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The Influence of Monetary Policy on Bank Profitability

A Study of Scandinavian and Central European Banks

Petter Eide & Lasse Nissen

Supervisor: Konrad Raff

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NORWEGIAN SCHOOL OF ECONOMICS

Abstract

In this thesis, we find support for the notion that interest rate hikes improve bank profitability. Our results imply that monetary policy might have had a more profound impact on bank profitability from 2021 onwards compared to the preceding decade. When decomposing bank profitability into its components, our analysis suggests that the effect of interest rates on bank profits comes through strong positive effects on net interest income and muted effects on non-interest income and loan loss provisions. Further, in a comparison of the effects in different countries, our findings indicate that the impact of interest rates on balance-sheet bank profitability might be stronger in Eurozone countries and Sweden than in Norway. Lastly, our estimations signal a potential negative impact of sudden interest rate hikes on Eurozone banks' stock prices and that sudden interest rate changes might not impact Norwegian and Swedish bank stock prices.

Keywords: Return on Assets, Net interest income, Non-interest income, Loan loss provisions

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Petter Eide

Lasse Nissen

Contents

1 Introduction

Our study aims to contribute to the existing literature on the effect of monetary policy on bank profitability in Scandinavia and central Europe. By using sovereign treasury yields and banks' financial statements, we assess whether interest rates significantly impact bank profitability and whether the impact differs across periods and borders.

In parallel with rapidly increasing interest rates, bank profitability has surged in many European countries since 2021, and the profits of large Norwegian banks have been a central topic in national media platforms. Some financial journalists have been clear in their verdict that rising interest rates have caused higher profitability for Norwegian banks through an increase in net interest margins (Erikstad, 2023). We find this narrative intriguing and considering the lack of empirical research on the relation between monetary policy and bank profitability in Norway specifically, this is an interesting topic to explore further.

The purpose of our thesis is twofold. On the one hand, we aim to assess the causal effects monetary policy changes could have on bank profitability. Thus, we will initially investigate general long-term effects, the main drivers behind these effects, and how the effects vary in different interest rate environments. On the other hand, we aim to bring this analysis into a Norwegian context and assess how the effects differ in Norway compared to other European areas. Unfortunately, the limited availability of specific macroeconomic and bank-specific data makes a comprehensive cross-country analysis across many European nations challenging. As a result, we limit our comparison to two specific areas of particular interest within the Norwegian context. Our comparative study will focus on Norway, Sweden, and the four largest economies of the Eurozone, namely Germany, France, Italy, and Spain.

In our thesis, we will test five predictions about the effect of monetary policy on bank profitability. Our first prediction is that monetary policy has a positive causal effect on banks' return on assets (ROA). Furthermore, some of the previous literature argues that this effect might weaken in low-interest-rate environments. Thus, our second prediction is that recent interest rate changes have had a more positive causal effect on banks' ROA than the interest rate changes in the low-interest rate period of the 2010s. After that, we will decompose the ROA into its components and test our third prediction that an increase in banks' net interest income drives the positive effect of monetary policy tightening on bank profitability. For prediction 4, we focus on the differences in effects between Norway and other regions. We predict that interest rate changes will impact Norwegian banks more strongly than Swedish and Eurozone banks due to what we believe to be a higher dependency on interest-related activities in Norway. Our fifth prediction is related to the stock markets' change in expectations regarding bank profitability due to sudden interest rate changes. We believe the strong earnings calls from banks since 2021 have made markets more optimistic about cash flow increases due to rate hikes and that sudden rate hikes have raised bank stock prices.

We conduct various analyses to examine our five predictions on the relationship between monetary policy and bank profitability. We use a fixed effects regression estimator, quarterly financial statements for banks, and quarterly interest rate data to test our first four predictions. We also include controls for current and expected economic conditions. Furthermore, we test our fifth prediction by doing an event study of bank stock price reactions to sudden interest rate changes. In this event study, we use intraday data to construct narrow event windows around monetary policy press releases and conferences held by central banks. We use these event windows to capture sudden changes in bank stock prices simultaneously with sudden interest rate changes. After that, we use a fixed effects estimator to regress the bank stock price changes on the sudden interest rate changes, controlling for bank characteristics.

To interpret the results of our analyses, we utilize a theoretical framework that decomposes the effect monetary policy has on bank profitability into smaller mechanisms. To analyze how interest rates might impact the different components of bank profitability, we use a framework presented by Borio, Gambacorta, and Hofmann (2015). We also utilize theories used by English, Van Den Heuvel, and Zakrajsek (2012) regarding the impact of monetary policy on bank stock prices.

Initially, we assess the effects of monetary policy on bank profitability without segmenting banks by region. We estimate a significant positive relationship between short-term interest rates and balance sheet bank profitability from 2010 to 2023. This relationship is estimated to strengthen in 2021-2023, indicating that recent interest rate hikes might have boosted bank profits significantly. Net interest income emerges as the primary contributor to this profitability increase in our model. These findings align with our initial three predictions on the relationship between short-term interest rates and bank profitability.

When comparing results for Norwegian banks with results for Swedish and Eurozone banks, we get opposing results for different analyses. On the one hand, our analysis of balance-sheet profitability indicates that banks in Norway might be the least positively affected by monetary policy tightening, which is against our fourth prediction. However, our stock market analysis yields results indicating that markets were more optimistic about Norwegian banks' ability to exploit rate hikes than Eurozone banks' ability to do so. These opposing results increase our suspicion that Norway's unique regulatory and competitive banking environment could limit Norwegian banks' financial statements' ability to reflect the causal impacts of rate hikes on profitability.

Our findings provide partial support to several existing papers. The results indicating a positive effect of short-term interest rates on bank ROA align with the findings of Borio et al. (2015). Moreover, the estimates implying that this effect has been stronger from 2021 and onwards support the narrative of Lopez, Rose, and Spiegel (2020) about the effect of policy rates on bank profitability being muted in negative interest rate environments. When separating the effects in the different regions, our results for Norwegian banks deviate from the others, as they imply no impact of monetary policy on Norwegian bank ROA. Further, the results from our decomposing of income channels align with the findings of Altavilla et al. (2018), who estimate insignificant interest rate coefficients when using non-interest income and loan loss provisions as dependent variables. Moreover, the results implying a negative impact of rate hikes on Eurozone bank stock prices are coherent with what Altavilla et al. (2018), Ampudia et al. (2018), and English et al. (2012) find. In contrast, the insignificant effect estimated for Norwegian and Swedish banks contradicts the findings of these papers.

2 Literature review

This section will present various academic studies relevant to our thesis. We will discuss these studies' applied methodologies and their results while elaborating both on how the work is related to our thesis and how our thesis contributes to the existing literature.

Findings in related literature regarding the causal effects of monetary policy on bank profitability are ambiguous. On the one hand, Borio, Gambacorta, and Hofmann (2015)[1] found support for the notion that both rising interest rates and steepening yield curves lead to higher bank profitability. They decomposed global bank profitability from 1995 to 2012 into its various components and regressed these components on monetary policy proxies, controlling for several macroeconomic, financial, and bank-specific parameters. The theoretical framework Borio et al. (2015) use is central to our predictions and interpretations of results. On the other hand, Altavilla, Boucinha, and Peydró (2018) [2] found no evidence of a causal impact of monetary policy changes on the quarterly reported bank profitability when holding macroeconomic and financial conditions constant. They investigated how monetary policy affected bank profitability in the Eurozone from 2000 to 2016 using a methodology similar to that of Borio et al. (2018) and an analysis of stock prices. We use the methodology of Altavilla et al. (2018), as we view their innovative inclusion of concrete controls for economic outlook as an improvement on previous methodologies. Further, Altavilla et al. (2018) complement their financial statement analyses by analyzing market reactions to interest rate changes, an approach we have adopted.

When bank profitability is decomposed in these papers, the ambiguity in the estimated effects is clarified. Altavilla et al. (2018) found that the effect on net interest income is offset by the opposing effects on non-interest income and loan loss provisions. They argue that these offsetting effects might become stronger in low-interest-rate environments. In contrast, Borio et al. (2015) found that a relatively stronger effect on net interest income outweighs the effects on non-interest income and loan loss provisions, even in a downward-trending interest rate environment. These discussions relate to our thesis as we also decompose bank profitability to assess what mechanisms are at play.

[1] From now on, referred to as Borio et al. (2015).
[2] From now on, referred to as Altavilla et al. (2018).

Existing literature's disagreements about the transmission of negative policy rates are of interest to us, as both Swedish and Eurozone banks have faced negative interest rates in the 2010s. Heider, Saidi, and Schepens (2021) address the growing evidence that banks' deposit rates have a zero lower bound while market-based debt instruments do not. Although many agree on such a zero lower bound, its impact on total bank profitability is debated. Ulate (2021) found that a zero lower bound on deposit rates, in combination with negative interest rates, always decreases bank profitability. In contrast, Eggertsson, Juelsrud, and Summers (2020) state that the impact depends on the structure of banks' assets and liabilities. Moreover, Lopez, Rose, and Spiegel (2020) are also critical towards the conclusion that negative interest rates lower bank profitability, as their findings are like those of Altavilla et al. (2018) and imply that increases in non-interest income offset the fall in net interest income. These discussions have implications for our expectations regarding how the impact of monetary policy on bank profitability differs between regions.

The effect of monetary policy on bank stock prices is less debated in existing literature. The literature relates to our thesis since we inspect how markets' perceptions of bank stocks change in case of a monetary policy change. Altavilla et al. (2018) found support for the notion that monetary policy changes had a negative causal relationship with bank stock prices. They analyzed daily stock price returns when unconventional monetary policies in the Eurozone were announced. We adopt the regression model Altavilla et al. (2018) used, which includes the same bank-specific controls utilized in their financial statement analyses. Their findings are coherent with the results of English, Van Den Heuvel & Zakrajsek (2014)[3] and Ampudia & Van Den Heuvel (2018)[4]. In these papers, intraday event studies with narrow windows around monetary policy announcements are utilized. We use this event-study approach instead of using daily data in our market price analysis. Interestingly, Ampudia et al. (2018) find that the magnitude of the impact varies notably over time and might even reverse to become positive. The theoretical frameworks of all these studies are utilized in our paper.

With our thesis, we aim to contribute to the existing literature on monetary policy and bank profitability, particularly regarding how these relationships vary across periods and economic regions.

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[3] From now on, referred to as English et al. (2014)
[4] From now on, referred to as Ampudia et al. (2018)

3 Institutional setting

With a few key exceptions, monetary policy developments have been similar in Norway, Sweden, and the Eurozone since 2010 (Norges Bank, 2023; Sveriges Riksbank, 2023a; European Central Bank, 2023). Policy rates were downward trending throughout most of the 2010s for all these regions. However, the use of unconventional monetary policies to combat the financial turmoil following the financial crisis of 2007-2008 led to negative policy rates in Sweden and the Eurozone (Altavilla et al., 2018). The Norwegian central bank did not turn to quantitative easing in this period, and the Norwegian policy rates were kept above zero. Due to the Covid-19 pandemic, policy rates were kept at or below zero from March 2020 until they started to rise rapidly in response to high inflation. In Sweden and the Eurozone, rate hikes started in the middle of 2022, while the Norwegian central bank initiated rate hikes in late 2021.

In Norway, bank profitability seems to have developed almost in parallel with policy rates since 2010. Throughout the 2010s, Norwegian banks' Return on Equity (ROE) fluctuated, and the ROE in 2019 ended marginally lower than the ROE in 2010 (Finanstilsynet, 2023). In 2020, ROE dropped due to the massive economic implications of the Covid-19 pandemic. After that, Norwegian banks increased their net income significantly in both 2021 and 2022 (Finans Norge, 2023). A key factor for the positive development in 2021 was strong performances in financial markets, which significantly reduced loan loss provisions (Finanstilsynet, 2022). A substantial increase in net interest income has been pointed out as a central driver for profitability for Norwegian banks from 2022 and onwards (Nordbakken, 2023). The profitability increase has been particularly large for some large banks. In May 2023, Norway's largest bank, DNB, traded at a stock price of 1.16 times the book value of equity, the second highest for any bank in Europe (Erikstad, 2023).

The largest Swedish banks have also increased their profitability notably since policy rates began an upward trajectory in early 2022 (Sveriges Riksbank, 2023b). Before Covid-19, large Swedish banks' ROAs were trending downwards. From 2021 and onwards, large Swedish banks have had an upward trend. However, in late 2023, higher interest rates are pressuring Swedish real estate companies, which elevates the risk of future loan loss provisions (Sveriges Riksbank, 2023b). Thus, like the Norwegian bank profitability, Swedish bank profitability seems to have followed policy rate developments quite closely since 2010.

Large Eurozone banks have also accomplished profitability increases since ECB rate hikes started (de Guindos, 2023). Before the Covid-19 pandemic, large Eurozone banks' profitability had been somewhat muted, which Altavilla et al. (2018) accredit partially to negative interest rates and extensive quantitative easing after the financial crisis. In contrast, in 2022, Euro area banks' ROE reached 8 percent, its highest level since the start of the banking union. This record was beaten again in the first half of 2023, with ROE almost turning into double-digits (de Guindos, 2023). Thus, the positive developments in Eurozone bank profitability align with the Norwegian and Swedish bank profitability developments.

Some structural differences between markets could indicate that Norwegian banks are more exposed to interest rate changes than other banks. The Norwegian loan market differs from loan markets in other European countries in some areas (Knudsen, 2022). In Sweden and Denmark, 30-40 percent of homeowners have a fixed-rate mortgage. This metric is much higher in the largest Eurozone countries, between 75 and 97 percent (Papalexatou & Matsaganis, 2022). Meanwhile, only 5 percent of Norwegian homeowners have fixed-rate mortgages. In addition, Norwegians generally have a higher leverage ratio than other countries, as owning one's home is more common than in other countries (Regjeringen, 2019).

Scandinavian and Eurozone banking stocks have performed quite similarly over the last two years. Figure A.1 in the appendix depicts the performance of Norwegian, Swedish, and Eurozone bank stock indices since December 2021. The total returns have been 12.5 percent, -0.2 percent, and 0.6 percent, respectively (Euronext, 2023; Nasdaq, 2023; MarketWatch, 2023). Since late 2021, the indices have diverged periodically, but there are no clear signs of specific indices consistently outperforming others.

