Erasmus University Rotterdam

Erasmus School of Economics

Master thesis in Financial Economics

Impact of low interest rates on bank profitability and risk-taking

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August 2018

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Abstract

This paper investigates the impact of the exceptionally low interest environment on the profitability as well as the risk-taking of banks. Using a sample consisting of 2,727 Euro area banks over the period 2011-2017 I analyze the relationship between the interest rate environment and bank profitability as well as risk-taking. I find that low short-term interest rates impair banks profitability when measured by either Return on Assets (ROA), Return on Equity (ROE) or the Net Interest Margin (NIM). Besides, I find a non-linear (concave) relationship between the profitability measures and the short-term interest rate. Moreover, I also test whether long-term interest rates or the yield curve slope also affect profitability. Consistent with the short-term interest rates, banks are also subject to decreasing profitability due to a flattening of the yield curve. From the yield curve perspective, I also find a non-linear (concave) association with profitability. In regard to bank risk-taking, the results show that banks increase their risk appetite by means of the "search for yield" channel to compensate for decreasing margins.

Keywords: *unconventional monetary policy, risk-taking, bank profitability, low interest rate environment, dynamic panel data models. European central bank.*

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1. Introduction

Following the Great Financial Crisis, central banks in the major economies intervened by undertaking a whole range of unconventional monetary measures, including balance sheet policies, forward guidance and extremely low interest rates, even delving into negative territory at times to stimulate the depressed state of the economy. The ECB highlights in its 2016 annual report that the expansionary monetary policies it implemented have had a positive impact on the economy as a whole. Due to the expansive intervention by the ECB, there has been an increase in lending activity as well as improvements in the quality of bank assets. Similarly, the results of other papers, such as Rostagno et al. (2016), provide empirical support for the various unconventional measures the ECB has adopted. Their results show that negative interest rate assisted in increasing the total amount of loans to companies in the Eurozone.

All things considered, there is a consensus among experts that the aggressive response at the early stages was critical for helping prevent a financial and economic meltdown. However, the IMF warns that if this scenario persists for much longer, it will have an adverse effect on the net interest margin and therefore on bank profitability, primarily due to the floor in interest rates on deposits, as well as a flattening of the yield curve (Cruz-García et al., 2017). In the context of declining net interest margins, banks have an incentive to compensate for the loss in net interest margin by increasing their risk-taking in an attempt to "search for yield". This behavior is more pronounced when nominal return targets are in place.

Considering declining bank profitability, it becomes clear that low interest rates have a negative effect on the net interest margin of banks. This effect is more profound when the rates are extremely low compared to when the rates are high, therefore it is alleged that there is a non-linear (concave) relationship between interest rates and the net interest margin. However, the overall effect on profitability is still unclear as decreasing net interest margin due to low interest rates oftentimes goes hand in hand with increasing non-interest income and also lower expenses (provisioning) due to a reduction of default probability.

In regard to the risk-taking, Altunbas et al. (2010) find that a prolonged period of low interest rates may induce banks to increase their risk to compensate for the reduction of the net interest margin. This newly-formed risk appetite comes forth via two channels. First, banks may boost profitability by altering their business model by increasing their non-interest activities. Accordingly, via this channel, banks will "search for yield" by engaging in more trading activities which will unquestionably increase overall risk. The second channel of risk-

taking pertains to credit risk assumed by banks. In the first instance, lower interest rates will reduce default probabilities, which in turn will reduce loan loss provisions while also boosting profits. Taking this into consideration, banks may try to capitalize on this opportunity by softening their lending standards which will boost their short-term profits. However, in the medium- and long-term, this lower loan portfolio quality will lead to higher credit losses.

This thesis will contribute to the literature in two ways. First, I analyze a set of European banks in a time-frame that also includes the period where the ECB has employed negative interest rates. Considering the non-linearities between interest rates and bank profitability, the results shall be interesting especially during the period of negative interest rates. Second, I further investigate the risk-taking channel as a consequence of ECB policy. The results of this paper shall provide some interesting insights about risk-taking and moral hazard for today's banks which have to abide by the strict Basel III regulatory framework. This research also has some contribution on the societal level. We live in a society where it has been proven time after time that governments would provide a safety net for its Global systematically important banks when all else fails. This safety net comes at the expense of the taxpaying individuals living in that society. If an extended period of low interest rates and flat yield curves could jeopardize the stability of the banking sector, it is imperative for the central bank to consider the other side of the coin before continuing with its aggressive expansive monetary policy. Therefore, the main purpose of this thesis is to test the following:

What is the impact of a prolonged low interest rate environment on bank profitability and risk-taking?

The results show that a low interest rate environment indeed impairs bank profitability irrespective of the profitability measure. I also find interesting non-linearities (concavity) between the interest rate environment and bank profitability. Regarding risk-taking, I find evidence that banks increase their "search for yield" when interest rates are low.

This thesis is structured as follows: Chapter 2 provides a detailed literature review on the determinants of bank profitability and risk-taking. In chapter 3 and 4 I discuss the data and methodology. Chapter 5 contains the results and in chapter 6 I conduct some robustness test to scrutinize the estimation technique. Finally, in chapter 7 I include the conclusion.

2. Literature Review

2.1 Bank profitability

Throughout the years there have been numerous research that examine the determinants of bank profitability. Most of the research are built on the findings of Demirgüç-Kunt & Huizinga (1999) who use bank-level data for 80 countries from 1988 to 1995 to analyze differences in net interest margins and bank profitability. Their study shows that differences in profitability can be attributed to various determinants, namely; bank characteristics, macroeconomic conditions, explicit and implicit bank taxation, deposit insurance regulation, overall financial structure, and underlying legal and institutional indicators. More recently, Athanasoglou et al. (2008) introduced a framework in which they categorize these determinants into bank-specific, industry-specific and macroeconomic factors. Additionally, in contrast to previous research Athanasoglou et al. (2008) take a more dynamic approach and allow for the persistency in profits. In the following, I highlight some of the research conducted on the determinants of bank profitability. As aforementioned, these determinants are separated into bank-specific, industry-specific and macroeconomic factors. Firstly, the group of bank-specific determinants suggested by Athanasoglou et al. (2008) includes size, bank capital, the level of (credit) risk, lending, revenue diversification, the business model or type of bank, efficiency and shares of publicly owned banks.

Size: On one hand it can be argued that the size-factor brings numerous benefits for larger banks compared to smaller ones. The reason is that a large size may result in economies of scale that will reduce the cost of gathering and processing information (Boyd & Runkle, 1993). Also, larger banks are likely to have a higher degree of product and loan diversification compared to smaller ones (Dietrich & Wanzenried, 2011). Moreover, large banks benefit from a funding advantage for being "too-big-to-fail", see Bijlsma et al. (2014)[1]. However, it has been proven that the benefits resulting from the size factor will not persist infinitely. For very large banks the size factor might become problematic due to bureaucratic reasons and rising agency costs, see Athanasoglou et al. (2008).

[1] Bijlsma et al. (2014) argue that large banks derive a funding advantage from being too-big-to-fail. To estimate the funding advantage, they explain the credit default swaps (CDS) spreads of small banks, extrapolate and predict the spreads for large banks. The difference between the predicted and observed spread is deemed as the too-big-to-fail funding advantage. Their results show that the funding advantage amounts to 67 basis points for large banks and 121 for global systemically important financial institutions (GSIFIs).

Bank Capital: Bank capital is measured by the ratio of equity to total assets. Existing evidence on the impact of bank capital on profitability are ambiguous. Demirgüç-Kunt & Huizinga (1999), Athanasoglou et al. (2008) and ECB (2015) find a positive relationship between bank capital and profitability, which confirms the notion that well-capitalized banks are less likely to face bankruptcy thus allowing these firms to benefit from lower funding costs. Conversely, Goddard et al. (2004) find a negative relationship between bank capital and profitability. This finding suggests that highly-capitalized banks might be more conservative and operate with more caution which could cause them to overlook potential lucrative diversification and growth opportunities.

Credit risk: In related theory, there is a clear consensus on the association of higher credit risk to lower profit margin. In the short term, higher credit risks decreases profits as increased credit risk decreases the quality of the loan portfolio resulting in higher provisions for expected loan losses which are directly subtracted from net profits. As such, when losses are incurred this will result in lower profits, see Bikker & Vervliet (2017) and Athanasoglou et al. (2008). Moreover, Bikker & Hu (2002) argue that banks take a pro-cyclical approach as supposed to an anti-cyclical in regard to the business cycle in order to stabilize profits.

Lending: Lending is characterized by the ratio of outstanding loans to total assets. Bikker & Vervliet (2017) argue that an increase in lending automatically increases net interest income, which has a positive effect on overall profit. However, increased credit risk as a result of more lending might have a negative impact on overall profitability through the aforementioned loan losses. Empirical evidence provided by Bikker & Vervliet (2017) and Dietrich & Wanzenried (2011) suggest that, on average, lending has a positive impact on profitability.

Diversification: Decreasing net interest margins during the last decade has prompted banks to "search for yield" in different non-traditional avenues. In this context, Elsas et al. (2010) find that banks typically initiate the diversification process by moving into the fee-based business. Thereafter, they continue this diversification process by engaging in trading activities or underwriting insurance contracts. The results of Trujillo-Ponce (2012) indicate that there is no relationship between revenue diversification and profitability measured in terms of ROA and ROE. Conversely, Bikker & Vervliet (2017) find a positive relationship between ROE/ROA and diversification, while also finding a negative relationship between diversification and net interest margin.

The second category of determinants described by Athanasoglou et al. (2008) is related to the industry. In this regard, I describe the most commonly used industry-specific determinants in the following.

Ownership: Molyneux & Thornton (1992) argue that there is no empirical evidence to support the significance of private ownership as it pertains to the profitability of banks. Nevertheless, Athanasoglou et al. (2008) examine this variable as the share of publicly-owned commercial banks in Greece was very high in that time making such an observation more appealing. In conformity with the former, they also find that there is no clear relationship between ownership and bank profitability. In contrast, Micco et al. (2007) find that publicly-owned banks operating in developing countries tend to perform weaker and incur higher costs compared to privately-owned banks.

