UNIVERSIDADE CATÓLICA PORTUGUESA

The impact of low monetary policy interest rates on bank profitability

An analysis of the post-crisis period

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Católica Porto Business School
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Resumo

Em várias economias desenvolvidas, medidas de política monetária expansionista levaram as taxas de juros da política monetária a níveis historicamente baixos após a crise de 2007/2008. A persistência ao longo do tempo de tal situação levantou a questão de quais são as implicações para o setor financeiro em termos de rentabilidade bancária, pois pode haver consequências para a capacidade dos bancos de conceder empréstimos e para a própria transmissão da política monetária. Desta forma, este estudo tem como objetivo analisar se as reduções na taxa de juros da política monetária levam a reduções na rentabilidade dos bancos e se essa relação é linear com o nível da taxa de juro. Abordamos esta questão com dados de bancos europeus e japoneses no período pós-crise, entre 2010 e 2018, considerando duas medidas para a rentabilidade dos bancos: margens líquidas de juros e retorno sobre os ativos médios. A estimação corrige problemas de endogeneidade seguindo o método generalizado de momentos (GMM) para dados em painel dinâmicos. Os resultados indicam que a rentabilidade bancária aumenta com a diminuição da taxa de juro da política monetária até um certo valor dessa taxa, relativamente baixo. A partir desse mesmo valor, esta relação inverte-se e as variáveis passam a aumentar em simultâneo.

Palavras-chave: rentabilidade bancária; taxas de juro; política monetária; margem líquida.

Abstract

In several developed economies, expansionary monetary policy has driven monetary policy interest rates to historically low levels after the 2007/2008 crisis. The persistence throughout time of such a situation has raised the question of what the implications are for the financial sector in terms of bank profitability, as there might be consequences for banks' ability to lend and the transmission of monetary policy itself. Therefore, this study aims to analyse whether decreases in the monetary policy rate lead to decreases in bank profitability, and whether this relationship is linear with the level of the policy rate. We approach this issue by analysing European and Japanese banks in the post-crisis period, from 2010 to 2018, considering two measures for bank profitability: net interest margins and return on average assets. The estimation corrects for endogeneity by following a generalised method of moments (GMM) approach for dynamic panel data. The results indicate that bank profitability increases with the decrease of the monetary policy rate up to a certain, low value for that rate. Beyond that same value, this relationship is inverted, and the variables start increasing simultaneously.

Keywords: bank profitability; interest rates; monetary policy; net interest margins.

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Introduction

In the aftermath of the subprime crisis of 2007/2008, interest rates in countries belonging to the Euro Area, as well as other countries such as Switzerland and Japan, have been persistently low and, in some cases, even negative. The latest values available for the Eurozone, as of May 2019, show that the interest rates on the main refinancing operations (MROs), the marginal lending rate facility and the deposit facility stand at 0.00%, 0.25% and -0.40%, respectively (European Central Bank, 2019b).

The interest rate structure is affected by many factors, one of them – and an important one, at that – being monetary policy. Monetary policy authorities – i.e. central banks – aim to stabilize inflation, i.e., the rate at which prices for goods and services rise, by setting short-term interest rates via the so-called policy rates, which in turn influence longer-term rates by guiding market participants' expectations and, in recent years, by intervening more directly via unconventional monetary policy measures such as asset purchasing programmes (Borio, Gambacorta and Hoffman, 2015).

In a context of low inflation, monetary authorities such as the European Central Bank (ECB) have driven the policy rate to unusually low levels for an unusually long period of time. Theoretically, a decrease in the interest rate makes borrowing less costly and saving less profitable; therefore, more people have access to credit and can expand their consumption and investment levels, with less incentive for saving and more for spending. This leads to a surge in demand

for commodities, which is not met by supply, resulting in an increase in prices (Romer, 2012). When it comes to the Euro Area, the value reported by the ECB in May for the Harmonised Index of Consumer Prices (HICP) was 1.2%, far from the set target of 2%. The lowest reported value in the last few decades was -0.6% in July of 2009, when the crisis was at its most flagrant; this value, however, repeated itself once again in January of 2015 (European Central Bank, 2019a). This deviation from the set target justifies the manipulation of interest rates to such low levels.

After the crisis, central banks have had to operate in unexplored territory, characterised by low growth and below-target inflation. In such a context, markets showed an increasing concern regarding the unintended and unexpected consequences of low and negative policy rates – namely, what happens to the financial sector in terms of banks' profitability (BIS, 2016)?

Banks' primary and most important source of earnings is net interest income. Some of the literature suggests there might be a strong, negative correlation between declining interest rates and bank profitability – in 2016, the FED advised banks to consider further drops in the policy rate as a "severely adverse scenario" (BIS, 2016). If we take net interest margins (NIMs) as a measure for profitability, for instance, there is some evidence that, at least considering the short-term, a decrease in the interest rate will erode banks' net interest income, thus compressing the margin, as deposit rates showed to be sticky when rates reached low levels, while lending rates declined more steeply (Heider, Saidi and Schepens, 2018; Jobst and Lin, 2016; Martinho, Oliveira and Oliveira, 2017 and Turk, 2016). But the literature suggests that there is a high degree of uncertainty surrounding the behaviour of institutions if rates continue to decline, or if these low levels persist for years to come (Bech and Malkhozov, 2016).

However, macroeconomic effects are also relevant. It can be argued that, simultaneously, decreases in the interest rate have a positive impact on

macroeconomic conditions from, for example, boosting activity – namely in terms of consumption, investment and lending, which then goes on to positively affect gross domestic product and price indices, among other macro variables. This, in turn, positively impacts bank profitability (Jobst and Lin, 2016; Marinho, Oliveira and Oliveira, 2017 and Turk, 2016).

Having said this, there does not seem to be a standardized approach to analyse this matter in pre-existent studies, and results are not so aligned, i.e. there is no consensus regarding the impact of changes in the central bank policy rate on bank profitability. This ambiguity attributes some importance to this study. Furthermore, the fact that bank profitability may have implications in terms of conducting monetary policy cannot be overlooked. Issues such as the level of lending provided by banks, the overall health of the financial system and the responsiveness of the banking sector may suffer consequences if profitability is very affected (Siakoulis et al., 2018).

In this sense, this paper aims to analyse the relationship between interest rates and profitability, in the period after the crisis, when a low interest rate environment has shown itself to be relatively strong and persistent. As has been mentioned, room for contribution arises from the lack of a firm consensus regarding this relationship, but also from the persistence throughout time of low interest rates in some major developed economies – this implies that an analysis using updated data is key, especially taking into account that, where negative rates have been implemented, it has happened fairly recently. Specificity in this study also comes from the choice of the policy rate, which is the rate directly implemented by the central bank, as opposed to the lending and deposit rates established by other authors, which represents a new perspective that can be more direct in the sense that it is not affected by individual banks' decisions.

To understand this relationship, we analyse 31 countries (belonging to the European Union, Switzerland, Norway and Japan) from 2010 to 2018. The

generalised method of moments with two stage least squares instruments is employed to address endogeneity concerns, alongside bank-fixed effects and heteroskedasticity-robust standard errors. Results indicate that the impact of policy rates on bank profitability depends on the level of the rate itself. This means that the relationship between these two variables is not a linear one; we found that an increase in interest rates will lead to an increase in bank profitability, only if the interest rate is above a value very close to zero. Otherwise, the variables move in opposite directions.

This paper is structured as follows: we will begin by a first section, showcasing the surrounding context regarding the evolution of interest rates and profitability. On a second section, we will summarize the pre-existent literature, both in theoretical and empirical terms. On a third chapter, we will present the raised hypotheses, the equations to be estimated and the proposed methodology, which are based on the second section. The empirical analysis is performed on the fourth chapter, including information concerning the data and the variables extracted for the purpose of this analysis and the main results. Finally, the conclusions, limitations and possible, interesting further research questions are posed on a last section.

