,097	***	0,081	-0,026	0,895	1,593	0,097	***	0,091	-0,043	1
Funding structure	267	1,156		0,561	0,974	9,533	1,592	1,391	*	5,434	1,002	168,625
Loan growth	265	22,609		207,502	-81,9	3,341,940	1,587	28,432	*	491,111	-100	17,108,890
ROAA	267	0,646	*	1,382	-9,89	7,59	1,593	0,607	***	1,766	-11,3	30,37
Loan rates	267	5,591	***	5,3	0,19	79,22	1,593	4,813	***	3,921	0,16	73,73
NITOI	267	29,16		27,063	-92,9	194,52	1,592	24,434		55,275	-1,883,330	378,44
Liquidity	263	20,667	***	18,284	0,02	93,36	1,573	18,551		17,21	0,01	99,64
<i>Panel F: Macroeconomic variables</i>												
GDP	267	1,905	***	0,477	1,126	2,6	1,593	2,654	***	1,077	0,659	5,354
CPI	267	1,744	***	0,688	0,938	2,45	1,593	1,643	***	0,589	0,368	2,558

5.2 Dependent variables

To measure banks risk-taking behavior, banks' risky assets should be evaluated. In their research, Bongiovanni et al. (2021) measure the riskiness of banks by using a dependent variable, which is a ratio of total assets, excluding cash and government securities, to a bank's total assets. Therefore, similar to Bongiovanni et al. (2021) dependent variable Risk ratio is the relation of a bank's risky assets to total assets. Risky assets are all assets excluding cash and government securities, and the development of these assets reflects the bank's risk appetite during uncertain times. Thus, decreasing the Risk ratio signals a lower share of risky assets on the bank's balance sheet.

5.3 Independent variables

Both bank-specific and macroeconomic variables are used as independent variables. Macroeconomic variables such as GDP growth and inflation affect each country's banking system and have yearly impact on each country's economic environment, whereas bank-specific variables determine how banks respond to these changes. In the following chapters the macroeconomic and bank-specific variables are examined and explained more thoroughly.

5.3.1 Bank-specific variables

For bank-specific variables, some standard variables and risk-focused measures are used. In this analysis, the bank-specific variables closely follow the ones used in previous research by Bongiovanni et al. (2021) and Molyneux et al. (2019). These variables evaluate banks' business model, funding structure and profitability.

Size is the natural logarithm of a bank's total assets and it is used to measure the relationship between risk appetite and the bank's size. According to the too-big-to-fail hypothesis, banks' risk appetite correlates with their size, proposing that bigger

international banks increase their risk-taking compared to smaller banks operating inside national borders. Especially in the Nordics, this variable plays a key role due to the greater number of small local banks, and some cooperative banks. Smaller cooperative banks' main business area is traditional banking services and greater risk-taking would endanger local customers' savings and loans. However, big banks are considered less risky due to the better resources to allocate risk and increase lending outside national borders.

The ratio of equity-to-assets (ETA) is widely used to measure bank's capitalization. ETA measures the bank's quality of capitalization, which is the level of debt used to finance assets. Therefore, higher value in ETA indicates lower amount of debt and less risk-taking. ETA evaluates banks' capability to repay all of its debt and thus being one of the most standard ratios to evaluate the healthiness of the business. However, banks that have lower ETA does not always indicate immediate problems in the business, rather seasons when the greater level of debt financing is needed for investments and creating new business operations. As mentioned in the previous chapters, greater risk-taking induces better profitability which often occurs in the environment of low interest rates.

Funding structure is the ratio of total customer deposits to total liabilities. The level of deposits measures banks' dependence on customer deposits, which has been one of the main concerns in the banking sector after the introduction of negative interest rates. After the interest rates fell below the former ultimate zero-bound, customer deposits that had been the conventional source of income for many banks had become a burden and banks started to pay customers for their deposits. Thus, majority of the banks started to charge customers with large amounts of cash on their accounts, such as corporates and institutions, causing them to steer their excess cash reserves to low risk investments in order to avoid the costs from banks. Eventually, banks have less costs for preserving cash and more incentives to replace the lost income with riskier lending and greater income. Thus, funding structure measures banks' possible increased risk-taking during the era of negative interest rates.