Concentration: According to the structure-conduct-performance (SCP), it is proclaimed that increased market power yields monopoly profits, see Athanasoglou et al. (2008). Based on this hypothesis we can assert that banks operating in a highly concentrated market would be able to price their deposits as a markdown on market rates and therefore systematically increase profits. In general, concentration is measured by the Herfindahl-Hirschman index (HHI), which is an indicator for the structure and concentration of the market. Alternatively, Cruz-García et al. (2017) argue that using market concentration as an indicator for competition would be faulty for two reasons. Firstly, in regard to competition, it is not only the amount of competitors in a market but also the degree of competition between them that is relevant. Secondly, indicators for market concentration do not capture the variance between banks within the same country. Athanasoglou et al. (2008) and Cruz-García et al. (2017) find weak empirical evidence to support a positive relationship between concentration and bank profitability. In contrast, ECB (2015) results show that there is a positive relationship between concentration and profitability.

The third category of determinants encompasses the impact of the macroeconomic factors on bank profitability. In light of this, the relevant macroeconomic indicators are discussed in the following.

Real GDP growth: Generally, Real GDP growth is often used as an indicator for the business cycle. According to the balance sheet channel theory, fluctuations in lending are explained not from supply but from demand factors (Bernanke and Gertler, 1995). Also, it is

alleged that the element of procyclicality is present in bank profits. In this context, Albertazzi & Gambacorta (2009) claim, on the one hand, that GDP growth positively influences the net interest income because an improvement in economic conditions would increase demand by households and firms. On the other hand, GDP growth positively affects profits via the loan loss provisions. Better economic conditions improve the financial positions of borrowers which, in turn, would improve the credit portfolio quality thus reducing the loan loss provisions. Albertazzi & Gambacorta (2009) results show that bank profits are pro-cyclical.

Inflation: Typically used as an important economic indicator, inflation denotes the general increase in prices. The effect that inflation has on profitability is ambiguous and almost impossible to assess. The net value of assets decreases with the presence of inflation. Inflation might also impact profitability through other indirect channels as business and family spending is largely impacted by this factor. Also, the effects of inflation cascades through the financial systems into the nominal interest rates, stock prices and into the real money supply, see Bikker & Hu (2002).

2.2 Interest rates and Bank profitability

Historically, most studies that analyze the determinants of bank profitability focus on the bank-specific, industry specific and main macroeconomic determinants. As a result, the interest rate is often overlooked and is deemed as a mere by-product of this subject. Recently, in light of the Great Financial Crisis where central banks intervened in unconventional manner, there have been more studies that incorporate the interest rates as one of its prime factors. The latter studies, such as Borio et al. (2015), provide a more comprehensive analysis on the effect of both short-term and long-term interest rates on bank profitability.

The main objective of monetary policy is to influence the short-term interest rate as well as the slope of the yield curve. The central bank can directly influence the short-term interest rate via the policy rate. In regard to the yield curve, the channels through which the central banks can influence its slope are more indirect. By managing the expectations of market participants (forward guidance) regarding the future path of the policy rate as well as through large-scale asset purchases, the central bank can synthetically steer long and medium-term rates to a desired level. Since the crisis, the Central bank started relying more heavily on forward guidance as an extra stimulus because the policy rates were already threading towards negative territory. Empirical evidence indicate that the increasing use of forward guidance resulted in

the term premium being compressed and even becoming negative in some instances (Borio et al., 2015).

Borio et al. (2015) argue that the level of interest rates as well as the slope of the yield curve have a positive relationship with the net interest margin of banks. Moreover, they state that this relationship might become more pronounced at very low levels of interest rates compared to high levels of interest rates, which suggests that the relationship between the level of interest rates and the net interest margin is concave as opposed to linear. They argue that this statement also holds for the relationship between the slope of the yield curve and the net interest margin.

With respect to the level of interest, bank deposits are generally priced as a markdown on market rates, which reflects the market power that banks have in concentrated markets (Borio et al., 2015). Furthermore, the spread between the deposit rates and lending rates form the net interest margin. In times of expansionary monetary policy, this margin becomes smaller as deposit rates are more inelastic compared to lending rates. The inelasticity of deposit rates stems the fact that savers would simply look for other alternative methods to store their money should deposit rates fall to zero or beyond. In this context, it can be deduced that the margin between lending and deposit rates would be compressed when the central bank engages in expansive monetary policy, whereas during monetary tightening the opposite would hold. Because the deposit rates are stickier than lending rates, there are reasons to believe that the relationship between interest rates and net interest margin might be non-linear (concave). This means that the impact on profitability is stronger for very low levels of nominal interest rates, while becoming lesser as interest rates move up. The results of Borio et al. (2015) support their claim, they find evidence for a positive relationship between interest rates and bank profitability. Additionally, they find significant non-linearities between the interest rate structure and bank profitability. Similarly, Genay & Podjasek (2014) and Bikker & Vervliet (2017) also find a positive effect of short-term interest rates on the net interest margin.

In regard to the slope of the yield curve, it is widely regarded that banks tend to borrow short and lend long. The short-term borrowings are done in the form of demand deposits while the long-term lending include mostly mortgages that have maturities that can last up to 30 years. The difference between the borrowing rate and the lending rate is collected as profits by banks, this is the so-called maturity transformation. As aforementioned, deposit rates are priced at a markdown on market rates, however this pricing method illustrates the oligopolistic power

that banks possess in some funding segment, such as the retail deposit segment. In a perfect world where banks have no oligopolistic power the only lasting component of their profitability is through maturity transformation (Borio et al., 2015). Hence the fact that a flat or downward sloping curve would be detrimental to a bank's soundness. The results from Altavilla et al. (2017) confirm this claim, they find that operationally efficient banks benefit more from monetary policy easing, while banks engaging more extensively in maturity transformation experience a higher increase in profitability after a steepening of the yield curve.

Consequently, it can be inferred that a prolonged period of unusually low interest rates might be problematic for the profitability of the banking sector, seeing that the effect on both interest rates and the slope of the yield curve is much stronger for low levels of interest rates, see Borio et al. (2015), Bikker & Vervliet (2017) & P. Cruz-García et al. (2017).

On the other end of the spectrum, the impact of low interest rates on non-interest income is less clear. All else being equal, lower interest rates should generate capital gains on banks' securities portfolio. Also, because banks hedge only partially, there might be some gains in this regard when interest rates decrease. Furthermore, fees and commissions might also rise when interest rates are low. When interest rates are low banks are far more active in lending activities which means more fees, such as the closing fees for loans. Moreover, in times of low interest rates, firms will start heavily searching for yield. During these times, there are more trading and M&A activity going on in the market. This will automatically increase the income of fees and commissions for banks.

All things considered, when measuring profitability as whole it is imperative to account for all the components of profitability. On the one hand, low interest rates and a flat yield curve impair profitability of banks through the net interest margins. On the other hand, low interest rates will result in higher non-interest income. Additionally, lower debt service charges in a low interest rate environment would boost profits through lower provisioning. In regard to profitability as a whole, empirical evidence is a bit ambiguous. Bolt et al (2012) find an insignificant relationship between non-interest income and the short-term interest rate. The findings of Genay & Podjasek (2014) suggest that low short-term interest rates and a flat yield curve is detrimental to the net interest margin. However, the net effect on overall profitability turns out to be positive because of the improved business cycle factor. Consequently, it seems that macroeconomic factors are more important than interest rates in determining profitability. Similarly, Bikker & Vervliet (2017) also find that low interest rates and a flat yield curve impair

net interest margin. Nonetheless, their results show that the overall level of profitability remained unchanged due to lower provisioning. Contrarily, Borio et al. (2015) find that the negative effects on the net interest margin more than offset the positive effect on non-interest income and provisioning, thus resulting in lower profitability. See Table 1 for a detailed overview of literature on determinants of bank profitability.

Table 1

Bank profitability literature meta-table

Literature overview on different analyses regarding the impact of bank-specific, industry-specific, macroeconomic indicators & interest rates on bank profitability

Study	Title	Market & Timeframe	Method	Variables	Results
Demirgüç-Kunt & Huizinga, 1999	Determinants of Commercial Bank Interest Margins and Profitability: Some International Evidence.	Sample consists of 80 countries in the years 1988-95. income statement and balance sheet data of commercial banks from the BankScope database provided by IBCA.	They examine the determinants of net interest margin for commercial banks. The regressions are estimated using weighted least squares pooling bank-level data.	Dependent= Net interest margin Independent= various bank characteristics and macroeconomic indicators.	Differences in interest margins and bank profitability reflect a variety of determinants: bank characteristics, macroeconomic conditions, explicit and implicit bank taxation, deposit insurance regulation, overall financial structure, and underlying legal and institutional indicators.
Bikker & Hu, 2001	Cyclical patterns in profits, provisioning and lending of banks and procyclicality of the new basel capital requirements.	Sample consists of 26 OECD countries for the last 2 decades before research.	This article analyses the interaction between business cycles and banks combining time series/cross section analysis.	Dependent= Profit before taxes Independent= Country dummies, various macroeconomic indicators Control: real money supply , inflation, capital & reserves.	profits appear to move up and down with the business cycle, allowing for accumulation of capital in boom periods. Provisioning for credit losses rise when the cycle falls, but less so when net income of banks is relatively high, which reduces procyclicality.
Athanasoglou, Brissimis & Delis 2008	Bank-specific, industry-specific and macroeconomic determinants of bank profitability.	panel of Greek banks that covers the period 1985–2001.	They examine the effect of bank-specific, industry-specific and macroeconomic determinants of bank profitability. They apply a GMM technique for endogeneity problems.	Dependent= ROA Independent= Various bank-specific, industry-specific and macroeconomic determinants Control= inflation, cyclical output	All bank-specific determinants, with the exception of size, affect bank profitability significantly. The business cycle has a positive, albeit asymmetric effect on bank profitability. No evidence is found in support of the SCP hypothesis.
Albertazzi & Gambacorta, 2009	Bank profitability and the business cycle	Sample consists of data from 10 industrialized countries (Austria, Belgium, France, Germany, Italy, the Netherlands, Portugal, Spain, United Kingdom and United States) over the period 1981–2003.	The model has been estimated using the GMM estimator	Dependent= NII, Non-interest income, operating costs, provisions, profit before taxes. Independent: various macroeconomic factors affecting business cycle Control= Structural factors	They find that bank profits pro-cyclicality derives from the effect that the economic cycle exerts on net interest income and loan loss provisions. Noninterest income is not significantly influenced by GDP changes suggesting that, contrary to previous findings, revenue diversification could contribute to the stabilization of bank profitability. Financial deepness stimulates bank profitability.
Cruz-García, de Guevara & Maudos, 2017	Interest Rates and Net Interest Margins: The Impact of Monetary Policy.	The sample used includes financial institutions (banks, savings banks, credit unions and other types of banks) from 32 OECD3 countries. The period examined is from 2003 to 2014.	The analysis of the net interest margin determinants is based on an estimation of a dynamic panel data model using the Generalized Method of Moments.	Dependent= NII Independent= short-term rate, short-term rate ^2 Control= i.e. Lerner index, credit risk, risk aversion, risk covariance etc.	The results obtained indicate that the impact of interest rates on the intermediation margin is quadratic rather than linear.
Borio, Gambacorta & Hofmann, 2015	The influence of monetary policy on bank profitability.	Data for 109 large international banks headquartered in 14 major advanced economies for the period 1995–2012.	This paper investigates how monetary policy affects bank profitability. They apply the System GMM estimator to conduct their study.	Dependent= NIM, Non interest income, provisions, ROA Independent= Short-term rate, short-term rate^2 Control= Macroeconomic indicators and bank-specific factors	They find a positive relationship between the level of short-term rates and the slope of the yield curve (the “interest rate structure”, for short), on the one hand, and bank profitability – return on assets – on the other.