A common denominator for the three economic regions is that bank profitability has developed relatively linearly with interest rate developments since 2010. Norway stands out from the three regions by not using unconventional monetary policies and having floating interest rates on a large share of mortgages.

4 Theoretical framework

In this section, we will focus on the underlying theories that form the basis for our predictions. These theories relate to monetary policy and its effects on bank profitability and bank stock prices.

4.1 Monetary policy effects on components of bank profitability

Bank income has three main components: net interest income, non-interest income, and loan loss provisions. Going forward, we will outline theoretical concepts from Borio et al. (2015) on how an interest rate increase is expected to impact these three main components. We will also present existing research on how competition and the share of fixed-rate loans could impact bank profitability.

4.1.1 Net interest income

In a normalized macroeconomic setting, a strong positive association between interest rates and net interest income is generally believed to exist. Borio et al. (2015) identify and categorize various mechanisms influencing net interest income, organizing them according to the mechanisms they work through. The effects are accredited to two key features of a term structure: *the level of interest rates* and *the slope of the yield curve*.

When decomposing the effects of *the level of interest rates*, Borio et al. (2015) list five mechanisms, of which three are relevant when interpreting our results: 1) the retail deposits endowment effect, 2) a quantity effect, and 3) a rate-adjustment lag effect.

The retail deposits endowment effect is related to banks' practice of increasing net interest margins by setting deposit rates below lending rates. Banks will aim to utilize a policy rate increase by increasing lending rates more than deposit rates.

Quantity effects are related to how interest rate changes could affect loan and deposit volumes differently. Loan demand is expected to be more sensitive to interest rate fluctuations than deposit demand, and the relationship between net interest income and interest rates is not always linear. For instance, a drop in loan demand following a significant rise in interest rates can offset the benefits from improved margins and adversely affect net interest income.

The *rate-adjustment lag effect* relates to deposit rates rising slower and falling faster than lending rates, increasing the net interest margin. Such effects are thought to be more prevalent in less competitive markets.

Regarding changes in *the slope of the yield curve,* Borio et al. (2015) state that a steeper curve is expected to positively impact net interest income. Furthermore, they explore certain quantity effects associated with a steeper yield curve, noting that it would eventually turn from a positive to a negative impact on profitability. This reversal is due to the higher elasticity of fixed-term mortgages compared to deposits. In other words, similarly to the changes in the interest rate level, changes in the yield curve slope seem to portray a non-linear relationship with net interest income.

In sum, the effects of monetary policy changes on net interest income are complex due to the many different mechanisms in play and the potential non-linearity. In general, the combined effect of each mechanism is expected to have a strong positive impact on net interest income.

4.1.2 Non-interest income

Borio et al. (2015) list three components that could impact the relationship between non-interest income and monetary policy measures: *the valuation effects on securities, hedging through derivates,* and *commissions*. They state that this relationship between interest rates and non-interest income is unclear but argue that the aggregated correlation could be negative.

Banks typically invest in various financial securities, making up the banks' security portfolio. A rising interest rate would negatively impact the market prices of, for instance, corporate or government bonds held by the bank, and the isolated valuation effects on securities will be a reduction in non-interest income. On the other hand, the hedging effect is assumed to strengthen non-interest income in case of rising interest rates and thus offset the security valuation effect to some degree. Lastly, banks' fees and commissions are generally thought to decrease with higher interest rates.

Borio et al. (2015) state that the relationship between the slope and non-interest income has received little attention in existing literature.

4.1.3 Loan loss provisions

Borio et al. (2015) state that, holding macroeconomic conditions constant, we typically expect higher interest rates and a steeper yield slope to be associated with increased loan losses. This relationship is thought to be concave, implying that the effect diminishes in high-interest-rate environments. The effect can be decomposed into two mechanisms. The first mechanism is that interest rate changes impact the probability of default on floating-rate loans. The second mechanism is how higher rates could lead to less risky lending behaviors, as Borio and Zhu (2012) described.

According to Borio et al. (2015), loan loss provisions are particularly sensitive to interest-rate changes in very low interest-rate environments. They argue that this sensitivity might be due to the likelihood of a very low-interest rate period following financial turmoil, such as the financial crisis that unfolded in late 2008. In these situations, banks typically have weak balance sheets and often extend loan terms, thus increasing the interest rate sensitivity of loans. Several papers provide evidence of this mechanism, for instance, Albertazzi and Marchetti (2010), in their analysis of the European banking sector post-crisis.

Comparable to a very low-interest rate environment, loan loss provisions are likely to have a higher sensitivity to interest rates when interest rates are very high. Further, Borio et al. (2017) describe the relationship between loan loss provisions and interest rates as likely concave, as increasing interest rates at a certain point would reduce both loan demand and loan supply to such a degree that provisions would fall.

According to Borio et al. (2017), the impact of a change in the yield curve's slope on loan losses is similar to the effect of a change in the level of interest rates. A larger difference between long and short rates would raise the average interest rate level and subsequently raise average debt service costs.

4.1.4 Other factors

The impact of monetary policy on the three key components of bank income is anticipated to be relatively consistent across different regions. In contrast, other factors, such as market competition and the prevalence of fixed-rate loans, are likely to vary more significantly by region. To address these variations, we will also use a theoretical framework that examines how these factors influence bank profitability.

Competition is found to be stronger among large banks, operating predominantly in international markets, and weaker among small banks, operating mainly in local markets (Bikker & Haaf, 2002). Moreover, Windsor, Jokipii, and Bussiere (2023) state that banks operating in countries with less competition are expected to have more pricing power.

Windsor et al. (2023) outline that banks operating in countries with a higher share of fixed-rate lending are likely to be more sensitive to changes in the yield curve's slope relative to countries with a lower share. When interest rates rise, the cost of new and rolling short-term funding for banks typically increases, which could squeeze net interest margins. This margin squeeze is thought to be particularly large for banks with a high share of fixed-rate loans.

4.2 Monetary policy effects on bank stock prices

According to English et al. (2014) the relationship between monetary policy and bank stock prices is ambiguous. On the one hand, monetary tightening could lead to a higher discount rate and an increase in the equity premium. These effects are expected to have a negative impact on stock prices in general. On the other hand, English et al. (2014) states that conventional wisdom is that rising interest rates are associated with higher bank profitability. This market perception is related to the dynamics between the various income components presented in Section 4.1, where positive effects on net interest income is thought to dominate the potential negative effects for other components. This expectation of higher profitability could make market participants anticipate increased cash flows in case of interest rate hikes, and drive bank stock prices upwards.

5 Research question and predictions

Our paper aims to investigate how banks' profitability is affected by interest rate changes. Therefore, we propose the following research question:

How do interest rates impact bank profitability, and is the impact different for different regions?

5.1 Predictions

Even though they note that the overall effect of interest rates on bank profitability is uncertain, Borio et al. (2015) predict that the causal relationship between policy rates and bank profitability generally is positive between 1995 and 2012 due to the positive effects on net interest margins dominating the negative effects on loan demand, non-interest commissions and loan losses. Their findings in 2017 indeed indicate that both rising short-term interest rates and a rising yield curve slope could impact bank profitability positively. These findings are during a period where both short-term rates and yield curve slopes exhibited a slight downward trend. From 2010 to 2021, short-term interest rates and yield curves in European economies were also trending downwards, and short-term rates became negative in economies within the Eurozone. More importantly, since 2021, we have seen rapidly rising interest rates in parallel with surging bank profitability across Europe, which we believe could reflect a positive impact of interest rate hikes. Considering the findings and theoretical framework of Borio et al. (2015) and the recent surge in interest rates, we therefore introduce our first prediction:

Prediction 1

Rising (falling) short-term interest rates and rising (falling) yield curve slopes lead to positive (negative) Return on Assets (ROA) for banks.

Our data set reflects a distinct trend shift for short-term interest rates. Through large parts of the 2010s, many European interest rates were very low and even negative. Previous literature suggests that the positive causal effect of monetary policy on bank profitability weakens in such environments, as a decline in net interest income is largely offset by an increase in non-interest income (Altavilla et al., 2018; Lopez et al., 2020). From 2021 and onwards, short-term interest rates have rapidly risen to levels perceived as more normal in a historical context. This development makes us anticipate that the causal positive effect of short-term interest rates on bank profitability has normalized and has become more profound. The fact that many European banks have continually reported strong profits since 2021 increases this suspicion. Thus, our second prediction is the following:

Prediction 2:

Short-term interest rates have had a stronger positive effect on banks' ROA from 2021 and onwards compared to the period from 2010 to 2020.

Borio et al. (2017) believe that the positive effect on net interest income from an interest rate hike is generally more powerful than negative effects. Consequently, we predict to find the following when decomposing banks' Return on Assets (ROA):

Prediction 3

When decomposing the reported Return on Assets (ROA), the positive (negative) effect of interest rate hikes (drops) is driven by higher (lower) net interest income.

Contrary to the approaches of Borio et al. (2015) and Altavilla et al. (2018), our study expands its scope by including regions outside the Eurozone. Thus, our study features heterogeneity in monetary policies. In contrast to the Swedish and the Eurozone central banks, the Norwegian central bank has not implemented unconventional policy strategies like negative interest rates and quantitative easing after 2010. We expect that negative interest rates in Sweden and the Euro area have not only reduced net interest margins but also caused a strategic shift towards greater reliance on non-interest income sources. As a result, we anticipate that Norwegian banks, who have faced positive interest rates, have a stronger dependence on net interest income. These thoughts form the basis of our fourth prediction:

Prediction 4

Rising (falling) short-term interest rates and steepening (flattening) yield curve slopes will have a stronger positive (negative) effect on the profitability of Norwegian banks.

Earlier studies' findings imply that positive interest rate surprises affect bank stock prices negatively over longer periods (Altavilla et al., 2018; Ampudia et al., 2018). The interpretation of these results has generally been that higher dividend discount rates and a worsening macroeconomic backdrop offset the expected positive cash flow effects for banks. We believe that the recent strong earnings reporting among many banks has made markets more optimistic about the positive impact rate hikes have on cash flows. Consequently, in case of an interest rate hike, we believe optimistic expectations for bank cash flows outweigh the pessimism connected to higher discount rates and more challenging financial conditions. Therefore, our fifth prediction is the following:

Prediction 5

Since 2021, sudden interest rate spikes (drops) have had a positive (negative) impact on Scandinavian and Eurozone bank stock prices.

6 Data selection

This section outlines our approach to data selection for examining our predictions. We will first detail the dependent variables and then discuss the selection of interest rates as variables of interest before we explain the inclusion of various control variables for accurate modeling. Lastly, we will present the intraday market data we use to test our fifth prediction.

6.1 General

Our data selection process involves gathering information from publicly listed banks in Norway, Sweden, and the four major Eurozone economies. However, due to issues with data availability, we are forced to exclude several banks from our sample. These exclusions are mainly because of two limitations: insufficient quarterly balance-sheet data, which limits our ability to apply all relevant controls in our analyses, and low stock trading volume, which could impact the reliability of our stock price-based analysis. The final count of banks from each region included in our study is detailed in Figure 1.

With a few exceptions, our data source for financial, macroeconomic, and bank-specific variables is Bloomberg. A complete overview of variables included in our dataset, including descriptions of the variables and their data sources, can be found in the appendix.

Figure 1
Sample of banks.

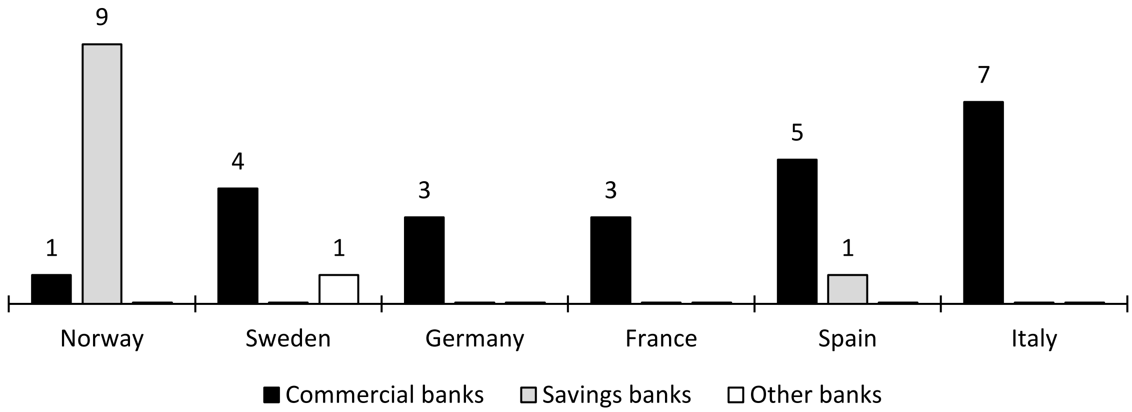

Figure 1: The number of banks in the dataset is segmented by country and classified by Orbis, with 23 banks identified as “commercial banks”, 10 as “savings banks”, and 1 in the category of “other banks”.

6.2 Dependent variables

As the theoretical framework outlines, banks generate income through three primary channels: net interest income, non-interest income, and loan loss provisions. The aggregate of these channels constitutes a bank's total income, and by subtracting total costs, we arrive at the net income. This net income forms the basis for calculating the return on assets (ROA), a key indicator of a bank's financial performance.

Figure 2

The profitability components' median and 16-84th percentile distributions.