Loan growth is closely linked to the previously introduced variable funding structure. Whereas the growth of lending might increase banks' profitability, loan growth is also related to the increased level of riskiness. One of the ECB's main goals of NIRP policy was to accelerate lending activity through bank lending channel and in this way increase customers' spending and investing and attempting to push the lagging inflation close to 2 % target level. In addition, banks are able to tackle the costs of customer deposits by increasing their income from bank lending. Loan rates is used to measure the average loan price and it is the ratio of interest income on loans to average gross loans. The assumption is that the loan prices decrease during NIRP due to the banks' need to increase their lending activity.

ROAA is one of the most common variables to measure banks' profitability. ROAA (return on average assets) is ratio of returns for year t divided by the average of assets between years t-1 and t. ROAA is expected to decrease during NIRP era, as banks do not have their regular deposit income and banks have to replace the lost income with increased lending activity. If a bank is not willing to take greater risks in order to cover costly deposits, the ROAA squeezes into negative territory. Non-interest income to total operating income (NITOI) is used to measure banks' business model and how it might change from interest oriented to more service oriented during the ultra-low interest rate era.

Liquidity is the ratio of liquid assets to total assets. According to the previous research, the growth of liquid assets increases banks' incentives to route the excess cash to more profitable assets and increasing the level of risky assets. However, in an environment with fewer investment possibilities excess liquidity can be routed to less risky and less profitable assets, such as short term equities. Due to the extensive monetary easing measures banks and companies have had lots of cash that needs to be held in form of assets and equities that yield profits and this increases the excess liquidity. Supporting "less skin in the game" theory, greater amount of liquid assets and cash increases banks

motives to increase riskier lending activity. Therefore, banks increase lending and receive income from their lending activity, and they have possibilities to take more risks.

5.3.2 Macroeconomic variables

The macroeconomic variables used in this analysis are GDP growth and national inflation rates. These both factors affect countries' banking sectors in different ways depending on the banks' ability to forecast and respond to the macroeconomic changes. According to Albertazzi & Gambacorta (2009) GDP growth and bank profits are correlated, which is important to research when analyzing banks' risk taking behavior. As stated previously, NIRP has raised concerns about banks' profitability and how it can be preserved when conventional banking activities such as deposits are no longer an option. Therefore, a reduction in GDP could reflect to bank profits and eventually as an increased bank risk. On the other hand, Athanasoglou, Brissimis and Delis (2008) have found that increased GDP could have a positive effect on bank profits in a form of increased loan demand. The implications of GDP on profits and simultaneously bank risk are not ambiguous and mainly country specific.

Inflation is each country's annual Consumer Price Index. Albertazzi & Gambacorta (2009) show an inverse relationship between inflation and risk, as they explain that usually increasing inflation is linked with lower bank risk. However, it is possible that steeply increasing inflation could accelerate banks' risk taking if the market becomes more volatile. During the past 20 years inflation has been relatively low in the Euro area and the key interest rates have been steadily declining. According to the economic theories, low interest rate environment should encourage banks to increase risk in order to make up the lost profits from lower interest income. In addition, low interest rates accelerate banks' lending activity, which should boost inflation. However, during NIRP era the extensive lending activity practiced by banks did not increase inflation from its all-time low levels. Therefore, it should be investigated whether Albertazzi and Gambacorta's (2009) theory holds with negative interest rates as well.