Chapter 1
Brief contextual analysis

Low and negative interest rates have been much discussed in the literature published in recent years, especially after the subprime crisis of 2008/2009. Levels of inflation have been below the usual target level of 2% for some time now, with some countries even reporting deflation, i.e., negative rates for inflation. After the crisis hit, Japan reported negative values for the yearly consumer price index from 2009 to 2012, and then once again in 2016. In 2018, this value was positive, but still under 1%. Switzerland can be considered a somewhat similar case, although the situation is much more recent than that verified for Japan, reporting deflation in the year of 2009 and, after that, from 2012 to 2016. In 2018, this value was close to Japan's, under the 1% mark. In the Eurozone, rates decreased until 2016, having then hit the zero-lower bound (OECD, 2019).

Central banks around the world have implemented non-conventional monetary policy measures in order to drive inflation up, pushing nominal policy rates down in an effort to stimulate the economy, at times going beyond the theoretical lower bound of 0%, also called the zero-lower bound (Galí, 2008). Naturally, this has implications regarding markets and the macroeconomic context. Some of those implications concern banks' profitability, which in turn impacts their survival – and literature and research that specifically focuses on this link between monetary policy and bank profitability is surprisingly lacking (Borio, Gambacorta and Hoffman, 2015).

The evolution of the main central bank interest rates, or policy rates, directly set by monetary policy authorities, from 2010 to 2018 for the Eurozone, other European countries and Japan is represented below, in Figure 1. Countries like Hungary and Romania have shown much more variability in the rate than others, such as Japan; however, low rates in Japan were implemented years before these other countries, and have thus become structural.

Except for Poland, Romania, Hungary and Norway, most countries reported values for the interest rate which were below 2% in 2010. In general, there is a clear decreasing trend, with a more pronounced break in 2012/2013, which coincides with the implementation of Central Banks of unconventional monetary policy measures such as quantitative easing. Denmark was the first country to implement a negative policy rate, -0.2%, which happened in 2012. Switzerland followed in 2014, with a rate of -0.25%, by which time Denmark's rate was up, although still negative, at -0.05%. Sweden implemented a rate of -0.35% more recently, in 2015, after hitting the zero-lower bound in the previous year, and when both Denmark and Switzerland stood at -0.75%. Within the considered time frame, Japan shows negative values from 2016 onwards, at -0.1%.

It is also interesting to note that, for all of these countries which have implemented a negative policy rate, the latter has stayed negative until the end of the considered period, that is, 2018. Besides Sweden in 2014, three other regions hit the zero lower bound: the Eurozone and Bulgaria, both in 2016, and Croatia, in 2018. The Eurozone and Bulgaria kept the policy rate at 0% from 2016 onwards. These trends coincide with those found by Berry et al. (2019) and Siakoulis (2018).

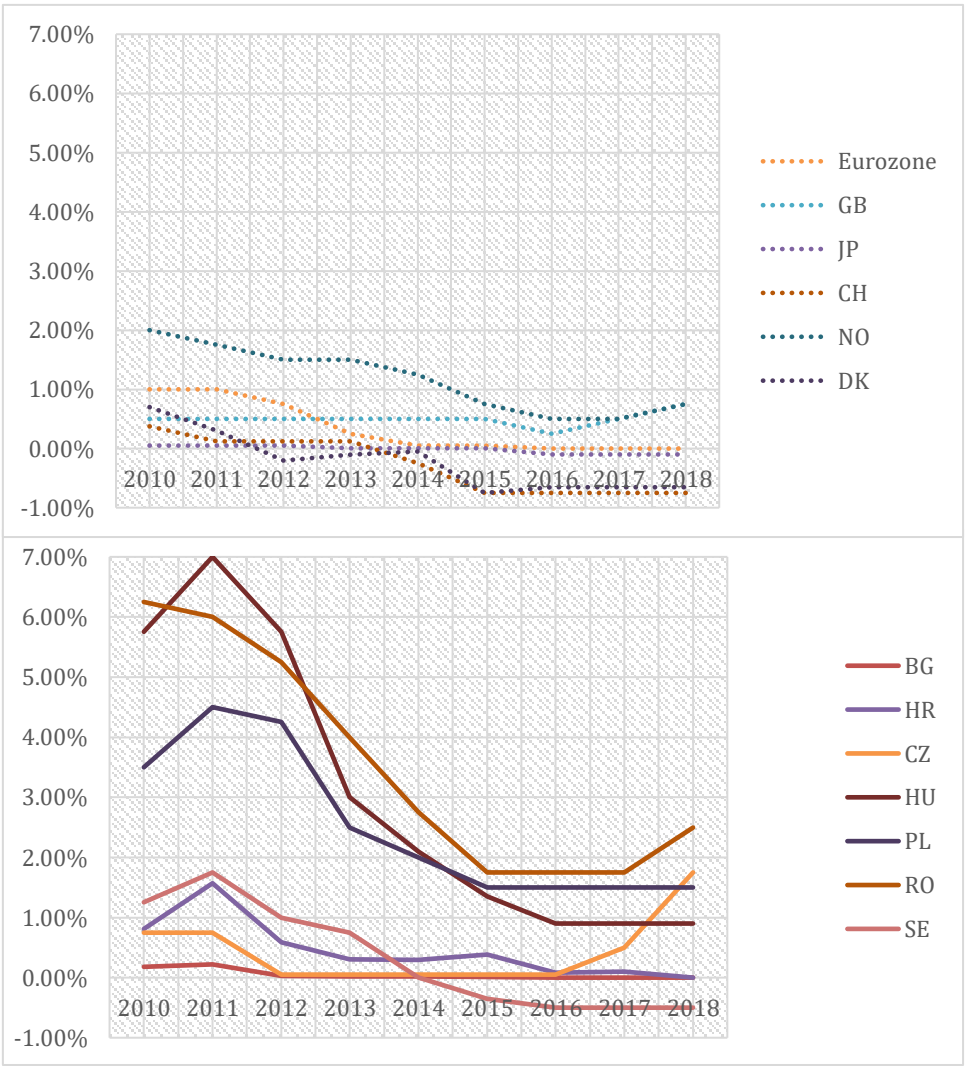

Figure 1: Evolution of the policy rate from 2010 to 2018.

To analyse a possible link between interest rates and bank profitability, measured in these two ways – by means of net interest margins and return on average assets –, we will first look at the pre-existent contributions by authors on this topic, both in theoretical and empirical terms.

Chapter 2
Literature Review

In this section, former contributions to the literature on bank profitability and interest rates, their advantages and setbacks will be presented. The chapter is divided in two – first, the theoretical framework is described, based on the scheme presented in Figure 2 below, while the empirical methodologies, datasets and variables used by the authors are separated in a second subsection.

1. Theoretical Framework

Even though monetary policy is not the sole determinant of interest rate structure, it plays a key role in its level: central banks set monetary policy rates, or base bank rates, which are short-term. This goes on to affect loan and deposit rates set by commercial banks, as well as market participants' expectations regarding future levels of short-term rates. This greatly shapes both the interest rate structure and economic agents' behaviour. A change in the policy rate will, therefore, influence the whole financial sector and banks in particular, as they adapt the rates that they charge markets in face of that change. Low rates can, on one hand, help economies recover, which will improve banks' balance sheets; on the other hand, and especially if the situation persists, they may end up eroding banks' profitability through lower net interest margins, defined as the difference

between interest expense and interest income, pondered by average earning assets (Berry et al., 2019; Borio, Gambacorta and Hoffman, 2015; Claessens, Coleman and Donnelly, 2017).