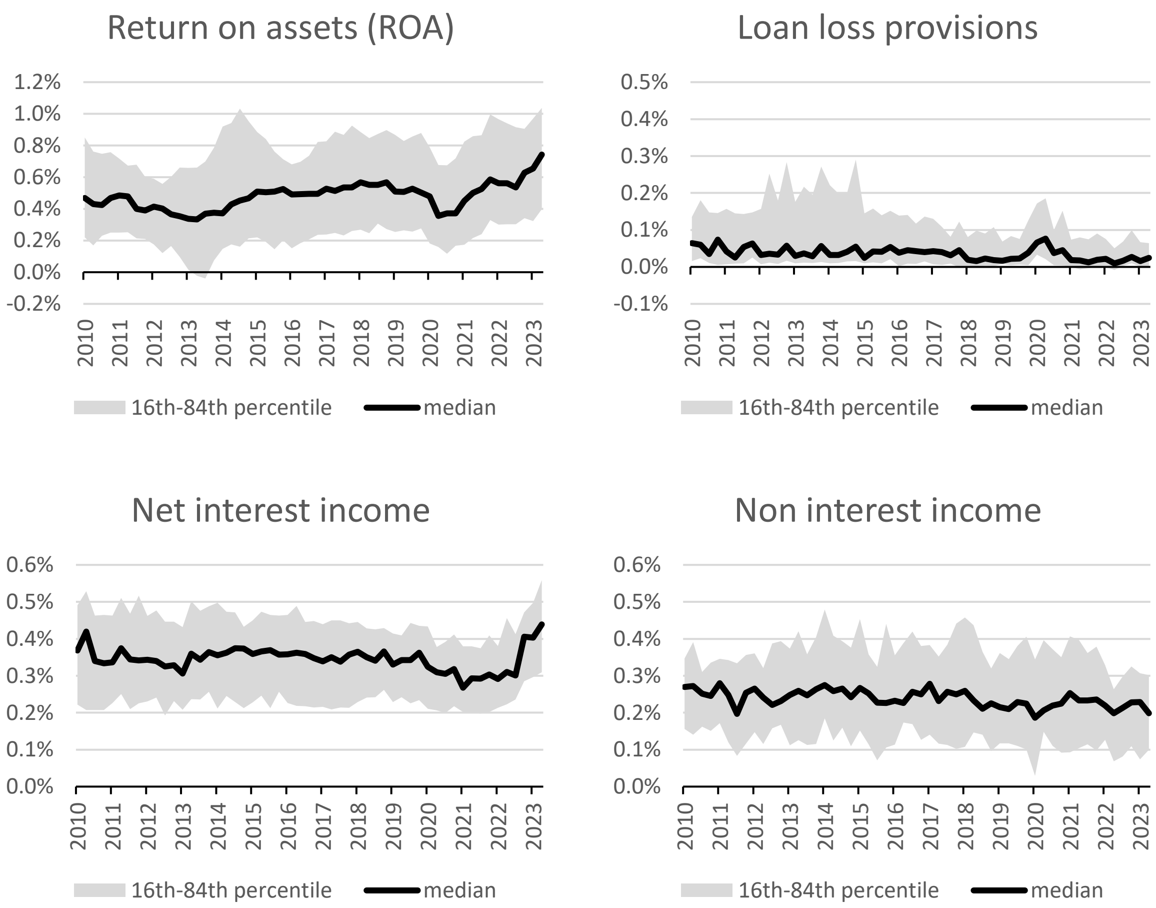

Figure 2: Development of the profitability of the banks in our data set, where all income variables are expressed as a percentage of total assets. The data is collected from Bloomberg.

Median values of return on assets and income channels are plotted in Figure 2. All income components are measured in share of total assets. Bank profitability trended upward from 2013 to the Covid-19 pandemic in March 2020. This period was marked by stable levels for all income channels, and cost reduction initiatives related to technological innovation and increased productivity could explain the profitability improvement in the period. From late 2020 lows, ROA has rebounded with a strong upward trend, which is the rationale for prediction 1.

When examining Figure 3, we observe that the Norwegian banks in our sample seem more dependent on net interest income. The divergence between the regions' net interest income dependence seems to increase gradually during the 2010s. This finding is relevant for prediction four and could be explained by our expectations of a strategic shift for Swedish and Eurozone banks towards greater reliance on non-interest income sources.

Figure 3

Net interest income as share of net revenue per region.

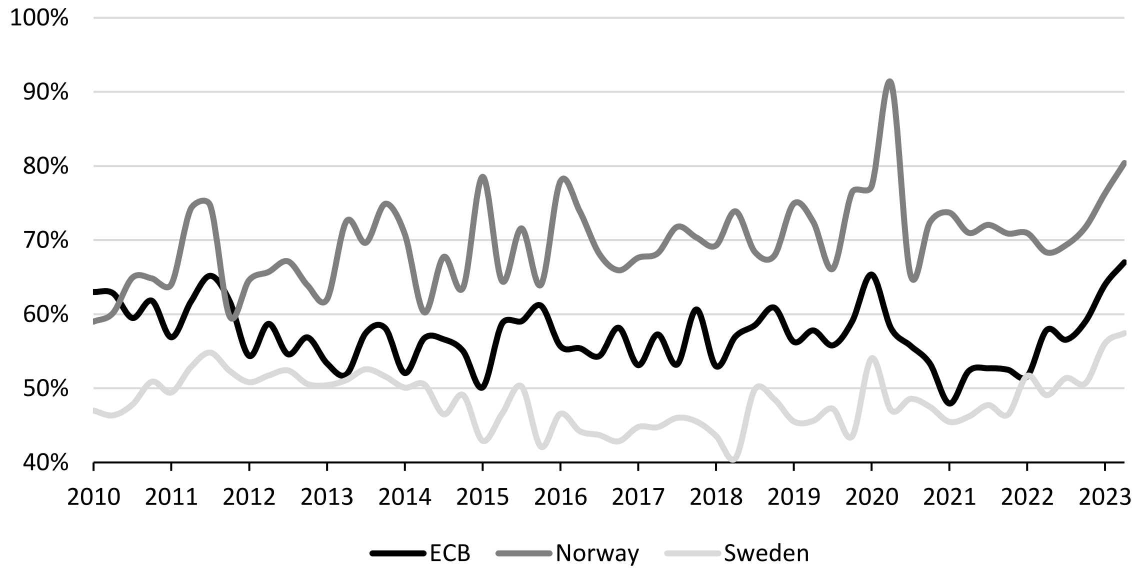

Figure 3: The median proportion of net interest income as a share of overall net revenue for banks in our data set, segmented by region. The data is collected from Bloomberg.

6.3 Variables of interest

To measure the effect of changes in both short-term rates and the term structure, we include the level of the short-term interest rate and the slope of the yield curve as our variables of interest.

6.3.1 Short-term interest rate

To capture the short-term effects of monetary policy, we include the short-term interest rate as a variable of interest. The selection of short-term interest rates depended on 1) data availability and 2) credit risk.

Altavilla et al. (2018) use Overnight Index Swaps (OIS) as short-term rate. Such OIS rates are our preferred short-term rates as they reflect interbank conditions and are considered the best proxies for risk-free rates (Hull & White, 2013). Because we control for risk factors[5], we aim to collect the best proxies for risk-free rates due to the potential of redundancy. However, Norway did not have an OIS before 2021, making us choose the optimal alternative. Without

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[5] We control for the Probability of Default (PD) and the VIX.

OIS rates, we view both IBORs and short-term government treasury yields as viable options for a short-term monetary policy proxy. According to Hull and White (2013), using IBOR rates leads to an incorrect no-default value, and thus, we prefer to use short-term treasury yields for our main results. However, we will also run our regression models using IBOR rates as a robustness test[6].

As in the paper by Altavilla et al. (2018), all Eurozone countries in our sample (Germany, Italy, France, and Spain) are represented by the 3-month Eurozone interest rate. This decision is based on the understanding that the broader monetary policy actions of the ECB largely influence short-term interest rates in these economies. In contrast, we use country-specific short-term rates for Norway and Sweden, which are not part of the Euro area.

6.3.2 Slope

We have included the slope of the yield curve as the second variable of interest to measure long-term economic outlooks. A steeper slope could benefit banks as they engage in maturity transformation activities, which involve borrowing short-term at lower rates and lending long-term at higher rates (Borio et al., 2017).

There are several alternative measures of the slope of the yield curve. For comparison reasons, we have chosen the same slope as Altavilla et al. (2018) by including the difference between 10-year- and 2-year government T-bond yields. We also include a similar approach to that of Altavilla et al. (2018) when selecting a country-specific slope for each economy, despite some countries being part of the Euro area. We do this as we expect that longer-term interest rates, compared to short-term rates, are influenced by country-specific conditions to a larger extent.

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[6] The robustness test is attached in Table A.5.

Figure 4
Development of 3-month treasury yields and yield curve slopes.

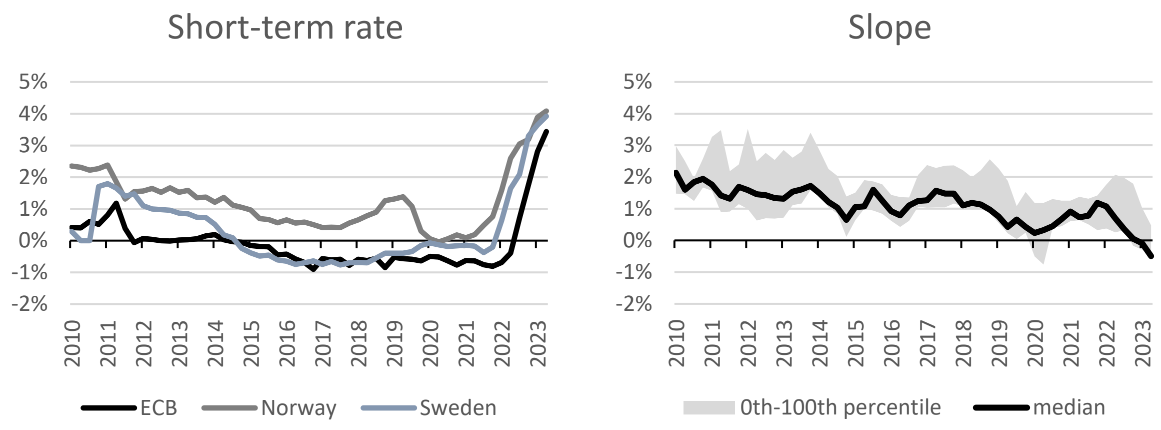

Figure 4: Development of variables of interest: short-term rate, represented by 3-month treasury bond yields and segmented by region, and slope, defined as the difference between 2- and 10-year sovereign treasury yields and segmented by country. The data is collected from Bloomberg.

By examining Figure 4, it becomes evident that Norway is the only economy in our study that maintained non-negative short-term interest rates throughout the entire period. In contrast to the Norwegian Central Bank, the central banks in the Eurozone and Sweden employed unconventional monetary policies[7] before and after the Covid-19 pandemic.

When examining the relationship between short-term interest rates and slope, we observe that both measures had a negative trend until 2020. However, the two measures have diverged since the sharp interest rate hike started in late 2021.

6.4 Control variables

Changes in bank profitability can be driven by many factors other than monetary policy. We will include various financial, macroeconomic, and bank-specific control variables in our regression model to reduce omitted variable bias and provide more accurate estimates of the relationship between monetary policy and bank profitability. Since these variables are included as controls, we will focus on explaining why they are included rather than describing their development.

[7] Use of either quantitative easing, negative interest rates, or both.

6.4.1 Financial control variables

By including non-financial firms' default probability (PD)[8], our model will control for country-specific default risk. Higher interest rates are typically associated with higher default rates in an economy, and it seems reasonable that high default rates raise banks' loan loss provisions.

Including the VIX[9] in our analysis allows us to control for the impact changing global market conditions might have on bank profitability. For example, an increase in global market volatility could lead to higher funding costs and a reduction in loan growth, which are expected to negatively impact bank profitability. Growing market volatility is also expected to correlate with lower interest rates, as central banks likely want to use accommodative monetary policy to stimulate distressed markets.

Figure 5
Development of financial control variables.

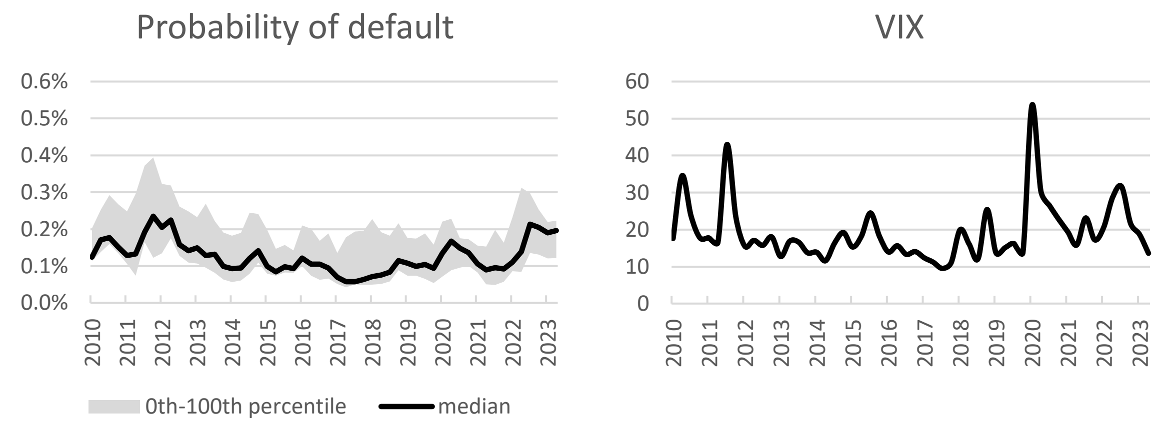

Figure 5: Development of financial control variables: Probability of default is segmented by country, and the VIX index is on a global scale. Definitions for these variables can be found in Table A.1. The data is collected from Bloomberg.

6.4.2 Macroeconomic control variables

We follow the approach of Altavilla et al. (2018) by incorporating both real and expected economic growth and inflation as controls. This decision aligns with central bank practices and the findings of several studies (e.g., Bernanke & Gertler, 1995; Boivin & Giannoni, 2006), which highlight that monetary policy is responsive to both actual economic conditions and macroeconomic expectations. Not controlling for these macroeconomic variables could

[8] PD is a forward-looking probability of default measure for non-financial firms, and the mean of PD is collected and plotted for non-financial firms in all 6 countries of our sample.
[9] The VIX, known as the "fear index", measures market expectations of near-term volatility, and reflects cross-country market uncertainty.

potentially violate the zero conditional mean assumption, leading to a bias in our estimates.

Figure 6

Mean of actual and 1 year ahead expected year-over-year GDP and CPI growth.

