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EUROPEAN BANK STOCK RETURNS AND ITS RELATION WITH INTEREST RATE RISK.

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I declare that the research was conducted in accordance with the rules governing scientific and academic integrity. I have read, and acted in accordance with, the Code of Ethics of the Faculty.

Preface

Firstly, I want to thank Prof. Dr. Rudi Vander Vennet for entrusting me with this captivating topic and the necessary papers to get me started, as well as for his guidance along the way. Secondly, I would like to thank Mathieu Simoens for providing data and addressing my questions throughout the writing process.

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List of Abbreviations

- BIS: Bank for International Settlements
- ECB: European Central Bank
- GFC: Great Financial Crisis
- HICP Harmonized Index of Consumer Prices
- HML: High Minus Low
- NIM: Net Interest Margin
- OIS: Overnight Indexed Swap
- PEPP Pandemic Emergency Purchase Programme
- SMB: Small Minus Big

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1 Introduction

Banks face a lot of different financial risks while performing their activities. There is credit risk, liquidity risk, currency risk, and also very important, interest rate risk. Interest risk describes how much a bank's earnings and valuations are affected by interest rate fluctuations. It is a very topical issue, given, for example, the recent collapse of Silicon Valley Bank. This collapse was, to a great extent, caused by bad management of interest rate risk. The bank invested heavily in long-term US bonds to get some return in a low/negative-interest environment. They were forced to sell these bonds at a loss when increasing rates caused depositors to demand higher returns, leading to a bank run which consequently caused the bank to fail (Reuters, 2023).

We are going to be interested in how interest rate risk affects bank stock returns. The importance of studying this relation lies in the fact that interest rate risk is positioned at the heart of our banking system and its activities (Entrop et al., 2017). Interest rates, and changes therein, can affect a bank through different channels. These channels can, as we will explain more thoroughly in our literature review, have an impact on the return of bank stocks.

Literature on the relation between interest rate risk and bank stock returns has mostly been looking at banks in the U.S. and some specific European countries. We contribute to the literature by emphasizing the use of a dataset containing banks from 17 European countries (Table 2). Another contribution we make is to analyze the effects of different periods, such as: the period of negative rates, the covid pandemic, and the recent upward shift in interest rates. We saw that most studies used datasets that were more focused on periods in the 1980s and 1990s, some using more recent datasets around the Great Financial Crisis, but overall lacking insight into recent developments. We find that, for the full sample period, there is a significant positive relation between interest rates and bank stock returns, situated in the middle-to-long-term rates. We nuance this result for different time periods, regions, yield spreads, and deposit ratios.

Our main research question in this thesis is going to be: "How does European interest rate risk affect the returns on European bank stocks?". We are also interested in the possibility of time-varying interest rate risk and the existence of regional differences. These topics are important to analyze because of the monetary policy implications that a deeper insight into the relation between interest rates and bank stock returns can have. Bank regulations can also be adapted to the existence of regional differences when a certain group of countries is found to carry more interest rate risk than the other. All of this comes down to the importance of financial stability, in which the banking sector plays an important role as a financial intermediary to the real economy.

To find an answer to our research question, we will look at the theoretical foundations for interest rate risk, how it originates, and how it relates to bank stock returns. Different angles will be dealt with. In the first part of our analysis, we will use interest rates in levels. This part includes a rather limited Stone two-factor model, in which we only look at the market beta of bank stocks and the interest rate risk, which we will compare with a more extended four-factor model, in which we include the SMB and HML factors from Fama and French. We will also take interest in whether or not a time-varying effect on interest rate risk exists, and how it affects bank stock returns. Thirdly we also consider regional differences that may influence interest rate risk. We compare estimates for both a 'core' and a 'periphery' group. Asides from using interest rates in levels, we will also analyze how changes in the slope of the yield curve affect bank stock returns in the context of a four-factor model. Finally, we look at how different levels of deposit ratios can affect interest rate risk.

1.1 Origin of interest rate risk

There are a couple of ways through which interest rate risk can originate. We divide these origins using the following subdivision, as found in BIS (1997). According to the authors, we can split up the origins of interest rate risk in to four types.

First, there is 'repricing risk'. It stems from differences in maturities, which translates into repricing mismatches between bank assets and liabilities. This phenomenon is also called 'maturity transformation'. The practice of financing your lending activities on a shorter term than the loans you are providing. These differences in maturities can cause the value of a bank's assets to adjust slower than that of its liabilities (e.g. deposits), and they can affect the Net Interest Margin (NIM) of a bank:

$$NIM = \frac{\text{Interest Revenue - Interest Expenses}}{\text{Average Earning Assets}} \tag{1}$$

As a second origin of interest rate risk, we consider 'yield curve risk'. Yield curve risk is also related to maturity transformation. It occurs when the yield curve makes unanticipated shifts. These shifts can be in the level of the yield curve (symmetrical), or in the slope (asymmetrical) (BIS, 2004). An example of a shift in the slope of the yield curve, is the recent inversion of yield curves, both in the U.S. and in Europe (Bahceli, 2022). This means that shorter-term rates increased more, and faster, than longer-term rates. The impact on banks has, however, been ambiguous. In theory, banks lend on the long term and finance their lending on the short term. An inversion of the yield curve would mean that banks have to lend at relatively lower rates than what it would cost them to finance through short-term deposits. In practice, we saw that banks anticipated these effects and that they would keep their deposit rates low, on purpose, to give themselves the opportunity to start lending more at higher rates, before their financing costs would start to increase. This caused the effects of a yield curve inversion to actually have had a positive effect for the bank's NIM.

As a third possibility, BIS (1997), finds 'basis risk' to be a source of interest rate risk. Basis risk relies on the imperfect correlation in changes of the interest rates that a bank pays and earns on different assets and liabilities. The authors give as an example the situation where a bank funds a one year loan that reprices monthly based on a one month U.S. Treasury Bill rate, with a one-year deposit that reprices monthly based on the one month libor. The loan and its funding have similar characteristics but run the risk of affecting the banks interest margin through the spread, caused by an imperfect correlation between the two rates.

Finally, 'optionality' is identified as a source of interest rate risk (BIS, 1997). In the case of interest rate risk in banks, optionality refers to the options that are embedded in instruments outside of trading accounts (loans, deposits). It implies the risk of having to deal with asymmetrical payoff characteristics, e.g. deposit instruments that allow depositors to withdraw their funds at any given time, which leaves the seller of an option (in this case, the bank) to carry more risk, if not properly managed. Additionally, options also have the possibility of creating additional leverage which can increase the extent to which banks suffer from interest rate changes

We can illustrate the channels of interest rate risk by looking at a simple bank balance sheet.

Assets	Liabilities
Loans	Deposits
Securities	Interbank Borrowing
Interbank Claims	Central Bank Borrowing
Cash + Liquid Assets	Bonds
	Capital

Figure 1: Basic bank balance sheet

On this bank balance sheet, we see an overview of the assets and liabilities that a bank tends to hold. For interest rate risk, loans and deposits will be the most important parts.

There are, however, certain measures a bank can take to mitigate exposure to interest rate risk. The Bank for International Settlements (BIS, 2004) provides a comprehensive report on what principles banks and bank managers should follow. They state that there are four core principles that should be applied in order to keep interest rate risk under control: 1) the bank board and senior management should appropriately oversee evolutions in interest rate risk 2) adequate risk management policies and procedures should be put in place along with 3) appropriate risk measurement, monitoring and control functions, and 4) there should be comprehensive internal controls and independent audits.

These very general principles can be applied differently according to how the bank itself is structured. It makes sense that, in practice, we see different degrees of risk management, and exposure to interest rate risk, across banks.

In what follows we will discuss briefly what the literature has done up until this point, and we will see some of the different methods and angles that have been used by other authors. Ensuing, we define the methodology that will be used. This includes the different models, but also our view on the different subquestions we are trying to answer (time-varying risk, yield curve slope, regional differences, and deposit ratios). We then describe the data we are going to be using, as well as the adjustments that need to be made. Then we get to the part where we analyze the results, and interpret them, as well as the practical consequences that these results have. We subsequently test for the robustness of our models, after which we briefly summarize this paper and its policy implications, as well as provide some recommendations for future research.

2 Literature Review

A lot has been written about interest rate risk and its relation with bank stock returns. In this part we will be looking at the literature, some of the different conclusions that have been drawn, and identified issues that we can incorporate in our analysis.

2.1 The relation between interest rate risk and bank stock returns

In the introduction, we discussed several ways in which interest rate risk can originate, and how it can impact different parts of the bank's balance and results. The relation with bank stock returns, however, contains more than the effects through bank income/losses. ECB (2005) talks about a direct and an indirect effect. Direct effects include the ones we discussed in regard to net interest margin (NIM) and asset/liability valuations, or changes therein. The indirect effects include the impact of changing rates on the credit quality and non-interest income of banks, which is negative when rates increase. The other indirect effect they talk about is the impact of rates on expectations of future economic activity. ECB (2005), gives as an example that increasing rates can signal a positive economic outlook which is good for banking activities in the future.

Entrop et al. (2017) studied interest rate risk for U.S. banks. They found that on average the interest rate risk was close to, but slightly lower than, zero. This would lead us to believe that interest rate risk is almost negligible. But they also found that, when looking at the distribution of interest rate risk coefficients, there are some banks with high, persistent exposures. Another important finding was that there seemed to be a strong linkage between bank characteristics and interest risk exposure. Banks that used more leverage showed higher absolute values in their interest betas, and an increase in bank size was related to more negative interest betas.

The literature has established that interest rate risk is indeed present in the banking sector. The question, however, lies in what extent this risk manifests itself in the short- or long-term rates, or what the magnitude of the impact on bank stock returns actually is. Furthermore, it is worth considering how biases in interest rate risk may be caused by other factors, such as the size or value of the firm.

Baele et al. (2015) uses a Bayesian model averaging technique to find what risk factors are considered relevant in determining bank stock returns. Their findings show that interest rate factors and bank stock returns are not necessarily related. They explain this by suggesting that markets were able to predict changes in interest rate risk, as well as assuming that banks were able to successfully hedge against this risk. The only risk factors they do find to be relevant are: market risk, real estate risk, and the HML Fama French factor. The latter is an indicator of differences in stock returns based on whether a firm has a high or low value.

Memmel (2011) finds that for a dataset of German banks, small and medium-sized banks show higher exposures to interest rate risk than larger banks. For larger banks the authors find that they use different derivatives, related to interest rates and debt, to protect themselves from interest rate risk. This is also shown by the results in Schuermann and Stiroh (2006), which looks at drivers of returns for US bank stocks. These findings support the need to control for firm size in our analysis. Viale et al. (2009) look at the common risk factors that are priced in bank stocks. They use different factor models, such as a CAPM model, a Fama-French model and an Intertemporal CAPM model (ICAPM), and apply this to a dataset of U.S. banks. The authors find that the excess return on the stock market, and the yield curve (more specifically its slope), have significant roles in explaining the cross-section of bank stock returns. They find that it would be more appropriate to use models using shocks in the term structure of interest rates, rather than the level of interest rates.

Lloyd and Shick (1977) look at the effects of short-term versus long-term rates on bank stock returns. They find that bank stocks are, in general, more sensitive to short-term than long-term rates. They came to this conclusion by estimating the two-factor model as proposed in Stone (1974). This model and the results from Lloyd and Shick (1977) will come back in the part on Methodology. Mansur and Elyasiani (1995) find the opposite for bank stocks during the period 1970-1992, with bank stocks being more sensitive to long-term rates than to short-term rates.

Neuberger (1991) studied the behavior of bank stock returns in the period 1979-1990. The author noticed an increase in total return volatility, accompanied by a decrease in average returns, relative to stocks in other sectors. His findings, related to risk factors, were that bank stock returns became increasingly more sensitive towards a broad market index, and less sensitive towards bond yields. The latter could, according to the author, be interpreted as a change in bank management strategies, using more instruments with adjustable rates, along with other hedging instruments. Ampudia and Van Den Heuvel (2022) confirms this, in the sense that he finds the composition of a bank's balance sheet, which is affected by bank management strategies, to be important for interest rate sensitivity. Other explanations, according to Neuberger (1991), could involve the banks operating in a different regulatory environment.

English et al. (2018) also, partly, discussed the impact of a bank's balance sheet on interest rate risk. The authors estimated bank stock price movements when interest rates changed. They found that an unanticipated increase in the slope or level of the yield curve would cause bank stock prices to decline. Another interesting finding in English et al. (2018) was that banks that were more dependent on core deposits suffered a more negative impact as a result of interest rate changes. ECB (2005) contradict this finding, as they state that banks, with a lower share of demand deposit funding, could be more exposed to interest rate risk.