2.3 Bank risk-taking

Another important side-effect of extreme expansionary monetary policy relates to the risk-taking channel. A prolonged period of unusually low interest rates could cause a reduction in the risk aversion of banks and other investors. Empirical evidence suggests that low interest rates reduces the net interest margin of banks, and to compensate for lost earnings banks have an incentive to increase their risk or "search for yield" especially when nominal return targets are in place. From this perspective, we can infer that the risk-taking channel relates to how changes in monetary policy can affect risk perceptions or risk-tolerance (Altunbas et al., 2010). In general, there are two channels through which banks increase their risk. First, banks may alter their business model and engage more in non-interest activities such as trading and fee-based businesses. The second channel relates to the credit risk that is assumed when extending loans (Bikker & Vervliet, 2017).

Weistroffer (2013) examined the behavior of Japanese banks during the late 1990s, when they were operating in an ultra-low interest rate environment. Their results show that Japanese banks reacted by increasing their systemic risk. First, banks started to carry large exposures of Japanese government bonds, which made them more vulnerable to interest rate fluctuations. More recently, banks started to alter their business model by branching out in venture capital and SME growth activities, which increased their risk considerably. In the Dutch market you can see that banks, such as ABN AMRO, have their own private equity department.

Regarding interest rate risk, Ioannidou et al. (2009) investigate the effect that changes in interest rates have on loan pricing in the Bolivian banking sector. Their results show that when interest rates are low, banks tend to increase their exposure to risky loans. On top of that, their evidence shows that the rates being charged for the new-and-riskier loans are relatively lower than what they normally charge to less risky borrowers. Remarkably, this is done more often by banks with lower capital ratios and worse loan portfolio quality.

Similarly, Jiménez et al (2009) investigate whether monetary policy affects bank risk-taking when it comes to individual bank loans in the Spanish market. Their findings suggest that low interest rates impact the overall risk on the loan portfolio in a paradoxical way. In the short term, lower interest rates reduce the debt service charge for the outstanding variable-rate loans, thereby reducing default probabilities while increasing loan portfolio quality. In the medium term, because banks have an increased risk appetite, they tend to "search for yield" by

softening their lending standards and grant loans to riskier borrowers, and in doing so, reducing the quality of their loan portfolio.

Bikker & Vervliet (2017) examine the effects of the low interest rate environment on bank risk-taking in the US market. They find no clear evidence that banks increased their risk exposure in an attempt to "search for yield". It appears that US banks maintained their level of profitability, and therefore mitigating the need to increase risk to compensate for a lower net interest margin. In contrast, they find that US banks significantly lowered their level of provisioning in the low interest rate environment. The latter finding suggests that these banks have maintained their level of profitability at the expense of having reserves for potential loan losses. See Table 2 for an overview of existing literature on the risk-taking channel.

Table 2

Risk-taking channel literature meta-table

Literature overview different analyses regarding the risk-taking channel

Study	Title	Market & Timeframe	Method	Variables	Results
Altunbas, Gambacorta & Marqués-Ibáñez, 2010	Does monetary policy affect bank risk-taking?	more than 1,100 listed banks operating in the European Union and the United States during 1998-2008	Panel data approach, with quarterly data. All bank-specific characteristics are lagged one period to solve for endogeinety bias	Dependent=v quarterly change of the expected default frequency (EDF) Independent= change in monetary market rate & Taylor rule Control= risk-appetite, difference in regulation	subdued short-term low interest rates over an extended period of time contributed to an increase in banks' risk.
Weistroffer, 2013	Ultra-low interest rates How Japanese banks have coped	Japanese banks from 1990 - 2012	Used various statistics to review how Japanese banks have responded to the adverse macroeconomic environment during the past ten to twenty years	Dependent= n.a. Independent= n.a. Control= n.a.	The response of Japanese banks to the ultra-low interest rate environment has helped improve capacities of the banking sector overall, but it has also increased systemic risk.
Rajan, 2005	Has financial development made the world riskier?	n.a.	The paper discusses the implications for monetary policy and prudential supervision.	Dependent= n.a. Independent= n.a. Control= n.a.	In particular, it suggests market-friendly policies that would reduce the incentive of intermediary managers to take excessive risk
Bikker & Vervliet, 2017	Bank profitability and risk-taking under low interest rates	all US commercial and savings bank insured by the Federal Deposit Insurance Corporation (FDIC) from 2001 to 2015	System GMM estimator to account for potential endogeneity	Dependent= PCL & TCR ratio Independent= short-term interest rates Control= various bank-specific, industry specific and macroeconic indicators	Banks did not compensate for their lower interest income by expanding operations to include trading activities with a higher risk exposure.

2.4 Hypotheses Development

The objective of this thesis is to investigate the effect of prolonged periods of low interest rates on both bank profitability and bank risk-taking in the Euro area. To examine this issue, I have formulated the following research question:

What is the impact of a prolonged low interest rate environment on bank profitability and risk-taking?

Various studies that examine the relationship between the interest rates and net interest margins find that as interest rates rise/fall there is an increase/decrease in the net interest margin. To check whether interest rates are significantly related to the net interest margin, I propose the first hypothesis:

Hypothesis 1: *Interest rates are positively related to bank profitability.*

Next to the level of interest rates, the yield curve slope is also important for bank profitability. As above-mentioned, in a perfect world where banks do not have any oligopolistic power, the only way banks would be able to make money with lending activity is through maturity transformation. Therefore, a flat yield curve slope would be detrimental to banks' profitability. To test this concept, I propose the second hypothesis:

Hypothesis 2: *the yield curve slope is positively related to bank profitability.*

Empirical evidence suggests that the impact that interest rates as well as the yield curve slope have on bank profitability are more pronounced for very low levels of interest rates and term premium. This suggests that the relationship between these variables may be non-linear. To examine whether this is true, I propose the third hypothesis:

Hypothesis 3: *The relationship between both the interest rates on one hand, and the yield curve slope on the other, with bank profitability is non-linear (concave).*

For the second part of my research I examine the risk-taking channel. It is alleged that banks increase their risk in order to compensate for losses on net interest margin in a low interest rate environment. Therefore, I propose my fourth hypothesis:

Hypothesis 4: *Bank risk-taking is negatively related to the level of interest rates.*

3. Data and Variable selection

In my research I adopt the method of Bikker & Vervliet (2017) to analyze the impact of a low interest rate environment on bank profitability and risk-taking among European banks. To analyze these issues, the profitability and risk-taking measures are regressed against various bank-specific and macroeconomic independent and control variables. This research differs from Bikker & Vervliet (2017) on various key points. Firstly, this research focuses on the European banking sector whereas Bikker & Vervliet (2017) focus on the US banking sector. Secondly, in this analysis I include several extra bank-specific as well as macroeconomic control variables in the model specification. Thirdly, I make drastic changes to risk-taking specifications by utilizing different dependent variables to capture the "search for yield" and the assumed credit risk.

3.1 Dependent Variables

The first model analyzes bank profitability (Model I) and the second model (Model II) analyzes bank risk-taking. The dependent variables of Model I are discussed in the following.

Net interest margin (NIM) is defined as the interest income minus the interest expenses divided by the total assets of its respective bank. As European banks generate most of their income by maturity transformation, it can be assumed that the net interest margin of banks are closely related to the overall profitability.

Return on Assets (ROA) is defined as net income divided by the average assets. This variable is commonly used in the literature for comparing the efficiency and operational performance of banks. Bank profitability is a direct product of the interest income as well as non-interest income, and an indirect product of its costs, particularly the provisions for loan losses. As previously discussed, low interest rates have an effect on all the above-mentioned items, in order to evaluate the net effects of low interest rates it is imperative to include ROA as a measure of overall profitability.

Return on Equity (ROE) represents the return on the invested capital by shareholders and is also an important performance measure that takes the perspective of shareholders. This variable is defined as the ratio of net income over total equity.

In the context of what has been discussed in section 2.2.3, two different risk measures are employed in order to assess the risk-taking that stems from the two risk-taking channels. For this analysis, the dependent variables of Model II are highlighted in the following.

Tier 1 ratio is defined as common equity (tier 1) and additional tier 1 divided by total risk-weighted assets. Tier 1 pertains to the first risk-taking channel in which it is alleged that banks alter their business model by increasing their non-interest activities in order to compensate for a narrower net interest margin. In this respect, a higher exposure to risky investments would translate into a lower tier 1 ratio and vice versa. Moreover, tier 1 is also seen as the best type of capital to absorb losses, hence banks with lower tier 1 ratios are often perceived as being riskier.

Non-performing loans (NPL) are loans on which no scheduled payments have been made for at least 90 days and are therefore considered to be in default. Since a portion of non-performing loans will result in losses for the bank, a high value for this ratio is associated with higher credit risk (Delis & Kouretas, 2011). Therefore, this variable is used as a credit risk proxy for model II.