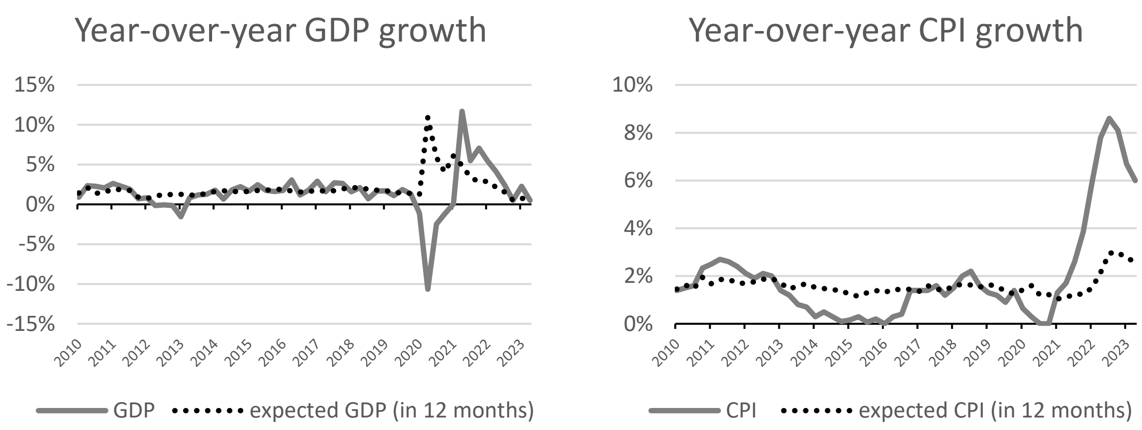

Figure 6: Development of macroeconomic control variables: presented as the mean across regions. Definitions for these variables can be found in Table A.1. The data is collected from Bloomberg and Bloomberg consensus forecast.

Figure 6 shows the importance of separating current and expected macroeconomic conditions, illustrating how the two can diverge substantially. Following the Covid-19 outbreak, the Norges Bank lowered interest rates (Figure 4) to offset the worsening macroeconomic conditions. This action exemplifies how there might be a strong positive association between actual economic activity and monetary policy.

Figure 6 shows how Bloomberg consensus forecasts for future inflation grew only moderately, even though actual inflation rates skyrocketed from 2022 and onwards. This observation exemplifies how policy rates might be more strongly associated with expected inflation than actual inflation levels in some environments. It underscores the necessity of including both the actual and the expected economic indicators in our model.

6.4.3 Bank-specific control variables

Bank-specific controls, limited to the non-performing loan ratio, tier 1 capital ratio, and cost-to-income ratio, are included because they allow us to control for banks' capital adequacy, cost efficiency, and loan portfolio quality. By including these controls, we can avoid endogeneity in our estimates due to differing balance sheet characteristics, which are believed to determine bank profitability and be correlated with policy rates.

6.5 Intraday variables

In the second part of our analysis, we aim to examine the impact of interest rate fluctuations and banks' stock prices. As specified in Section 6, our method requires minute-by-minute data on stock prices and interest rates. Because we do not have intraday data for short-term government bonds, we will use country-specific OIS rates as proxies for short-term interest rates. As outlined when we discussed our variables of interest above, the OIS rates are the most favorable short-term interest rate proxies. In our market price analysis, we focus on a more recent time series (2021-2023), and thus, we have sufficient OIS rate data available for all regions.

We have collected 1-month OIS data measured intraday for all three regions in our sample, and we use the same banks in both the first and second analyses to increase the comparability of results across analyses. Figure A.3 in the appendix shows the estimated interest rate surprises following each central bank's press release and press conference. The sign and magnitude of the interest rate surprise for Norwegian, Swedish, and Eurozone OIS rates. This variation is illustrated in the descriptive statistics for estimated interest rate and stock price surprises in Table A.3 in the appendix.

The slope coefficient we use in the second analysis also differs from the one applied in the first. Instead of using the difference between 2-year and 10-year government T-bond yields, we will use the difference between 2-year and 5-year government T-bond yields. This alteration is only due to intraday data availability, which is better in 5-year than 10-year government bonds. Another implication of limited data availability is that we will use a common slope for all the Eurozone banks.

7 Empirical strategy

7.1 Prediction 1 and 2

To test predictions 1 and 2, we will adopt the regression model Altavilla et al. (2018) used to assess the impact of interest rate changes on balance-sheet bank profitability. We will run this model in two specifications, one for each prediction-testing. Specification 1 will be identical to the baseline model used by Altavilla et al. (2018), and specification 2 will contain two additional dummy interaction terms. These dummy interaction terms will separate the interest rate effects in the two periods. The dummy variable will equal one if a particular observation is between 2021 and 2023 and will be zero otherwise. This variable is interacted with both the short-term interest rate and the slope and allows us to assess how the impact of interest rates has differed in recent years compared to previous years. We will use a fixed effects estimator like Altavilla et al. (2018), as both economic theory and Hausman testing suggest that endogeneity due to unobserved bank-specific effects makes using a random-effects estimator inappropriate.

Equation 1 depicts the regression model we will use to test prediction 1. With some slight modifications, the equation will also be the basis for testing predictions 2 through 4.

$$ROA_{i,j,t} = \alpha_i + \beta_1 ROA_{i,j,t-1} + \beta_2 r_{j,t} + \beta_3 s_{j,t} + \Omega X_{j,t} + \Phi Z_{i,j,t-1} + \epsilon_{i,j,t}$$

Equation 1: Regression model used to test prediction 1.

Where:

$ROA_{i,j,t}$ is the reported quarterly return on assets for bank i in region j at time t

a_i is the bank-specific and time-fixed unobserved effects for bank i

$r_{j,t}$ is the 3-month treasury bond yield for region j at time t

$s_{j,t}$ is the difference between 2-year and 10-year treasury bond yields for region j at time t

$X_{j,t}$ is a vector of macroeconomic and financial controls for region j at time t

$Z_{i,j,t-1}$ is a vector of bank-specific controls for bank i in region j at time $t-1$

$\beta_{1,2,3}$ are the coefficient estimates for the lagged ROA, the short-term interest rate and the slope

Ω is a vector of coefficient estimates for macroeconomic and financial controls

Φ is a vector of coefficient estimates for bank-specific controls

$\epsilon_{i,j,t}$ is the error term for bank i in region j at time t

For prediction 1, the estimated coefficients β_2 and β_3 will be interpreted as the approximate effects of interest rate changes on bank stock profitability across periods. For prediction 2, the coefficients for the dummy interaction terms will be interpreted as the approximate difference in the effect of interest rate changes on bank profitability from 2021 to 2023 compared to 2010-2020. The estimates will be compared against the expected effects using a 5% significance level and heteroskedasticity-robust standard errors clustered by bank.

In our model, we have considered all variables' stationarity. When running both ADF-Fisher chi-square tests and Levin, Lin & Chu tests for stationarity, some test results indicate non-stationarity. These non-stationary variables are the ROA, short-term rates, yield curve slope, current and expected CPI growth controls, and tier 1 capital ratio. However, when we run Pedroni-tests for panel-data cointegration between ROA and non-stationary independent variables, all tests yield results indicating cointegration. Hence, we will use these variables in their levels. As Altavilla et al. (2018) justify using a fixed effects estimator to estimate our model, we do not use an Error Correction Model (ECM).

In our model, we lag our bank-specific controls to prevent simultaneity issues linked to the dependent variable ROA. Further, the lagged ROA is included to control for potential bias due to dynamic effects emerging in a fixed effects model (Nickell, 1981).

7.2 Prediction 3 and 4

When testing prediction 3, we will utilize the same independent variables as for prediction 1. However, instead of using the ROA as the dependent variable, we will use the banks' net interest income, non-interest income, and loan loss provisions as a share of total assets. Thus, we will run these three models and compare the results to assess whether our predictions regarding the various income components could be viable.

We run additional Pedroni tests to ensure cointegration between these new dependent variables and the non-stationary independent variables discussed in Section 7.1. Although the results generally indicate cointegration, they are not unanimous, unlike the test statistics estimated using ROA. Therefore, our results will be tested for robustness using transformed non-stationary variables, an analysis discussed further in Section 9.3.

When testing prediction 4, we will use the same regression model as depicted in Equation *1* but split our sample according to the banks' regions to obtain separate coefficient estimates for each region. After that, we will compare the estimates obtained for Norwegian banks with the results for Swedish and Eurozone banks and discuss potential reasons for the outcome.

Contrary to the regression models for prediction 2, we will not include dummy interaction terms in the models we use to test predictions 3 and 4. We do this because our predictions are about general effects unrelated to differences between time periods.

7.3 Prediction 5

To test our prediction regarding stock market reactions to interest rate changes, we combine the regression model used by Altavilla et al. (2018) with the estimation technique used by Ampudia et al. (2018).

We have estimated two event windows for each of the last 11 monetary policy announcements from Norges Bank, Sveriges Riksbank, and the European Central Bank. The first event window starts 10 minutes before the central bank press release and ends 20 minutes after. The second event window starts 10 minutes before the press conference held by the central bank starts and ends 20 minutes after the press conference is over. Thus, interest rate variables and bank stock prices are measured four times for each announcement date. Using these measures, we compute the percentage change in stock prices for individual banks and the basis point change in interest rates from before to after each event window and use these measures in our model. If a bank is located in Norway, the estimation windows for Norwegian central bank announcements are used along with the Norwegian 1-month OIS and the Norwegian slope. The equivalent Swedish windows and interest rates are used if a bank is located in Sweden. The equivalent estimation windows and interest rates for the Eurozone are used for Eurozone banks.

Our regression model deviates somewhat from the model used by Altavilla et al. (2018) due to the estimation technique described above. Altavilla et al. (2018) use daily data on interest rate changes and stock price changes. To avoid endogeneity, they must include controls for all significant financial or macroeconomic news that might be released the same day as the monetary policy announcements. In contrast, we use narrow intraday estimation windows, and thus, we limit the possibility of factors other than monetary policy events impacting stock prices. Consequently, our model does not include a vector of news controls. Avoiding the need to use news controls is the primary motivation Ampudia et al. (2018) have for using intraday data. Still, we believe the market reaction to a particular bank's stock price depends on characteristics like the bank's cost efficiency, lending risk, and capital adequacy. Therefore, we include controls for bank-specific characteristics in our model, just like Altavilla et al. (2018) do. We also use a fixed effects estimator to control for unobserved bank-specific effects since running a Hausman test indicates that using a random effects estimator is inappropriate. Our utilized regression model is given by Equation 2:

$$\frac{y_{i,j,t} - y_{i,j,t-1}}{y_{i,j,t-1}} = \phi_0 + \phi_1(r_{j,t} - r_{j,t-1}) + \phi_2(s_{j,t} - s_{j,t-1}) + \theta Controls_{i,t} + \eta_{i,j,t}$$

Equation 2: regression model to be used for testing prediction 5 regarding monetary policy and bank stock prices. 2

Where:

$y_{i,j,t}$ is the stock price of bank i in region j at time t

ϕ_0 is the bank-specific fixed effect

$r_{j,t}$ is the 1-month OIS rate for region j at time t

$s_{j,t}$ is the difference between 2-year and 5-year government bond yields for region j at time t

$Controls_{i,j,t}$ is a vector of bank balance-sheet characteristics for bank i in region j at the end of the preceding fiscal quarter of time t

$\phi_{1,2}$ are coefficient estimates for short-term rate and slope variables

θ is a vector of coefficient estimates for the vector $Controls_{i,j,t}$

$\eta_{i,j,t}$ is the error term for bank i in region j at time t

The estimated coefficients ϕ_1 and ϕ_2 will be interpreted as the approximate effects of interest rate changes on bank stock prices in the different regions, and the estimates will be compared against our expectations in prediction 5. We will first estimate the model using all banks in our dataset, interpreting the estimated aggregate effects for all banks. Thereafter, we will estimate the model for each region separately to assess how the impact of interest rates on bank stock prices might have differed between regions.

8 Results and discussion

8.1 Prediction 1 and 2

Table 1 presents the results that will be used to assess our first and second predictions. The results are compiled with an unbalanced panel dataset of 34 banks observed in 54 quarterly periods, totaling 1,549 observations.

We see that in specification 1, the short-term rate coefficient is significant and positive, and the slope coefficient is insignificant at a 5% level. The short-term rate coefficient estimate is 1.01. The estimates imply that when holding all controls constant, a 25 basis point increase in the short-term rate is associated with a 0.25 basis point increase in the ROA. Although this indicated impact might seem low, the median ROA in our dataset is only 50 basis points. Thus, the estimates imply that modest rate hikes can notably impact the ROA. These results fall somewhere between the findings of existing literature. The positive short-term coefficient estimate aligns with the results of Borio et al. (2015). However, the insignificant estimate for the slope is more in agreement with Altavilla et al. (2018). Consequently, our first prediction is partially challenged, as the slope coefficient estimate contradicts our expectations.

When turning to specification 2, we see that the short-term rate coefficient and the yield curve's slope coefficient are estimated to be insignificant at a 5% level. These results could indicate no impact of monetary policy on bank profitability in 2010-2020. Adding the dummy interaction term has nearly zero impact on the estimated slope coefficient. In contrast, the magnitude of the estimated short-term rate coefficient is substantially reduced and far from significant. These estimates imply that the slope of the yield curve's impact on bank profitability was equally non-existent in both periods but that the impact of short-term interest rates on bank profitability might differ significantly between the two periods. Thus, the results support our second prediction and the findings of both Lopez et al. (2020) and Altavilla et al. (2018), who argue that the impact of monetary policy on bank profitability weakens in very low-interest rate environments. Consequently, our findings contradict Ulate (2021).

Table 1

Effect of monetary policy on bank profitability for the whole sample.