Choi et al. (1992) used a multifactor model to study the sensitivity of bank stock returns to different risks, including market risk, interest rate risk, and exchange rate risk. They looked at a dataset in the period 1975-1987, covering 48 U.S. banks, and concluded that unexpected movements in interest rates are negatively related to bank stock returns.

2.2 Time-varying interest rate risk

A significant part of the literature discusses time-varying effects of interest rate risk. Performing estimations on datasets in different periods of time can deliver drastically different results. This part will cover some of the relevant literature.

Bessler and Kurmann (2014) acknowledged the time-varying aspect of interest rate risk and incorporated this in their model for bank stock returns. Their research covered U.S. banks over the period 1990-2011. They found that interest rate risk became positive in the post-1999 period due to continuous improvement in the tools that are available to manage interest rate risk. In Bessler et al. (2015), the authors also gave growth in asset securitization and secondary loan markets as reasons for this positive effect. Ferrer et al. (2016) also find that the relation between bank stock returns and interest rates is time-dependent. They specifically looked at the relation of returns with 10-year yields. They conclude that there was a strong positive relation during the great financial crisis (GFC). According to Ferrer et al. (2016), an explanation for this strong relation can be found in the contagion effects that become stronger during periods of financial turbulence, as well as a so-called flight-to-quality effect, where investors flee to safer government bonds.

Chen and Chan (1989) found that bank stock returns were more sensitive to interest rates in periods of increasing rate. Although, as mentioned earlier, a lot has changed in risk management, so this result might not hold up in our analysis.

2.2.1 Low for long policy and bank stocks

Ampudia and Van Den Heuvel (2022) looked at the effects of monetary policy on European bank equity values. They found that, on average, a decrease in the short-term policy rate tended to cause an increase in bank stock values. The opposite effect was found during periods of low or even negative rates. The authors also saw that surprise cuts in long-term rates had a positive effect on bank stock values during the period of low/negative rates. Additionally, the authors found that the composition of a bank's balance sheet is important in determining the impact of interest rate changes. They specifically find that reliance on deposits plays an important role in explaining the opposite relation between interest rates and bank stocks during periods of low or negative interest rates. An explanation, by Ampudia and Van Den Heuvel (2022), is that banks are reluctant to pay negative rates on their deposits, putting pressure on their net interest margins.

Inhoffen et al. (2021) find that, in a negative interest rate environment, bank profitability comes under pressure because of their unwillingness to pass through negative deposit rates to their depositors. Claessens et al. (2017) find that a drop in interest rates cause net interest margins to go lower, with a stronger effect as rates are lower. Additionally, they find that the negative effect, during a low-for-long rate spell, becomes more negative per extra year of low rates.

These negative effects on bank profitability could cause banks to have to look at taking more risk, by lending to riskier firms. Bottero et al. (2019) find that the higher the liquidity of a bank's balance sheet (not those with more consumer deposits), the more affected this bank will be by negative interest rates. These banks will take more risk by shifting their lending to smaller and riskier firms. Heider et al. (2019), on the other hand, find that banks with a higher reliance on deposits tend to take more risk in a negative interest rate environment.

These findings suggest that including the possibility to differentiate between a low/negative interest rate environment in our analysis, and a period of normal interest rates, could be beneficial to the value of our research.

2.3 Regional differences in interest rate risk

The literature also recognizes certain regional differences in the relation between bank stock and interest rate risk.

Ferrer et al. (2016) find, besides the existence of time-varying effects, that the relation between interest rate risk and bank stock returns seems to be location-dependent. They conclude that peripheral European countries, such as Portugal, Ireland and Greece, show weaker relations, while core countries show stronger relations. Oertmann et al. (2000) also find that interest rate risk tends to differ across countries.

Hoffmann (2019) also finds a regional difference in interest rate risk, concluding that countries, where banks use fixed rates on their mortgages, are more likely to show a negative relation between interest rates and bank net worth, which we can extend into bank stock returns. Countries, where banks use variable rates for mortgages, have a distribution of interest rate risk that is shifted more to the right, thus showing more positive exposures.

3 Methodology

In this part, we discuss the methodology that will be used in the analysis (5) and robustness (6) parts of this thesis.

Literature on stock returns generally refers to Sharpe (1964), Lintner (1965) and Black et al. (1972) as having created a model, the CAPM asset-pricing model, that had a big influence on how we think about average stock returns and risk. They used the premise of the market portfolio being mean-variance optimizing, inspired by Stuart and Markowitz (1959). This is where the CAPM model came into the field of financial economics.

Stone (1974) expands on the Sharpe-Lintner asset pricing model by adding the possibility to quantify interest-rate risk. Doing this, he improves the estimation of equity market betas by reducing noise and instability in the latter. In his approach, Stone (1974) adds a debt market index to reflect the returns on bonds. His work is reflected in the following two-factor model:

$$R_{jt} \ = \ \alpha_j \ + \ \beta_m R_{mt} \ + \ \beta_i R_{it} \ + \ \varepsilon_{jt} \tag{2}$$

With R_{jt} the return on security j, α_j, β_m and β_i constant characteristics of security j; R_{mt} and R_{it} the returns on an equity and a debt index, which would be the interest rate (level) in our case; and ϵ_j a random variable specific to the security j. The Stone two-factor model gives us a good base for the model we will end up using in our further analysis. Lloyd and Shick (1977) tested the two-factor model and found it to be suitable. Adding an interest rate factor to a CAPM equation seems, according to Lloyd and Shick (1977), to be a good addition.

However, there are some adjustments to be made in order to end up with the appropriate model. In what follows, we will give an overview of these adjustments.

3.1 Fama French

According to Fama and French (2004), the Sharpe-Lintner CAPM model has been very important in applications, mainly because of how it can be used in a powerful and intuitive manner to estimate the relation between risk and expected stock returns. However, they find that the model is severely flawed when empirically testing the results, delivering expected returns that are too high for high-beta stocks, and too low for low-beta stocks. The relation between the market beta and expected stock returns is flatter than the CAPM model would make us believe (Fama and French, 2004).

In Fama and French (1992) the authors provide an extension to the traditional Sharpe-Lintner CAPM model which add to the explanatory power of the model. They propose, along with the market risk premium, to add a factor for size effect (SMB) and a factor for the value premium (HML). The reason is that these factors would explain the cross-sections of average stock returns, because they would absorb the effect of size and the equity-to-price ratio on average stock returns. This effect being that small firms tend to have higher stock returns than large firms and firms with a high equity-to-price ratio tend to have higher stock returns than firms with a low equity-to-price ratio. The SMB and HML factors are further explained in the section on data (section 4). It is worth noting that the results from Fama and French (1992) are based on data for nonfinancial firms.

By introducing the Fama French factors, we get the following equation:

$$R_{jt} = \alpha_j + \beta_m R_{mt} + \beta_i R_{it} + \beta_s SMB_t + \beta_h HML_t + \varepsilon_{jt} \tag{3}$$

With the addition of β_s as the coefficient for the SMB factor, and β_h as the coefficient for the HML factor. We end up with a model that is very similar to the hybrid model that was proposed in Jareño (2008).

When we estimate equations (2) and (3) in our analysis, we will put focus on β_i given that this coefficient represents the sensitivity of bank stock returns to interest rates. Important in the interpretation of this coefficient will be whether or not it is significantly different from zero. If it is, we are also going to be interested in the sign of the coefficient. A positive coefficient means that an increase in the interest rate at hand will have a positive impact on bank stock returns. The opposite is true when the coefficient is negative. We base our hypotheses, of the results, on what has been found in the literature.

Ampudia and Van Den Heuvel (2022) find that, for short-term rates, the relation between interest rates and bank stock returns should be significant and negative. They nuance this by stating that the period of negative rates caused this relation to become positive. For our full-sample analysis on short-term rates, we thus expect a significant negative coefficient. When it comes to long-term rates, Ampudia and Van Den Heuvel (2022) finds an insignificant coefficient, again with a nuance for the period of negative rates, where they find a significant negative coefficient. Bessler and Kurmann (2014) also find overall that the coefficient is insignificant. This will be our initial hypothesis for long-term rates.

3.2 Time-varying interest rate risk

Up until now, we made the assumption that the coefficient for the interest rate is constant over time. Bessler and Kurmann (2014), along with Ampudia and Van Den Heuvel (2022), find, however, that bank risk exposures are in fact time-varying. This means we should incorporate a way to allow the coefficient to change over time. We do this by splitting our sample according to different subperiods.

Now, to determine how we should split our sample, we take a look at the following graphs:

Figure 2: 1-month OIS rate

We see on these graphs that, up until the financial crisis, interest rates climbed consistently. This was followed by an extended period of declining rates, including a spell of negative rates. More precisely, the ECB started decreasing its policy interest rate on October 8th 2008, following the collapse of Lehman Brothers on September 15, 2008, and the consequential breakdown of the money market (ECB, 2010). It makes sense to choose the beginning of October 2008 as the end of a continuous streak of increasing rates pre-GFC. In our dataset, the most fitting date would be Friday, October 3rd, 2008, as we use weekly data on Fridays.

Additionally, Elyasiani et al. (2020) finds that coefficients for interest rate risk differ between pre-financial crisis data, showing lower absolute values, and post-financial crisis data, showing higher absolute values. This gives us reasoning to also include a time dummy for the post-financial crisis period, including the period of the financial crisis itself.

Another noteworthy period within our dataset is that of the negative interest rates. For this period, we look at our dataset to find the first date with negative values. This brings us to September 5th, 2014, when the 1 Month OIS rate dips into the negatives for the first time in our dataset, with the other maturities following suit. This period of negative rates lasts until August 12th, 2022, when the 1 Month OIS rate is the last one to go back to positive values. In order to avoid overlap between our subperiods, we cut off the period of negative rates at an earlier point. This way we can add a dummy that covers the corona pandemic.

The reason we would like to look at the period of the corona pandemic, is that it resembles a period of turmoil in financial markets, as well as an increased level of uncertainty in the global economy. These facts could potentially cause anomalous results in our analysis. According to WHO (2020), we could officially start talking about a pandemic as of March 10th 2020. In our dataset, the earliest datapoint that corresponds with this is friday the 13th of March, 2020. Determining the official end of the pandemic is challenging, but the impact the pandemic had on financial markets has more or less died out, giving way to a new phase that involves rising interest rates and yield curve inversions.

In 2022, rates started increasing again. Following a tilt, by central banks, towards a tighter policy to combat inflation. The first mention of increasing policy rates, in a monetary policy decision, was made during the meeting in June 2022, although longer-term rates were already climbing in the previous months. This makes it difficult to pinpoint an exact date when interest rates started to go up, which is why we put the first data point of 2022 as the point of interest.

Knowing this, we can determine five subperiods, within our dataset, to which we should pay more attention. By doing this, we can see if any significant changes, in interest rate risk, appear during these periods.

Period	Start date	End date
Rising rates pre-GFC (P-GFC)	7/01/2005	3/10/2008
GFC + Post-GFC (GFC)	10/10/2008	29/08/2014
Negative interest rates (NI)	5/09/2014	6/03/2020
Covid pandemic (CP)	13/03/2020	31/12/2021
Increasing rates 2022 (IR)	7/01/2022	10/02/2023

Table 1: Subperiods for time-varying model

As we end up with 5 subperiods, we will have to do 5 estimations. The reason to estimate these subperiods separately, as opposed to using time dummies, is to obtain results that are easily interpretable. This means that the estimated coefficients immediately show the effect of our explanatory variables on bank stock returns. We perform these estimations on equation 3.

3.3 Slope of the yield curve

As discussed in Part 2, not only the levels of the interest rates are relevant for assessing interest rate risk, but the slope of the yield curve also plays a role. Elyasiani et al. (2020) find that changes in long-term and short-term rates have a significant impact on bank stock returns, while medium-term rates don't have a clear impact. The slope of the yield curve, thus, becomes a relevant factor in our analysis. The authors also find that the overall impact of changes in the slope of the yield curve is negative, for an extensive set of banks.

For assessing the impact of the slope of the yield curve, we can use the following model:

$$R_{jt} \ = \ \alpha_j \ + \ \beta_m R_{mt} \ + \ \beta_i SLOPE_t \ + \ \beta_s SMB_t + \ \beta_h HML_t \ + \ \varepsilon_{jt} \tag{4}$$

We define the slope of the yield curve as the difference between the yield in the long term and the short term. More specifically, we look at the 10Y-3M and 10Y-2Y spreads. A more in-depth explanation of these spreads is given in the 'Data' section of this thesis.