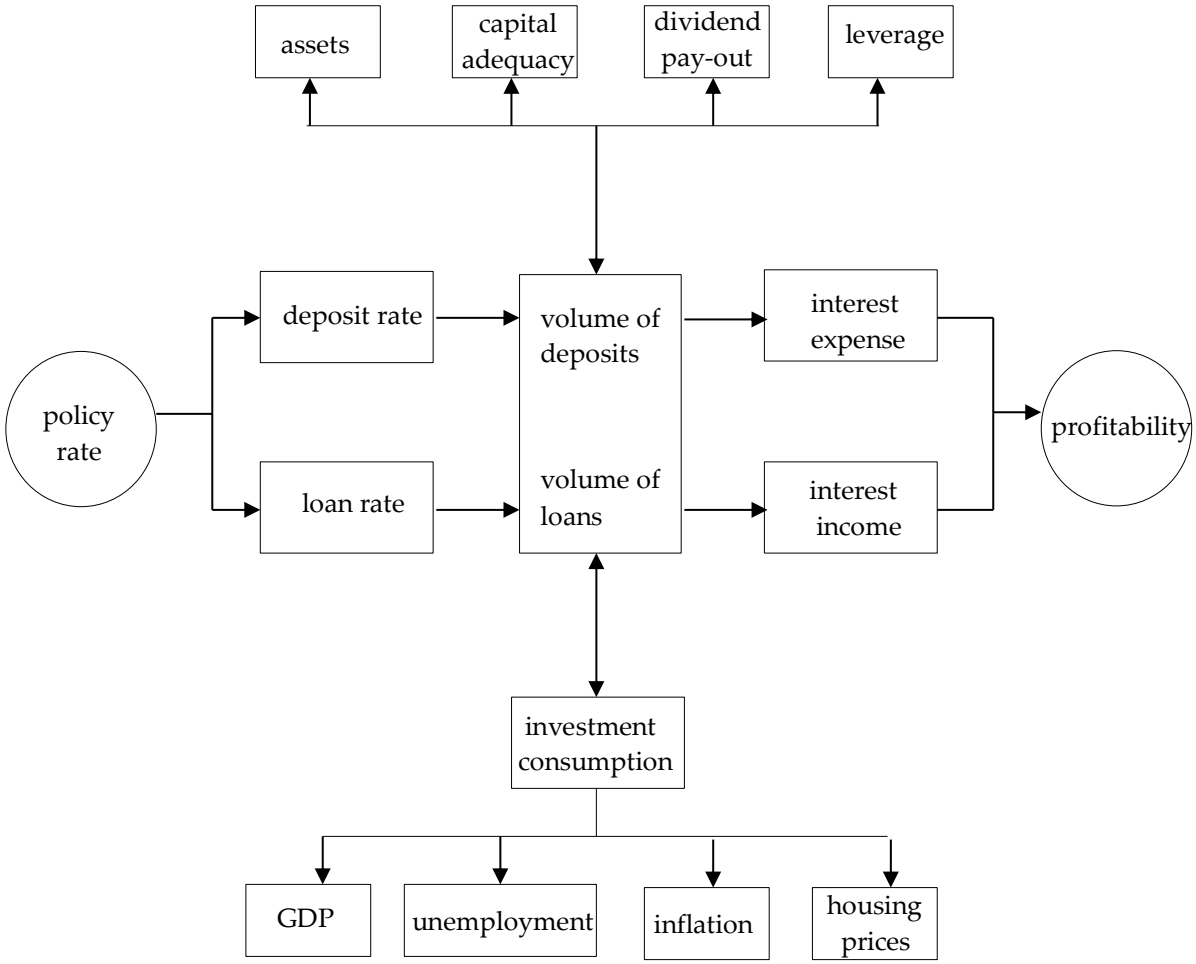

Figure 2: Transmission of the policy rate to bank profitability.

Having said that, the transmission of negative policy rates to markets and the real economy is nor direct nor smooth – historically, banks have showed reluctance in passing negative rates through to depositors. Figure 2 shows the mechanism through which the policy rate set by Central Banks may affect individual banks' profitability, based on the literature. According to Angori, Aristei and Gallo (2019), Berry et al. (2019), Bech and Malkhozov (2016) and Claessens, Coleman and Donnelly (2017), deposit rates determined by banks are

usually stickier than loan rates. In other words, lending rates are generally agreed to vary more than deposit rates do in face of a change in monetary policy. This effect is stronger the lower policy rates are, which can be attributed to the concern that clients would choose to significantly withdraw their deposits in face of low or below-zero deposit rates and switch to cash-forms of savings, due to lack of incentives to pay to keep money in the bank, meaning that banks would risk losing clientele and the volume of deposits would fall. According to the authors, however, if banks do not engage in low or negative deposit rates, their profitability in terms of interest margins will suffer as interest expense remains more or less stable, but interest income goes down, since loan rates will most likely decrease as the cost of funding for banks also decreases with the fall of the policy rate. This may affect banks' ability to lend. Furthermore, cross-sectional differences among banks can play a crucial part in the bank rate passthrough, namely in terms of size and capitalization, as total assets and the amount of capital available has a bearing on the availability of funding for future lending decisions (Abulaila and Alhathlool, 2016; Claessens, Coleman and Donnelly, 2017; European Central Bank, 2005 and Gambacorta and Iannotti, 2011).

Although there is the possibility of depositors turning to cash-forms of savings, from the perspective of firms and households, the costs of foregoing deposits and opting to hold liquidity in this form cannot be ignored; namely, in what concerns secure storage and transport. Having said that, some of these costs hold a significant fixed component, which implies that, if interest rates are expected to remain very low or negative for a long period of time, incurring in these costs may become less of a burden for banks' clients in the long-run and they may still opt for this solution. In fact, in Switzerland, the Euro area and Denmark, the demand for cash has not showed an increasing trend in recent years, despite low and sometimes negative interest rates (Bech and Malkhozov, 2016; Berry et al., 2019; Fernandes and Mota, 2014 and Jobst and Lin, 2016).

However, there is no unanimous consensus in the literature regarding this relationship's direction. For instance, and contrastingly to what other authors have said, Busch and Memmel (2015) argue that an increase in interest rates leads to a decline in net interest income in the following years, meaning, in the short-term. Some authors argue that the quantity of loans, and not just the loan rate, can invert this relationship. Claessens, Coleman and Donnelly (2017) argue that low for long interest rates may stimulate the economy and improve the quality of loans and the environment for lending, which theoretically could lead to an increase in a bank's long-term profitability. Borio and Gambacorta (2017) also mention that lower short-term rates arising from expansionary monetary policy are associated with higher lending, but they find that this relationship is no longer true in the presence of very low rates. The authors associate this to the persistence of these low rates – as lower profitability makes accumulating capital more difficult, the basis for additional lending is destroyed, thus inverting the trend. Heider, Saidi and Schepens (2018) state that, when policy rates decrease, banks' cost of funding lowers and their net worth increases. This, in turn, should allow them to expand lending. The authors also find that this is not true in the presence of negative rates. The overall net effect of changes in the monetary policy rate on profitability is not clear ex-ante, since several factors are at play here: spill over macroeconomic effects, interest rate pass-through and sensitivity of loan and deposit rates and decisions on the amount of loans and deposits (Angori, Aristei and Gallo, 2019 and Berry et al., 2019).