3.2 Independent Variables

The aim of this thesis is to provide some insights on the impact of interest rates on bank profitability and risk-taking, naturally, the independent variables will be related to the interest rate environment. In the following I will discuss the reasoning for each independent variable separately as well as the hypothesized sign as it pertains to both model I and model II.

Short-term interest rate is represented by the 3-month interbank rate also known as Euribor for banks in the Euro area. It can be presumed that the interest rate is positively related to the net interest margin. In this light, low interest rates will reduce the net interest margin. However, with respect to overall profitability, there is no clear impact as low interest rates will increase non-interest income and reduce provisions for loan losses. All things considered, as European banks derive most of their income from lending activities it can be expected that low interest rates will also decrease profitability for all measures. Hence, the hypothesized sign for the short-term interest rate is positive. In regard to model II, it is expected that low interest rates would increase risk and vice-versa. From this we can infer that there is a negative relationship between the short-term rate and both channels of risk-taking.

Yield-curve slope is approximated by the difference between the 10-year government bond yield and the short-term interest rate. In regard to bank profitability, a positive relationship is expected as in a "perfect world", the only lasting component of net interest margin would come from the maturity transformation. Hence, a wider (positive) term premium

would signify more income from maturity transformation. With respect to bank risk-taking, the expected sign is negative as higher returns from maturity transformation should mitigate the incentive, all else being equal, to increase risk for the purpose of compensating for loss in net interest margin.

In line with Borio et al. (2015), both of these variables also enter the equation in quadratic form to depict their non-linear (concave) relationship with respect to profitability. A concave relationship between the interest rate and profitability would imply that the impact on profitability is much stronger for very low levels of interest rates. Generally, empirical evidence shows that there is de facto a concave relationship between these variables. As such, it is expected that the quadratic form of the short-term interest rate and yield curve slope should have a negative coefficient.

3.3 Control Variables

Considering the existing literature in this field, I include several bank-specific and macro-economic factors as control variables in the models. The control variables do not differ significantly from each other, however there are some changes between control and dependent variables between the model I and model II.

Size is characterized by the logarithm of total assets. Its impact on profitability is unclear as the results of previous literature seem to be somewhat ambiguous. Therefore, the hypothesized sign of the coefficient is both positive and negative. Concerning bank risk-taking, Bikker & Vervliet (2017) argue that larger banks have a better risk management and diversification and therefore experience less risk. In light of this, the hypothesized relationship between size and risk-taking is negative.

Lending is characterized by the ratio of outstanding loans to total assets. Lending positively affects profitability through the net interest income, therefore, in line with related studies the expected sign of the coefficient is positive. From a risk-taking perspective, it can be argued that more lending affects the riskiness via the quality of the loan portfolio. However, if the lending standards are maintained, there will be no effect in terms of the quality of the loan portfolio. Hence, I have no a priori sign for its effect on risk-taking.

Capitalization is represented by the ratio of total equity over total assets and is a measure of a bank's soundness. Considering section 2.2.1., the a priori sign of the coefficient

is positive in view of profitability. The notion in doing so, stems from the fact that sound banks benefit from lower funding costs. As for risk-taking, the expected sign is also positive.

Diversification, expressed as the ratio of non-interest income over total income, illustrates the degree that banks rely on traditional lending practices. Empirical evidence shows some ambiguity in regard to this variable, however, it can be expected that diversification has a negative sign in reference to the net interest margin. As for the other profitability measures there is no a priori sign for diversification. Regarding risk-taking, diversification can mean that banks shift from "safe" lending practices to relatively riskier non-traditional activities such as trading. In light of this, the expected sign for diversification in connection with risk-taking is positive.

Efficiency is represented by the cost to income ratio. This gives a clear view of how a bank is being run by its managers. Empirical evidence suggests that efficiency has a positive impact on profitability. Conversely, non-efficient banks are more likely to engage in more risk taking to boost profits, therefore the a priori sign for the risk-taking channel is negative.

The risk-taking measures NPL and Tier 1 ratio are treated as dependent variables in model II, but are considered to be explanatory variables in Model I.

Provision for credit losses (PCL) represents the quality of the loan portfolio and, therefore, its credit risk. In the short-term, higher credit risk decreases profits as the provisions for expected loan losses are directly subtracted from net profits. The expected relationship between PCL and profitability is therefore negative. This variable is excluded from model II.

Tier 1 ratio expresses a bank's risk exposure, as such, a higher risk exposure should generate higher returns. In light of this, the hypothesized sign of this coefficient is positive.

Non-performing loans (NPL) is also a depiction of the loan portfolio quality. The general level of NPLs have risen drastically over the last decade for European banks. Feng & Wang (2018) find that European banks are less profitable than their US counterparties partly due to the fact that European banks incur more costs in dealing with the high levels of NPLs compared to US banks. Taking this into consideration it is expected that NPLs have a negative effect on bank profitability.

Real GDP growth is an indicator for the business cycle. As mentioned above, lending is mostly driven by demand factors as opposed to supply factors. With that being said, an increase in real GDP would increase demand of households and firms and, in its turn, positively affect profitability. With respect to risk-taking, the results are expected to generate a positive coefficient.

Inflation is another important indicator for the business cycle. The effects hereof are almost impossible to assess, as seen from section 2.2.1., therefore, there is no a priori sign for this variable.

Housing price index measures the general price growth in residential housing for a country. In line with Borio et al. (2015), it is expected that the growth in housing prices positively impacts profitability. In terms of the risk-taking channel there is no a priori sign for the relationship.

3.4 Data

The data sample used in this analysis consists of all commercial, savings and cooperative banks operating in the 19 euro area countries from 2011 to 2017. Pure investment banks and other non-banking financial institutions are not considered as these do not have deposits, making it impossible to analyze the effects of low interest rates on the net interest margin. All data are denoted in yearly frequency, for data that are not available in yearly frequency I compute the yearly averages to include in my sample. Furthermore, I choose to exclude all subsidiaries from my sample and make use of consolidated data. In total, the final sample consists of 2,727 individual banks. The selected data sample has various advantages. Firstly, the chosen timeframe allows us to examine European banking crisis from its beginning up until recent time, which thoroughly captures the low interest environment. Secondly, this data has a broad coverage as it includes banks from all countries that are subject to ECB monetary policy.

To collect all bank-specific data, I use Orbis bank focus which is a commercial database issued by Bureau van Dijk that specializes in income statement and balance sheet data for the banking sector. As all the countries being considered for this analysis are constituents of the euro area, I use the 3-month Euribor rate as a representation for the short-term interest rate which is obtained from Eurostat. Regarding long-term interest rates, Altavilla et al. (2017) find that there is no significant difference between a general euro area yield curve and country specific sovereign yield curve when examining its effect on bank profitability. Taking this into consideration, I construct a euro area yield curve slope by subtracting the 3-month Euribor from a basket of 10-year euro area government bond yields obtained from Eurostat. All data pertaining to the macroeconomic indicators real GDP growth and Inflation are retrieved from Eurostat and World bank, respectively.

To account for outliers, I winsorize all variables and replace the extreme values with the values at the 1^{st} and 99^{th} percentile. As an extra measure, I examine the sample to check whether there are irrational values present despite the winsorization process. For example, the ratio of non-interest income divided by total assets and tier-1 ratio could never be above 100% or below 0%. Fortunately, the winsorization process has removed all nonsensical values. See Table A.1 and Table A.2 for a complete description of all the variables including their hypothesized sign and data source.

Table 3

Descriptive Statistics for all variables

This table presents the summary statistics of all variables. Statistics include the number of observations, the mean, the standard deviation, the minimum and the maximum. All variables are denoted as percentages except for size which is the logarithm of total assets.

Variable	N	Mean	Std. Dev.	Min	Max
ROA	13,267	0.36	0.60	-2.33	3.19
ROE	13,225	3.58	5.70	-25.18	26.53
NIM	13,190	2.04	0.71	0.03	5.03
Short-term interest rate	19,782	0.25	0.55	-0.33	1.39
Yield curve slope	19,782	1.17	0.52	0.44	1.76
Size	13,275	13.17	1.67	9.69	18.33
Capitalization	13,215	10.71	6.96	2.50	60.21
Diversification	13,235	36.48	17.23	0.79	100.00
Credit risk proxy (NPL)	9,122	6.17	7.01	0.03	35.48
Efficiency	13,598	76.33	17.80	30.63	145.89
Lending	13,197	57.49	16.99	3.53	89.49
Tier 1 Ratio	8,931	16.64	7.47	7.70	56.00
PCL	12,838	0.35	1.05	-2.92	5.33
Real GDP growth	19,782	1.42	1.78	-9.10	25.60
HPI	19,040	3.10	3.46	-7.60	9.20
Inflation	19,782	1.36	0.94	-2.10	4.98

Table 3 provides the descriptive statistics for all variables. The statistics show that there are considerable differences across banks and country for several variables. The variance of ROA and ROE are particularly high for the sample period considering that their standard deviations are much larger than their means. ROA has a mean of 0.36% and varies between -2.33% and 3.19% whereas ROE has a mean of 3.58% and it varies between -25.18% and 26.53%. Similar to the aforementioned profitability measures, NIM has a mean of 2.04%, however the variance is much lower which can be extracted from the relatively low standard deviation as well as the lower relative spread between its minimum and its maximum value. Based on these findings it can be noted that the profitability of European banks were extremely low for the sample period, which is expected and can be attributed to the low interest rates environment.

The Size variable has a mean of 13.17 and varies between 9.96 and 18.33. The relatively low standard deviation for variable indicate a low variance between banks. Next, the diversification variable has a mean of 36.48% and a standard deviation of 17.23%. From its min-max spread it can be seen that there are banks with relatively no non-interest income on one hand, as well as banks that generate most of their income via non-interest activities. NPL has a mean of 6.17% with a lot of variance as can be concluded from its standard deviation. Efficiency has a mean of 76.33% with a standard deviation of 17.80%. The maximum observation of 145.89% illustrates that there are banks that are making heavy losses in the European banking sector. Lending has a mean of 57.49% with a standard deviation of 16.99%. Again, from the minimum and maximum values it can be extracted that there are banks that rely almost completely on lending practices as well as banks that operate virtually independent of lending. The latter two variables provide some support for the belief that European banks generate most of their income through maturity transformation. As the mean of lending is above the 50% mark while the mean of diversification remains below the 50% mark, it can be asserted that lending is still, on average, the most important source of income for European banks.