3.4 Regional differences

We have seen, in papers such as Ferrer et al. (2016) and Oertmann et al. (2000), that the effects of interest rate risk on bank stock returns can also be looked at as being location-dependent. This is why we will test for regional differences. For this analysis, we will use the four-factor model, as described in equation 3.

Here it is crucial to differentiate between core European countries and peripheral European countries. To analyse the potential regional differences, we split our dataset into these core and peripheral countries. This then makes it possible to estimate two four-factor models, which will give us an idea on how these regional differences look like. We limit this part of the analysis to only use the 5-year maturity of our OIS rates. This rate is not as volatile as e.g. the 1-month rate and we also assume that the 5-year rate can serve as a proxy for the interest rate that banks face when issuing non-mortgage loans.

The exact division of our dataset can be found in the part on data.

3.5 Deposit ratio

Some papers have pointed out the significance of deposits in determining interest rate risk (Ampudia and Van Den Heuvel (2022), Heider et al. (2019)). We decide to test this by taking into account the deposit ratio of the banks in our sample. This decision is partly based on the approach of Ampudia and Van Den Heuvel (2022), but also on the fact that the deposit ratio gives us an idea of how the bank funding structure is set up and to what extent it is reliant on deposits.

Our banks can be split up into three groups: Low, Medium, and High deposit ratios. The section on data gives more details on the exact division of these groups. We then estimate our four-factor model on our full sample period, using the 1-month and the 10-year interest rates, on each of these three groups. These two rates will represent a "short-term" and a "long-term" rate. Following the literature, we expect that banks with a higher reliance on deposits will show a higher stock return sensitivity to interest rates. We also expect that the effect on the short-term rate will be positive and that it will be negative on the long-term rate.

Due to the attention that has been given to this period in the literature, we will also estimate this model for the period of negative interest rates and compare it to results for the rest of the sample period.

3.6 Type of estimator

When looking at which type of panel estimator we should use, we arrive at two options: the 'Random effects' and 'Fixed effects' estimators. To find our preferred estimator, we apply the following reasoning.

Firstly, the results of the Hausman test, which looks at the consistency of 'Random effects' when comparing it to that of 'Fixed effects'. Performing this test gives us results in favor of 'Fixed effects'. A 'Fixed effects' estimator is generally more consistent than 'Random effects'. Secondly, the 'Fixed effects' estimator assumes that cross-sectional units within the dataset are "unique" and are not arbitrarily drawn from a distribution. This is the case within our specific dataset.

These reasons lead us to choose the 'Fixed effects' estimator to conduct our analysis.

4 Data

The data we will be using consists of bank stock returns, market indices, interest rates and the Fama French factors. All data spans the period between 7/01/2005 and 10/02/2023. In what follows, we will give a brief overview of the structure of this data, and, if necessary, the adjustments we made to make the data suitable for our analysis.

4.1 Stock data

Our data on the stock market was retrieved from the Refinitiv database. This for both the bank stocks and the market index.

4.1.1 Bank stock returns

The dataset on bank stocks consists of weekly observations for the total returns indices of 99 Eurozone banks, all of which are listed publicly and have had total assets over 10 EUR billion for at least one year. Table A1 gives an overview of all banks in our sample. We use the total return indices, as opposed to stock price indices, to correct for e.g. stock splits and dividend payments. To then obtain the return for bank j, in period t (R_jt), we use the following formula:

$$R_{jt} \;=\; ln(r_{jt}) \;-\; ln(r_{jt-1}) \tag{5}$$

With r_{jt} the value of a bank's return index at time t

4.1.2 Adjustments

Since not all banks were listed on the stock exchange for the entire period, or were undergoing some other changes, making the data not valid at certain points, we had to make some choices in what observations we were going to leave out.

"AIB Group plc" (ISE:A5G) is an example of a bank which data we had to adjust. Between 2011 and 2017 the bank was delisted from the stock exchange due to the Irish government taking a $>$ 99% equity stake in the bank. The same goes for "Permanent TSB Group Holdings plc" (ISE:IL0A) for which we omit data from 2011 to 2015. Another bank, of which we had to adjust the data, is "Bank of Cyprus". The reason for this is that the "Bank of Cyprus Public Company Limited" was incorporated in the holding company "Bank of Cyprus Holdings Public Limited Company" in 2016. More specifically, this process caused us to omit data for this bank from 9/01/2017 to 19/01/2017.

We also made adjustments to data for other banks in our sample. These adjustments concerned banks with betas that were too small: Bank of Valletta (MT:BOV), Vseobecna

Uverova (SK:VUB) and HSBC Trinkaus & Burkhardt (D:TUB). After making these adjustments, we are left with 98 banks in our dataset.

Country	Banks
Austria	3
Belgium	2
Croatia	2
Cyprus	3
Czechia	2
Finland	3
France	18
Germany	9
Greece	8
Ireland	3
Italy	19
Malta	1
Netherlands	5
Portugal	5
Slovakia	1
Slovenia	1
Spain	13
Total	98

Table 2: Number of banks in dataset, per Eurozone country

4.1.3 Market index

We collected data for the MSCI Europe index. This index will be used as the market factor in our analysis.

Table 3 gives an overview of our stock data's descriptive statistics.

	n	mean	sd	min	max	range
Bank sample	70,441	-0.21	5.92	-41.69	32.25	73.93
MSCI Europe	945	0.12	2.60	-24.34	12.52	36.85

Table 3: Descriptive statistics of market data

In Figure 3, we compare the performance of the MSCI Europe total return index with that of the STOXX Europe 600 banks gross return index. The bank index serves as a proxy for our bank sample, and will not be used in our further analysis. We see that, in the pre-GFC period, the returns of both indices were similar. The period after that shows a divergence in the total performance, but overall the two indices follow the same trends.

Figure 3: Performance of the MSCI Europe and STOXX Europe 600 Banks indices

4.1.4 Core vs. Periphery

As discussed in the methodology section, we want to divide the banks in our dataset into a group of banks within core European countries, and a group of banks within peripheral European countries. Table 4 shows our division of core vs peripheral, or core vs GIPS countries.

Core	Periphery
Austria	Greece
Belgium	Italy
France	Portugal
Germany	Spain
Netherlands	

Table 4: Division of countries in our dataset into 'Core' and 'Periphery' group

This table allows us to divide our banks according to the country they are located in. Worth noting is that we don't include all countries in our sample for this analysis. Croatia, Cyprus, Czechia, Finland, Ireland, Malta, Slovakia, and Slovenia are left out.

4.2 Interest rates

The data for the interest rates was also retrieved from Refinitiv. In total we collected data from 15 different maturities over the period 7/01/2005 to 10/02/2023. The source of interest rates that we are interested in is the Overnight Index Swap (OIS). This is because the OIS rate gives us an accurate representation of what investors expect the effective interest rate to be over a certain term (Sengupta & Tam, 2008).

Using different maturities helps us to have a detailed look at how different interest rates impact bank stock returns. This way we can pinpoint the maturities that have a significant impact, and those that do not.

4.2.1 Level of interest rates

In our two-factor, our four-factor, and our time-varying models, we use the level of the interest rates. Throughout the years, these levels fluctuate as monetary policy and financial markets change. We will estimate separate models for each maturity, with a focus on the 1-month, 3-month, 1-year, 5-year, 10-year, and 30-year rates. Table 5 shows some descriptive statistics about our interest rates, Figures 4 and 5 give a visual representation of these rates over time.

	n	mean	sd	min	max	range
1 MONTH	945.00	0.72	1.45	-0.52	4.31	4.83
3 MONTH	945.00	0.75	1.47	-0.55	4.34	4.89
1 YEAR	945.00	0.84	1.54	-0.63	4.66	5.29
5 YEAR	913.00	1.24	1.56	-0.72	4.77	5.49
10 YEAR	913.00	1.75	1.51	-0.52	4.86	5.38
30 YEAR	787.00	1.85	1.23	-0.27	4.73	5.00

Table 5: Descriptive statistics of interest rate data

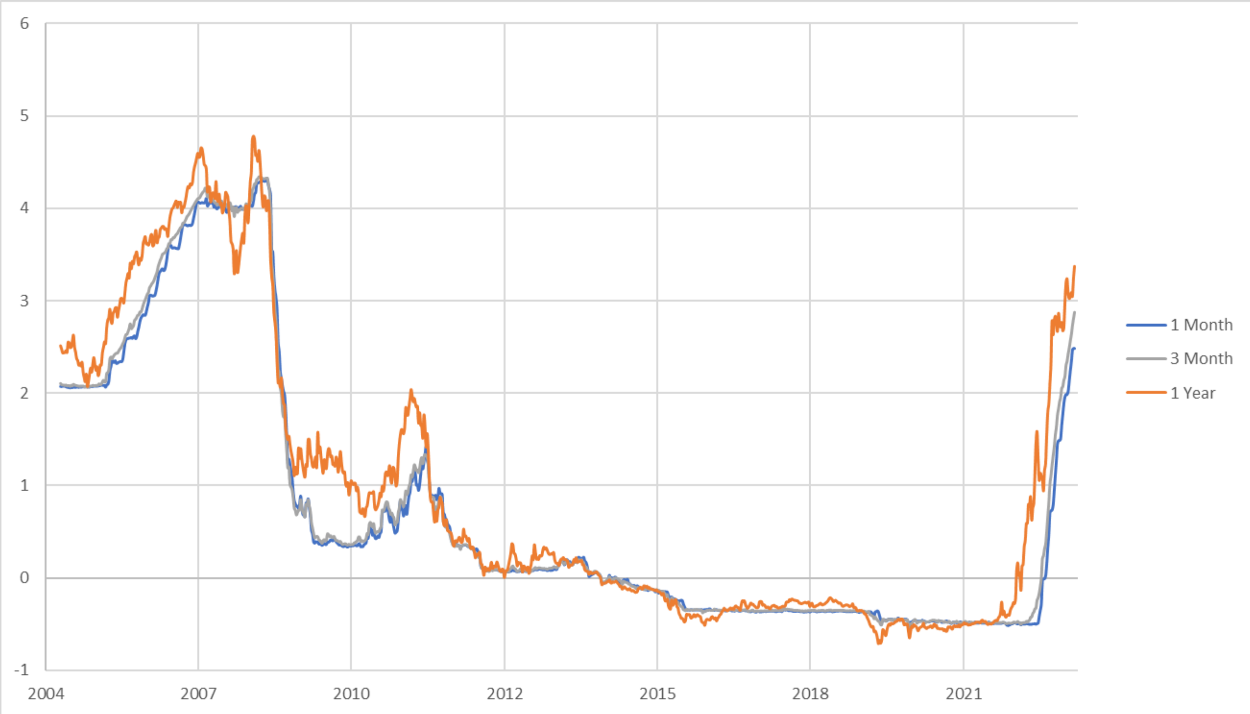

Figure 4: Short-term OIS yields over time

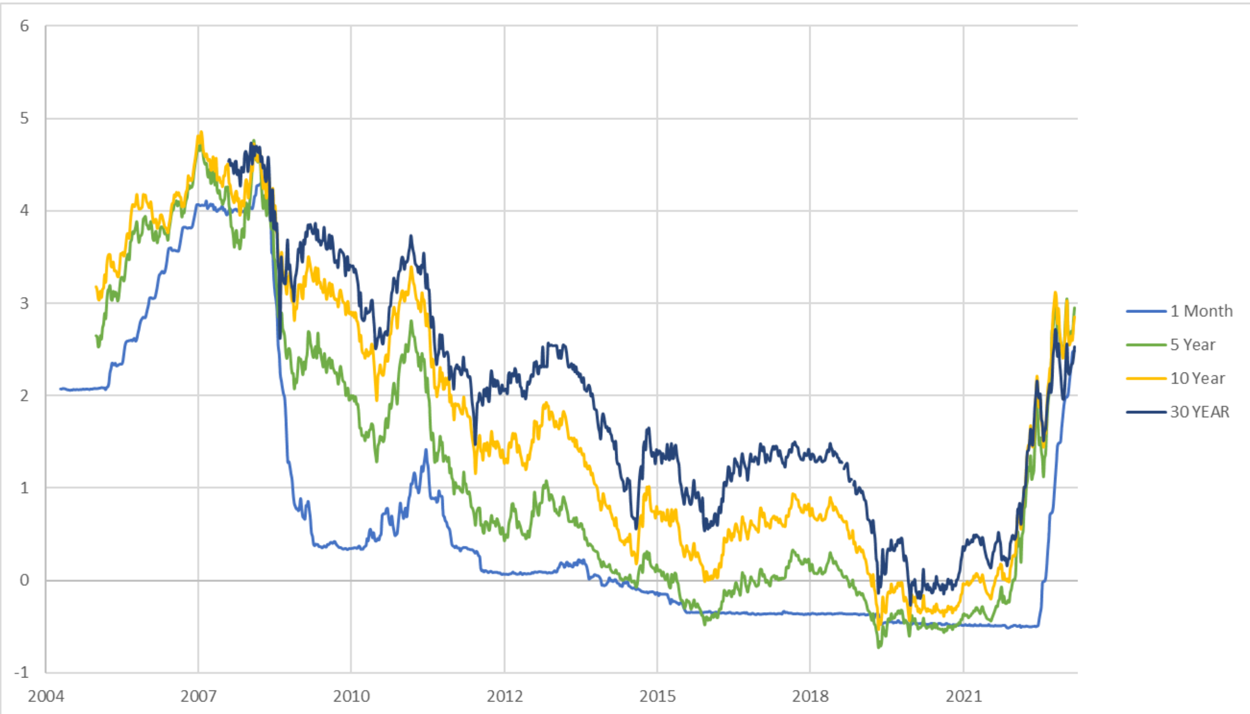

Figure 5: Long-term OIS yields over time

4.2.2 Yield spreads

As said in the part on methodology, We define the slope of the yield curve as the difference between the yield in the long term and the short term. In our case, we will be using the