	2010-2023	With post-2020 dummy
	(1)	(2)
$ROA_{i,j,t-1}$	**0.81*** (0.01)**	**0.81*** (0.02)**
Short term $rate_{j,t}$	**1.01* (0.46)**	0.34 (0.73)
$Slope_{j,t}$	-0.86 (0.63)	-0.84 (0.70)
$(Post\ 2020_t) \times (Short\ term\ rate_{j,t})$	-	**1.64* (0.79)**
$(Post\ 2020_t) \times (Slope_{j,t})$	-	1.33 (1.84)
VIX_t	**-0.17*** (0.04)**	**-0.16*** (0.04)**
Real GDP $growth_{j,t}$	**0.41*** (0.09)**	**0.49*** (0.10)**
Real CPI $growth_{j,t}$	**0.76*** (0.19)**	**0.95*** (0.27)**
Expected real GDP $growth_{j,t}$	**0.46* (0.19)**	**0.65** (0.22)**
Expected real CPI $growth_{j,t}$	-0.60 (0.66)	-1.03 (0.70)
Probability of $default_{j,t}$	**-29.99*** (8.50)**	**-29.50*** (8.50)**
NPL $ratio_{i,j,t-1}$	-0.16 (0.13)	-0.18 (0.14)
Tier 1 capital $ratio_{i,j,t-1}$	-0.12 (0.13)	-0.19 (0.16)
Cost to income $ratio_{i,j,t-1}$	-0.02+ (0.01)	**-0.02* (0.01)**
Bank fixed effects	Yes	Yes
Num. Obs.	1,549	1,549
R^2	0.731	0.731

Table 1: Each column presents the coefficient estimates from fixed effects-regressions with different variables included for individual banks i and/or country j over time t. Column (1) are the results when not including dummy interaction terms that measure the difference in monetary policy effects in 2021-2023 compared to 2010-2020. Column (2) are the estimation results when such dummy interaction terms are included. The dummy variable "Post 2020" equals 1 if an observation is in

Q1 2021-Q2 2023 and equals zero otherwise. The dependent variable is the banks' ROA. Observations are quarterly and from Q1 2010 to and including Q2 2023. Variables of interest are the short-term rate (the 3-month treasury yield in region j) and the slope of the yield curve (the difference between 2-year and 10-year treasury yields), both of which are measured in percentages. Control variables include the VIX index, the real year-over-year GDP and CPI growth, expected 1-year ahead GDP and CPI growth, regional probability of default for non-financial firms, NPL-ratio, tier 1 capital ratio and the cost-to-income ratio. The superscripts ***, **, * and + indicate significance at the 0.1%, 1%, 5% and 10% levels, respectively. Heteroskedasticity-robust standard errors are in parentheses.

Turning our attention to the dummy interaction terms, we see that the coefficient estimate for $(\text{Post } 2020_t) \times (\text{Short term rate}_{j,t})$ is positive and significant on a 5%-level. The estimates imply that when holding all controls constant, a 25 basis point increase in the short-term rate could have increased the ROA by 0.41 basis points more from 2021 to 2023 than an identical rate hike increased the ROA from 2010 to 2020. The coefficient magnitude of 1.6 is somewhat higher than the short-term rate coefficient in specification 1, which was 1.0. This result supports our prediction that short-term interest rates have had a stronger impact on bank profitability since 2021 compared to the previous ten years. Furthermore, we see that the coefficient estimate for the slope dummy interaction is far from significant. The results indicate that our second prediction regarding the impact of the yield curve slope is correct and that the impact on bank profitability has not differed notably since 2021 compared to 2010-2020. Nevertheless, rather than indicating that the yield curve slopes have had equally positive causal relationships with bank profitability, they convey an equal insignificance in impacting bank profitability in the two periods.

In summary, our results support our first and second predictions for the impact of short-term interest rates on bank profitability, but our first prediction for the yield curve's slope is challenged. The results indicate that short-term rates could be more critical than yield curve slopes in determining banks' profitability. We will now discuss some potential reasons to explain why our prediction regarding the yield curve slope seems incorrect.

One reason could be that the negative relationship between loan loss provisions and bank profits has been particularly strong since 2010. The general flattening of the slopes might have kept loan defaults low through low average interest rates across maturities, and this reduction of loan loss provisions could have offset a reduction in net interest income.

Furthermore, the effect on net interest income might have been weak. This finding could reflect the non-linear relationship between yield curve slopes and net interest income due to quantity effects, as proposed by Borio et al. (2017). As shown in Section 6.3.2, sovereign yield curves have been trending downwards since 2010, and the yield slopes have thus come down to relatively low, and several times even negative, levels. In these periods of very low yield curve slopes, a higher elasticity of fixed-term mortgage volume compared to medium-term deposit volume might have limited reductions in net interest income. In other words, very low yield curves might have increased loan demand enough that the negative effects from deposit reductions are offset.

A third possibility is that banks could have shifted their attention towards non-interest income due to a persisting low-interest environment, which could limit the effect of the yield slope on overall bank profitability. As mentioned in Section 4.1.2, academics and field experts have not outlined any clear impact of changes in the term structure on non-interest income. What they do note, however, is that banks that rely more on maturity transformation activities, i.e., borrowing and lending activities, tend to have a stronger impact of yield curve changes on overall profitability (English et al., 2014). Altavilla et al. (2018) rely partially on this narrative when explaining their results of no impact of the yield curve on bank profitability. They argue that the persisting low interest rates and flat yield curves of the 2010s have forced banks to become less dependent on interest-related activities and more reliant on commissions, fees, and other income sources.

From the results, we draw that the challenges in predicting the impact of changing yield curve slopes on bank profitability in times of extraordinary financial uncertainty are immense. The divergence between short-term rates and yield curve slopes from 2022 and onwards, which was punctuated under Section 6.3, shows how the relationship between short-term rates and the yield is complex and can potentially reverse in specific periods. Therefore, a general answer to the question of how yield curve slopes affect bank profitability might not be possible to obtain.

8.2 Prediction 3

Table 2 presents the results used to evaluate our third prediction about net interest income being the source of the positive relationship between interest rates and bank profitability. The utilized dataset is the same as in the previously presented regressions. We see that the coefficient estimate for the short-term rate is positive and significant when using net interest income as the dependent variable, and the estimate is insignificant when the dependent variable is non-interest income and loan loss provisions. These results are thus in line with our fourth prediction, and they are more coherent with Altavilla et al. (2018) than Borio et al. (2015). The coefficient estimate for the yield curve's slope is insignificant across all specifications. This insignificance somewhat clarifies the causes of the insignificant yield curve estimates in our ROA analysis for prediction 1. The results could support both the presence of sensitive quantity effects in net interest income and the possible shift of focus towards non-interest income discussed in Section 8.1. Due to our prediction focusing on net interest income, we will not elaborate on the findings for non-interest-related income.

The significant short-term rate coefficient for net interest income supports the theory that the retail endowment effects might be more prevalent than the opposing quantity effects. Such dominance of net interest margin effects could reflect that the competitive landscape has generally been favorable for European banks from 2010 to 2023 and that churn rates potentially have been low. Such competition-related effects could contribute to lower sensitivity in loan demand, which could limit the reduction in loan demand in case of an interest rate hike. Muted quantity effects could indicate that there are few banks to choose from or that there might be poor transparency in the market of financial services borrowers face.

Considering the significant estimate obtained for net interest income, we find the complete insignificance of the short-term coefficient estimate when using loan loss provisions as a dependent variable peculiar. Both net interest income and loan loss provisions are closely linked to interest-related operations. Thus, one would assume that either both or none of the estimates would be significant simultaneously. However, the insignificance might be explained by the concavity of the relationship between the short-term rate and loan loss provisions outlined by Borio et al. (2015), who argue that the sensitivity of provisions increases both in low and high-interest rate environments. The distance between the low- and high-points of the interest rates in our period is considerable, with a majority of observations from either very low or rapidly increasing interest rate environments. Thus, the fact that relatively few of our observations are from periods with interest rates at historically normal levels could imply that there is no clear linearity in the relationship between interest rates and loan loss provisions in our data.

Table 2

Effect of monetary policy on income components for the whole sample.
Related to prediction 3.

	Net interest income	Non-interest income	Loan loss provisions	ROA
$Y_{i,j,t-1}$	**0.42*** (0.02)**	**0.18*** (0.03)**	**0.08** (0.03)**	**0.81*** (0.01)**
Short term rate$_{j,t}$	**1.14*** (0.20)**	-0.30 (0.29)	0.43 (0.37)	**1.01* (0.46)**
Slope$_{j,t}$	-0.50+ (0.28)	0.22 (0.39)	0.73 (0.51)	-0.86 (0.63)
VIX_t	**-0.05** (0.02)**	**-0.15*** (0.03)**	0.03 (0.03)	**-0.17* (0.04)**
Real GDP growth$_{j,t}$	-0.01 (0.04)	-0.08 (0.05)	**-0.30*** (0.07)**	**0.41*** (0.09)**
Real CPI growth$_{j,t}$	-0.07 (0.08)	-0.04 (0.12)	-0.20 (0.15)	**0.76*** (0.19)**
Expected real GDP growth$_{j,t}$	**-0.43*** (0.09)**	-0.00 (0.12)	**-0.47** (0.15)**	**0.46* (0.19)**
Expected real CPI growth$_{j,t}$	**0.95*** (0.28)**	-0.09 (0.41)	0.22 (0.53)	-0.60 (0.66)
Probability of default$_{j,t}$	-1.72 (3.60)	-8.95+ (5.24)	**14.93* (6.79)**	**-30.00*** (8.50)**
NPL ratio$_{i,j,t-1}$	0.10+ (0.05)	0.09 (0.08)	**0.75*** (0.11)**	-0.16 (0.13)
Tier 1 capital ratio$_{i,j,t-1}$	-0.06 (0.06)	**-0.25** (0.08)**	-0.12 (0.11)	-0.12 (0.13)
Cost to income ratio$_{i,j,t-1}$	-0.00 (0.00)	0.00 (0.01)	-0.01 (0.01)	-0.02+ (0.01)
Bank fixed effects	Yes	Yes	Yes	Yes
Num. Obs	1,410	1,565	1,547	1,549
R^2	0.393	0.111	0.121	0.731

Table 2: Each column presents the coefficient estimates from fixed effects-regressions when having the dependent variable equal banks' net interest income, non-interest income, loan loss provisions and ROA, respectively. All dependent variables are measured in basis points of total assets. Observations are quarterly and from Q1 2010 to and including Q2 2023 for individual banks i and/or country j over time t. Variables of interest are the short-term rate (the 3-month treasury yield in region j) and the slope of the yield curve (the difference between 2-year and 10-year treasury yields), both of which are measured in percentages. Control variables include the VIX index, the real year-over-year GDP and CPI growth, expected 1-year ahead GDP and CPI growth, regional probability of default for non-financial firms, NPL-ratio, tier 1 capital ratio and the cost-to-income ratio. The superscripts ***, **, * and + indicate significance at the 0.1%, 1%, 5% and 10% levels, respectively. Heteroskedasticity-robust standard errors are in parentheses.

8.3 Prediction 4

Table 3 presents the results that will be used to assess our fourth prediction. We observe that in column (1), the short-term rate and slope coefficients are statistically insignificant at the 5% level. This finding is against our implicit prediction that monetary policy impacts bank profitability in Norway. These estimates align with the findings in Altavilla et al. (2018), who obtained insignificant short-term interest rate and slope coefficients.

The results differ when examining the results for the Eurozone (2) and Sweden (3). For these regions, the coefficient estimates for short-term rates are both positive and statistically significant, at the 5% level for the Eurozone and even more robustly at the 1% level for Sweden. This finding is against our prediction that the short-term interest rate impacts bank profitability more in Norway than in the other regions and rather implies the opposite. The results for the Eurozone and Sweden are in line with the results of Borio et al. (2015), who found a positive and statistically significant relationship between the short-term interest rate and bank profitability.

However, similar to the estimates obtained for Norway, the slope coefficients for Eurozone and Swedish banks are insignificant at the 5% level. These results suggest that the steepness of the yield curve has not played a significant role in influencing bank profitability in these regions. The insignificance of the yield curve coefficients is discussed in Section 8.1 and will thus not be elaborated on.

The first factor that could explain the lack of significance in Norway is a required notification period, possibly muting the retail endowment effect. Norwegian banks are regulated by law to wait 6 weeks from the announcement of an interest rate increase on existing loans until the increase influences customers (Finansavtaleloven § 3-13 (2)) [10]. To our understanding, no other region in our sample has such a requirement. The notification period in Norway leads to a lag in the transmission of the central bank policy rate, which could slow the retail endowment effect for Norwegian banks compared to banks in the Eurozone and Sweden. This effect is expected to be enhanced by the fact that we use quarterly data instead of yearly data. By examining Figure 3, we observe that net interest income as a share of net revenue increased later in Norway compared to the two other regions, even though the short-term

[10] The notification period was extended from 6 to 8 weeks in July 2023.

interest rates started to surge earlier in Norway post Covid-19. This observation could reflect the lagged income effect for Norwegian banks.

The second factor that could explain the insignificance of the short-term rate coefficient in Norway is the level of bank competition. Competition is an unobserved variable we do not have sufficient data to control for. Nevertheless, some observations make us suspect a lighter competitive environment in Norway. For instance, Norway has a notably lower number of commercial bank branches per capita than the Eurozone countries and Sweden[11], which could indicate less competition in the Norwegian commercial banking sector. Additionally, our sample's median total asset size is ~20 times larger for commercial banks than savings banks. In Norway, 9 out of 10 listed banks are savings banks, which could indicate a less competitive environment, given Bikker and Haaf's findings (2002) that smaller, local banks are typically less competitive than larger banks.

If competition really is weaker in Norway, deposit rates could fall faster than lending rates in periods of falling interest rates, and this could make a positive rate-adjustment effect offset a negative retail endowment effect. In contrast, banks in more competitive markets are not expected to gain from such rate-adjustment effects, as they, to a larger extent, are forced to lower deposit rates in line with lending rates to prevent churn. By examining Figure 3, we observe a positive trend in net interest income as a share of net revenue for Norway in the period of downward trending interest rates (2010-2019). In contrast, our banks from Sweden and the Eurozone had a downward trend in net interest income as a share of net revenue. These developments could reflect a weaker rate adjustment effect in Sweden and the Eurozone, possibly explained by higher competition in these regions.

[11] See Figure A.2.

Table 3

Effect of monetary policy on bank profitability segmented by region.