6 Results

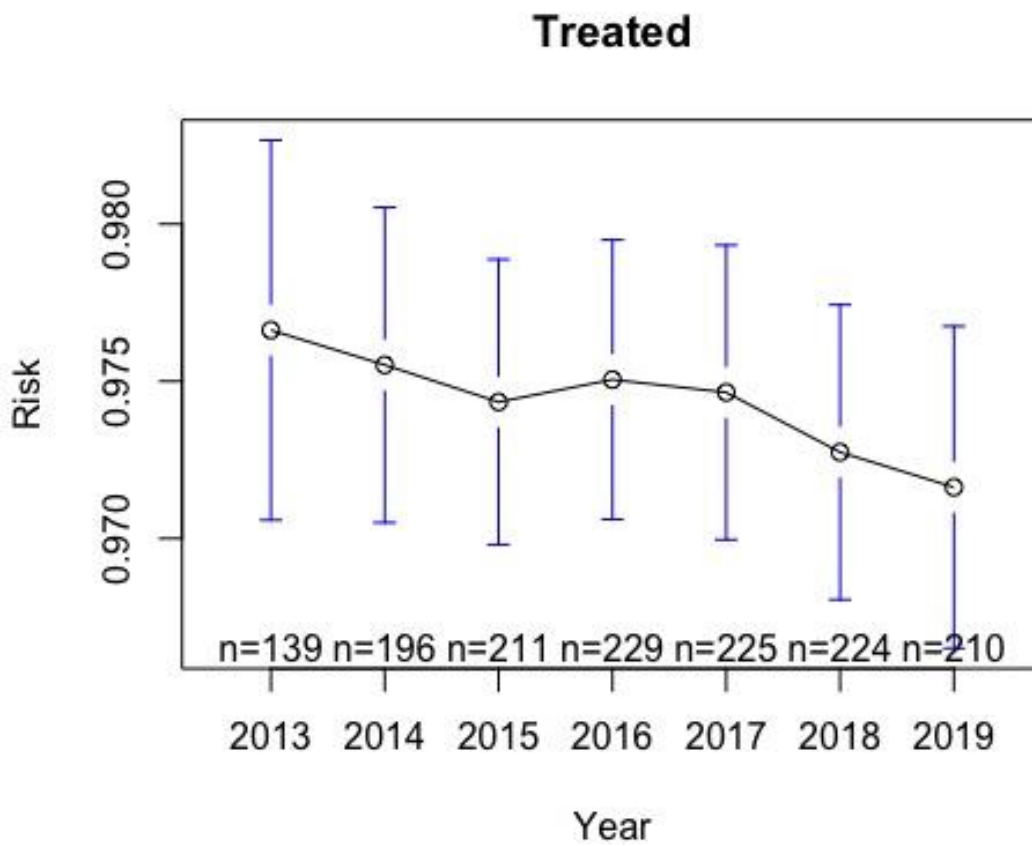
The descriptive statistics are presented in Table 1 and it is divided into two categories, treatment and control groups. Both groups include figures prior and after the introduction of NIRP and the overall time period is from 2013 to 2019. Overall the bank specific figures follows the expected direction as in both Molyneux et. al (2019) and Bongiovanni et al. (2021) papers. There are some few inconsistencies in the figures that can be mainly explained by the limitations of data.

As seen in Table 1, NIRP has relatively similar effect on both treatment and control groups. As expected, Nordic banks reduced their share of deposits and loan prices. At the same time their liquidity increased during NIRP period. In addition, Nordic banks increased their debt financing, which can be seen as an decrease in ETA by 0,7 percentage points. At the same time ROAA increased by 0,4 percentage points, which can be seen as a result of increased debt financing and loan growth. Both ETA and Loan rates have decreased and ROAA has increased at a 1% significance level. As stated in the previous chapters it is expected that banks affected by NIRP reduce their loan prices, increase debt financing and by increasing their lending activity, banks are aiming to maintain their profitability.

Control group's figures follow the same trend as the treatment group's, however it can be seen that non-NIRP adopter banks' funding structure changes to opposite direction than its counterparty group. A 24 percentage point increase in the funding structure implies that the non-NIRP adopter banks have increased their share of deposits in relation to total liabilities. Higher share of deposits is expected result as control group's banks have not adopted negative interest rates and therefore deposits are a source of profits. Taking other figures account, control group also has had similar development than treatment group in ROAA, ETA and Loan rates, all at significance level at 1%. Furthermore, it is notable to mention that whereas Nordic banks have had higher ETA and ROAA, control group has had less risky assets both prior and after the introduction of NIRP.

Figure 1 shows the share of treatment group's risky assets and it can be seen that after the introduction of NIRP there has decline in risky assets, excluding the years 2016 and 2017. The amount of risky assets declined by 1,3 percentage points at 1% significance level. Therefore, unlike the economic theories of banks' increased risk taking during low or negative interest rates, Nordic banks has reduced their risky assets.

Figure 1. Risk ratio development of Nordic banks



After the introduction of NIRP, control group's risky assets have similar trend as treatment group. According to the Figure 2 there has been a relatively steep decline in Risk ratio in years 2014 and 2015. From 2013 to 2019 the amount of risky assets declined

by 2,2 percentage points. As noted previously, control group's Risk ratio has been at a lower level at all times in comparison to treatment group. This is reasonable due to the fact that control group has not adopted negative interest rates and there is no pressure to find alternative sources for profits that are safe and considered as traditional banking services.