10Y-3M and the 10Y-2Y spreads. These were calculated from our data on interest rates. A graph of the spreads gives us the following result:

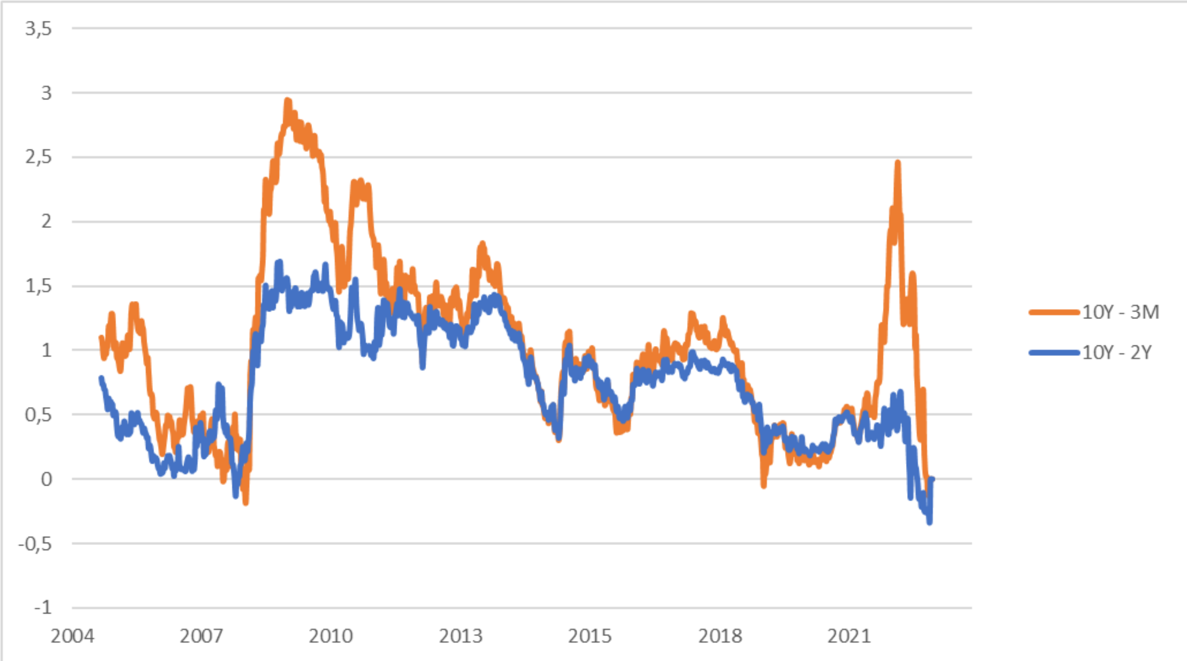

Figure 6: Yield spreads between 10Y-3M and 10Y-2Y

The evolution of these spreads is not straightforward when compared with how yields evolved over the same period. Up until the great financial crisis (GFC), there appeared to be a negative relation between yields and spreads. In the period following the crisis, we saw a peak in spreads while yields were already plummeting. Worth pointing out, is that the 10Y-3M and 10Y-2Y spreads diverged during this post-GFC period, as well as during the year 2021.

4.3 Fama French factors

We get our data for the Fama French factors straight from the Kenneth R. French website. More specifically, we use the "Fama/French European 3 Factors" dataset, containing weekly data from July 1990 to January 2023. We only use the data from the last week of 2004 up until the most recent data.

	n	mean	sd	min	max	range
SMB	943.00	0.06	0.51	-3.98	2.42	6.40
HML	943.00	-0.01	0.48	-2.19	2.21	4.40

Table 6: Descriptive statistics of Fama French factors (SMB and HML)

Within this dataset, we find the SMB, HML and Rm-Rf factors. In what follows we give a brief explanation on what these factors mean.

SMB stands for Small-Minus-Big and is used to factor in the effect of smaller companies generating higher returns, compared to big companies. French uses three different portfolios for this: value, neutral, and growth. It is calculated using the following formula:

$$SMB = 1/3(SmallValue + SmallNeutral + SmallGrowth) \\ -1/3(BigValue + BigNeutral + BigGrowth) \quad (6)$$

HML stands for High-Minus-Low, it is used as a factor to look at the difference in returns between companies with high Book-to-market values (B/M) and low B/M values. For determining the HML factor, French also distinguishes between value and growth stocks. HML is calculated using the following formula:

$$HML = 1/2(SmallValue + BigValue) - 1/2(SmallGrowth + BigGrowth) \quad (7)$$

4.4 Correlations between explanatory variables

As we are looking at different specifications in our analysis, we can obtain different results for each specification. It is possible be that we misspecified our model by using a two-factor equation, which we then correct by extending our model to the four-factor equation. In order to determine where biases can occur, we look at the correlation between our explanatory variables in Table 7.

	1M	3M	1Y	5Y	10Y	30Y	SMB	HML	MKT	10Y2Y	10Y3M
1M	1.00										
3M	1.00	1.00									
1Y	0.97	0.98	1.00								
5Y	0.88	0.90	0.93	1.00							
10Y	0.83	0.84	0.87	0.98	1.00						
30Y	0.79	0.79	0.80	0.93	0.98	1.00					
SMB	-0.01	-0.01	-0.01	-0.00	0.00	-0.00	1.00				
HML	-0.01	-0.00	0.00	-0.00	-0.01	-0.00	-0.31	1.00			
MKT	-0.09	-0.09	-0.08	-0.06	-0.05	-0.04	-0.22	0.08	1.00		
10Y2Y	-0.02	-0.04	-0.05	0.28	0.44	0.54	0.01	-0.02	0.04	1.00	
10Y3M	-0.01	-0.00	0.08	0.42	0.54	0.58	0.02	-0.00	0.05	0.88	1.00

Table 7: Correlations between explanatory variables

We see that all our interest rates are highly correlated with each other, with a decreasing correlation as gaps between maturities become larger. The 1-month and 3-month are perfectly correlated, meaning that when we estimate different models, one using the 1-month rate, and the other using the 3-month rate, we should get similar results. For the SMB and HML factors, we don't find any correlation with interest rates, meaning that there should be no upward or downward bias in our interest rate coefficients, however, we do find that the market factor is correlated with both SMB and HML, albeit in different directions. Because of this correlation, it makes sense to include the Fama French factors in our model. We do this to avoid omitted variable bias, which means that we would have estimated a biased coefficient. This specification error can not be solved by increasing the sample size, making the coefficient biased and inconsistent (Gujarati, 2011).

4.5 Deposit ratio

Based on different papers that discuss the importance of bank deposits on interest rate risk, we decide to split our bank sample into three parts: Low, Medium, and High. This split is based on each bank's average deposit ratio over our sample period. Banks in the Low group have an average deposit ratio that belongs to the 25% lowest in the sample, those with a High ratio belong to the 25% highest, and the Medium group contains the middle 50% of banks. We choose this division because we want to have enough observations in each group, while still accounting for the differences in deposit ratios.

We calculate the deposit ratio using the following formula:

$$\text{Deposit ratio} = \frac{\text{Total deposits}}{\text{Total assets}} \tag{8}$$

The data on gross loans and total deposits was retrieved via Refinitiv.

By dividing our bank sample according to their deposit ratios, we obtain the following groups that are split up by the corresponding intervals. The banks in the medium group have deposit ratios that lie in between the Low and High intervals:

	Low	Medium	High
Banks	24	48	24
Deposit ratio interval	[0.217,0.588]		[0.810,2.431]

Table 8: Division of bank sample

Due to a lack of data, we were only able to use 96 banks in this part instead of the 98 banks in our other estimations.

5 Results

After establishing our methodology, and describing our dataset, we now look at how our models perform when subjected to the data.

We start with looking at our simple two-factor model, and will then compare the results with the four-factor model. This is followed by our time-varying, yield spread, regional differences, and finally deposit ratio analysis

5.1 The two-factor model

Table 9 looks at the market beta and the interest rate risk across different maturities. We immediately notice that the market beta is highly significant, at the 1 percent level, for all estimations. The results for interest rate risk are more nuanced. The coefficient for the 1-month yield is not highly significant, meaning that we don't have sufficient evidence to prove that there is a correlation between the 1-month yield and the bank stock returns within our sample. One possible explanation for this result may lie in the tendency of banks to protect themselves against short-term interest rate fluctuations by restricting the transmission of short-term rates to deposit rates (Hoffmann et al., 2019). This practically transforms deposits into long-term, fixed-rate funding sources, thus limiting the impact of short-term rate changes on bank profitability, and consequently on bank stock returns.

When we look at interest rate risk for higher maturities, we notice that results start to become significant at the 1% level, for the 1- and 5-year rates. The 10-year yield has a less significant impact, although its coefficient is still statistically significant at the 5% level. If we take, for example, the coefficient for the 1-year rate, this means that an increase in this rate by 1%-point would cause bank stock returns to increase, on average, by 0.05038%-points. Our findings align with the understanding of how banks generate their net interest margin. For increasing yields, across the yield curve, banks typically adjust their loan rates, which are the mid-to-long-term yields, while they tend to keep deposit rates, which are the short-term yields, at lower levels.

A result that stands out in Table 9, is that the 30 Year yield is insignificant in terms of its impact on bank stock returns. It is possible that this result stems from the use of hedging instruments to insulate banks from long-term interest rate risk. Another possibility is the use of adjustable rate mortgages, which makes it easier to hedge against changes in long-term rates (Neuberger, 1991).

Table 9: Results for the two-factor model

	Model: $R_{jt} = \alpha_j + \beta_m R_{mt} + \beta_i R_{it} + \varepsilon_{jt}$					
	Bank Stock Returns					
	1 MONTH	3 MONTH	1 YEAR	5 YEAR	10 YEAR	30 YEAR
β_m	1.04305***	1.04324***	1.04345***	1.04488***	1.04452***	1.05830***
	(0.00794)	(0.00793)	(0.00793)	(0.00806)	(0.00806)	(0.00883)
β_i	0.02744*	0.03576**	0.05038***	0.04727***	0.03802**	0.00991
	(0.01491)	(0.01467)	(0.01400)	(0.01453)	(0.01523)	(0.02132)
FE/RE	FE	FE	FE	FE	FE	FE
Observations	70,441	70,441	70,441	68,026	68,026	57,912
Adjusted R^2	0.19631	0.19634	0.19642	0.19728	0.19722	0.19791

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

5.2 The four-factor Fama French model

Now let us compare the results from our two-factor model with the results of the four-factor model, thus including the Fama French factors HML and SMB. In table 10, we see that the coefficients for the 1-month and 2-month yields become less significant. Another difference is the decrease in the value of the interest rate coefficient for all maturities except for the 30-year yield. Looking again at the coefficient for the 1-year rate, we now find that a 1%-point increase in this rate would on average only cause the banks stock return to increase with 0.03791%-point. This is less than without the Fama French factors. Adding the Fama French factors to the model clearly impacts our results for interest rate risk. How can we explain this? In the data section we already looked at the correlations between our different explanatory variables. There was no correlation between the Fama French factors and the interest rate variables. We did find, however, that the market factor was correlated to the Fama French factors. Adding these factors thus has an impact on the market beta because the SMB and HML factors explain systematic risks that are not taken into account in the market factor. This also has an impact on the way we view the relation between interest rates and bank stock returns, which explains the change in coefficients and significance levels.