The Tier 1 ratio has a mean of 16.64% and has a standard deviation of 7.74%. From the minimum and maximum values, it can be noted that some banks are much riskier than others. The credit risk proxy has a mean of 0.35% and has a standard deviation of 1.05. This relatively large standard deviation shows that European banks differ a great deal when it comes to assuming credit risk.

The macroeconomic variables highlight the differences across European countries. As expected, there are significant differences between countries in terms of the real GDP growth rate with Ireland having the highest mean at 7.34%. In contrast, Greece has the lowest real GDP growth with a mean of -2.57%. Similarly, changes in housing prices also vary a lot across countries, with Greece having the lowest mean of -5.0%. In general, the inflation rates are fairly constant across the European countries varying between the 1% and 2%, except for Greece and Cyprus both of which have low mean inflation rates.

Moreover, Table 5 shows that there are a lot of missing data pertaining to the bank-specific variables. Most of the missing data stem from the years 2011 and 2012, for some unexplained reason those years yielded a large scarcity of data. Despite the missing data issue, Stata indicates that the final panel dataset is strongly balanced.

Finally, I include a correlation matrix in Table A.3 to examine whether there are multicollinearity issues present in the data sample. ROA and ROE have the highest correlation with a value of 0.87, considering that these variables will not be used in the same equation it is safe to conclude that there are no multicollinearity issues present in the data sample.

4. Methodology

The research will be conducted by means of two different model specifications, namely, Model I and Model II.

4.1 Model Specification

Model I explains bank profitability from interest rates and other determinants of profitability:

$$\Pi_{it} = c + \delta X_{it}^{IR} + \alpha \Pi_{i,t-1} + \beta X_{it}^{BS} + \gamma X_{it}^{Macro} + \lambda_i + \varepsilon_{it} \quad (1)$$

The dependent variable Π_{it} of model I represents the profitability of bank i in year t. Analogous to previous studies I include several profitability measures to fully capture the effect of interest rates from different perspectives. Prior research finds that bank profits tend to persist over time. Therefore, in accordance with Athanasoglou et al. (2008), I also take a more dynamic approach and allow profits to persist over time. The degree of persistence is captured by the lagged dependent variable coefficient α, for values between 0 and 1. A value close to 1 implies that there is a high degree of persistence whereas a value close to zero means that the degree of persistence is very weak. The interest rate environment is expressed by the vector variable X_{it}^{IR} and includes the short-term interest rate, long-term interest rate (minus the short-term interest rate) as well as the quadratic function of both rates to capture the concave relationship between interest rates and profitability. The vector variable X_{it}^{BS} represents the bank-specific determinants, i.e. size, capitalization, diversification, non-performing loans (NPL), efficiency, lending, Tier 1 ratio and credit risk proxy (PCL). Subsequently, the vector variable X_{it}^{Macro} captures the macro economic environment which includes inflation, real GDP growth and the housing price index (HPI). Furthermore, I incorporate the variable λ_i to account for the potential bank-fixed effects in my dataset. Lastly, the variable ε_{it} represents the error term.

Model I is employed to test the aforementioned hypotheses 1, 2 and 3. The main variables of interest to examine these hypotheses are the short-term interest rate, long-term interest rate, short-term interest rate² and long-term interest rate².

- **Hypothesis 1**: Interest rates are positively related to bank profitability.

  H0: Coefficient short-term interest rate > 0

- **Hypothesis 2:** the yield curve slope is positively related to bank profitability.

  H0: Coefficient long-term interest rate > 0

- **Hypothesis 3**: The relationship between both the interest rates one on hand, and the yield curve slope on the other, with bank profitability is non-linear (concave).

  $H0_1$: Coefficient short-term interest rate^2 < 0

  $H0_2$: Coefficient long-term interest rate^2 < 0

Model II specifies bank risk-taking as a function of the interest environment and various other factors.

$$r_{it} = c + \alpha r_{i,t-1} + \delta X_{it}^{IR} + \alpha\beta X_{it}^{BS} + \gamma X_{it}^{Macro} + \lambda_i + \varepsilon_{it} \quad (2)$$

In this model r_{it} is defined as the degree of risk-taking risk taking for bank i in year t. As previously mentioned, the degree of risk-taking is proxied by two different risk-taking measures, namely, Tier 1 ratio and the credit risk proxy (PCL). Prior research in regards to the risk-taking channel suggest that risk-taking tend to persist over time. Specifically, Delis & Kouretas (2011) find that bank risk-taking is highly persistent and provide various arguments to support this issue[2]. Consequently, I include the lagged dependent variable to account for the persistence in risk-taking. Again, the coefficient α captures the degree of persistence for values between 0 and 1. The remaining independent and control variables are all similar to Model I except for the quadratic terms for short- and long-term rate as well as PCL which are excluded from model II.

Model II is included to test hypothesis 4. The main variable of interest to examine hypothesis 4 is the short-term interest rate.

- **Hypothesis 4:** Bank risk-taking is negatively related to the level of interest rates

  $H0_1$: Coefficient short-term interest rate < 0

  $H0_2$: Coefficient long-term interest rate < 0

[2] Delis & Kouretas (2011) provide 4 arguments to explain persistence in bank risk-taking. Firstly, persistence might be explained by the existence of intense competition which can accommodate risk-taking. Secondly, most banks engage in relationship-banking and repeatedly dealing with the same risky customers will have a lasting effect on the level of risk-taking. Thirdly, as bank-risk taking is related to the business cycle, banks may need more time to smooth its profits as it pertains to the cycle movements, which will result in persistent risk-taking. Finally, regulation can explain risk persistence as the moral hazard that arises as a result thereof may induce banks to increase their risk for a prolonged period. In regard to the longevity of the persistence, they find no persistence beyond one year which suggest that risk will persist at first, but will return back to its equilibrium level in the long-term.

The specifications of both model I and model II shows that these are fixed effects models. The rationale for using a fixed-effects estimator instead of a pooled OLS estimator, is because a pooled OLS estimator disregards the potential unobservable heterogeneity. A fixed-effects model examines whether there are unobserved but fixed variables across banks or time. Seeing that we are dealing with a panel data with banks all across Europe, there is a great probability that there are time-invariant effects that vary across the banks in the sample. For instance, profitability levels across countries can differ simply because of cultural differences and work ethic. Subsequently, I perform the Hausman specification test to examine whether there are bank-specific effects present. By the rejection of the null hypothesis we can conclude that the fixed-effects model is therefore the preferred model. In addition, I perform the Breusch-Pagan LM test for cross-sectional correlation in fixed effects model to test whether the errors are heteroskedastic. I fail to reject the null hypothesis of homoskedasticity.

4.2 Dynamic Modelling

From model I and model II it can be inferred that bank-risk taking and bank profitability persist over time. The dynamic nature of these variables is well documented and supported by the results of existing literature, such as, Athanasoglou et al. (2008), Bikker & Vervliet (2017) and Borio et al. (2015). There are two potential problems that should be accounted for before the estimation process, namely, endogeneity and the dynamic panel bias.

Firstly, endogeneity problems occur when there is a correlation between the explanatory variable and the error term. There are three potential sources for endogeneity namely, unobservable heterogeneity, simultaneity and a dynamic underlying economic process (Wintoki et al., 2012). Firstly, Simultaneity occurs when there is a loop in causality between the dependent and the independent variables and both are simultaneously determined. For instance, managers increase their risk-taking to improve profits, in this light, risk-taking determines profit. However, the reverse might also be true, if low profits induce managers to increase risk-taking. In this case both variables are simultaneously determined. Secondly, if the underlying process itself is dynamic, then past realizations of the dependent variables have an impact on the current independent variables and vice-versa. This would mean that current bank-specific variables are affected by past levels of profitability as well as past values of the same independent variables (Wintoki et al., 2012). For instance, highly profitable banks can increase

their equity simply by retaining profits, this would mean that current values of equity are partly products of past levels of profitability. Similarly, profitable banks can easily invest more to increase their size, and a larger size in the future might also affect future profitability, see García-Herrero et al. (2009). The above-mentioned examples show that there are numerous ways that a dynamic underlying process can manifest itself between the bank-specific variables and profitability.

Secondly, the dynamic panel bias arises from the fact that traditional estimation techniques such as the OLS and fixed-effects models are not suitable for estimation in a dynamic setting. This inadequacy stems from the fact that these estimation models would generate a correlation between the lagged dependent variable and the error term which would bias results (Bikker & Vervliet, 2017).

To account for these problems, I consider using the S-GMM estimator that is proposed by Arellano & Bover (1995) and Blundell & Bond (1998). The S-GMM estimator uses lagged values of the dependent variable both in levels and in differences as well as lagged values of the potentially endogenous regressors as internal instruments for current realizations of the endogenous regressors (Bikker & Vervliet, 2017). In doing so, all the 3 issues of endogeneity as well as the dynamic panel bias are controlled for. The validity of the S-GMM relies on a set of 3 strict criteria. First, there should be no second-order serial correlation. Second, as the S-GMM uses multiple lags as instruments, the system should be overidentified or in other words, the instruments need to be valid. Third, the subset of instruments that are used in the levels equation need to be strictly exogenous (Wintoki et al., 2012).

To carry out the S-GMM estimation process, I use the xtabond2 function in Stata. Before interpreting results, it is imperative to check whether the results of the tests meet all 3 aforementioned criteria. The null hypothesis of no autocorrelation in the AR(2) test cannot be rejected for any of the models. Therefore, it can be concluded that the errors are serially uncorrelated. Furthermore, the null hypothesis of exogeneity in the Difference-in-Hansen tests of exogeneity of instrument subsets cannot be rejected for any of the models. In contrast, the null hypothesis of overidentifying restrictions are valid in the Sargan-Hansen test is rejected for all models. From this it can be concluded that the instruments are in fact endogenous. Unfortunately, as the criterium of valid instruments is not met, there is some doubt whether the S-GMM estimation technique will provide unbiased results.