Figure 2. Risk ratio development of non-NIRP adopter banks

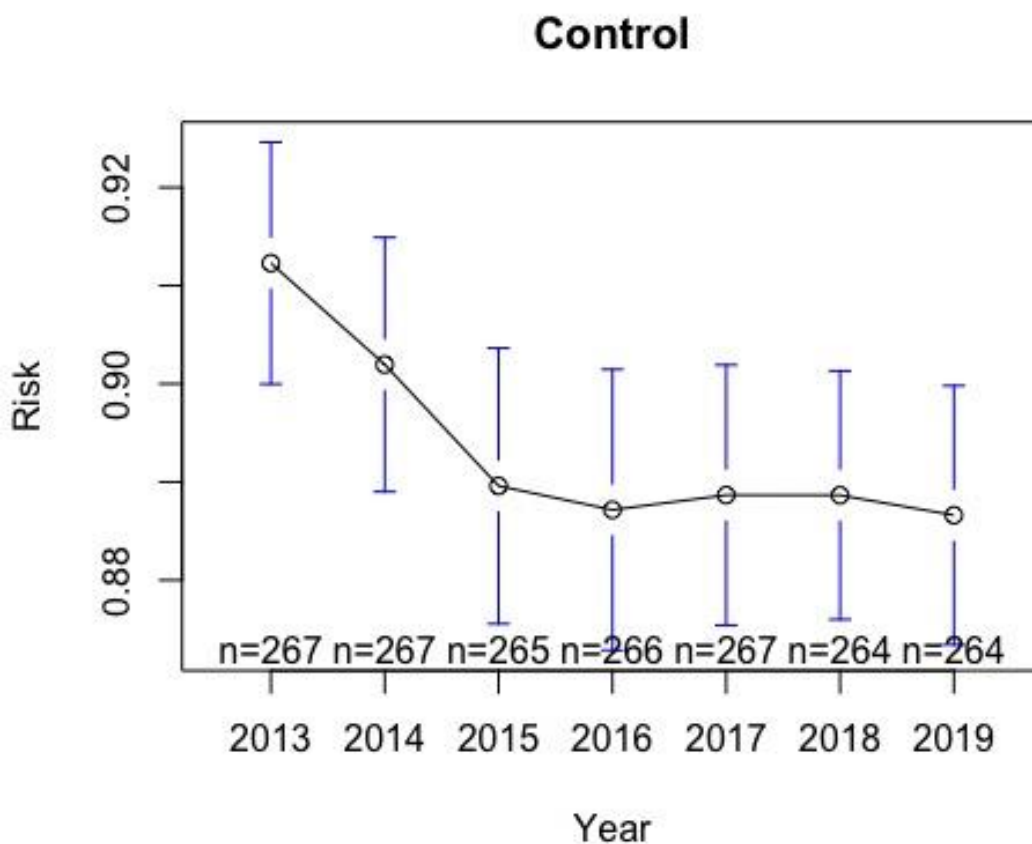


Table 2 shows the regression analysis and the measured NIRP-effect. Similarly to the previous findings, the NIRP effect is statistically significant at a 1% level and negative value implicates a 10 percentage point decrease in risky assets in Nordic banks. Therefore, the results generated from the regression analysis follows the pattern observed in the descriptive statistics and the analysis implies that the Nordic banks decreased the amount of risky assets after the introduction of NIRP. The outcome of this

analysis can be explained by multiple factors - however the ECB's unconventional monetary policy plays an essential role in the NIRP's adverse effect on banks' risk taking behavior. As mentioned in the chapter 4, the ECB launched different monetary easing tools such as quantitative easing, which helped NIRP-adopter banks to allocate their funds to safer and more liquid assets and increase their lending activity to tackle the issues with weaker profitability caused by lost income on deposits. Nordic central banks Riksbank and DNB have followed mainly similar path as the ECB in their easing methods and therefore the effects of NIRP are aligned in the Nordics as in the Euro area in general.

The rest of the regression analysis measures the NIRP-effect on country- and bank-specific variables. As it can be seen in the Table 2, the coefficient on Liquidity is statistically significant at a 5% level and the analysis shows an inverse relationship between liquidity and risk-taking, which implies that less liquid banks tend to take more risks. On the other hand, Bongiovanni et al (2021) suggests that this relation is a result of sufficient use of liquidity to manage balance sheet risk, which occurs when there are mismatches between assets' and liabilities' maturities.