Thus, besides this direct effect of the level of the policy rate on bank profitability, we can also consider a second effect, which manifests itself via broader economic conditions. The way macroeconomic variables may impact bank profitability is also depicted in Figure 2. Decreases in the interest rate made by central banks in some developed economies in order to boost economic activity can lead to more optimistic expectations, discourage savings and

encourage spending by the public in terms of investment and consumption. A decrease in the policy rate which transmits to both lower deposit and lending rates set by individual banks allows for easier and cheaper access by the public to loans, spurring demand for loans and decreasing demand for deposits. Additionally, as interest rates diminish, non-performing loans also diminish as borrowers' debt service becomes lighter (Borio and Gambacorta, 2017; Claessens, Coleman and Donnelly, 2017; Genay and Podjasek, 2014 and Jobst and Lin, 2016). This results in increased consumption and investment by households and firms. It can be argued that negative rates increase household consumption and lead agents to rebalance their portfolios by looking into other investment opportunities, benefitting aggregate demand. Portfolio rebalancing helps firms lower their costs, meaning that more investments become profitable, further spurring an increase in aggregate demand. Furthermore, possible increases in future income strengthen borrowers' repayment capacity, lowering banks' expected costs and improving their balance sheet situation. This goes on to affect gross domestic product (GDP), price levels (as demand for goods and services overtakes supply) and unemployment levels. Macroeconomic conditions may thus be critical – in fact, a 2015 study conducted by the European Central Bank found that macroeconomic factors had the most impact on bank health (ECB, 2015, cited in Claessens, Coleman and Donnelly, 2017). There is evidence that bank profitability has not worsened due to such positive effects largely outweighing negative ones, as most Euro Area banks have increased lending volumes and decreased interest expenses since the crisis (Cœuré, 2016).

One important point made by Turk (2016) is that the full effects from negative rates on bank profits may not be able to be observed if we use data that corresponds to the immediate period after or close to the crisis. For most countries, policy rates only became significantly negative or at the zero-lower bound in recent years – a possible impact on profitability might only manifest

itself in coming years, meaning that an analysis including more recent data is crucial to attempt to see meaningful results.

The possible impact on bank profitability is relevant due to the importance of stable bank margins for the overall economy, as it may be argued that loss of bank profitability can have negative implications for the wide economy as it may decrease or even impede lending, thus destabilizing this function of the banking system, on one hand, and jeopardizing the pass-through of monetary policy measures, on the other hand (Borio and Gambacorta, 2017; Genay and Podjasek, 2014 and Turk, 2016). Banks, especially those of smaller dimension, heavily rely on the spread between long- and short-maturity rates to generate earnings, and a compression of this margin may impede their normal functioning as lending entities. This issue may be especially relevant in some countries, due to differences in banking sectors across nations – countries with many small banks such as Germany may be more affected by low rates than others. Additionally, rates that are low for a long time may lead to increased vulnerability to shocks (Claessens, Coleman and Donnelly, 2017).

2. Empirical Framework

An empirical difficulty that is noteworthy and that most authors touched upon is endogeneity. The introduction of negative policy rates in European Union countries coincided with a decrease in longer maturity, higher risk yields, but asset purchase programmes such as quantitative easing make it harder to isolate the effect of negative policy rates. The impact of the macroeconomic context may be a defining factor that makes it harder to look at interest rates alone.

In their analysis, Borio and Gambacorta (2017) take this endogeneity issue into account. They analyse 108 major international banks' consolidated accounts from 13 countries, with the data being taken from the BankScope database. They look at a considerably long period of time, 20 years, but with a lack of very recent data – from 1995 to 2014. This is a construction upon an earlier paper that considers a sample of 18 years, from 1995 to 2012 (Borio, Gambacorta and Hoffman, 2015). The authors' approach to this problem is to test whether the impact of short-term interest rates on bank lending differs when those rates are at particularly low levels. To do so, they use the annual growth rate of loans as the dependent variable, and the change in the three-month interbank rate as a proxy for the monetary policy indicator as the main explanatory variable. They take the endogeneity issue – i.e., the possibility that the state of the banking sector and the macroeconomic environment could also affect monetary policy conditions – into consideration. To mitigate this problem, they use the generalised method of moments (GMM) estimator for dynamic panel data, with Blundell and Bond instruments. Additionally, they introduce time- and bank-fixed effects and a wide range of controls – bank-weighted cyclical indicators and bank-specific characteristics. They conclude that reduction in the profitability of banks leads to lower sensitivity of lending to changes in interest rates.

Borio, Gambacorta and Hoffman (2015) analyse a different issue using the same data. The several explained variables in the model they adopted are the relevant income component divided by total assets, including net interest income. The authors aim to explain this component through the three-month interbank rate, the slope of the yield curve, both of these indicators in quadratic form and control variables that are macroeconomic indicators, as well as time- and bank-fixed effects. They follow the same methodology as Borio and Gambacorta (2017). Additionally, the authors suggest that the characteristics of the data itself may help mitigate endogeneity issues – while bank profitability

may have an impact on monetary policy decisions, it would be in aggregate terms; when we consider the profitability of an isolated bank, that is not likely to happen. The study's contribution is largely based on its finding that the relationship between interest rates and bank profitability is not a linear one. They find that an increase in the level of interest rates has a positive impact on net interest income, and that this relationship is concave, meaning that changes in the rate have a larger impact when it is close to zero. They also found the same evidence for non-linearity of this relationship when considering return on average assets as a measure for bank profitability.

Busch and Memmel (2015) use a sample of German banks ranging from 1968 to 2013, with data being taken from the Deutsche Bundesbank. They analyse net interest income as the explained variable. They estimate a linear equation using a GLS estimator, which is fairly different from what other authors have done as they do not focus on the endogeneity issue. Their results are also different from the results presented by the majority of the authors, denoting room for discussion. They conclude that an increase in the interest rate has a negative, statistically significant net effect on profit in the short-run. However, in the long run, they estimate that this effect becomes positive.

Genay and Podjasek (2014) study the impact of the quarterly average three-month U.S. Treasury bill interest rates on two variables, net interest margins (NIMs) and return on assets (ROAs). The authors consider a span of twelve years, from 2003 to 2014, and include several control variables, similar to those used by other authors, such as GDP growth rate, unemployment rate, house prices and bank asset-size classes. Their sample comprises US commercial banks and they estimate a linear model adjusting for heteroskedasticity. They conclude that higher short-term interest rates are associated with higher net interest margins, with these effects being more pronounced for smaller banks, but find no clear conclusion for return on assets. They also contribute to the literature by stating

that, whichever direction the impact takes, it is small in magnitude – and changes in economic conditions matter relatively much more.

Claessens, Coleman and Donnelly (2017) also look into these same two dependent variables – net interest margins and return on assets. They investigate whether there is a relationship between lower rates and the decline in profitability and market valuation, and whether this relationship changes in a low rate environment. They address the endogeneity issue by controlling for bank-specific and time-specific characteristics and using a large panel and, similarly to Borio, Gambacorta and Hoffman (2015), they consider a non-linear relationship – they hypothesize that the effects of interest rates on NIMs are likely to be larger in a low-rate environment if the spreads on loans over deposit rates increase with the rate level. Unlike these authors, however, they use unconsolidated banking data so as to isolate the effect of a country's interest rate on only the bank's operations in that country. The final sample comprises banks from 47 countries, from 2005 to 2013. The main independent variable is the yearly average three-month sovereign rate. The authors find that declines in rates are associated with lower NIMs, and that this effect is stronger the lower the rate is, and the longer it has been low, even though all effects are relatively small. They analyse the non-linearity of the relationship by considering a threshold of 1.25% for the interest rate. Controlling for bank size, they also reach the conclusion that small banks may have greater difficulty in maintaining their net interest margins in a low rate environment. As for return on assets, they find equally small, but mainly non-significant results. However, due to the endogeneity issue, they reiterate that the relationship they find is not necessarily causal. Additionally, they raise a point regarding accounting standards, which vary across countries, possibly limiting comparisons among them.

Heider, Saidi and Schepens (2018) retrieve data from DealScan, Bureau van Dijk and SNL Financial for Euro Area countries. They test whether negative

policy rates lead to both greater risk taking and less lending by banks. They deal with endogeneity by using a difference-in-differences approach. The authors find that when the ECB reduced the deposit facility rate in 2014, banks with more deposits bet on riskier firms for lending, i.e., when rates become negative, banks that rely mainly on deposits take on more risk and lend less, as their net worth is more affected.