As the lagged values of the endogenous variables fail to produce valid instruments for all the models considered, I opt for the fixed-effects estimation technique in a dynamic setting to analyze the relationship between interest rates and bank profitability as well as risk-taking.

Finally, to test the robustness of the results, I present the results of the Pooled OLS estimation technique, as the difference between the fixed effects estimator and the Pooled OLS provide a credible range for the lagged dependent variable coefficient (Bikker & Vervliet, 2017). Thereafter I will assess the robustness of the S-GMM results by examining if its coefficient falls within this credible range.

5. Empirical Results

In the previous section it became clear that using lagged values of the bank-specific regressors as instrumental variables could produce inconsistent estimates. Therefore, I use the fixed-effects estimator in this section to exemplify the relationship between interest rates and bank profitability as well as risk-taking.

5.1 Results for bank profitability

Model I explores the relationship between bank profitability and interest rates. See Table 4 for the empirical results of the different profitability measures that are employed.

Net interest margin (NIM)

The first column presents the results for the NIM. As can be seen, the lagged dependent variable is highly significant with a coefficient of around 0.23, which means that a 1% increase in the previous NIM is associated with a 0.23% increase in the NIM of the following period. This result is in line with, amongst others, Athanasoglou et al. (2008) who also find a moderate degree of profit persistence. Moving on to the interest rate environment, the results show that the coefficient for short-term interest rate is highly significant and positive. A 1% increase in the level of short-term interest is associated with approximately 0.36% increase in NIM. In other words, as interest rates decrease, it can be expected that the level of NIM will also decrease as a result. Borio et al. (2015), Genay & Podjasek (2014) and Bikker & Vervliet (2017) find similar results. Moreover, the results show that the quadratic term of the short-term interest rate is negative and also highly significant. This implies that there is a concave relationship between the level of short-term interest rate and bank profitability. Hence, the impact of interest rates on bank profitability becomes more profound for very low levels of interest rates. With respect to the slope of the yield curve, the coefficient is found to be positive and significant. A 1% increase in the slope is related to a 0.24% increase in NIM. Considering this, a flattening of the yield curve would be detrimental to the net interest margins of banks. Next, in line with Altavilla et al. (2017), the quadratic term of the yield curve slope is found to be negative and significant. This finding implies that the impact of the yield curve slope becomes more profound as the yield curve becomes flatter. Therefore, a flat or downward sloping yield curve would be very detrimental to the soundness of banks that rely heavily on maturity transformation.

With respect to the bank-specific variables, the size variable is negative and highly significant. This result is in line with Athanasoglou et al. (2008) who argue that the size factor

could become problematic due to bureaucratic reasons and rising agency costs. Next, in line with Demirgüç-Kunt & Huizinga (1999), Athanasoglou et al. (2008) and ECB (2015), capitalization is found to be positive and significant. In the case of NIM, the coefficient for diversification is negative and significant. The logic behind this is, if a bank diversifies its operations it would rely less heavily on lending practices which would in turn result in a lower net interest margin. Similarly, as lending is found to be positive, it can be inferred that less lending would result in a lower net interest margin. Both NPL and PCL are positive and significant, which implies that increases in credit risk can boost margins in the short-term, however, as discussed in previous section, this can lead to losses in the longer term. Finally, the coefficients for all macroeconomic indicators are found to be positive as well as significant. An improvement in the macroeconomic environment would induce companies to make investments, and as a result, an increase in demand for loans would improve margins.

Return on Assets (ROA)

The results for the ROA profitability measure are presented in column 2 of Table 4. By the coefficient of the lagged dependent variable it can be deduced that profits tend to persist over time when measured in terms of ROA also. In regard to the short-term interest rate, the coefficient is positive as well as highly significant. A 1% increase in short-term interest rate is associated with a 0.093% increase in ROA. A possible explanation for the coefficient being much lesser when compared to the lagged NIM, is that ROA measures overall profitability whereas NIM only measures profitability that is derived from lending practices. Therefore, the interest rates are far more impactful when it comes to NIM because the ROA includes other non-interest income sources which would generate more income as interest become lower. The results also show that there is a negative association between the quadratic term of the short-term interest rate and ROA. Again, the negative coefficient suggests that the relationship between these variables is concave, meaning that the impact becomes greater as interest rates move towards the zero lower bound. As for the yield curve slope, the coefficient seems to be positive and significant. Once more, this implies that flat or downward sloping yield curve could be very detrimental to a bank's overall profitability. Conversely, the quadratic term of the yield curve slope is found to be insignificant.

Table 4

Regression results for bank profitability

This table presents the empirical results for the impact of interest rates on profitability. Each column represents a different model using one of the profitability measures NIM, ROA or ROE. All regressions are estimated using fixed effects estimation. All models include year time dummies (not reported). All variables are expressed in percentage terms except for size. Statistical significance is measured by t-test and they are reported under the coefficients. ***, **, * represent significance at 1, 5, and 10 percent significance levels respectively.

	NIM	ROA	ROE
NIM_{t-1}	0.2294***		
	(0.0117)		
ROA_{t-1}		0.4805***	
		(0.0115)	
ROE_{t-1}			0.5552***
			(0.0117)
Short-term interest rate	0.3622***	0.0926***	0.0463***
	(0.0622)	(0.0902)	(0.0998)
Short-term interest rate²	-0.4511***	-0.6098***	0.6937***
	(0.121)	(0.1753)	(0.0169)
Yield curve slope	0.235**	-0.612*	0.4758*
	(0.1421)	(0.2067)	(0.0193)
Yield curve slope²	-0.0798*	0.2221	0.2073
	(0.0467)	(0.068)	(0.0075)
Size	-0.4337***	0.2224***	0.0228***
	(0.0279)	(0.0405)	(0.0798)
Capitalization	0.0200***	0.0168**	0.1874***
	(0.0024)	(0.0036)	(0.0396)
Diversification	-0.0157***	0.0088***	0.087***
	(0.0004)	(0.0006)	(0.0007)
Lending	0.0118***	0.0019*	-0.0143*
	(0.0008)	(0.0011)	(0.013)
Efficiency	0.0034	0.014*	0.1396
	(0.000)	(0.0003)	(0.0041)
NPL	0.0114	-0.0139***	-0.1734***
	(0.0011)	(0.0017)	(0.0194)
PCL	0.0247	-0.2772***	-0.2735***
	(0.004)	(0.0059)	(0.0067)
Tier 1	-0.0009	0.0057***	0.0487**
	(0.0014)	(0.002)	(0.0231)
Real GDP	0.0277*	0.0217*	0.4105*
	(0.0062)	(0.0091)	(0.1009)
HPI	0.0068***	0.0213**	0.0343***
	(0.0023)	(0.0034)	(0.0379)
Inflation	0.0396*	0.0486	0.0537*
	(0.0105)	(0.0153)	(0.1692)
Constant	0.7386	-0.1833	1.8756*
	(0.4154)	(0.0592)	(0.6555)
Number of observations	6,589	6,590	6,591
Number of banks	1,886	1,887	1,888
Adjusted R^2	0.4140	0.1954	0.2418

Contrary to the findings of the NIM regression, the size variable is found to be positive for the ROA specification. This result corresponds with Boyd & Runkle (1993), who argue that a larger size can harvest economies of scale that will reduce the cost of gathering and processing information. Similarly, capitalization is found to be positive and significant. Regarding diversification, this coefficient is found to be positive and significant whereas in the NIM regression it is negative. It is imperative to note that ROA is a measure of overall profitability, which means that expanding in new business ventures will most likely increase overall profitability. Furthermore, both lending and efficiency are found to be positive and significant which corresponds with the findings of related literature. Moreover, the coefficients for both PCL and NPL are negative as well as significant in this specification. Note that these variables are found to be positive in the NIM regression. The rationale behind this lies in the fact that provisions are direct costs that are deducted from profit. Also, banks incur more costs in dealing with high levels of NPLs which, in turn, reduces profitability (Feng & Wang, 2018). Next, the Tier 1 ratio is positive and significant, which implies that higher level of risk exposure should generate higher profits. From the macroeconomic perspective, GDP and HPI are found to be positive and significant whereas inflation is found to be insignificant.

Return on Equity (ROE)

The results of the ROE regression are shown in Table 4 column 3. Again, I find empirical evidence that supports profit persistence theory. As the lagged dependent variable is positive and significant across all specifications, it can be inferred that the bank profitability model is truly dynamic. Similar to the ROA results, the short-term rate is positively and significantly associated with the ROE. A 1% increase in short-term rate corresponds with a 0.46% increase in ROE. Once more I find a concave relationship between the short-term rate and the ROE. From the yield curve slope perspective, I find a positive and concave relationship with ROE. These results concur with the results of Borio et al. (2015).

For the rest of the control variables, the results are similar to the findings of the ROA specification except for the lending variable which is found to be negative in case of ROE.

5.2 Results for bank risk-taking

Model II examines the relationship between interest rates and bank risk-taking, see Table 5.

Tier 1 ratio

The first column of Table 5 examines the so-called "search for yield" phenomenon that is allegedly displayed by banks. Empirical evidence on bank risk-taking suggests that there is a high degree of persistence when it comes to risk-taking behavior. The results of this study are in accordance with previous findings as the lagged Tier 1 is positive and significant. With respect to the interest rate environment, existing literature on this matter tend to find that interest rates are negatively associated with risk-taking, see Delis & Kouretas (2011). The results of the concerning regression suggest a positive and significant relationship between the short-term rate and the Tier 1 ratio. In essence, lower interest rates are associated with lower Tier 1 ratios, which means that banks become riskier as interest rates move downwards. This result provides more evidence for the "search for yield" prophecy. As for the yield curve slope, I find no significant relationship with bank risk-taking.

In terms of size, I find a negative and significant relationship with bank-risk taking. A 1% increase in size corresponds with a 0.20% decrease in Tier 1. From this it can be inferred that larger banks tend to take more risks than small banks. Large banks are more likely to be engaged in trading activities whereas small banks rely mostly on traditional banking practices. Similar to Delis & Kouretas (2011), I find a positive relationship between capitalization and bank risk-taking. The positive coefficient for capitalization indicates that banks that are heavily capitalized tend to have lower exposures to risky assets. The results also show a negative relationship between efficiency and the Tier 1 ratio. This means that more efficient banks tend to take more risks compared to less efficient ones. The rest of the bank-specific variables as well as all the macroeconomic factors are found to be insignificant.