	Norway	Eurozone	Sweden
	(1)	(2)	(3)
$ROA_{i,j,t-1}$	**0.84***** **(0.03)**	**0.81***** **(0.02)**	**0.66***** **(0.04)**
Short term $rate_{j,t}$	0.37 (0.92)	**1.60*** **(0.79)**	**1.65**** **(0.56)**
$Slope_{j,t}$	-0.33 (1.43)	-1.16 (0.95)	-0.87 (0.77)
VIX_t	**-0.34***** **(0.08)**	-0.09 (0.06)	**-0.25***** **(0.05)**
Real GDP $growth_{j,t}$	0.19 (0.28)	**0.40***** **(0.12)**	**0.32*** **(0.13)**
Real CPI $growth_{j,t}$	**1.05*** **(0.51)**	**0.98***** **(0.30)**	0.17 (0.27)
Expected real GDP $growth_{j,t}$	0.79+ (0.45)	0.27 (0.28)	0.13 (0.22)
Expected real CPI $growth_{j,t}$	0.32 (1.09)	-2.19 (1.39)	0.07 (0.91)
Probability of $default_{j,t}$	-14.30 (15.40)	**-34.32*** **(15.57)**	-4.76 (10.37)
NPL $ratio_{i,j,t-1}$	1.22 (1.86)	-0.12 (0.16)	-0.14 (0.90)
Tier 1 capital $ratio_{i,j,t-1}$	-0.18 (0.21)	-0.12 (0.27)	**0.35*** **(0.15)**
Cost to income $ratio_{i,j,t-1}$	-0.01 (0.01)	-0.04 (0.03)	**-0.10*** **(0.04)**
Bank Fixed Effects	Yes	Yes	Yes
Num.Obs.	396	941	212
R^2	0.78	0.71	0.87

Table 3: Each column presents the coefficient estimates from fixed effects-regressions for Norwegian banks, Eurozone banks and Swedish banks, respectively. Observations are quarterly and from Q1 2010 to and including Q2 2023 for individual banks i and/or country j over time t. The dependent variable is banks quarterly Return on Assets (ROA), which is measured in basis points. Variables of interest are the short-term rate (the 3-month treasury yield in region j) and the slope of the yield curve (the difference between 2-year and 10-year treasury yields), both of which are measured in percentages. Control variables include the VIX index, the real year-over-year GDP and CPI growth, expected 1-year ahead GDP and CPI growth, regional probability of default for non-financial firms, NPL-ratio, tier 1 capital ratio and the cost-to-income ratio. The superscripts ***, **, * and + indicate significance at the 0.1%, 1%, 5% and 10% levels, respectively. Heteroskedasticity-robust standard errors are in parentheses.

Norges Bank's distinct monetary policy measures could explain the estimated insignificant relationship between bank profitability and short-term interest rates in Norway. Norges Bank refrained from introducing negative interest rates, unlike the ECB and the Swedish Riksbank. Ulate (2021) argues that negative interest rates, particularly when coupled with a zero lower bound on deposits, always lead to declining bank profitability.

Hence, if Ulate (2021) is correct, the statistically significant estimates obtained for Sweden and the Eurozone could be attributed to a strong causal effect of interest rates on bank profitability in periods with negative policy rates. By Altavilla et al. (2018), the low but positive interest rate environment in Norway might have weakened the causal effect of interest rates on bank profitability and cause the lack of statistical significance in column (1). However, when testing prediction 2, our results indicated no significant impact of interest rates on bank profitability in 2010-2020. Considering the fact that the majority of banks used to obtain these results were either Swedish or from the Eurozone, these results support the narrative of Lopez et al. (2020) more than the arguments made by Ulate (2021). This observation makes us suspect that the high significance of monetary policy on Swedish and Eurozone banks' profitability is explained by other factors. Such factors could be the structural ones discussed above.

8.4 Prediction 5

Table 4 presents the results that we will use to test prediction 5. The dataset consists of the same 34 banks analyzed earlier, observed in 22 event windows from 2021 to 2023. In the regressions, stock price changes are measured as percentage changes, while interest rate changes are measured as percentage point changes[12]. When inspecting the interest rate coefficient estimates for the various countries, we see that the results diverge significantly from our fifth prediction.

[12] See Equation 2.

Table 4
Effects of monetary policy surprises on bank stock prices.
Related to prediction 5.

	All	Eurozone	Norway	Sweden
	(1)	(2)	(3)	(4)
Short term rate surprises$_{j,t}$	**-4.745***** **(0.924)**	**-7.824***** **(1.086)**	-0.309 (1.710)	0.244 (2.006)
Slope surprises$_{j,t}$	**-6.217**** **(2.258)**	**-15.639***** **(3.458)**	2.894 (2.760)	-4.509 (8.234)
NPL ratio$_{i,j,t}$	**-0.727***** **(0.156)**	**-0.676**** **(0.257)**	**1.217***** **(0.315)**	0.940 (2.145)
Tier 1 capital ratio$_{i,j,t}$	**0.247**** **(0.091)**	**0.634*** **(0.310)**	0.042 (0.046)	**0.428*** **(0.211)**
Cost to income ratio$_{i,j,t}$	-0.003 (0.003)	0.006 (0.007)	-0.005 (0.003)	0.018 (0.020)
$(\text{Short term rate}_{j,t}) \times (\text{NPL ratio}_{i,j,t})$	**0.339***** **(0.058)**	0.270 (0.157)	**-0.363***** **(0.088)**	-0.324 (1.208)
$(\text{Slope}_{j,t}) \times (\text{NPL ratio}_{i,j,t})$	**1.658***** **(0.275)**	1.045 (0.673)	0.795 (0.617)	-0.831 (4.259)
$(\text{Short term rate}_{j,t}) \times (\text{Tier 1 capital ratio}_{i,j,t})$	**-0.086**** **(0.028)**	-0.104 (0.088)	-0.019 (0.016)	0.417 (0.618)
$(\text{Slope}_{j,t}) \times (\text{Tier 1 capital ratio}_{i,j,t})$	-0.136 (0.089)	-0.333 (0.384)	-0.012 (0.053)	1.616 (2.328)
Bank fixed effects	Yes	Yes	Yes	Yes
Num. Obs.	690	396	185	109
R^2	0.229	0.454	0.196	0.436

Table 4: Each column presents the coefficient estimates from fixed effects-regressions for All banks, Eurozone banks, Norwegian banks and Swedish banks, respectively, for individual banks i and/or country j over time t. Dependent variable is stock price changes, which are measured as percentage changes. Short-term rate surprises are sudden changes in the 1-month OIS, measured in percentage points change. Slope surprises are sudden changes in the difference between 2-year and 5-year government treasury yields, measured in percentage points change. Control variables include the NPL-ratio, tier 1 capital ratio and the cost-to-income ratio. The NPL ratio and Tier 1 capital ratio control variables are also interacted with the levels of the 1-month OIS rate and the Slope of the yield curve on a given announcement date. The superscripts ***, **, * and + indicate significance at the 0.1%, 1%, 5% and 10% levels, respectively. Heteroskedasticity-robust standard errors are in parentheses.

Assessing the results for the Eurozone, we see that both the short-term rate surprise and the yield curve surprise coefficients are estimated to be highly significant and negative. The short-term rate estimate implies that a sudden one percentage point rise in short-term rates is associated with a 7.8 percent drop in bank stock prices, holding bank characteristics constant. Alternatively, a sudden 0.1 percentage point increase in short-term rates is associated with a 0.78 percent drop in bank stock prices. These findings speak against our predictions of a positive impact of sudden interest rate changes on Eurozone bank stock prices and instead indicate that markets responded quite negatively (positively) to sudden interest rate hikes (drops), which is like the findings of Altavilla et al. (2018), English et al. (2012) and Ampudia et al. (2018).

None of the interest rate coefficient estimates are significant for the Norwegian and Swedish banks. Thus, our expectation of a positive (negative) impact of sudden interest rate hikes (drops) on Norwegian and Swedish bank stock prices is challenged. Moreover, the results contradict the findings of Altavilla et al. (2018), English et al. (2012), and Ampudia et al. (2018).

Considering that the results from our ROA analysis indicate a strong positive impact of interest rate hikes on Eurozone bank profitability since 2021, the significantly negative short-term interest rate coefficient for Eurozone bank stocks is unexpected. There could be several reasons we obtain such divergence in our results. One cause could be that we have overestimated the significance of optimism for increased bank profitability in case of an interest rate hike compared to the pessimism induced by increased discount rates and a worse macroeconomic backdrop. Such a dynamic could very well be the case for the Eurozone, as the recent financial turmoil makes it reasonable to believe that market sentiment might be very sensitive to interest rate changes in the region. Another possibility is that there has been a lag effect after an interest rate hike before market participants turn optimistic about bank stocks due to these market players possibly "fence-sitting" and awaiting quarterly financial updates from banks before they turn positive and buy the stocks. We would argue that the explanation of macroeconomic and geopolitical headwinds causing more weighting in the negative associations linked to rising interest rates is more reasonable than such lag effects.

Although the insignificance of the interest rate coefficients for Norwegian banks was not predicted, it falls in line with our other unpredicted results from previous analyses. As we previously found no indications of a significant impact of interest rates on Norwegian balance-sheet bank profitability, it makes sense that the positive expectations for future bank cash flows from rising interest rates are not strong enough to create a positive effect of rate hikes on bank stock prices. Importantly, our results still imply some positive association between rate hikes and bank profitability. However, the results indicate that these effects are not strong enough to overthrow the negative associations regarding rising discount factors and a worsening macroeconomic backdrop, as presented in Section 4.2.

When comparing results for the different regions, our suspicion of rate adjustment effects for Norwegian banks increases. Our findings imply that markets are more optimistic about Norwegian banks' future cash flows than Eurozone banks' future cash flows in case of a rate hike. These findings contradict our results when testing prediction 4, which implied that Norwegian balance-sheet profitability was the least positively impacted by rate hikes. Thus, we suspect more firmly that the insignificance of interest rate hikes on Norwegian balance-sheet profitability might reflect the Norwegian banking market's structural characteristics rather than the Norwegian banks' poor ability to exploit rising interest rates.

A possible explanation for our results regarding Norwegian and Swedish banks is that few observations hinder the model's ability to capture significant effects. With only 185 observations, the number of controls added might be too high for the model to capture a significantly positive effect. Thus, utilizing a longer time series, our model might have yielded significant results. However, we must acknowledge that the control for the NPL-ratio yielded significant results, indicating that the dataset generally has enough observations to estimate significant relationships. Significant controls are also the case in the results for the Swedish regression, which yields a significant tier 1 capital ratio coefficient. These significances make us somewhat less concerned that limited data length for each country hinders the estimation process.

9 Robustness

9.1 Fixed effects estimator

Including the lagged ROA as an independent variable could induce dynamic panel bias in a fixed effects model (Nickell, 1981). Therefore, we will control for such biases by estimating our model using System-GMM and pooled OLS estimators, as Altavilla et al. (2018) do. We will not include a random effects estimator, as Hausman testing indicates the inappropriateness of such an estimator. When using the System-GMM estimator, we utilize the same specification as Altavilla et al. (2018). The results can be found in Table A.4 in the appendix, where we can see that the estimates from the S-GMM-estimator and the POLS-estimator are very similar to those obtained from the FE-estimator. The coefficient estimates are similar in magnitude and standard errors for both the short-term rate and the yield curve slope. Thus, the results favor our usage of a fixed effects estimator.

9.2 Treasury bills as a short-term interest rate proxy

As mentioned under Section 6.3.1, Norway has not had an overnight indexed swap before 2022, which makes using the preferred OIS rate as our short-term rate variable to test our four first predictions challenging. Even though the 3-month government treasury yields we have utilized are very similar to the 3-month OISs at a quarterly level, there are some deviations between the two, and we want to control for bias due to these small fluctuations. Therefore, we test the sensitivity of our estimate results by using 3-month IBOR rates as our short-term interest rate proxy, and the results from said test can be found in Table A.5 in the appendix.

We see that using IBOR rates as short-term rate proxies causes both the magnitude and the significance of short-term rate coefficient estimates to increase. In specification 1, the short-term coefficient estimate increased in magnitude from 1.01 to 1.33, implying that bank profitability might be impacted more by a given change in IBORs than the same change in T-bill yields. This finding seems natural as interbank rates better reflect the bank's interest rate conditions than the sovereign yields. However, their reflection of bank credit conditions is precisely why we chose not to use IBORs in our main results. Their inclusion of a credit premium makes them less of a purely monetary policy-effected risk-free interest rate, which is what our research question concerns.

In specification 2, the dummy interaction for the short-term rate' estimate increases massively from 1.64 to 2.25, indicating that the difference in effects between 2010-2020 and 2021-2023 is stronger for the IBORs than the t-bill yields. One possible explanation for the stronger magnitude in the dummy interaction estimate could be the credit risk premium included in the IBOR rates. Rapid interest rate hikes and various events of financial turmoil since 2021 could have raised credit risk premiums notably compared to the credit premium levels in the low-interest period in the preceding decade. In general, the results of our analysis seem to be robust to using IBORs as short-term rate proxies.

9.3 Non-stationary variables in levels

As mentioned in Section 7.2, we will test the model used for prediction 3 for robustness by transforming non-stationary variables. We will use first difference transformation to make all non-stationary variables stationary and assess whether test results differ.

The results from the robustness test can be found in Table A.6 in the appendix. Interestingly, the transformation has made the short-term interest rate coefficient estimate in the loan loss provisions specification significant and negative. This coefficient estimate is the opposite of what one would expect to get for the loan loss provision variable, as it implies that higher interest rates could reduce loan losses.

First difference-transformation eliminates a lot of the comparability with the ROA analysis, as first differencing makes the model estimate other effects than the model would with the interest rates in levels. (Spearot, 2014) When using first difference transformation, the income components' interest rate estimates reflect more short-term than long-term effects. Therefore, the first difference approach could yield biased results if part of the effects are lagged due to the absence of important long-term mechanisms. As previously mentioned, the relationship between interest rates and loan loss provisions could be non-linear. However, considering the long period from 2010 to 2023 we have used to estimate these results, we see a significantly negative interest rate coefficient estimate to be very unlikely to represent the true effects. Further, neither Altavilla et al. (2018) nor Borio et al. (2015) conducted first difference robustness tests in their studies. In sum, we believe the results might indicate the inappropriateness of using a first-difference transformation for our variables due to the transformation removing a crucial long-term component of the effect.