Angori, Aristei and Gallo (2019) estimate the main determinants of net interest margins for a sample of around 3 000 banks from the Euro Area, from 2008 to 2014. They retrieved data from the Bureau van Dijk Bankscope database, relying primarily on balance sheet observations. The authors used a mix of consolidated and unconsolidated data due to a lack of observations for unconsolidated accounts. They control for the regulatory environment, country macroeconomic characteristics, financial market characteristics and bank-level determinants. In their estimation equation, they include the first lag of net interest margins, the dependent variable, as an explanatory variable, which allows to capture the persistence overtime of the dependent variable. Regarding the methodology, they use a single-stage estimation approach, dealing with endogeneity by adopting a system GMM estimator with Arellano and Bover instruments. The authors conclude that banks' sustainable profitability has been at risk since the crisis and that this effect is becoming more and more pronounced with time, despite measures of the ECB to overcome this issue.

Overall, even though most authors seem to believe that the decline of profitability has been associated with the decline of interest rates, whether measured by net interest margins, return on assets or other variables, the lack of a firm consensus regarding this impact, coupled with the increasing importance of this topic as interest rates remain at low values, provide a valid justification for the scope and goal of this research. Room for contribution also arises from the

fact that previous studies use somewhat outdated data, which may be less likely to capture the effect of negative interest rates, as these have been implemented quite recently and are a fairly new phenomenon.

From this analysis of the literature review, we are able to find some patterns in the way different authors go about estimating any relevant relationship on the topic. However, for the most part, there is a fair amount of diversity in all aspects – dependent variables, geographical and time scope of the analysis, choice of the interest rate and methodology. The following chapter presents the options taken in this study to approach the topic, based on the empirical literature review.

Chapter 3
Hypotheses and Methodology

Stemming from the described theoretical concepts and connections made previously by other authors are the hypotheses presented in this section. We also present the main equations to be estimated and their specifications.

1. Hypotheses

Taking Bech and Malkhozov's (2016), Heider, Saidi and Schepens' (2018) and Jobst and Lin's (2016) perspective into account, we can adopt the idea that a variation in the policy rate will affect banks' loan rates more than their deposit rates, as these are stickier due to the concerns raised in the literature review regarding deposit withdrawals, especially in the context of low interest rates. This makes it possible for us to formulate a first hypothesis:

H1: The policy interest rate is positively associated with banks' profitability.

Furthermore, some authors suggest that the level of the policy rate will have a non-linear relationship with bank profitability. It can be argued that a decrease in already very low interest rates will have a stronger impact on profitability (Borio, Gambacorta and Hoffman, 2015; Borio and Gambacorta, 2017 and Claessens, Coleman and Donnelly, 2017). This makes it possible for us to raise a second hypothesis:

H2: The impact of the policy interest rate on banks' profitability is not linear with the rate level.

The econometric method employed and the empirical specifications of the proposed analysis are presented in the subsection below.

2. Equation and econometric method

In order to examine the above hypotheses, we estimate the following equation:

$$profitability_{i,j,t} = \alpha_i + \theta_t + \beta profitability_{i,j,t-1} + \boldsymbol{\mu g}(i_{j,t}) + \boldsymbol{\gamma Y}_{j,t} + \boldsymbol{\delta X}_{i,j,t} + \varepsilon_{i,j,t} \quad (\boldsymbol{Eq.1})$$

Regarding the indices, i refers to a given bank, j to a given country and t to a given year. α_i refers to bank-fixed effects and θ_t to time-fixed effects. The time indices and relationships are identical to those found in Angori, Aristei and Gallo (2019). Control variables include $Y_{j,t}$ and $X_{i,j,t}$, referring to vectors that comprise macroeconomic and bank-specific characteristics, respectively. Note that macroeconomic variables are country/year variables. This includes the main explanatory variable, i.e., the central bank policy rate, which is written as function. This function includes three different specifications for the impact of the policy rate – a linear relationship, a quadratic relationship and the inclusion of levels for the rate, read by dummy variables. The works of Bech and Malkhozov (2016), Borio, Gambacorta and Hoffman (2015), Borio and Gambacorta (2017) and Claessens, Coleman and Donnelly (2017) consider three specific thresholds: low interest rates ($i < 1.25\%$), very low interest rates ($i <$

0.5%) and negative interest rates ($i < 0\%$). This study adopts this notation as well.

Following Angori, Aristei and Gallo (2018), Borio, Gambacorta and Hoffman (2015) and Hansen (2016), and using a dynamic panel regression, we include profitability lagged by one year as an explanatory variable. We can take first-differences of $Eq.1$, eliminating the bank-specific effect, like so:

$$\Delta profitability_{i,j,t} = \theta_t + \beta \Delta profitability_{i,j,t-1} + \boldsymbol{\mu} \Delta \boldsymbol{g}(i_{j,t}) + \boldsymbol{\gamma} \Delta \boldsymbol{Y}_{j,t} + \boldsymbol{\delta} \Delta \boldsymbol{X}_{i,j,t} + \Delta \varepsilon_{i,j,t} \quad (\boldsymbol{Eq.2})$$

The main identification problem that our estimation faces is an endogeneity issue. Firstly, the first difference of the lag of profitability will be correlated with the error term in the period $t-1$. Additionally, a common problem when looking at monetary policy, that is widely addressed in the selected literature, is that monetary policy is most likely endogenous – the state of the banking sector is affected by and can affect monetary policy. If that is the case, then any relationship found between negative policy rates and falling banks' profitability comes from biased estimators, since a deteriorating economy causes both (Angori, Aristei and Gallo, 2019; Borio and Gambacorta, 2017 and Heider, Saidi and Schepens, 2018).

To solve this issue, we estimate $Eq.2$ correcting for endogeneity. We use the generalised method of moments (GMM) estimator for dynamic panel data, similarly to Angori, Aristei and Gallo (2019), Borio, Gambacorta and Hoffman (2015) and Borio and Gambacorta (2017). The instruments used correspond to the first lags of the difference for the explanatory and control variables, as well as the

first lags by themselves. For $\Delta profitability_{i,j,t-1}$, we chose two lags of the same variable to avoid correlation with $\Delta\varepsilon_{i,j,t}$ (Hansen, 2016).

As mentioned in the works of Borio, Gambacorta and Hoffman (2015) and Borio and Gambacorta (2017), the specification of the equation itself may also contribute to mitigating the endogeneity issue – the fact that we look at each bank individually and not at the banking sector in aggregate terms reduces this problem, as the decisions of one particular bank do not have the same influence as the aggregate.

Lastly, robust (or White) standard errors are used, as a way to correct for any possible level of heteroskedasticity in our sample, similarly to what Angori, Aristei and Gallo (2019), Genay and Podjasek (2014) and Heider, Saidi and Schepens (2018) do.

The data collected for this estimation, along with the estimation results, are presented in the following chapter.

Chapter 4
Empirical analysis

We collected data at the individual bank level and at the macroeconomic level. The variables, their measurement and some descriptive statistics are presented below, as well as the results of the empirical analysis and the answer to the research hypotheses posed in Chapter 3.

1. Data[1]

To measure profitability, similarly to the works of Borio, Gambacorta and Hoffman (2015), Claessens, Coleman and Donnelly (2017) and Genay and Podjasek (2014), we use two variables in parallel – net interest margins (NIM) and return on average assets (ROAA). The first is the difference between interest returns and expenses, as a percentage of interest-bearing assets. The second refers to net income as a percentage of average total assets.

The main explanatory variable is a function of the monetary policy interest rates. The interest rate used in this estimation is the policy rate directly dictated by central banks, and not the lending and deposit rates defined by each individual bank, as some authors have chosen to use – this means the policy rate is a macro variable at the central bank's level of decision, varying with country

[1] For more detailed information on each variable, how it is measured and its source, see the Annex.

and year, but not bank, as mentioned in the previous chapter. This approach has its advantages and disadvantages, which will be discussed further ahead; however, it can be said that it adds some specificity to this study in the sense that it allows us to analyse the impact of a central bank's decision directly, instead of looking at the impact it had on rates defined by individual banks, as these are influenced by many other factors other than simply the policy rate itself (Berry et al., 2019 and Siakoulis et al., 2018). This means that we leave room in between a change in the monetary policy rate and banks' profitability for individual banks to set their own lending and deposit rates and volumes based on their specific conditions (e.g. cost structures, access to financing options, market competitiveness, etc).