Table 10: Results for the four-factor model

	Model: $R_{jt} = \alpha_j + \beta_m R_{mt} + \beta_i R_{it} + \beta_s SMB_t + \beta_h HML_t + \varepsilon_{jt}$					
	Bank Stock Returns					
	1 MONTH	3 MONTH	1 YEAR	5 YEAR	10 YEAR	30 YEAR
β_m	1.04897***	1.04912***	1.04932***	1.05136***	1.05101***	1.06362***
	(0.00811)	(0.00810)	(0.00810)	(0.00823)	(0.00823)	(0.00901)
β_i	0.02135	0.02700*	0.03791***	0.03968***	0.03200**	0.01469
	(0.01486)	(0.01463)	(0.01397)	(0.01447)	(0.01515)	(0.02120)
β_s	0.60766***	0.60797***	0.60816***	0.61590***	0.61508***	0.60553***
	(0.04323)	(0.04322)	(0.04321)	(0.04399)	(0.04399)	(0.04838)
β_h	1.38856***	1.38770***	1.38559***	1.39237***	1.39347***	1.39424***
	(0.04622)	(0.04623)	(0.04624)	(0.04695)	(0.04694)	(0.05015)
FE/RE	FE	FE	FE	FE	FE	FE
Observations	70,317	70,317	70,317	67,902	67,902	57,788
Adjusted R^2	0.20697	0.20698	0.20703	0.20803	0.20800	0.20892

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

5.3 Time-varying models

In this section, we look at the different results for our models when we split the sample in different time periods, as defined in the methodology section. Then we estimate equations for the four-factor model (equation 3), using these subsamples, on our different maturities.

5.3.1 Pre-GFC

The first result we can deduce is that the period pre-GFC turns out to have a highly significant negative coefficient for the relation between interest rates and bank stock return. This is the case for all maturities. During this period, rates mostly increased. We also see an increase in the absolute value of the coefficient as we go to higher maturities. This result is in line with what we expected in our hypothesis. When rates increase, the NIM of a bank is compressed, because of the tendency of consumer deposits to increase, while loan demand decreases. An increase in interest rates generally also means a decrease in valuations of other assets that banks may keep on their balance sheet. These effects cause bank stock returns to decrease. We suspect that the higher risk for longer maturities comes from a larger reduction in loan demand when rates increased.

5.3.2 Post-GFC

In the post-GFC period, including the period of the GFC itself, we find insignificant coefficients for the short-term rates. For long-term rates, our findings show a significant positive interest rate coefficient, which supports the findings of Ferrer et al. (2016), who found a positive relation between 10-year rates and stock returns. Following their reasoning, we can say that the positive coefficient is related to contagion effects that become stronger during periods of financial turbulence, of which the GFC is a great example. Our findings do however not align with Elyasiani et al. (2020). They find that interest risk had lower absolute values pre-GFC and higher absolute values during and post-GFC. In general we don't find evidence for this to be true..

5.3.3 Low and negative interest rates

Another subperiod we are interested in, a period that has been a key discussion point in financial literature, is the period of negative interest rates. Our results are rather surprising, in the sense that the literature expects a positive relation between short-term interest rates and bank stock returns, and a negative relation for long-term rates, in a period of negative interest rates (Ampudia & Van Den Heuvel, 2022).

We find results that differ from this hypothesis. The 1-month interest coefficient is highly significant and negative, the 3-month coefficient is slightly significant and also negative, and the 5-year rate coefficient is significant but positive. An explanation for the significance of short-term rates can be found in the fact that these rates are primarily affected by monetary policy. The monetary policy regime changed drastically in this period of negative rates, and banks needed to adjust to these changes. For example, negative rates forced banks to lend more, in order to keep up their NIM. Banks refused to pass through negative deposit rates to their depositors, putting a strain on profitability, and causing banks to be more risk-seeking. Combine this with an increase in credit quality, and we see an increase in bank profitability, which has a positive impact on bank stock returns (ECB, 2020). The positive coefficient for the 5-year rate can be explained by the different behavior of this rate, as opposed to shorter-term rates. The 5-year rate actually increased for a while during the period of negative rates. We, thus, have to interpret its coefficient differently than for short-term rates. The increase in the 5-year rate, while short-term rates stayed negative, caused the spread earned on maturity transformation to be more profitable for banks, explaining the positive coefficient. This also establishes the importance of the 5-year rate in the pricing of bank loan rates.

5.3.4 Corona pandemic

The corona pandemic also shows some surprising results, especially for the 1-month rate. We find that, during the pandemic, a decrease of the 1-month interest rate by 1 %-point caused an increase in bank stock returns of 27.00743%-points on average. The pandemic brought a lot of uncertainty into financial markets, making investors flee to safe-haven investments. This meant that prices of short-term bonds increased, causing the yields to go down. The ECB also introduced their Pandemic Emergency Purchase Programme (PEPP) to ensure low borrowing cost and increase lending by European banks. In addition, they kept their key policy rates at a really low level.

The only other significant interest rate coefficient is that of the 30-year rate. We find a positive coefficient. Overall, our results for this period are very diverse, but mostly insignificant, making interpretation difficult. We do know that the quality of bank assets suffered under an increase in household and corporate defaults, putting a strain on the sustainability of bank profits.

5.3.5 Increasing rates in 2022

Lastly, we look at the recent period of increasing rates, starting in early-2022. The coefficient for interest rates in this period is significant and positive across all periods. When we compare this to the pre-GFC period, a complete shift in the relation between interest rates and bank stock returns appears. Both periods are accompanied by increasing rates, but bank stock returns behave in different directions. We can explain the positive coefficients because banks have kept their deposit rates low while increasing rates on newly issued loans (ECB, 2022b), this caused a boost in bank NIMs. These results offer insights into the positive short-term effects of increasing rates. Banks should also be aware that, in the mid-to-long-term, increasing rates can have a negative impact on equity values.

5.3.6 Other factors

We have discussed the time-varying effect of interest rate risk, but the other factors in our model also show some interesting results. Firstly, we find that, during the period of negative rates the SMB factor no longer had a significant coefficient. This means that the "small firm effect", which is represented by the SMB factor, did not play a significant role in the determination of bank stock returns during the period of negative rates. The "small firm effect", means that stocks of small firms have an excess return over stocks of big firms. Our findings suggest that, during the period of negative rates, the returns in our sample of bank stocks did not behave like those of small-cap firms.

Another interesting finding is that the market beta seems to have increased again starting from the Covid pandemic. This is noteworthy because the market beta had come down, with the introduction of a negative rate regime, after an increase during the GFC. These findings suggest a general increase in market risk for the banks in our sample. This goes against what the regulators have been trying to achieve.

Table 11: Results 1 Month rate

	Dependent variable:					
	Bank Stock Returns					
	Full-sample	Pre-GFC	Post-GFC	Negative rates	Covid	Increasing
β_m	1.04897***	0.88025***	1.08730***	0.91803***	1.15395***	1.04993***
	(0.00811)	(0.01455)	(0.01443)	(0.01829)	(0.02156)	(0.03588)
β_i	0.02135	-0.30935***	0.05424	-0.84431***	-27.00743***	0.32407***
	(0.01486)	(0.03371)	(0.08126)	(0.29820)	(5.96397)	(0.08478)
β_s	0.60766***	0.28010***	0.87918***	0.03609	0.60025***	0.54244***
	(0.04323)	(0.06000)	(0.08280)	(0.09347)	(0.14847)	(0.20387)
β_h	1.38856***	0.65539***	2.01004***	0.86782***	0.83293***	0.93620***
	(0.04622)	(0.10195)	(0.09364)	(0.09614)	(0.10597)	(0.12104)
FE/RE	FE	FE	FE	FE	FE	FE
Observations	70,317	15,746	24,326	20,427	6,346	3,472
Adjusted R^2	0.20697	0.21290	0.22137	0.12222	0.33188	0.21321
Note:						*p<0.1; **p<0.05; ***p<0.01

Table 12: Results 3 Month rate

	Dependent variable:					
	Bank Stock Returns					
	Full-sample	Pre-GFC	Post-GFC	Negative rates	Covid	Increasing
β_m	1.04912***	0.88225***	1.08766***	0.91743***	1.15809***	1.05304***
	(0.00810)	(0.01453)	(0.01442)	(0.01830)	(0.02234)	(0.03584)
β_i	0.02700*	-0.29673***	0.07002	-0.52778*	-10.59537	0.26712***
	(0.01463)	(0.03364)	(0.08678)	(0.29985)	(7.46579)	(0.07530)
β_s	0.60797***	0.28846***	0.88079***	0.03467	0.50873***	0.55965***
	(0.04322)	(0.05996)	(0.08267)	(0.09349)	(0.14718)	(0.20358)
β_h	1.38770***	0.65889***	2.01394***	0.86510***	0.84301***	0.94691***
	(0.04623)	(0.10199)	(0.09356)	(0.09614)	(0.10613)	(0.12097)
FE/RE	FE	FE	FE	FE	FE	FE
Observations	70,317	15,746	24,326	20,427	6,346	3,472
Adjusted R^2	0.20698	0.21258	0.22138	0.12201	0.32991	0.21275
Note:						*p<0.1; **p<0.05; ***p<0.01

Table 13: Results 1 Year rate

	Dependent variable:					
	Bank Stock Returns					
	Full-sample	Pre-GFC	Post-GFC	Negative rates	Covid	Increasing
β_m	1.04932***	0.88793***	1.08783***	0.91598***	1.13913***	1.05778***
	(0.00810)	(0.01446)	(0.01432)	(0.01829)	(0.02264)	(0.03547)
β_i	0.03791***	-0.27677***	0.09588	0.20678	5.74147	0.24431***
	(0.01397)	(0.03405)	(0.08589)	(0.28864)	(3.66392)	(0.06432)
β_s	0.60816***	0.30630***	0.88180***	0.03060	0.51139***	0.55975***
	(0.04321)	(0.05989)	(0.08215)	(0.09348)	(0.14722)	(0.20313)
β_h	1.38559***	0.66708***	2.01832***	0.86319***	0.83502***	0.97698***
	(0.04624)	(0.10208)	(0.09236)	(0.09615)	(0.10641)	(0.12095)
FE/RE	FE	FE	FE	FE	FE	FE
Observations	70,317	15,746	24,326	20,427	6,346	3,472
Adjusted R^2	0.20703	0.21199	0.22140	0.12190	0.32996	0.21317
Note:						*p<0.1; **p<0.05; ***p<0.01

Table 14: Results 5 Year rate

	Dependent variable:					
	Bank Stock Returns					
	Full-sample	Pre-GFC	Post-GFC	Negative rates	Covid	Increasing
β_m	1.05136***	0.90252***	1.08763***	0.91802***	1.15039***	1.06801***
	(0.00823)	(0.01524)	(0.01418)	(0.01830)	(0.02163)	(0.03527)
β_i	0.03968***	-0.56857***	0.15295***	0.38822**	-0.21105	0.25324***
	(0.01447)	(0.06104)	(0.05614)	(0.15675)	(0.60870)	(0.08874)
β_s	0.61590***	0.34390***	0.88274***	0.04801	0.50175***	0.60195***
	(0.04399)	(0.06336)	(0.08147)	(0.09371)	(0.14720)	(0.20272)
β_h	1.39237***	0.75471***	2.03421***	0.88438***	0.85154***	0.99582***
	(0.04695)	(0.10846)	(0.09035)	(0.09655)	(0.10647)	(0.12160)
FE/RE	FE	FE	FE	FE	FE	FE
Observations	67,902	13,331	24,326	20,427	6,346	3,472
Adjusted R^2	0.20803	0.22625	0.22160	0.12214	0.32971	0.21172
Note:						*p<0.1; **p<0.05; ***p<0.01

Table 15: Results 10 Year rate

	Dependent variable:					
	Bank Stock Returns					
	Full-sample	Pre-GFC	Post-GFC	Negative rates	Covid	Increasing
β_m	1.05101***	0.89925***	1.08688***	0.91702***	1.14815***	1.07343***
	(0.00823)	(0.01527)	(0.01417)	(0.01830)	(0.02167)	(0.03531)
β_i	0.03200**	-0.71784***	0.17580***	0.10807	0.36394	0.16596*
	(0.01515)	(0.07395)	(0.05865)	(0.10976)	(0.42534)	(0.09903)
β_s	0.61508***	0.32132***	0.87979***	0.03885	0.50678***	0.63974***
	(0.04399)	(0.06345)	(0.08139)	(0.09379)	(0.14721)	(0.20257)
β_h	1.39347***	0.72434***	2.03363***	0.86945***	0.83775***	0.98666***
	(0.04694)	(0.10822)	(0.09007)	(0.09644)	(0.10680)	(0.12205)
FE/RE	FE	FE	FE	FE	FE	FE
Observations	67,902	13,331	24,326	20,427	6,346	3,472
Adjusted R^2	0.20800	0.22669	0.22165	0.12192	0.32977	0.21049
Note:						*p<0.1; **p<0.05; ***p<0.01

Table 16: Results 30 Year rate

	Dependent variable:					
	Bank Stock Returns					
	Full-sample	Pre-GFC	Post-GFC	Negative rates	Covid	Increasing
β_m	1.06362***	1.01198***	1.08604***	0.91517***	1.13815***	1.07563***
	(0.00901)	(0.03405)	(0.01416)	(0.01826)	(0.02183)	(0.03534)
β_i	0.01469	-1.64230***	0.32638***	-0.00431	1.05417***	0.15255
	(0.02120)	(0.57473)	(0.07104)	(0.09062)	(0.31126)	(0.12790)
β_s	0.60553***	0.22595**	0.88589***	0.04661	0.51083***	0.66012***
	(0.04838)	(0.11080)	(0.08138)	(0.09361)	(0.14704)	(0.20188)
β_h	1.39424***	0.50808***	2.04791***	0.90875***	0.80485***	0.98304***
	(0.05015)	(0.16749)	(0.08976)	(0.09642)	(0.10676)	(0.12252)
FE/RE	FE	FE	FE	FE	FE	FE
Observations	57,788	3,360	24,326	20,284	6,346	3,472
Adjusted R^2	0.20892	0.21804	0.22204	0.12273	0.33092	0.21017
Note:						*p<0.1; **p<0.05; ***p<0.01

5.4 Slope of the yield curve

In previous subsections we looked at models containing the level of different interest rates as the factor for interest rate risk. In this subsection we look at our four-factor model (equation 3) when we use the slope of the yield curve, instead of the level of interest rates. As discussed in the part on methodology, we use the 10Y-2Y and the 10Y-3M spreads to represent the slope of the yield curve.