9.4 Inclusion of controls

The magnitude and significance of our interest rate variables could be sensitive to what controls we include in our model. Like Altavilla et al. (2018), we believe that all controls included in our model are essential factors to hold constant when attempting to find the causal impact of interest rates on bank profitability. Still, we include Table A.7 in the appendix, showing how interest rate coefficient estimates change when gradually including more controls. The table shows that with only a few exceptions, the short-term rate is estimated to be significant and positive, and the yield curve is estimated to be insignificant. Thus, the results support the notion that the estimations from Section 8.1 are valid.

10 Limitations

In this section, we examine the limitations and constraints of our study on the relationship between interest rates and bank profitability.

First, we do not control for international banking operations, competition levels, and maturity transformation strategies due to a lack of data availability. Moreover, like Altavilla et al. (2018), we do not include a control for bank asset size. We expect these variables to be correlated with bank profitability and that omitting them could reduce the accuracy of our estimates.

Second, we use a linear model to predict what could be a non-linear relationship. Thus, our model might not fully capture the nuances of how changes in interest rates affect bank profitability, especially at very high or very low levels of interest rates. Our usage of linear models can lead to an oversimplified understanding of monetary policy's impact on bank profitability, potentially leading to underestimated or overestimated coefficients.

Third, results for prediction 5 could lack robustness due to different factors. This analysis's short and recent time series limits our ability to compare its results with those from predictions 1 through 4. Moreover, stock and OIS data from Norway and Sweden markets are less liquid than Eurozone data. A lower trading volume in Norwegian and Swedish securities could make it difficult for our model to register minor but significant stock price changes in reaction to interest rate changes in these regions. Lastly, we do not test the impact of monetary policy surprises on the stock prices of companies in other industries. Comparing changes in banking stocks with changes in other stocks could provide more information on the prevalence of optimism regarding banking cash flows.

11 Conclusions

With this thesis, we attempt to contribute to existing literature on the impact of monetary policy on bank profitability. We adopt existing methodologies and theoretical frameworks and apply them to our unique research question, which combines a focus on the general effects of monetary policy on bank profitability and a focus on comparisons across periods and regions.

Without segmenting banks by regions, our findings suggest a positive relationship between short-term interest rates and bank profitability. Our results support the notion that this positive relationship could have been stronger from 2021 and onwards compared to the downward trending interest rate environment of the 2010s. As anticipated, our findings indicate that the relationship between interest rates and bank profitability could be driven mainly by the net interest income channel. Moreover, the results imply that changes in the yield curve slope might not impact bank profitability.

The estimates we obtain imply that short-term interest rates could have a positive causal relationship with balance-sheet bank profitability in Sweden and the Eurozone but that there might not be a significant impact on Norwegian banks' financial statements. The results are the opposite of our predictions of Norwegian banks being most strongly impacted by bank profitability. However, our stock market analysis indicates that markets could be more optimistic about Norwegian bank's exploitation of interest rate hikes than Eurozone banks' ability to do so. In other words, our analyses make us inconclusive about the strength of monetary policy effects on bank profitability in Norway compared to the Eurozone. For further research, we believe controlling for differences in regulatory systems and competitive landscapes between countries could provide meaningful insights into regional differences in the effect of monetary policy on bank profitability.

12 Sources

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13 Appendix

Table A.1
Definitions of key variables.

Variable	**Description**
Return on assets$_{i,j,t}$:	Net income over total assets.
Short-term interest rate$_{j,t}$:	3-month treasury bond yields for Norway, Sweden and the Eurozone.[13]
Slope$_{j,t}$:	Difference between 2- and 10-year sovereign treasury yield.
VIX$_{t}$:	Global market's expectation of volatility over the next 30 days.
Real GDP growth$_{j,t}$:	Actual year-on-year quarterly growth.
Real CPI growth$_{j,t}$:	Actual year-on-year quarterly growth.
Expected real GDP$_{j,t}$:	Median 1 year ahead expected GDP growth, according to Bloomberg consensus forecast.
Expected CPI$_{j,t}$:	Median 1 year ahead expected CPI growth, according to Bloomberg consensus forecast.
Proability of default$_{j,t}$:	Median regional probability of default for non-financial firms.[14]
NPL ratio$_{i,j,t}$:	The ratio of non-performing loans to total loans.
Regulatory capital ratio$_{i,j,t}$:	The ratio of tier 1 capital to risk-weighted assets.
Cost-to-income ratio$_{i,j,t}$:	The ratio of operating expenses to the sum of net interest income, fees, non-interest income and provisions.

Table A.1: Definitions of variables included at a quarterly frequency on either a country-specific j and/or a bank-specific i level from time t Q1 2010 to Q2 2023. The data source is Bloomberg, unless specified otherwise.

[13] We have collected the 3-month Euro area interest rate for countries within the ECB.
[14] Source is NUS Credit Research Initiative (2023).

Figure A.1

Performance of various bank stock indices.

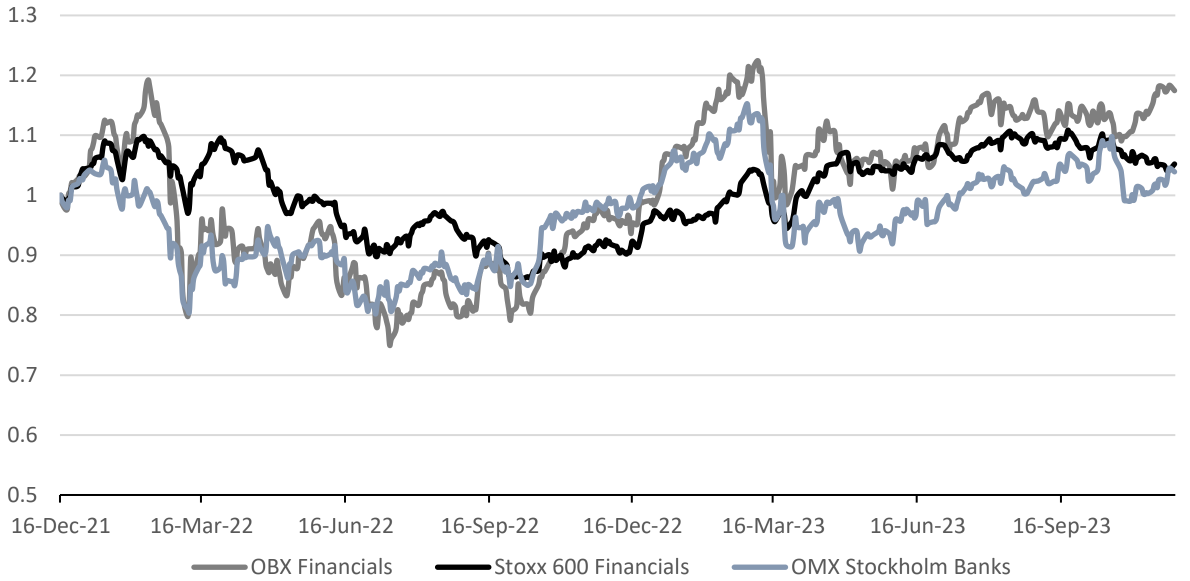

Figure A.1 1: The return of key banking- and financial services-indices in Norway, Sweden and the Eurozone in the last two years. Index = 1 at date 16-Dec-21.

Figure A.2

Commercial bank branches per 100,000 adults.

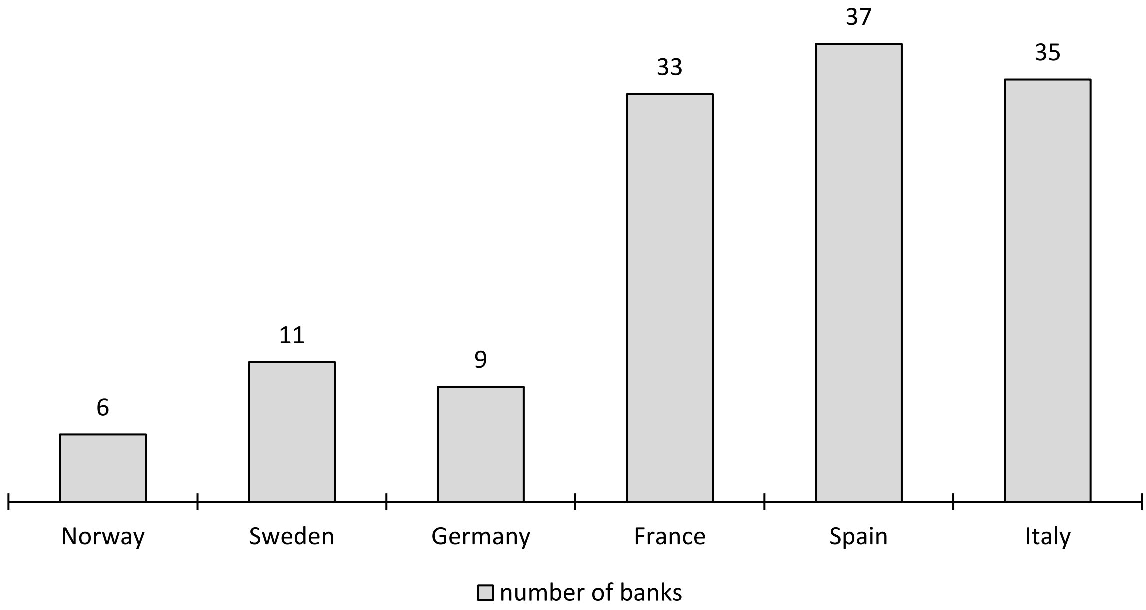

Figure A.2: The number of commercial bank branches per 100,000 adults, segmented by country. A lower number of branches could indicate relatively less competition, while a higher number could indicate relatively more competition. Source is The World Bank (2023).

Table A.2

Descriptive statistics for financial, macroeconomic and bank-specific variables.

Variables	Mean	SD	Min	Q25	Median	Q75	Max	N
Dependent variables (in basis points)								
Return on assets$_{i,j,t}$	49.97	33.50	-134.55	27.51	48.39	70.32	172.28	1756
Net interest income$_{i,j,t}$	34.50	12.94	-56.68	25.49	34.52	41.90	132.01	1637
Non-interest income$_{i,j,t}$	24.97	13.30	-10.47	15.64	23.90	31.50	100.73	1798
Provisions$_{i,j,t}$	6.96	11.41	-42.96	1.12	3.39	9.41	202.80	1766
Variables of interest (in percentages)								
Short term rate$_{j,t}$	0.38	1.08	-0.90	-0.54	0.06	0.96	4.08	1835
Slope$_{j,t}$	1.19	0.74	-0.80	0.72	1.14	1.69	2.87	1835
Financial control variables (in percentages)								
VIX$_t$	19.16	7.88	9.51	13.95	16.86	21.67	53.54	1835
Probability of default$_{j,t}$	0.15	0.07	0.04	009	0.14	0.19	0.39	1835
Macroeconomic control variables (in percentages)								
Real GDP growth$_{j,t}$	1.37	3.71	-21.95	0.17	1.52	2.84	19.10	1828
Real CPI growth$_{j,t}$	2.11	2.24	-1.00	0.70	1.60	2.70	12.34	1835
Expected GDP$_{j,t}$	2.17	1.83	-0.95	1.15	1.80	2.58	12.67	1835
Expected CPI$_{j,t}$	1.69	0.60	0.60	1.25	1.60	2.00	4.00	1825
Bank-specific control variables (in ratios)								
NPL$_{i,j,t}$	4.31	4.86	0.13	0.75	2.84	5.39	26.70	1609
Tier 1 capital$_{i,j,t}$	14.73	3.74	0.20	12.16	14.20	17.00	32.22	1767
Cost-to-income$_{i,j,t}$	2.04	3.09	-17.80	0.75	1.46	3.04	19.69	1747

Table A.2: Descriptive statistics for variables included in the balance-sheet analyses for individual banks i and/or country j over time t. The return on assets, net interest income, non-interest income and loan loss provisions are measured in basis points of total assets. The short-term rate is the 3-month treasury yield. The slope is the difference between 2-year and 10-year treasury yields. Probability of default is the regional probability of default for non-financial firms. Expected GDP and CPI growth is the running 1-year ahead expectations for year-over-year growth according to Bloomberg consensus forecast. The NPL-ratio is the ratio of non-performing loans to total loans. The tier 1 capital ratio is the ratio of tier 1 capital to total assets. The cost-to-income ratio is ratio of total operating cost to total revenue.

Table A.3

Descriptive statistics of estimated intraday surprise changes.

Variables	Mean	SD	Min	Q25	Median	Q75	Max	N
Stock price changes (in percentages)								
Stock price changes$_{i,j,t}$	0.12	1.16	6.46	-0.47	0.13	0.75	6.58	695
Interest rate surprises (in basis points)								
Short term rate$_{j,t}$	0.85	5.21	-12.73	-0.25	0.00	0.40	15.06	764
Slope$_{j,t}$	-0.67	2.22	-6.83	-1.50	-0.79	0.27	6.22	814

Table A.3: Descriptive statistics for estimated stock price changes and interest rate changes included in the dataset used to test prediction 5 for individual banks i and/or country j over time t. Stock price changes are the percentage change in prices, while interest rate surprises are the basis point difference in interest rates from before to after policy announcement events. Observations are from the last 11 monetary policy announcements for the Norwegian, Swedish and Eurozone central bank. The dates for the observations range from September 2021 until November 2023.

Figure A.3

1-month OIS rates surprise-estimations – last 11 monetary policy press releases and press conferences.