Regarding the different levels of the policy rate to be included in the third specification, we consider two dummy variables based on the literature review, $divlow$, which takes the value of 1 if the policy rate is positive and equal or below 0.5%, and 0 otherwise; and $dilow$, which takes the value of 1 if the policy rate is between 0.5% and 1.25%, and 0 otherwise. By considering them jointly, we are considering positive interest rates below 1.25%.

The microeconomic data refers to bank-specific characteristics and was extracted from the BankFocus database. It is unbalanced, panel data and comprises 2 050 entities with a time span ranging from 2010 to 2018. This sample is composed of 312 commercial banks, 1 096 cooperative banks and 642 savings banks.

These banks are located in one of 31 countries – namely, the 19 countries belonging to the Eurozone, and 12 other countries outside the Euro Area – Bulgaria, Croatia, Czech Republic, Denmark, Hungary, Poland, Romania, Sweden, the United Kingdom, Norway, Switzerland and Japan. From the 2 183 banks, 1 571 belong to the Eurozone. The countries outside the Euro Area were included in the dataset due to one of two reasons: they are either part of the

European Union or have engaged in negative interest rates in recent years (more precisely, Switzerland, Norway and Japan).

It is also noteworthy that, similarly to Claessens, Coleman and Donnelly (2017), we use unconsolidated data to analyse the impact of an interest rate on the bank in a specific country only, rather than having it disperse over several countries where the bank may operate.

The collected bank-specific variables, which make up the vector X, are total assets ($tassets$), the capital adequacy ratio in accordance with the Basel III regulatory framework ($capitaladq$); the leverage ratio ($leverage$), defined as the ratio between total liabilities and total assets and the dividend pay-out ratio ($divpayout$), defined as the ratio between dividends and net income.

The macroeconomic data within the vector Y was collected variable by variable for each of the aforementioned countries, from databases such as the European Central Bank's annual reports, official press releases, OECD and Eurostat.

The macro variables are defined as follows: $gdppc$ refers to real gross domestic product (GDP) per capita, $hicp$ refers to inflation as measured by the harmonized index of consumer prices (with 2015 as the base, i.e. 2015=100), $hprice$ is the housing price index (again with 2015 as the base, i.e. 2015=100) and $unemployment$ is the average annual unemployment rate.

To clean the data, we started by trimming the two dependent variables, NIM, and $ROAA$, and the variable $tassets$, with a dual-sided cut of 0.5%.

2. Descriptive statistics

The main statistics of the two dependent variables and the remaining nine explanatory and control variables can be found below, in Table 1.

For our sample, the average NIM is positive and approximately 2.028%, while the average ROAA is also positive, but fairly low, at approximately 0.335%. Regarding the remaining variables, we can see that the average policy rate is negative, at -0.009%. Gross domestic product *per capita* is around 37.549 thousand Euros. Inflation is 101.121 on average, slightly above the 2015 benchmark of 100, while housing prices are 107.529 on average, also above the 2015 benchmark. The mean of the unemployment rate is 4.474%. Regarding bank-specific variables, average total assets is 1244.436 million Euros, the average capital adequacy ratio is 19.205%, the average dividend pay-out ratio is 25.557% and the average leverage is 0.900%.

Relatively high differences between the maximum and minimum for variables such as the gross domestic product per capita, unemployment rates and total assets suggest significant differences between the countries and banks under analysis, i.e., a heterogenous sample in cross-sectional terms.

Dependent variables					
	Mean	*Median*	*Standard deviation*	*Minimum*	*Maximum*
NIM (%)	2.028	2.030	0.560	-0.010	6.400
ROAA (%)	0.335	0.250	0.332	-2.240	4.860
Independent variables					
GDP per capita (th EUR)	37.549	34.900	8.618	7.300	81.000
Inflation (2015=100)	101.121	100.400	1.592	96.200	109.000
Housing prices (2015=100)	107.529	107.500	7.324	90.090	131.350
Unemployment (%)	4.474	4.100	1.333	2.200	22.100
Policy rate (%)	-0.009	0.000	0.244	-0.750	1.750
Total assets (M EUR)	1244.436	478.514	2678.340	15.521	28074.270
Capital adequacy (%)	19.205	18.070	6.645	7.020	133.400
Dividend pay-out (%)	25.557	19.850	23.530	-265.700	326.550
Leverage (%)	0.900	0.905	0.038	0.043	0.988

Descriptive statistics for 3211 observations.

Table 1: Main descriptive statistics of the dependent and independent variables.

3. Preliminary analysis

A first analysis of the data allows us to generate Figures 3 and 4.

The relationship between the policy rate and bank profitability as measured by NIMs is a curve, meaning that there may be statistical indication that, when policy rates decrease (increase), net interest margins vary in the same direction, i.e., also decrease (increase), but only when the policy rate is positive. This does not allow us to confirm our first hypothesis, H1, without a restraint on the level of the policy rate. Furthermore, this relationship is not linear. This allows us to confirm the second hypothesis, H2. The lower (higher) the policy rate, the less (more) impact it seems to have on bank profitability, for a non-negative value of that rate. However, if we consider negative policy rate values, the more negative it is, the more it seems to impact bank profitability.

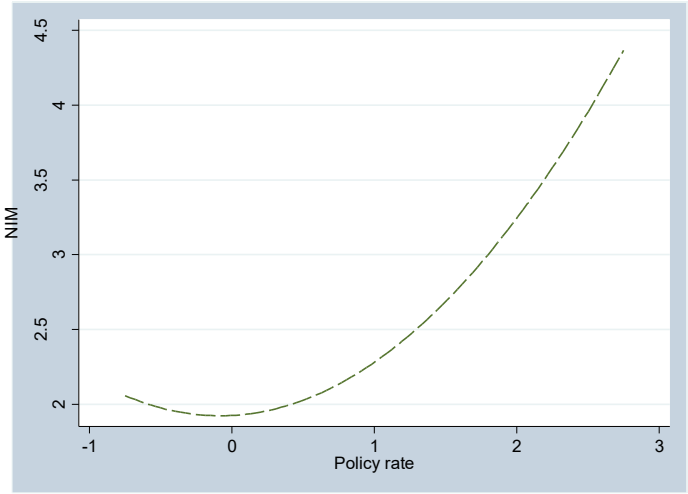

Figure 3: Relationship between the policy rate and NIM.

If, instead, we look at Return on Average Assets (ROAA) as our measure for profitability, we can withdraw the same conclusions. However, the turning point for the relationship when considering this dependent variable is no longer

around 0%, but closer to 0.5%, meaning that the impact of positive, very low interest rates is similar to that of negative interest rates on return on average assets.

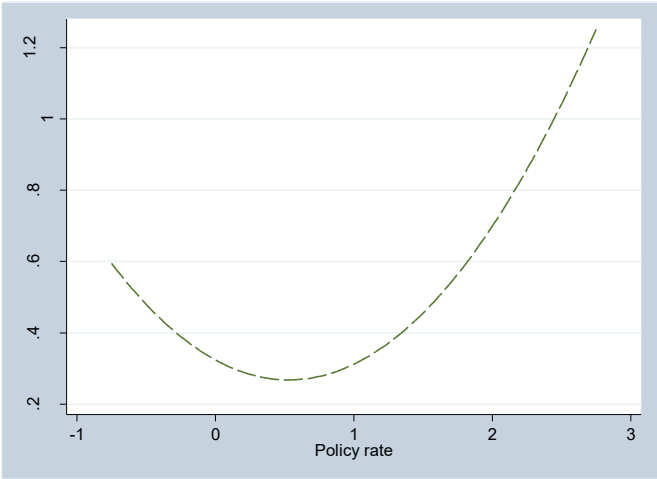

Figure 4: Relationship between the policy rate and ROAA.