Table 17 gives us the results when using this slope factor in the four-factor model, with the Fama French factors. It immediately becomes apparent that only the 10Y-2Y spread has a significant impact on bank stock returns. This impact is negative, meaning that a widening of the 10Y-2Y spread causes a negative impact on the return of bank stocks, in our sample. The 10Y-3M spread doesn't have a significant coefficient.

Table 17: Results for the four-factor models with yield spreads

	Dependent variable:	
	Bank Stock Returns	
	10 Year - 2 Year	10 Year - 3 Month
β_m	1.05131***	1.05011***
	(0.00823)	(0.00824)
β_i	-0.10889***	0.01815
	(0.03959)	(0.03119)
β_s	0.61467***	0.61231***
	(0.04398)	(0.04400)
β_h	1.38997***	1.39545***
	(0.04697)	(0.04694)
FE/RE	FE	FE
Observations	67,902	67,902
Adjusted R^2	0.20803	0.20795
Note:		*p<0.1; **p<0.05; ***p<0.01

The results we find here are rather contrary to what the literature suggests. Generally, a widening of the spread would mean that banks can make more money through maturity transformation. This should be positive for returns on bank stocks. The fact that we find the opposite effect, for the 10Y-2Y spread, could be caused by an unwillingness to increase lending in favorable conditions based on the fact that banks lend money on a risk-adjusted basis. It is possible that banks generally decided that the risk of increasing their lending activities was too high, which caused them to keep money in safer, more liquid assets. On the other hand, in the period of low and negative rates, we saw a serious decrease in yield spreads. If we follow the reasoning that we used when explaining time-varying effects in this period, we can argue the negative relation between the 10Y-2Y spread and bank stock returns was due to an increased quality of loans, and an overall increase in lending.

One potential explanation for the lack of significance of the 10Y-3M yield spread in affecting bank stock returns is that the short-term nature of the 3-month yield may lead to higher levels of volatility in this spread. A higher volatility means that effects from an increase or decrease in rates are generally not long-lasting. As a result, the impact of the 10Y-3M yield spread on bank stock returns may be less persistent or enduring, and in our case, not significant.

5.5 Regional differences

In this section, we look at how regional differences might affect interest rate risk. We have split up our bank sample into two groups, 'Core' and 'Periphery', according to the division we established in the part on data. We end up with two different estimations of the four-factor model (equation 3), one for each group, which we show in Table 18.

Table 18: Results of regional differences for 5-month rate

	Dependent variable:	
	Bank Stock Returns	
	Core	Periphery
β_m	0.95022***	1.13008***
	(0.00971)	(0.01432)
β_i	-0.03679**	0.11813***
	(0.01667)	(0.02574)
β_s	0.58697***	0.66815***
	(0.05198)	(0.07629)
β_h	0.90392***	1.83030***
	(0.05499)	(0.08282)
FE/RE	FE	FE
Observations	27,780	29,930
Adjusted R^2	0.26727	0.18999
Note:	*p<0.1; **p<0.05; ***p<0.01	

The results for the market beta and Fama French betas are highly significant, both for the 'Core' group and the 'Periphery' group. This is in line with what we expect for these factors. As for the coefficients of the 5-month interest rate, the results are more nuanced. We find that changes in the 5-month rate have a highly significant positive effect on bank stock returns for banks within the 'Core' group of countries. For the banks within the 'Periphery' group, we find highly significant positive results.

An explanation for these opposite results can be found in the way monetary policy is conducted within a monetary union. Monetary policy by the ECB is conducted in a uniform matter, barring unconventional instruments such as the 'Transmission Protection Instrument' (ECB, 2022c), meaning that the same monetary policy is applied across the different countries within the area it is targeting. The consequence of this is that the effects of said policy may be asymmetrical. Duarte et al. (2020) find that stock returns (financial and non-financial) and long-term interest rates move similarly across euro area countries. The authors find that asymmetries in monetary policy are more likely to be found in consumer price inflation (HICP), consumption, unemployment, and housing prices. These asymmetries are mostly due to differences in the way financial markets are structured, how the regulatory environment is set up, and the macroeconomic conditions in a specific country. We can thus assume that regional differences in bank stock returns could originate from indirect effects through credit quality and loan demand caused by asymmetries in monetary policy transmission.

Hoffmann (2019) finds another explanation for these regional differences, stating that countries where banks apply fixed rates to their mortgages typically have lower, or even negative interest rate risk, as opposed to variable-rate mortgages that cause a more positively shifted distribution of interest rate risk exposures. This makes sense given that fixed rates mean that increases in interest rates would mostly affect the rates that banks pay on their customer's deposits, while their interest income stays behind. For variable rates, the loan rates would also increase in this situation, leaving a possibly negative effect for bank NIMs. When looking at which countries fall under fixed rates, and which countries fall under variable rates, we see that the first group closely represents our 'core' group while the second group resembles the 'periphery' group. This gives us reason to believe that the type of mortgage rate (variable or fixed) could be another valid explanation for the regional differences that we find.

5.6 Deposit ratio

In this subsection, we examine the outcomes of our estimations after dividing our bank sample into three groups based on their deposit ratios. Table 19 gives us the results when we do full sample estimations on our four-factor model (equation 3), while Table 20 shows us the results when we add a dummy for the period of negative rates. Both tables show results for the short-term (1-month rate) and long-term (10-year rate) effects.

We find that, for our full sample estimations, no subgroup of banks shows significant interest rate sensitivity to bank stock returns, when we split them by their level of deposit ratio. We find this for both short- and long-term rates. This means that the level of the deposit ratio does not affect the interest rate risk of a bank over the complete sample period, contrary to our hypothesis, as stated in the methodology. Possible explanations could be that banks are not as dependent on deposits for funding their activities as we expected. They may have diversified into other funding sources. Of course, we have to nuance these results because of the fact that we use the full sample. When we split our sample into two periods, negative interest rates and the rest of the time period, we get different results. The effects for the period of negative rates can be interpreted as the sum of β_i and β_{neg}. We then find significant results, for the negative rate period, for the banks with a Low and Medium deposit ratio, and this for short-term rates. Banks with a higher deposit ratio turn out to have a significant coefficient outside of the period of negative rates, this is for the long-term rate. These findings are the opposite of what we hypothesized. Based on Ampudia and Van Den Heuvel (2022), we expected a negative effect for long-term rates and a positive effect for short-term rates, in a period of negative rates. We can explain our findings by assuming that these banks are making use of other sources of funding, besides deposits, that allow them to benefit from low or negative rates.

Table 19: Results for different levels of deposit ratio

	Low		Medium		High	
	1 MONTH	10 YEAR	1 MONTH	10 YEAR	1 MONTH	10 YEAR
β_m	1.29957***	1.30280***	1.02697***	1.02964***	0.77265***	0.77273***
	(0.01543)	(0.01569)	(0.01261)	(0.01281)	(0.01371)	(0.01387)
β_i	0.00142	0.01854	0.02355	0.02970	0.01368	0.03496
	(0.02796)	(0.02797)	(0.02320)	(0.02400)	(0.02544)	(0.02566)
β_s	0.66171***	0.67501***	0.65294***	0.65931***	0.38069***	0.38552***
	(0.08241)	(0.08396)	(0.06728)	(0.06850)	(0.07299)	(0.07400)
β_h	1.72606***	1.73452***	1.34947***	1.35439***	0.93052***	0.93029***
	(0.08715)	(0.08861)	(0.07234)	(0.07350)	(0.07777)	(0.07873)
FE/RE	FE	FE	FE	FE	FE	FE
Observations	19,734	19,062	31,446	30,279	16,946	16,466
Adjusted R^2	0.28380	0.28462	0.18677	0.18823	0.16960	0.16992

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

Table 20: Results for different levels of deposit ratio, with time dummy

	Low		Medium		High	
	1 MONTH	10 YEAR	1 MONTH	10 YEAR	1 MONTH	10 YEAR
β_m	1.29928***	1.30229***	1.02761***	1.03002***	0.77323***	0.77377***
	(0.01545)	(0.01570)	(0.01263)	(0.01282)	(0.01372)	(0.01388)
β_i	-0.01145	0.00076	0.02986	0.03666	0.02501	0.06267**
	(0.03136)	(0.03446)	(0.02571)	(0.02915)	(0.02815)	(0.03121)
β_s	0.65745***	0.67135***	0.65606***	0.66479***	0.38504***	0.39545***
	(0.08258)	(0.08416)	(0.06743)	(0.06866)	(0.07315)	(0.07417)
β_h	1.72347***	1.73246***	1.35205***	1.35949***	0.93354***	0.93840***
	(0.08722)	(0.08874)	(0.07240)	(0.07360)	(0.07784)	(0.07884)
$\alpha_{neg-int}$	-0.00465**	-0.00126	-0.00280*	-0.00039	0.00104	0.00096
	(0.00194)	(0.00157)	(0.00170)	(0.00132)	(0.00168)	(0.00141)
$\beta_{neg-int}$	-1.21217**	0.06976	-1.06104**	0.21498	0.06912	0.15986
	(0.57645)	(0.22309)	(0.50072)	(0.18585)	(0.50797)	(0.20053)
FE/RE	FE	FE	FE	FE	FE	FE
Observations	19,734	19,062	31,446	30,279	16,946	16,466
Adjusted R^2	0.28394	0.28458	0.18684	0.18823	0.16954	0.17002

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

6 Robustness tests

6.1 Changes in specification

A way to test the robustness of our models is to make changes in their specifications or in the approach we take in using dummies or subsamples. We perform two robustness tests for changes in specifications: 1) We use a dummy instead of two subsamples to check the robustness of regional differences, and 2) We add yield spreads to our four-factor model.

We check if, by using a dummy instead of two different subsamples (in equation 3), we can obtain robust results for our regional differences analysis. Table 21 shows us the results for this estimation. We find that the sign of the coefficients remains the same as in the estimation with subsamples. The coefficient β_i gives the interest rate sensitivity for banks in the periphery. We again obtain a highly significant positive coefficient, as we did in the subsample estimation. We obtain the coefficient for the core country group by adding β_i and β_{core} together. This gives us a slightly negative impact, which is not significant. This is in contrast to our subsample estimation, where we did find significant results for both groups. Our results for regional differences don't appear to be robust.

Our second test is to introduce yield spreads in our original four-factor model (equation 3), in addition to the level of interest rates. Within our analysis, we initially estimated models with level interest rates and yield spreads separately. We now test what the impact is of including both variables in our estimations. The results can be found in Tables 22 and 23. When we add the 10Y-2Y spread, we see that our level interest betas become less significant for all maturities, except for the 1-month and 30-year rates which were already insignificant. Instead, the yield spread beta shows some significance, although less than for the original estimation in Table 17. Looking at the results when we add the 10Y-3M spread, we see really robust results for both the level interest rates and the yield spread beta. The 3-month rate becomes slightly more significant. Overall, our results are less robust for the 10Y-2Y spread, and more for the 10Y-3M spread.