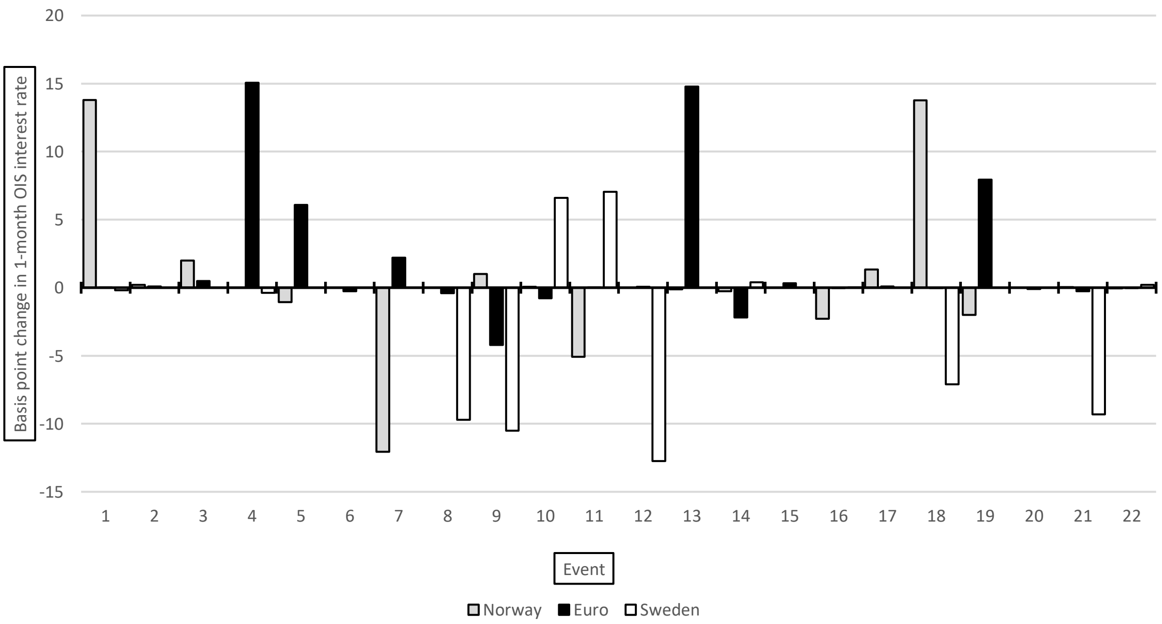

Figure A.3: Changes in 1-month Overnight Indexed Swaps (OIS) for Norway, Sweden and the Eurozone estimated in our 22 estimation-windows (using the 11 last monetary policy press releases and the 11 last monetary policy press conferences for the Norwegian, Swedish and Eurozone central banks). Events occur between 21.09.2021 and 23.11.2023.

Table A.4

Robustness-test of coefficient estimates related to prediction 1 using different estimators.

	Fixed effects	System GMM	Pooled OLS
$\mathrm{ROA}_{i,j,t-1}$	**0.82*** (0.02)**	**0.98*** (0.07)**	**0.91*** (0.01)**
$\text{Short-term rate}_{j,t}$	**1.01* (0.46)**	**1.81* (0.92)**	**1.48** (0.46)**
$\mathrm{Slope}_{j,t}$	-0.86 (0.63)	0.80 (0.86)	0.33 (0.59)
VIX_{t}	**-0.17*** (0.04)**	**-0.19* (0.08)**	**-0.20*** (0.04)**
$\text{Real GDP growth}_{j,t}$	**0.41*** (0.09)**	**0.50** (0.18)**	**0.46*** (0.09)**
$\text{Real CPI growth}_{j,t}$	**0.76*** (0.19)**	0.13 (0.28)	**0.43* (0.17)**
$\text{Expected real GDP growth}_{j,t}$	**0.46* (0.19)**	**0.99** (0.31)**	**0.73*** (0.19)**
$\text{Expected real CPI growth}_{j,t}$	-0.60 (0.66)	1.56 (1.10)	-0.55 (0.66)
$\text{Probability of default}_{j,t}$	**-30.00*** (8.50)**	**-19.52* (9.04)**	-4.42 (6.97)
$\text{NPL ratio}_{i,j,t-1}$	-0.16 (0.13)	0.12 (0.15)	-0.04 (0.08)
$\text{Tier 1 capital ratio}_{i,j,t-1}$	-0.13 (0.14)	0.08 (0.20)	0.11 (0.10)
$\text{Cost to income ratio}_{i,j,t-1}$	-0.02+ (0.009)	-0.01+ (0.00)	-0.01 (0.01)
Bank fixed effects	Yes	Yes	Yes
Num. Obs	1,410	1,357	1,549
R^2	0.73	-	0.88
AR(1)	-	0.00	-
AR(2)	-	0.06	-

Table A.4: Each column presents the coefficient estimates from regressions using a fixed effects-estimator, a System GMM-estimator and a Pooled OLS-estimator, respectively. In column (2) are the lag of all endogenous and exogenous variables included as instrumental variables. The dependent variable is banks quarterly Return on Assets (ROA), which is measured in basis points. Variables of interest are the short-term rate (the 3-month treasury yield in region j) and the slope of the yield curve (the difference between 2-year and 10-year treasury yields), both of which are measured in percentages. Control variables include the VIX index, the real year-over-year GDP and CPI growth, expected 1-year ahead GDP and CPI growth, regional probability of default for non-financial firms, NPL-ratio, tier 1 capital ratio and the cost-to-income ratio. The superscripts ***, **, * and + indicate significance at the 0.1%, 1%, 5% and 10% levels, respectively. Heteroskedasticity-robust standard errors are in parentheses.

Table A.5

Estimates related to predictions 1 and 2 using IBOR rates as short-term interest rates.

	(1)	(2)
$ROA_{i,j,t-1}$	**0.82*** **(0.01)**	**0.81*** **(0.01)**
Short-term $rate_{j,t}$	**1.33*** **(0.47)**	0.48 (0.65)
$Slope_{j,t}$	-0.79 (0.63)	-0.70 (0.69)
$(Post\ 2020_t) \times (Short\ term\ rate_{j,t})$	-	**2.25*** **(0.91)**
$(Post\ 2020_t) \times (Slope_{j,t})$	-	1.90 (1.74)
VIX_t	**-0.17***** **(0.04)**	**-0.16***** **(0.04)**
Real GDP $growth_{j,t}$	**0.40***** **(0.08)**	**0.51***** **(0.10)**
Real CPI $growth_{j,t}$	**0.80***** **(0.18)**	**0.98***** **(0.26)**
Expected real GDP $growth_{j,t}$	**0.52**** **(0.20)**	**0.75***** **(0.23)**
Expected real CPI $growth_{j,t}$	-0.82 (0.66)	-1.40+ (0.72)
Probability of $default_{j,t}$	**-33.32***** **(8.69)**	**-31.41***** **(8.71)**
NPL $ratio_{i,j,t-1}$	-0.14 (0.13)	-0.16 (0.14)
Tier 1 capital $ratio_{i,j,t-1}$	-0.07 (0.14)	-0.18 (0.16)
Cost to income $ratio_{i,j,t-1}$	-0.02+ (0.01)	**-0.02*** **(0.01)**
Bank fixed effects	Yes	Yes
Num. Obs.	1,549	1,549
R^2	0.731	0.732

Table A.5: Each column presents the coefficient estimates from regressions using a fixed effects-estimator, a System GMM-estimator and a Pooled OLS-estimator, respectively. In column (2) are the lag of all endogenous and exogenous variables included as instrumental variables. Observations are quarterly and from Q1 2010 to and including Q2 2023 for individual banks i and/or country j over time t. The dependent variable is banks quarterly Return on Assets (ROA), which is measured in basis points. Variables of interest are the short-term rate (the 3-month interbank offered rate in region j) and the slope of the yield curve (the difference between 2-year and 10-year treasury yields), both of which are measured in percentages. Control variables include the VIX index, the real year-over-year GDP and CPI growth, expected 1-year ahead GDP and CPI growth, regional probability of default for non-financial firms, NPL-ratio, tier 1 capital ratio and the cost-to-income ratio. The superscripts ***, **, * and + indicate significance at the 0.1%, 1%, 5% and 10% levels, respectively. Heteroskedasticity-robust standard errors are in parentheses.

Table A.6

Regression estimates for prediction 3, using first-difference transformation of non-stationary variables.

	Net interest income	Non-interest income	Loan loss provisions
$Y_{i,j,t-1}$	**0.45***** **(0.02)**	**0.19***** **(0.03)**	**0.09***** **(0.03)**
$\text{Short term rate}_{j,t} - \text{Short term rate}_{j,t-1}$	**102.11*** **(41.68)**	-41.61 (59.36)	**-237.90**** **(76.88)**
$\text{Slope}_{j,t} - \text{Slope}_{j,t-1}$	-47.15 (37.65)	-25.49 (53.95)	-46.49 (70.15)
VIX_t	**-0.06**** **(0.018)**	**-0.16***** **(0.03)**	0.01 (0.03)
$\text{Real GDP growth}_{j,t}$	-0.01 (0.04)	-0.10+ (0.05)	**-0.29***** **(0.07)**
$\text{Real CPI growth}_{j,t} - \text{Real CPI growth}_{j,t-1}$	**-52.53***** **(15.80)**	23.55 (23.10)	-5.32 (29.86)
$\text{Expected real GDP growth}_{j,t}$	**-0.47***** **(0.08)**	-0.01 (0.11)	**-0.44**** **(0.14)**
$\text{Expected real CPI growth}_{j,t} -$ $\text{Expected real CPI growth}_{j,t-1}$	**-43.38***** **(35.59)**	-61.68 (51.66)	103.95 (66.67)
$\text{Probability of default}_{j,t}$	**11.12***** **(3.20)**	-7.50+ (4.54)	**15.94**** **(5.84)**
$\text{NPL ratio}_{i,j,t-1}$	0.05 (0.05)	**0.17*** **(0.08)**	**0.79***** **(0.10)**
$\text{Tier 1 capital ratio}_{i,j,t-1} -$ $\text{Tier 1 capital ratio}_{i,j,t-2}$	-0.05 (0.08)	-0.03 (0.12)	0.11 (0.16)
$\text{Cost to income ratio}_{i,j,t-1}$	0.00 (0.00)	0.00 (0.01)	-0.01 (0.01)
Bank fixed effects	Yes	Yes	Yes
Num. Obs	1,391	1,545	1,528
R^2	0.367	0.104	0.121

Table A.6: Each column presents the coefficient estimates from fixed effects-regressions when having the dependent variable equal banks' net interest income, non-interest income and loan loss provisions, respectively. All dependent variables are measured in basis points of total assets. Observations are quarterly and from Q1 2010 to and including Q2 2023 for individual banks i and/or country j over time t. Variables of interest are the short-term rate (the 3-month treasury yield in region j) and the slope of the yield curve (the difference between 2-year and 10-year treasury yields), both of which are measured in percentages. Control variables include the VIX index, the real year-over-year GDP and CPI growth, expected 1-year ahead GDP and CPI growth, regional probability of default for non-financial firms, NPL-ratio, tier 1 capital ratio and the cost-to-income ratio. The variables for the short-term rate, the slope, the real CPI growth, the expected CPI growth and the tier 1 capital ratio are first difference transformed. The superscripts ***, **, * and + indicate significance at the 0.1%, 1%, 5% and 10% levels, respectively. Heteroskedasticity-robust standard errors are in parentheses.

Table A.7

Robustness-test of coefficient estimates related to prediction 1 using a gradual inclusion of control variables.

	2010-2023					
	(1)	(2)	(3)	(4)	(5)	(6)
$ROA_{i,j,t-1}$	**0.85***** **(0.01)**	**0.83***** **(0.01)**	**0.84***** **(0.01)**	**0.83***** **(0.013)**	**0.82***** **(0.01)**	**0.82***** **(0.02)**
Short term $rate_{j,t}$	**0.75*** **(0.31)**	-0.02 (0.36)	0.35 (0.38)	**0.84*** **(0.42)**	**0.96*** **(0.45)**	**1.01*** **(0.46)**
$Slope_{j,t}$	-0.90+ (0.51)	**-1.51**** **(0.52)**	-1.00+ (0.56)	-0.80 (0.56)	-0.72 (0.60)	-0.86 (0.63)
VIX_t		**-0.20***** **(0.04)**	**-0.21***** **(0.04)**	**-0.17***** **(0.04)**	**-0.17***** **(0.04)**	**-0.17***** **(0.04)**
Real GDP $growth_{j,t}$		**0.44***** **(0.08)**	**0.49***** **(0.08)**	**0.46***** **(0.08)**	**0.42***** **(0.09)**	**0.41***** **(0.09)**
Real CPI $growth_{j,t}$		**0.57***** **(0.15)**	**0.66***** **(0.17)**	**0.66***** **(0.17)**	**0.75***** **(0.17)**	**0.76***** **(0.19)**
Expected real GDP $growth_{j,t}$			**0.54**** **(0.18)**	**0.55**** **(0.18)**	**0.50**** **(0.19)**	**0.46*** **(0.19)**
Expected real CPI $growth_{j,t}$			-0.42 (0.62)	-0.28 (0.62)	-0.44 (0.65)	-0.60 (0.66)
Probability of $default_{j,t}$				**-19.79**** **(7.46)**	**-27.36***** **(8.25)**	**-30.00***** **(8.50)**
NPL $ratio_{i,j,t-1}$						-0.16 (0.13)
Tier 1 capital $ratio_{i,j,t-1}$						-0.13 (0.14)
Cost to income $ratio_{i,j,t-1}$						-0.02+ (0.01)
Bank fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Num. Obs	1,720	1,713	1,713	1,713	1,549	1,549
R^2	0.73	0.74	0.74	0.74	0.79	0.73

Table A.7: Each column presents the coefficient estimates from regressions using a fixed effects-estimator with a certain amount of control variables included. In column (6) are the estimates used as main results to test prediction 1. Observations are quarterly and from Q1 2010 to and including Q2 2023 for individual banks i and/or country j over time t. The dependent variable is banks quarterly Return on Assets (ROA), which is measured in basis points. Variables of interest are the short-term rate (the 3-month interbank offered rate in region j) and the slope of the yield curve (the difference between 2-year and 10-year treasury yields), both of which are measured in percentages. Control variables include the VIX index, the real year-over-year GDP and CPI growth, expected 1-year ahead GDP and CPI growth, regional probability of default for non-financial firms, NPL-ratio, tier 1 capital ratio and the cost-to-income ratio. The superscripts ***, **, * and + indicate significance at the 0.1%, 1%, 5% and 10% levels, respectively. Heteroskedasticity-robust standard errors are in parentheses.