These assumed relationships, however, may be biased, as we do not control for any variable. Therefore, we provide a more in-depth analysis of the results obtained, which can be found in the following subsection.

4. Estimation results

The main estimation results can be found in Tables 2 and 3 below – Table 2 refers to estimations using net interest margins as the dependent variable, while Table 3 refers to the same estimation for return on average assets.

Specification (I) tests a linear relationship between the policy rate and bank profitability. Specification (II) includes the squared value of that rate in the

equation, transforming the equation into a quadratic, non-linear one. Finally, specification (III) includes the dummy variables mentioned previously, which refer to low levels of the policy rate, i.e., equal or below 1.25% and 0.5%. These dummy variables are included together as an interaction term with the policy rate.

Considering net interest margins and taking into account the first specification, we can conclude that there is an estimated negative relationship between the policy rate and bank profitability, statistically significant at the 1% level, all else held constant. This leads us to reject our first hypothesis, H1. As for the macroeconomic variables, we estimate that an increase in the unemployment rate will lead to a decrease in bank profitability, with a 5% level of significance, which is aligned with the results found by other authors in the literature review, in the sense that favourable macroeconomic conditions were estimated to positively impact bank profitability, and vice-versa. The remaining macroeconomic variables are not statistically significant. As for bank characteristics, there are two interesting, and statistically significant at the 1% significance level, results: total assets and leverage ratios both are estimated to negatively affect net interest margins. However, we performed an overidentification test (Hansen's J) – a coefficient which is significantly different from zero could represent either the invalidity of a chosen instrument, or structural misspecification of the equation; in specification I, we cannot rule out this possibility. One possible explanation is that the considered linear relationship does not fit the values.

For the same dependent variable, we can now take a look at the second specification, which now reports a quadratic, non-linear form. The overall impact of the policy rate on bank profitability is now positive (more specifically, 1691.425), and statistically significant at the 1% level. This is in line with what we observed in the previous subsection, in Figure 3 – the impact of the policy rate

on net interest margins will be positive (i.e., an increase in the policy rate will lead to an increase in net interest margins, all else held constant) from a certain level of the interest rate onwards (this level is estimated to be 0.00023%). This allows us to partially confirm our first hypothesis, H1, conditioned on the level of the interest rate, and confirm our second hypothesis, H2. Regarding the remaining explanatory variables, there was no change in the significant coefficients. Another point to make is regarding Hansen's test – indeed, we can now safely reject any form of misspecification or invalidity of instruments in the equation, for any significance level. This can confirm the previously made supposition that the issue was considering a linear form for the estimation.

Regarding the third and last specification, we included two levels for the policy rate by including the presented dummy variables. By summing them and interacting them with the level of the policy rate, we aim to find whether there is a difference in the impact of the policy rate on profitability when considering low, but non-negative, rates. The coefficient for this term is positive, 0.158, which would indicate that, when interest rates are between 0% and 1.25%, i.e., when they are low, the impact on bank profitability as measured by net interest margins is estimated to be higher than when we consider rates outside this interval. However, we cannot make this inference, as the coefficient is not statistically significant. Regarding the remaining significant variables, the signs present no change when compared to specification (II).

Considering now the results present in Table 3, regarding the second measure for profitability, return on average assets, and specification (I), we can take a similar conclusion regarding the impact of the policy rate on bank profitability, compared to the one we took from specification (I) for the first dependent variable. We estimate that an increase in the policy rate leads to a decline in return on average assets, thus rejecting H1. In terms of macroeconomic controls, we do not find statistical significance for any of the variables. In terms of

microeconomic variables, however, we conclude that the dividend pay-out ratio and leverage both have a negative impact on profitability, statistically significant at the 1% level. Bank dimension, as measured by total assets, seems to have a positive impact on return on average assets – which is opposite to what we found for net interest margins.

When we move on to specification (II), the quadratic form of the policy rate is high, positive and statistically significant at the 1% significance level, which allows us to confirm the non-linearity of the relationship between the rate and return on average assets; having said that, the coefficient for the policy rate is negative, which would mean we could draw the same conclusions that we did for net interest margins, but this coefficient is not statistically significant. Regarding the remaining control variables, there is no change compared to the previous specification.

Finally, considering the third specification, we face a similar situation to the one for net interest margins, as the coefficient for the interaction between the policy rate and the sum of the two dummies is not statistically significant.

Overall, for both dependent variables, the non-linearity assumption seems to be important, so the introduction of the quadratic form of the policy rate is key, but the inclusion of the policy rate level is not statistically significant for any specification. Therefore, the preferred specification is (II). When considering net interest margins as the way to measure bank profitability, we can confirm H2, and partially confirm H1 – as interest rates increase, bank profitability increases as well, which is in accordance with the literature review; however, we only find that this is true for a certain value of the policy rate onwards, which is very close to zero. For lower values, the relationship is exactly the inverse. For return on average assets, the results are less significant and harder to read, allowing us to confirm H2 only.

Dependent variable: Net Interest Margin (NIM)			
Explanatory variables	Linear (I)	Quadratic (II)	Level of rate (III)
$\boldsymbol{NIM_{ij,t-1}}$	0.746***	0.749***	0.743***
	(0.112)	(0.113)	(0.113)
$\boldsymbol{i_{jt}}$	-0.357***	-0.389***	-0.378**
	(0.114)	(0.107)	(0.115)
$\boldsymbol{i_{jt}^2}$		845.907*	1038.508**
		(454.869)	(486.575)
$\boldsymbol{i_{jt} * (divlow + dilow)}$			0.158
			(0.132)
$\boldsymbol{gdp_{jt}}$	0.035	0.012	-0.005
	(0.052)	(0.043)	(0.046)
$\boldsymbol{hprice_{jt}}$	-0.007	-0.005	-0.009
	(0.007)	(0.007)	(0.013)
$\boldsymbol{hicp_{jt}}$	0.005	0.014	-0.046
	(0.020)	(0.019)	(0.053)
$\boldsymbol{unemployment_{jt}}$	-0.083**	-0.069**	-0.052
	(0.033)	(0.034)	(0.036)
$\boldsymbol{capitaladq_{ijt}}$	-0.001	-0.002	-0.001
	(0.003)	(0.004)	(0.004)
$\boldsymbol{divpayout_{ijt}}$	0.001	-0.001	-0.001
	(0.003)	(0.004)	(0.001))
$\boldsymbol{leverage_{ijt}}$	-1.935***	-1.990***	-2.094***
	(0.355)	(0.348)	(0.367)
$\boldsymbol{\log tassets_{ijt}}$	-0.320***	-0.345***	-0.349***
	(0.095)	(0.099)	(0.099)
Exogeneity test	123.035***	126.515***	137.459 ***
Hansen test	11.842*	10.107	8.343

The model is estimated using the dynamic Generalised Method of Moments (GMM) panel methodology. There are 3211 observations. Robust standard errors are presented in parentheses. *** p<0.01, ** p<0.05, * p<0.1. The variables considered endogenous are profitability lagged by one period, the policy rate and the price-macro variables, i.e., $\Delta\boldsymbol{gdp_{jt}}$, $\Delta\boldsymbol{hprice_{jt}}$ and $\Delta\boldsymbol{hicp_{jt}}$. The instruments for these variables are $\boldsymbol{NIM_{ij,t-2}}$ and the first lag of the remaining endogenous variables (first lag of the first difference), as well as the first lag of those variables by itself. The exogeneity test allows us to conclude that the variables considered endogenous are, in fact, not exogenous for any of the specifications considered, for any level of significance. A significant Hansen test could represent either an invalid instrument or misspecification. We can conclude for no misspecification for any significance level in II and III, although we cannot reject misspecification for 1% significance level in I.