Table 21: Results for core-periphery analysis with regional dummy

	Dependent variable:
	Bank Stock Returns
	Core
β_m	1.04436***
	(0.00880)
β_i	0.11562***
	(0.02189)
β_s	0.62351***
	(0.04700)
β_h	1.37799***
	(0.05039)
β_{core}	-0.14980***
	(0.03090)
FE/RE	FE
Observations	57,710
Adjusted R^2	0.21047
Note:	*p<0.1; **p<0.05; ***p<0.01

Table 22: 10Y-2Y spread

	Dependent variable:					
	Bank Stock Returns					
	1 MONTH	3 MONTH	1 YEAR	5 YEAR	10 YEAR	30 YEAR
β_m	1.05148***	1.05164***	1.05188***	1.05206***	1.05198***	1.06433***
	(0.00824)	(0.00824)	(0.00824)	(0.00823)	(0.00823)	(0.00905)
β_i	0.00614	0.01275	0.02677*	0.03477**	0.03317**	0.02543
	(0.01652)	(0.01634)	(0.01559)	(0.01461)	(0.01516)	(0.02424)
β_{slope}	-0.10276**	-0.09549**	-0.07945*	-0.09550**	-0.11126***	-0.04993
	(0.04288)	(0.04315)	(0.04314)	(0.03999)	(0.03960)	(0.05461)
β_s	0.61533***	0.61586***	0.61649***	0.61686***	0.61665***	0.60673***
	(0.04402)	(0.04401)	(0.04399)	(0.04399)	(0.04399)	(0.04840)
β_h	1.38995***	1.38972***	1.38863***	1.38817***	1.38812***	1.39334***
	(0.04697)	(0.04697)	(0.04698)	(0.04698)	(0.04698)	(0.05016)
FE/RE	FE	FE	FE	FE	FE	FE
Observations	67,902	67,902	67,902	67,902	67,902	57,788
Adjusted R^2	0.20802	0.20803	0.20806	0.20809	0.20808	0.20892
Note:						*p<0.1; **p<0.05; ***p<0.01

Table 23: 10Y-3M

	Dependent variable:					
	Bank Stock Returns					
	1 MONTH	3 MONTH	1 YEAR	5 YEAR	10 YEAR	30 YEAR
β_m	1.05082***	1.05094***	1.05110***	1.05118***	1.05094***	1.06212***
	(0.00825)	(0.00825)	(0.00824)	(0.00825)	(0.00825)	(0.00906)
β_i	0.02556	0.03160**	0.04160***	0.03926***	0.03160**	-0.00690
	(0.01583)	(0.01554)	(0.01461)	(0.01452)	(0.01554)	(0.02496)
β_{slope}	0.03216	0.03538	0.03661	0.01128	0.00378	0.06777
	(0.03237)	(0.03232)	(0.03185)	(0.03129)	(0.03198)	(0.04137)
β_s	0.61471***	0.61487***	0.61485***	0.61532***	0.61487***	0.60130***
	(0.04403)	(0.04402)	(0.04401)	(0.04402)	(0.04402)	(0.04845)
β_h	1.39441***	1.39355***	1.39152***	1.39259***	1.39355***	1.39370***
	(0.04694)	(0.04695)	(0.04696)	(0.04695)	(0.04695)	(0.05015)
FE/RE	FE	FE	FE	FE	FE	FE
Observations	67,902	67,902	67,902	67,902	67,902	57,788
Adjusted R^2	0.20797	0.20799	0.20803	0.20802	0.20799	0.20894
Note:						*p<0.1; **p<0.05; ***p<0.01

6.2 Sample of banks

Another test we perform is to change the sample of banks within our dataset, leaving certain banks out, and seeing how results differ. One approach we take is leaving out additional low-beta banks. These include most of the so-called "Caisses-Regionales" that belong to the Credit Agricole group in France. In total, we have 13 of these "Caisses Regionales". When we estimate our four-factor model on this sample, we find that market betas and Fama French coefficients remain highly significant, such is the case in our full sample estimations. However, the results for our interest rate betas are somewhat different. We see that, across maturities, interest rate risk is more significant in terms of its impact on bank stock returns, except for the 30-year rate. This makes sense, given that the Caisses Regionales are all subjected to the same interest risk policies of Credit Agricole, thus, excluding them from our dataset removes a certain bias towards their risk policy.

Table 24: Results for four-factor model with reduced bank sample

	Dependent variable:					
	Bank Stock Returns					
	1 MONTH	3 MONTH	1 YEAR	5 YEAR	10 YEAR	30 YEAR
β_m	1.17794***	1.17803***	1.17802***	1.18007***	1.17947***	1.19397***
	(0.00939)	(0.00938)	(0.00938)	(0.00954)	(0.00954)	(0.01051)
β_i	0.05405***	0.05941***	0.06821***	0.06360***	0.04964***	0.01600
	(0.01725)	(0.01697)	(0.01621)	(0.01691)	(0.01779)	(0.02515)
β_s	0.67431***	0.67417***	0.67340***	0.68070***	0.67925***	0.66937***
	(0.05005)	(0.05004)	(0.05002)	(0.05098)	(0.05098)	(0.05640)
β_h	1.62869***	1.62721***	1.62422***	1.63333***	1.63524***	1.63828***
	(0.05381)	(0.05382)	(0.05383)	(0.05471)	(0.05471)	(0.05873)
FE/RE	FE	FE	FE	FE	FE	FE
Observations	58,434	58,434	58,434	56,339	56,339	47,583
Adjusted R^2	0.22904	0.22907	0.22914	0.23008	0.22999	0.23051
Note:						*p<0.1; **p<0.05; ***p<0.01

We also re-estimate our time-varying regressions with this reduced sample. The full results can be found in the appendix, but we give an overview of the general changes in our coefficients in Table 25. For both the pre-GFC and post-GFC periods, we find rather robust results, in the sense that all coefficients become slightly more positive (or less negative) but remain equally significant. In the period of negative rates we find varying results for β_i, the short-term rate coefficients become more negative, and the long-term rate coefficients become more positive. The other coefficients remain either insignificant or become slightly more positive. For the covid period, we find that the interest coefficient becomes more negative for the 1-month rate, and decreases for the 30-year rate. All other coefficients become slightly more positive. The final period, with increasing rates, we find robust results for the market and Fama French betas, but the interest coefficients show different behaviour. For short-term rates, we find a decrease in the coefficient, while in the long-term we find an increase, and an even more significant coefficient for the 10-year rate. Overall, these results seem to be robust for the periods before negative rates, and less robust from negative rates onward.

	Pre-GFC	Post-GFC	Negative rates	Covid	Increasing
β_m	+	+	+	+	+
β_i	+	+	ST: - & LT: +	-	+/-
β_s	+	+	Not significant	+	+
β_h	+	+	+	+	+

Table 25: General effects on coefficients by a reduction in the bank sample

7 Policy implications

We find that interest rate risk has a positive relation with bank stock returns, but this did not hold up when we examined different time periods. When looking at the time-varying effects, we notice a shift in the sign of the coefficients, especially for short-term interest rates in the recent period of increasing rates. This means that policymakers should be careful in examining the impact of future policy. This will be a different impact than what we saw in the pre-GFC period, which also consisted of increasing rates.

The ECB is already aware of the effects of the recent increase in rates on bank stock returns. They state that in the short-term returns might increase, but that in the middle- or long-term, these returns could decrease due to lower asset values (ECB, 2022a). They continue to supervise the volume of interest swaps, held by banks, which represents their hedging against interest rate risk. Our recommendation would be that, due to the now positive interest rate risk, the ECB is careful when considering lowering their policy rates again in the future. Banks today may have stronger hedging mechanisms in place to mitigate interest rate risk compared to the past. However, their improved income streams could lead to a reduction in their volumes of interest rate swaps, potentially increasing their exposures once again.

Our findings of an increase in the market beta point towards an increase in systemic risk within European banks. This should be monitored by the banking supervisor as systemic risk is something that should be limited, in order to avoid major contagion upon bank failures and to secure stability in the financial sector in general.

We also recommend that future policy changes should be communicated in a transparent manner. This can help ease the impact of rate changes on bank stocks, as expectations of future interest rates are then much more clear.

8 Conclusions and recommendations for future research

In our research, we have estimated different models to analyze the relation between interest rate risk and bank stock returns. We conclude that our full-sample estimations of the two-factor and four-factor models delivered results that showed a highly significant positive sensitivity of bank stocks to 1-year and 5-year interest rates. The 10-year rate also had a significant positive effect, although less significant than for 1-year and 5-year rates. We explained this by assuming that banks are able to keep deposit rates low while adjusting their loan rates to interest rate changes. The signs of our results were robust, but we found that by using a different sample, coefficients for the 1-month and 3-month rates also became highly significant.

Our analysis of the time-varying aspect of interest rate risk also delivered interesting results. We found that pre-GFC, interest rate risk was highly significant and negative, across all maturities. This is in line with what we expected and is a normal result given the expected compression of Net Interest Margins. The period post-GFC showed a division between short- and long-term rates, with the first group showing insignificant coefficients, while the second group shows significant positive coefficients. For the period of negative rates we found that particularly the 1-month and 5-year rates showed significant results, with the 3-month rate returning a slightly significant result. However, the 1-month and 3-month coefficients were negative, while the 5-year coefficient was positive. In explaining these results, we put an emphasis on a drastic change in the monetary policy regime, in combination with different behavior in the interest rates themselves. During this negative interest period, we also observed an insignificant SMB factor coefficient, leading us to conclude that bank stock returns did not behave like small-cap returns. The most noteworthy observation was during the Covid period where we found a highly significant negative coefficient for the 1-month rate. A 1%-point decrease of the 1-month rate caused a 27.00743%-point increase in bank stock returns during that period. Lastly, for the period of increasing rates, we found that increasing rates were accompanied by a positive interest rate risk across all maturities, showing a change in the overall relation between interest rates and bank stocks.

Another factor we used to measure interest rate risk was the slope of the yield curve, we used yield spreads to measure this slope. We found that, between the 10Y-2Y and the 10Y-3M spreads, only the 10Y-2Y spread was significant, with a negative coefficient. This was then explained by the perception of higher volatility in the 3-month yield, causing effects not to be long-lasting. The significant effect of a 10Y-2Y spread can be explained by an increase in credit quality that is implied by a decrease in the spread.

We also looked at regional differences by performing a core-periphery analysis. Our results showed that interest rate risk was highly significant and positive for banks within peripheral countries, while a highly significant negative effect was found for the core group. We explained this by pointing out the differences in how financial markets are structured and regulated, and thus the way monetary policy is passed through in different countries. Our explanation also included the way mortgage rates are set up in different countries. The result for peripheral countries was robust for using a different specification. We did however find that, by using a dummy to indicate the region of a bank instead of splitting the sample, the interest rate coefficient for the core group turned out to be insignificant.

Lastly, we analyzed the effects of different levels of deposit ratios on interest rate risk. We found that dividing banks by their deposit ratios did not explain interest rate risk in our full sample. When differentiating between the period of negative rates, and the rest of the sample, we did find significant interest rate risk. More specifically, the short-term rates for the Low and Medium level deposit ratio groups of banks had highly significant, negative coefficients.

One limitation of our research is that we only took into account the deposit ratio of our banks as a bank specific variable. Future research could include additional variables, such as leverage and the loan-to-deposit ratio, to further analyze what exactly impacts the interest rate risk in a bank. Additionally, future research could perform a decomposition of interest rates, into a term premium and an expectations component. This would enable a deeper look into how bank stock returns react to changes in markets and economic conditions. One could also consider incorporating exchange rate risk into our factor model, building further on the work of Choi et al. (1992).

Overall, our findings contribute to a comprehensive understanding of the complex relationship between interest rate risk and European bank stock returns, providing insights into the sensitivity of bank stocks to different interest rate maturities, the changing dynamics over time, the influence of yield spreads as the slope of the yield curve, regional differences, and the role of deposit ratios in shaping interest rate risk.