Non-performing loans (NPL)

The second column of Table 5 describes the credit risk channel of bank-risk taking. According to this channel banks tend to increase risk by lowering credit standards in order to boost profits. Analogous to related literature, the risk-taking behavior in terms of non-performing loans tend to persist over time. With reference to the interest rate environment, I am unable to find any significant relationships which would describe the dynamics between the assumed credit risk and interest rates. This is in contrast with studies such as, Delis & Kouretas (2011) and Bikker & Vervliet (2017), who do find positive and significant relationships between these variables.

Table 5

Regression results for risk-taking channel

This table presents the empirical results for the impact of interest rates on risk-taking. Each column represents a different model using one of the profitability measures NPL or Tier 1. All regressions are estimated using fixed effects estimation. All models include year time dummies (not reported). All variables are expressed in percentage terms except for size. Statistical significance is measured by t-test and they are reported under the coefficients. ***, **, * represent significance at 1, 5, and 10 percent significance levels respectively.

	Tier 1	**NPL**
Tier 1_{t-1}	0.2966***	
	(0.0123)	
NPL_{t-1}		0.289***
		(0.0154)
Short-term interest rate	0.0345**	-0.5838
	(0.0605)	(0.8355)
Yield curve slope	0.0978	0.8672
	(0 .0361)	(0.5136)
Size	-0.2021***	-0.1511***
	(0.0115)	(0.3910)
Capitalization	0.6012***	0.0003
	(0.0225)	(0.0332)
Diversification	-0.0048	-0.0297***
	(0.0045)	(0.0065)
Efficiency	-0.0107***	-0.0068*
	(0.0025)	(0.0035)
Lending	-0.0597	-0.0725
	(0.0079)	(0.0111)
Real GDP	0.2477	0.1588**
	(0.0574)	(0.0875)
HPI	0.0071	-0.0206
	(0.0217)	(0.0265)
Inflation	-0.1909	0.0632
	(0.0649)	(0.0872)
Constant	0.2234	0.8345
	(0.3401)	(0.9325)
Number of observations	6345	5636
Number of banks	1868	1958
Adjusted R^2	0.40	0.22

Size has a negative association with the level of NPLs, which infers that larger banks have a lower degree of non-performing loans compared to smaller banks. Moreover, diversification is negatively related to non-performing loans. As banks become less reliant on lending practices it can be expected that non-performing loans will decrease as well. Also, in accordance with Delis & Kouretas (2011), I find a negative relationship between efficiency and the level of non-performing loans. Naturally, less efficient banks have a lower profit margin compared to highly efficient banks, therefore, the incentives to softening credit standards in an attempt to boost profits are far greater.

6. Robustness tests

As discussed in section 4.2, the superlative method to deal with endogeneity issues in a dynamic setting is by means of the GMM estimator. However, this estimation technique relies on three strict criteria, namely, no autocorrelation in the second order, the subset of instruments should be strictly exogenous, and the system should be overidentified. As it is shown that the system is not overidentified and, therefore, the instruments are invalid, the utilization of the GMM technique might provide inconsistent estimates. As a result of this, I opt to use the GMM estimation process to test the robustness of the results provided by the fixed-effect estimator.

Following Bikker & Vervliet (2017) I use the results of the fixed-effect estimator and the pooled OLS to create a credible range in which the true value of the coefficient lies. Bikker & Vervliet (2017) and Wintoki et al. (2012) argue that using pooled OLS in a dynamic setting would provide inconsistent estimates for the lagged dependent variable that is biased upwards. Contrarily, the fixed-effects estimator would provide estimates for the lagged dependent variable that is biased downward. From this it can be inferred that the true estimate of the coefficient for the lagged dependent variable lies between this so-called credible range. As such, if the estimates of the GMM estimator lie within this credible range, they can be deemed as somewhat robust. The results of the pooled OLS and GMM estimation techniques are presented in Table A.4-A.5.

Firstly, for the bank-profitability model I choose to test the robustness for the NIM and the ROA regressions, the results are shown in Table A.4. The results show that the lagged NIM coefficient, produced by the S-GMM model, lies within the credible range. Similarly, it can be seen that the estimate for the ROA lagged dependent variable also falls within this credible range. Consistent with Bikker & Vervliet (2017), I find some robustness for the results that are produced by the S-GMM model. As for the remaining variables, the S-GMM estimates are all fairly consistent with the fixed-effects estimates (see section 5.1.) for both profitability measures except for some deviation in the significance levels.

Secondly, the results for the risk-taking channel are denoted in Table A.5. Considering the aforementioned credible range, it can be seen that the lagged dependent variable of the S-GMM estimator lies well between the coefficient of the lagged dependent variables of the pooled OLS as the fixed-effects estimator. Therefore, as this coefficient lies within the credible range it can be assumed that the results provided by the S-GMM estimator are robust to some degree. Again, the remaining estimates provided by the S-GMM estimator are fairly consistent

with the results provided by the fixed-effects estimator in the main model in section 5.2. With respect to the tier 1 model, the main difference between the fixed-effects and the S-GMM estimations pertain to the size and capitalization variables. In the fixed-effects model they are found to be significant whereas in the S-GMM model they are found to be insignificant.

All in all, it can be assumed that the results found for model I and model II are sensibly robust. This is consistent with Bikker & Vervliet (2017), who also encounter problems with endogeneity and do not meet all three criteria for using the G-MM estimation technique. Surprisingly, other papers such as Borio et al. (2015) and Albertazzi & Gambacorta (2009), who use similar variables as well as instruments to assess the impact of interest rates on bank profitability do not encounter such problems when it comes to meeting the S-GMM criteria.

7. Conclusion

It is alleged that the ECB's aggressive response by setting low interest rates at the early stages of the financial crisis was critical for helping prevent a profound financial and economic meltdown in the European union. However, a prolonged period of consistently low interest rates might have adverse effects on the net interest margin of banks, and therefore also their profitability, especially when interest rates are very low or even negative. As a result, bank managers have more incentive to increase risk in order to compensate for diminishing profitability in a low interest rate environment.

To tackle this issue, this thesis aims to examine the impact of the interest rate environment on bank profitability as well as on bank risk-taking. By means of a large panel consisting of Euro area banks for the years 2011-2017, I collect various bank-specific, interest rate variables and macroeconomic indicators to analyze whether the interest rate environment has a positive effect on profitability and risk-taking.

I find empirical evidence that the interest rate is positively associated with the NIM. From this it can be presumed that when the ECB engages in expansive monetary policy by setting lower interest rates as well manipulating the yield curve, banks will have to deal with lower margins. In addition, I also find that there is a non-linear (concave) relationship between the interest rate environment and the NIM. This indicates that the detrimental effects on the NIM are more pronounced when interest rates are unusually low, and the yield curve is unusually flat. In essence, by setting the interest rates really low or even negative as well as flattening the yield curve by means of quantitative easing, the ECB might be really impairing the interest margins of banks.

As I have discussed, a decreasing NIM does not necessarily mean a decreasing overall profitability, as the NIM is only a component of profitability. Other factors, such as non-interest income and decreasing loan loss provisions might come into play and positively affect profitability in a low interest rate environment. Therefore, I also include ROA and ROE as measures for overall profitability. The findings are somewhat consistent with the findings in regard to the NIM regression. The main take-away here suggests that as the ECB moves in to a prolonged period of low and negative interest rates, overall profitability of banks will also suffer as a consequence. I also find that a flattening or inverted yield curve is detrimental to overall profitability as well. This provides evidence that Euro area banks rely heavily on lending practices as opposed to more investment banking practices. Once more, I find that the

relationship between the short-term interest rate on one hand and the ROA as well as the ROE on the other hand, is concave by nature. I find no non-linearities when comparing the yield curve slope with ROA and ROE.

In regard to the risk-taking channel, I estimate the impact of low interest rates on risk-taking by means of the tier 1 and the NPL risk proxies. I find empirical evidence that suggest a positive association between the level of interest rate and the tier 1 ratio. This finding suggests that banks become riskier in terms of the "search for yield" channel as interest rates become lower. This can be explained by the increased incentive to boost profits in order to offset losses in the NIM component of profitability. This behavior is more pronounced especially when nominal return targets are in place. Furthermore, I find no evidence that suggests that banks increase credit risk to offset losses during low interest periods.

All in all, the evidence that I provide with my thesis are consistent with the notion that the ECB should be careful when implementing a prolonged period of low interest rates environment. Our financial system relies heavily on the soundness of the banks that provide liquidity in the market. Therefore, banks should also be considered when making decisions regarding the interest rate environment.

There are several limitations to this research which can be improved upon. Firstly, due to most of the bank-specific data being missing, a lot of observations have been lost in the beginning phase of the crisis. Secondly, I am unable to find a proper solution for the endogeneity issues and therefore cannot provide hard-evidence for my findings even though I have found some degree of robustness to these findings. Part of the problem is that I could not find enough data for a longer timeframe. In a small T and large N context, this will result in a dynamic panel bias, also known as the Nickell bias. Lastly, further studies could decompose unconventional monetary policy completely and examine each measure independently in order to assess which ones are most effective for both the economy as the soundness of the banks.

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Appendix

Table A.1

Summary of variable descriptions and data sources for Model I

This table presents the description of dependent variables, independent variables and control variables for model 1. Data sources and hypothesized effect of the independent variables on profitability are also presented in this table.