ROAA, Loan rates and Size are statistically significant at a 10% level, which all support the previous findings of NIRP-effect on these variables. It is expected that the Loan rates decrease during NIRP as the lending activity amongst banks increases and the pricing for loans become more competitive. In addition, the regression analysis implies that a decrease in the bank size results as a greater the risk taking. This supports the theory of less skin-in-the-game, where smaller banks are more motivated to grant loans to riskier borrowers to boost their profitability. Despite the decrease in banks' overall risk taking and possibly more profitable business, banks' ROAA increased by 0,2 percentage points during NIRP period. Thus, it can be stated that in general banks managed to tackle profitability problems in a challenging NIRP environment.

It is important to note that there are some limitations regarding this thesis that might have an effect on the results. This paper focuses mainly on comparing differences in

monetary policy across in broadly comparable countries. Consequently, the setup of this paper does not follow the difference-in-differences framework in the traditional sense. First, this paper omits some macro and country-specific factors from the regression such as the VIX index, ratio of non-performing loans-to-gross loans, and the policy rates as they are not considered to contribute significantly to the results. Second, I only run one regression that covers all of the variables. This setup is chosen to keep the research straight forward and simple. The setup differs from that of Bongiovanni et al. (2021) who run regressions using multiple combinations of variables. Therefore, the findings of this thesis do not show the correlation between NIRP effect and banks' risk taking behavior as strongly as in Bongiovanni et al.'s (2021) research. Nevertheless, both studies delivered similar results, which is that the risk ratio of NIRP adopter banks decreased during negative interest rate era.

Table 2. NIRP effect and risk figures

	Dependent variable	
	Risk ratio	
nirpeffect	-0.010 ^{***} (0.003)	
Size	-0.001 [*] (0.001)	
ETA	0.038 (0.034)	
Funding structure	-0.001 (0.0003)	
Loan growth	0.00000 (0.00000)	
ROAA	0.002 [*] (0.001)	
Loan rates	-0.001 [*] (0.001)	
NITOI	-0.00000 (0.00001)	
Liquidity	-0.0003 ^{**} (0.0001)	
CPI	0.00003 (0.001)	
GDP	-0.001 (0.001)	
Observations		3,132
<i>Significance level:</i> * p<0.1; ** p<0.05; *** p<0.01		

7 Conclusions

Negative interest rates have caused uncertainty about the stability of the financial sector and the health of banks' balance sheets. The ECB had to form monetary policy tools in order to tackle hindering inflation and euro banks' challenges in providing loans. At the same time, the deposit funding continued deteriorating during the NIRP era. During 2015 and 2020, all four Nordic countries Finland, Sweden, Norway, and Denmark had adopted negative interest rates. Due to their similar qualities in the banking sector, Nordic banks are treated as one counterparty and they are compared to the non-NIRP-adopter banks in this thesis.

The empirical findings reported in this thesis suggest that after the implementation of negative interest rates, Nordic banks have had relatively healthy balance sheets and there has not been a clear shift to riskier lending to help the weak profitability. Unlike the previous literature proving that euro banks have increased their lending activity during the NIRP era and especially high-deposit banks have moved towards riskier lending, Nordic banks have reduced risky assets and there has not been a significant change in the volume of lending. According to the results, Nordic banks tackled profitability problems and became safer during an uncertain economic environment. Therefore, the null hypothesis is rejected as the negative interest rates impacted Nordic banks' asset allocation to prevent unnecessary risks. Thus, H1 is rejected, as on the contrary Nordic banks reduced the share of their risky assets and reallocated their assets to safer ones.

Due to the limitation of consistent data for years 2013-2019 there could be more significant findings that could explain the shift in the risk ratio in more detail. For further research, it would be interesting to examine how Nordic banks' riskiness has developed after the long period of negative interest rates ended in September 2022 and the inflation turned to a steep increase. Thus, the risk factors have shifted and banks are now facing new challenges: a prolonged period of negative interest rates have created maturity mismatches between banks' liabilities and assets. When the interest rates take

a steep upward turn, the maturity risk realizes and banks' ability to pay interest to customers deposits endangers. Therefore, the spillover effects of the ECB's expansionary monetary policy and the racing inflation might have long-lasting impact on the stability of the global banking sector. In the next few years, the real consequences of the negative interest rates may be revealed.

The topic of banks' risk taking behavior during unconventional interest rate environment has not been much studied in the academic literature. Therefore, to understand the extensive impacts of NIRP requires more empirical research, a broader set of bank data, and a more precise definition of the measure of "risk-taking" as risk can be measured and defined in multiple ways. Moreover, thorough research could provide tools for banks to adapt in a constantly changing interest rate environment and to prevent a highly challenging situation such as the NIRP era 2014-2022.

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