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A Appendix

A.1 Data

Table A1: List of banks

Nr.	Bank	Country
1	BNP Paribas SA	France
2	Deutsche Bank Aktiengesellschaft	Germany
3	Crédit Agricole S.A.	France
4	Banco Santander, S.A.	Spain
5	Société Générale Société anonyme	France
6	ING Groep N.V.	Netherlands
7	Intesa Sanpaolo S.p.A.	Italy
8	UniCredit S.p.A.	Italy
9	Commerzbank AG	Germany
10	Banco Bilbao Vizcaya Argentaria, S.A.	Spain
11	Nordea Bank Abp	Finland
12	CaixaBank, S.A.	Spain
13	Dexia SA	Belgium
14	Natixis S.A.	France
15	ABN AMRO Bank N.V.	Netherlands
16	Crédit Industriel et Commercial	France
17	KBC Group NV	Belgium
18	Erste Group Bank AG	Austria
19	Bankia, S.A.	Spain
20	Banco de Sabadell, S.A.	Spain
21	Banca Monte dei Paschi di Siena S.p.A.	Italy
22	Deutsche Postbank AG	Germany
23	Banco BPM S.p.A.	Italy
24	Bank of Ireland Group plc	Ireland
25	Raiffeisen Bank International AG	Austria
26	AIB Group plc	Ireland
27	Banco Popular Español, SA	Spain
28	Landesbank Berlin Holding AG	Germany
29	BPER Banca SpA	Italy
30	SRH N.V.	Netherlands
31	Unione di Banche Italiane S.p.A.	Italy
32	Banco Español de Crédito, S.A.	Spain

33	National Bank of Greece S.A.	Greece
34	Unicaja Banco, S.A.	Spain
35	Bankinter, S.A.	Spain
36	Irish Bank Resolution Corporation Limited	Ireland
37	Banco Comercial Português, S.A.	Portugal
38	OP Yrityspankki Oyj	Finland
39	Piraeus Financial Holdings S.A.	Greece
40	Eurobank Ergasias Services and Holdings S.A.	Greece
41	Banco Espírito Santo, S.A.	Portugal
42	Mediobanca Banca di Credito Finanziario S.p.A.	Italy
43	Permanent TSB Group Holdings plc	Ireland
44	Permanent TSB Group Holdings plc	Ireland
45	Wüstenrot & Württembergische AG	Germany
46	Alpha Services and Holdings S.A.	Greece
47	Banca Mediolanum S.p.A.	Italy
48	Caisse Régionale de Crédit Agricole Mutuel de Paris et d'Ile-de-France	France
49	Credito Emiliano S.p.A.	Italy
50	BAWAG Group AG	Austria
51	Banca Popolare di Sondrio S.p.A	Italy
52	Banca Popolare di Milano Società per Azioni	Italy
53	Aareal Bank AG	Germany
54	Liberbank, S.A.	Spain
55	Komercní banka, a.s.	Czechia
56	Banca Carige S.p.A. - Cassa di Risparmio di Genova e Imperia	Italy
57	Banco BPI, S.A.	Portugal
58	Bank of Cyprus Holdings Public Limited Company	Cyprus
59	Bank of Cyprus Public Company Limited	Cyprus
60	Cyprus Popular Bank Public Co. Ltd.	Cyprus
61	Caisse Régionale de Crédit Agricole Mutuel Brie Picardie Société coopérative	France
62	Caisse Régionale de Crédit Agricole Mutuel Nord de France Société coopérative	France
63	FinecoBank Banca Fineco S.p.A.	Italy
64	Caisse Régionale de Crédit Agricole Mutuel du Languedoc Société coopérative	France
65	ATEbank SA	Greece
66	NIBC Holding N.V.	Netherlands

67	Banco Pastor S.A.	Spain
68	Emporiki Bank of Greece SA	Greece
69	Credito Valtellinese S.p.A.	Italy
70	comdirect bank AG	Germany
71	Caisse régionale de Crédit Agricole Mutuel Atlantique Vendée	France
72	Caisse Régionale de Crédit Agricole Mutuel Sud Rhône Alpes	France
73	Caisse Régionale de Crédit Agricole Mutuel Alpes Provence Société coopérative	France
74	Oldenburgische Landesbank AG	Germany
75	Banco de Valencia SA	Spain
76	Marfin Egnatia Bank S.A.	Greece
77	Caisse Régionale de Crédit Agricole Mutuel de Normandie-Seine Société coopérativ	France
78	Nova Ljubljanska Banka d.d.	Slovenia
79	Van Lanschot Kempen NV	Netherlands
80	Zagrebacka banka d.d.	Croatia
81	Hellenic Bank Public Company Limited	Cyprus
82	Privredna banka Zagreb d.d.	Croatia
83	TT Hellenic Postbank SA	Greece
84	Banco di Desio e della Brianza S.p.A.	Italy
85	Caisse régionale de Crédit Agricole Mutuel d'Ille-et-Vilaine Société coopérative	France
86	Nuova Banca dell'Etruria e del Lazio S.p.A.	Italy
87	Caisse Régionale de Crédit Agricole Mutuel de La Touraine et du Poitou, SC	France
88	Banca Generali S.p.A.	Italy
89	Banif - Banco Internacional do Funchal, S.A.	Portugal
90	Banif SGPS, SA	Portugal
91	Credito Bergamasco SpA	Italy
92	Caisse Regionale de Credit Agricole Mutuel Toulouse 31	France
93	Banco di Sardegna S.p.A.	Italy
94	Caisse régionale de Crédit Agricole Mutuel Loire Haute-Loire Société coopérative	France
95	MONETA Money Bank, a.s.	Czechia
96	Caisse Régionale de Crédit Agricole du Morbihan	France
97	Aktia Pankki Oyj	Finland
98	Banco Guipuzcoano, SA	Spain

A.2 Robustness Tests

Table A2: Results for 1-month rate with reduced sample

	Dependent variable:					
	Bank Stock Returns					
	Full-sample	Pre-GFC	Post-GFC	Negative rates	Covid	Increasing
β_m	1.17794***	0.96946***	1.22110***	1.08820***	1.24995***	1.22483***
	(0.00939)	(0.01593)	(0.01666)	(0.02180)	(0.02504)	(0.04229)
β_i	0.05405	-0.28963***	0.23360**	-1.01274***	-29.40971***	0.29626***
	(0.01725)	(0.03666)	(0.09417)	(0.35794)	(6.99042)	(0.09990)
β_s	0.67431***	0.31065***	1.02514***	0.07565	0.63721***	0.68407***
	(0.05005)	(0.06588)	(0.09568)	(0.11141)	(0.17272)	(0.24024)
β_h	1.62869***	0.81936***	2.40704***	1.02054***	1.02074***	1.06046***
	(0.05381)	(0.11212)	(0.10830)	(0.11459)	(0.12353)	(0.14263)
FE/RE	FE	FE	FE	FE	FE	FE
Observations	58,434	13,574	20,322	16,683	5,111	2,744
Adjusted R^2	0.22904	0.24047	0.24385	0.14421	0.35099	0.24976

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

Table A3: Results for 3-month rate with reduced sample

	Dependent variable:					
	Bank Stock Returns					
	Full-sample	Pre-GFC	Post-GFC	Negative rates	Covid	Increasing
β_m	1.17803***	0.97137***	1.22126***	1.08743***	1.25336***	1.22725***
	(0.00938)	(0.01591)	(0.01665)	(0.02181)	(0.02596)	(0.04223)
β_i	0.05941***	-0.27774***	0.25691**	-0.60151*	-10.11169	0.24811***
	(0.01697)	(0.03658)	(0.10064)	(0.35986)	(8.70809)	(0.08872)
β_s	0.67417***	0.31856***	1.02442***	0.07384	0.53703***	0.69796***
	(0.05004)	(0.06583)	(0.09553)	(0.11143)	(0.17123)	(0.23987)
β_h	1.62721***	0.82265***	2.40883***	1.01722***	1.03249***	1.07005***
	(0.05382)	(0.11216)	(0.10821)	(0.11460)	(0.12374)	(0.14253)
FE/RE	FE	FE	FE	FE	FE	
Observations	58,434	13,574	20,322	16,683	5,111	2,744
Adjusted R^2	0.22907	0.24020	0.24387	0.14394	0.34888	0.24949
Note:						*p<0.1; **p<0.05; ***p<0.01

Table A4: Results for 1-year rate with reduced sample

	Dependent variable:					
	Bank Stock Returns					
	Full-sample	Pre-GFC	Post-GFC	Negative rates	Covid	Increasing
β_m	1.17802***	0.97671***	1.21905***	1.08574***	1.23763***	1.23023***
	(0.00938)	(0.01583)	(0.01654)	(0.02180)	(0.02632)	(0.04179)
β_i	0.06821***	-0.26001***	0.23786**	0.26561	4.20018	0.24154***
	(0.01621)	(0.03706)	(0.09986)	(0.34600)	(4.29185)	(0.07578)
β_s	0.67340***	0.33537***	1.01261***	0.06934	0.53774***	0.69060***
	(0.05002)	(0.06575)	(0.09493)	(0.11142)	(0.17128)	(0.23930)
β_h	1.62422***	0.83042***	2.39165***	1.01551***	1.02787***	1.09894***
	(0.05383)	(0.11225)	(0.10682)	(0.11461)	(0.12407)	(0.14248)
FE/RE	FE	FE	FE	FE	FE	FE
Observations	58,434	13,574	20,322	16,683	5,111	2,744
Adjusted R^2	0.22914	0.23973	0.24384	0.14383	0.34883	0.25014
Note:						*p<0.1; **p<0.05; ***p<0.01

Table A5: Results for 5-year rate with reduced sample

	Dependent variable:					
	Bank Stock Returns					
	Full-sample	Pre-GFC	Post-GFC	Negative rates	Covid	Increasing
β_m	1.18007***	0.99128***	1.21601***	1.08823***	1.24690***	1.23927***
	(0.00954)	(0.01668)	(0.01638)	(0.02181)	(0.02512)	(0.04154)
β_i	0.06360***	-0.56023***	0.19930***	0.46594**	-0.58442	0.27040***
	(0.01691)	(0.06650)	(0.06546)	(0.18702)	(0.71527)	(0.10451)
β_s	0.68070***	0.37258***	0.99852***	0.09031	0.52838***	0.72577***
	(0.05098)	(0.05098)	(0.09413)	(0.11170)	(0.17123)	(0.23875)
β_h	1.163333***	0.92131***	2.37923***	1.04079***	1.04653***	1.12033***
	(0.05471)	(0.11932)	(0.10447)	(0.11508)	(0.12414)	(0.14322)
FE/RE	FE	FE	FE	FE	FE	FE
Observations	56,339	11,479	20,322	16,683	5,111	2,744
Adjusted R^2	0.23008	0.25536	0.24397	0.14412	0.34880	0.24918

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

Table A6: Results for 10-year rate with reduced sample

	Dependent variable:					
	Bank Stock Returns					
	Full-sample	Pre-GFC	Post-GFC	Negative rates	Covid	Increasing
β_m	1.17947***	0.99128***	1.21601***	1.08823***	1.24690***	1.23927***
	(0.00954)	(0.01668)	(0.01638)	(0.02181)	(0.02512)	(0.04154)
β_i	0.04964***	-0.56023***	0.19930***	0.46594**	-0.58442	0.27040***
	(0.01779)	(0.06650)	(0.06546)	(0.18702)	(0.71527)	(0.10451)
β_s	0.67925***	0.37258***	0.99852***	0.09031	0.52838***	0.72577***
	(0.05098)	(0.05098)	(0.09413)	(0.11170)	(0.17123)	(0.23875)
β_h	1.63524***	0.92131***	2.37923***	1.04079***	1.04653***	1.12033***
	(0.05471)	(0.11932)	(0.10447)	(0.11508)	(0.12414)	(0.14322)
FE/RE	FE	FE	FE	FE	FE	FE
Observations	56,339	11,479	20,322	16,683	5,111	2,744
Adjusted R^2	0.22999	0.25536	0.24397	0.14412	0.34880	0.24918

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

Table A7: Results for 30-year rate with reduced sample

	Dependent variable:					
	Bank Stock Returns					
	Full-sample	Pre-GFC	Post-GFC	Negative rates	Covid	Increasing
β_m	1.19397***	1.08817***	1.21383***	1.08493***	1.23402***	1.24745***
	(0.01051)	(0.03752)	(0.01635)	(0.02177)	(0.02537)	(0.04163)
β_i	0.01600	-1.44328**	0.36246***	0.02010	1.03188***	0.16161
	(0.02515)	(0.63332)	(0.08270)	(0.10815)	(0.36461)	(0.15064)
β_s	0.66937***	0.23232*	0.99941***	0.09068	0.53915***	0.78809***
	(0.05640)	(0.12210)	(0.09402)	(0.11156)	(0.17108)	(0.23778)
β_h	1.63828***	0.68318***	2.38578***	1.07299***	0.99488***	1.10651***
	(0.05873)	(0.18456)	(0.10378)	(0.11491)	(0.12450)	(0.14431)
FE/RE	FE	FE	FE	FE	FE	FE
Observations	47,583	2,840	20,322	16,566	5,111	2,744
Adjusted R^2	0.23051	0.24566	0.24434	0.14484	0.34974	0.24763

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