Variables	Description	Data Source	Hypothesized effect on profitability
Panel A: Dependent Variables			
Net interest margin (NIM)	Difference between net interest income and interest expense divided by total assets	Orbis bank focus	
Return on Assets (ROA)	Ratio of net income over total assets	Orbis bank focus	
Return on Equity (ROE)	Ratio of net income over total equity	Orbis bank focus	
Panel B: Independent Variables			
Short-term interest rate	3-month Euribor	Eurostat	+
Long-trerm interest rate	10-year Euro area government bonds minus 3-month Eu	Eurostat	+
Short-term interest rate²	3-month Euribor squared	Eurostat	-
Long-term interest rate²	10-year Euro area government bonds minus 3-month Euribor squared	Eurostat	-
Panel C: Control Variables			
Size	Logarithm of total assets	Orbis bank focus	+/-
Capitalization	Ratio of Total Equity over total assets	Orbis bank focus	+
Diversification	Total non-interest income divided by total income	Orbis bank focus	+
Lending	Ratio of total loans over total assets	Orbis bank focus	+
Efficiency	Cost to income ratio	Orbis bank focus	+
Tier 1 ratio	Common equity (tier 1) and additional tier 1 divided by total risk-weighted assets	Orbis bank focus	+
Non-performing loans (NPL)	Ratio of non-performing loans over total loans	Orbis bank focus	-
Credit Risk Proxy (PCL)	Provision for credit losses over total assets	Orbis bank focus	-
Real GDP growth	Average yearly real GDP growth rate	Eurostat	+
HPI	Average price growth in residential housing for a country	Eurostat	+
Inflation	CPI inflation	World bank	+/-

Table A.2

Summary of variable descriptions and data sources for Model II

This table presents the description of dependent variables, independent variables and control variables for model II. Data sources and hypothesized effect of the independent variables on profitability are also presented in this table.

Variables	Description	Data Source	Hypothesized effect on Risk taking
Panel A: Dependent Variables			
Tier 1 ratio	Common equity (tier 1) and additional tier 1 divided by total risk-weighted assets	Orbis bank focus	
Credit Risk Proxy (PCL)	Average yearly real GDP growth rate	Eurostat	
Panel B: Independent Variables			
Short-term interest rate	3-month Euribor	Eurostat	-
Long-term interest rate	10-year Euro area government bonds minus 3-month Euribor	Eurostat	-
Panel C: Control Variables			
Size	Logarithm of total assets	Orbis bank focus	-
Capitalization	Ratio of Total Equity over total assets	Orbis bank focus	+
Diversification	Total non-interest income divided by total income	Orbis bank focus	+
Lending	Ratio of total loans over total assets	Orbis bank focus	+/-
Efficiency	Cost to income ratio	Orbis bank focus	-
Real GDP growth	Average yearly real GDP growth rate	Eurostat	+
HPI	Average price growth in residential housing for a country	Eurostat	+/-
Inflation	CPI inflation	World bank	+/-

Table A.3

Correlation Matrix

	ROA	ROE	NIM	Short-term interest rate	Long-term interest rate	Size	Capitalization	Diversification	Lending	Efficiency	Tier 1 Ratio	NPL	PCL	Real GDP growth	Inflation	HPI
ROA	1.0000															
ROE	0.8726	1.0000														
NIM	0.2252	0.1666	1.0000													
Short-term interest rate	-0.0061	0.0058	0.1533	1.0000												
Long-term interest rate	0.0039	0.0244	0.1718	0.7585	1.0000											
Size	-0.0826	-0.0135	-0.3702	0.0197	0.0055	1.0000										
Capitalization	0.1965	-0.0027	0.1398	-0.0256	-0.0631	-0.3106	1.0000									
Diversification	-0.0229	-0.0572	-0.4689	-0.1445	-0.1314	0.1590	0.1064	1.0000								
Lending	0.0291	0.0284	0.1860	0.0641	0.0237	0.1057	-0.1184	-0.3285	1.0000							
Efficiency	-0.3875	-0.3316	-0.0738	-0.1460	-0.1860	-0.0509	-0.0819	0.0280	0.0015	1.0000						
Tier 1 Ratio	0.1431	0.0156	-0.0724	-0.0960	-0.1391	-0.2173	0.6306	0.1205	-0.3510	-0.1578	1.0000					
NPL	-0.1945	-0.2396	0.0806	0.1200	0.1441	-0.0665	0.1352	0.1858	-0.1692	-0.2904	0.1113	1.0000				
PCL	-0.2464	-0.2850	0.0757	0.0651	0.0362	-0.0041	0.0796	0.1840	-0.1488	-0.4769	0.1160	0.6062	1.0000			
Real GDP growth	0.0796	0.0611	-0.0871	-0.3263	-0.5056	0.1223	-0.0491	0.0477	-0.0038	0.2939	-0.0294	-0.3741	-0.2784	1.0000		
Inflation	0.0448	0.0591	0.0768	0.6884	0.7226	0.0556	-0.0550	-0.1375	0.0774	-0.0496	-0.1263	-0.0126	-0.0764	-0.3991	1.0000	
HPI	0.0287	0.0555	-0.0153	-0.3418	-0.5072	0.0800	-0.1202	-0.1198	0.0787	0.4205	-0.1583	-0.5534	-0.5115	0.7208	-0.1145	1.0000

Table A.4

S-GMM & Pooled OLS Regressions results for bank profitability

This table presents the robustness results for the impact of interest rates on profitability. The first two columns represents the ROA and NIM estimated with the S-GMM estimation technique. The next two columns show the results of the ROA and NIM estimates using the Pooled OLS estimation technique. All models include year time dummies (not reported). All variables are expressed in percentage terms except for size. Statistical significance is measured by t-test and they are reported under the coefficients. ***, **, * represent significance at 1, 5, and 10 percent significance levels respectively.

	NIM	**ROA**	**NIM**	**ROA**
	GMM		**Pooled OLS**	
NIM_{t-1}	0.6818***		0.8265***	
	(0.0396)		(0.0690)	
ROA_{t-1}		0.4971***		0.6784**
		(0.0752)		(0.0095)
Short-term interest rate	0.1694*	0.2792***	0.3400*	0.1740***
	(0.0946)	(0.1271)	(0.1664)	(0.0098)
Short-term interest rate²	-0.0845*	-0.0040*	-0.0459**	0.07410***
	(0.2260)	(0.2893)	(0.0121)	(0.0122)
Yield curve slope	0.3339*	0.4439*	0.0917*	0.1444
	(0.2020)	(0.2503)	(0.0690)	(0.2350)
Yield curve slope²	-0.1157*	-0.1896	-0.1360*	-0.0148*
	(0.0658)	(0.0836)	(0.0550)	(0.0775)
Size	-0.0381***	0.0321**	0.0064***	0.0294***
	(0.0125)	(0.0156)	(0.022)	(0.0029)
Capitalization	0.0200	0.0194**	0.0075***	0.0159***
	(0.0105)	(0.0094)	(0.0011)	(0.0015)
Diversification	-0.0058***	0.0065**	-00040***	.0005***
	(0.0021)	(0.0027)	(0.0002)	(0.0003)
Lending	0.0029*	0.0001	-0.0013***	-0.0143
	(0.0020)	(0.0021)	(0.002)	(0.013)
Efficiency	0.0022*	0.0065*	-0.0002	0.0142**
	(0.012)	(0.0027)	(0.001)	(0.0003)
NPL	0.0057	-0.0065***	0.0007	-0.012*
	(0.0024)	(0.0037)	(0.0005)	(0.0008)
PCL	0.0320	-0.0173***	0.0466***	-0.2135***
	(0.0272)	(0.0032)	(0.0037)	(0.0053)
Tier 1	-0.0018	0.0094**	-0.0034***	0.0027***
	(0.0045)	(0.0053)	(0.0006)	(0.018)
Real GDP	0.0319*	0.0126*	0.0543***	0.0519*
	(0.0125)	(0.0158)	(0.0056)	(0.0079)
HPI	0.0089*	0.0183**	0.0543**	0.0027
	(0.0056)	(0.0088)	(0.0016)	(0.0023)
Inflation	0.0038	0.0035	0.0055*	0.0228
	(0.0181)	(0.0230)	(0.0109)	(0.0152)
Number of observations	6,589	6,590	6,589	6,589
Number of banks	1,886	1,886		
Number of instruments	140	140		
AR(2)	0.411	0.219		
Sargan-Hansen test	0.002	0.000		
Difference-in-Hansen	0.370	0.592		
Adjusted R^2			0.8626	0.5811

Table A.5

S-GMM & Pooled OLS Regressions results for risk-taking channel

This table presents the robustness results for the impact of interest rates on risk-taking. The first two columns represents the NPL and Tier 1 ratio estimated with the S-GMM estimation technique. The next two columns show the results of the NPL and Tier 1 ratio estimates using the Pooled OLS estimation technique. All models include year time dummies (not reported). All variables are expressed in percentage terms except for size. Statistical significance is measured by t-test and they are reported under the coefficients. ***, **, * represent significance at 1, 5, and 10 percent significance levels respectively.

	Tier 1	**NPL**	**Tier 1**	**NPL**
	GMM		**Pooled OLS**	
Tier 1 $_{t-1}$	0.6793***		0.8460***	
	(0.0559)		(0.0055)	
NPL $_{t-1}$		0.681***		0.8473**
		(0.0305)		(0.0060)
Short-term interest rate	0.0931**	0.0993	0.0244	0.0646***
	(0.0094)	(0.0898)	(0.0713)	(0.0836)
Yield curve slope	0.0676	0.9858	0.0634	0.1014
	(0.0430)	(0.0803)	(0.0409)	(0.5104)
Size	-0.1300	0.3501**	0.0316	0.0039
	(0.1473)	(0.1323)	(0.0193)	(0.0025)
Capitalization	0.0327	0.013	0.2198***	0.0059
	(0.010)	(0.1026)	(0.0097)	(0.0013)
Diversification	-0.0171*	-0.0213	-0.0031	0.0064***
	(0.0209)	(0.0235)	(0.0023)	(0.0003)
Lending	-0.0056*	0.0091	-0.0170***	0.0008
	(0.0194)	(0.0023)	(0.0020)	(0.0003)
Efficiency	-0.00295*	-0.0040*	-0.0178	0.0012**
	(0.0153)	(0.0027)	(0.0018)	(0.0002)
Real GDP	0.0174*	0.0584***	0.257***	0.2044*
	(0.0174)	(0.0941)	(0.0507)	(0.0065)
HPI	-0.0418	-0.0651	-0.0455**	0.1595*
	(0.0406)	(0.0477)	(0.0156)	(0.0019)
Inflation	-0.0328	0.0424	-0.0169*	0.0223
	(0.0803)	(0.1036)	(0.0173)	(0.0086)
Number of observations	6,345	5,129	5,129	5,129
Number of banks	1,868	1,818		
Number of instruments	95	95		
AR(2)	0.122	0.144		
Sargan-Hansen test	0.000	0.000		
Difference-in-Hansen	0.320	0.077		
Adjusted R^2			0.7109	0.826