Table 2: Estimation results for the dependent variable NIM.

Dependent variable: Return on Average Assets (ROAA)			
Explanatory variables	Linear (I)	Quadratic (II)	Level of rate (III)
$\boldsymbol{ROAA_{ij,t-1}}$	0.294*	0.413**	0.485**
	(0.176)	(0.191)	(0.214)
$\boldsymbol{i_{jt}}$	-0.330**	-0.139	-0.147
	(0.158)	(0.133)	(0.135)
$\boldsymbol{i_{jt}^2}$		1647.023***	1818.23***
		(615.673)	(639.537)
$\boldsymbol{i_{jt} * (divlow + dilow)}$			-0.196
			(0.212)
$\boldsymbol{gdp_{jt}}$	0.022	0.047	0.080
	(0.064)	(0.063)	(0.078)
$\boldsymbol{hprice_{jt}}$	-0.003	0.005	-0.010
	(0.008)	(0.009)	(0.019)
$\boldsymbol{hicp_{jt}}$	-0.003	-0.010	0.062
	(0.027)	(0.025)	(0.082)
$\boldsymbol{unemployment_{jt}}$	-0.080	0.014	0.0001
	(0.052)	(0.055)	(0.059)
$\boldsymbol{capitaladq_{ijt}}$	0.004	0.001	0.003
	(0.006)	(0.005)	(0.006)
$\boldsymbol{divpayout_{ijt}}$	-0.003***	-0.004***	-0.004***
	(0.001)	(0.001)	(0.001)
$\boldsymbol{leverage_{ijt}}$	-3.483***	-3.391***	-3.326***
	(1.065)	(1.040)	(1.163)
$\boldsymbol{\log tassets_{ijt}}$	0.278**	0.126*	0.188***
	(0.114)	(0.126)	(0.138)
Exogeneity test	19.754***	27.495***	29.701 ***
Hansen test	10.847*	14.237**	13.167**

The model is estimated using the dynamic Generalised Method of Moments (GMM) panel methodology. There are 3211 observations. Robust standard errors are presented in parentheses. *** p<0.01, ** p<0.05, * p<0.1. The variables considered endogenous are profitability lagged by one period, the policy rate and the price-macro variables, i.e., $\Delta\boldsymbol{gdp_{jt}}$, $\Delta\boldsymbol{hprice_{jt}}$ and $\Delta\boldsymbol{hicp_{jt}}$. The instruments for these variables are $\boldsymbol{ROAA_{ij,t-2}}$ and the first lag of the remaining endogenous variables (first lag of the first difference), as well as the first lag of those variables by itself. The exogeneity test allows us to conclude that the variables considered endogenous are, in fact, not exogenous for any of the specifications considered, for any level of significance. A significant Hansen test could represent either an invalid instrument or misspecification. We cannot reject misspecification for 1% significance level in I, nor in II and III for a 5% significance level.

Table 3: Estimation results for the dependent variable ROAA.

Conclusion

As many modern economies delve in an environment characterized by expansionary monetary policy, with lowering policy interest rates, it becomes imperative to look at what effect, if any, this has on bank profitability. A literature review may lead us to conclude that this issue has not been standardized in empirical terms, and that no firm, unequivocal relationship has been found between the variables.

This work's findings are somewhat in line with what authors such as Bech and Malkhozov (2016), Borio and Gambacorta (2017), Claessens, Coleman and Donnelly (2017), Heider, Saidi and Schepens (2018) and Jobst and Lin (2016) have found in their research. For our sample, which analyses mainly European, but also Japanese banks, we find that, as the policy rate decreases, profitability measured by net interest margins and return on average assets decreases as well, but only for a certain level of the interest rate onwards. We find evidence that the relationship is not a linear one – for low, near zero interest rates, we estimate that the policy rate and bank profitability vary in opposite directions.

This can be attributed to a number of reasons. It may be argued that deposit rates are not that sticky and actually go down after a decrease in the policy rate, as banks might be able to pay out very low or negative rates on deposits since these are generally preferred by the public to cash-forms of liquidity. Additionally, banks are able to increase the volume of loans even in face of a decrease in the loan rate, meaning that interest income does not necessarily go

down. These two effects combined might indicate that, even in the presence of negative policy rates, banks have the ability to generate positive interest margins.

It is also interesting to note that, surprisingly, macroeconomic controls did not seem to be significant in our estimation, apart from the unemployment rate in some situations. Bank controls, on the other hand, are significant, namely the leverage ratio and the dimension of the banks, and also the dividend pay-out ratio when considering return on average assets. This indicates that individual banks can have an impact on their profitability which goes beyond the macroeconomic policy which is dictated externally to them, by adjusting factors over which they have control.

These result can lead up to a few implications. The most important one refers to the way central banks conduct monetary policy. Central banks aim to ensure the health of the financial system alongside their main policy goals. If lowering interest rates shows evidence of also lowering profitability for the majority of banks, it can be argued that this may lead to a decay in the health of the financial system, as low profit in the long run can lead to the erosion of lending, contraction of banks' assets and balance sheets and even an increase in risk-taking (Heider, Saidi and Schepens (2018). Additionally, low profitability represents a challenging situation for banks, as they must aim at achieving a higher degree of income diversification, so as to not rely so heavily on loan-deposit margins. This may require deep structural, technological and managerial changes. Furthermore, the transmission of monetary policy itself may be hindered. If banks' lending and deposit rates are not responsive to the central bank's policy rate, then monetary authorities will see the usual channels of transmission of their policy blocked and their efforts to influence savings and investment patterns rendered ineffective, or at least less effective (Angori, Aristei and Gallo, 2019; Berry et al., 2019; Borio and Gambacorta, 2017 and Siakoulis et al., 2018).

This work has some important limitations that may hamper results and provide guidance for further research. The main issue is the data collected, as there is limited data available for some banks and some specific variables, with omitted observations. Data regarding bank-specific characteristics related to their accounting statements is also fairly exposed to mistakes in input. Furthermore, the inclusion of other control variables may improve the study, such as banks' liquidity ratios, accounting standards – as regulatory settings can be extremely varied across economies – and the shape of the yield curve.

Additionally, it can be argued that what brings specificity to the study can also be a problem – namely, the choice of the variable to use as the policy rate. This study uses the policy rate directly set by the central bank, as opposed to what some other authors have done by using bank-specific rates, namely, loan and deposit rates chosen as a response to changes in those policy rates. While using a macro rate guarantees a "cleaner" look at the root of the monetary policy change, instead of looking at a variable that is already affected by bank-specific factors, the advantage of using bank-specific rates is precisely that these change with the bank, country and year, as opposed to changing with only the country and year, as central bank rates do – i.e., they provide more variability in the observations. This may be better for estimation purposes.

Further study could include a wider range of countries, including perhaps other large economies such as the United States, as well as an analysis using updated data for negative rates separately. We found evidence, as other authors have also previously studied, that negative interest rates show results that are vastly different from those reported for non-negative rates. Therefore, an in-depth analysis of this particular situation could be of interest.

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Annex

Definition of variables:

Variable	Description	Unit	Source
nim	Net interest margin. Difference between interest income and expense, weighted by average earning assets.	%	BankFocus database
$roaa$	Return on average assets. Net income weighted by average total assets.	%	BankFocus database
i	Monetary policy interest rate	%	ECB annual reports 2010-2016; 2017 and 2018 policy press release; BIS Statistics; Bulgarian National Bank statistics
$divlow$	Dummy variable. Takes the value 1 if $0\% \geq i \geq 0.5\%$, 0 otherwise.	-	-
$dilow$	Dummy variable. Takes the value 1 if $0.5\% > i \geq 1.25\%$, 0 otherwise.	-	-
$gdppc$	Real Gross domestic product per capita	Thousand Euros per capita	Eurostat; Worldbank
$hprice$	Housing prices	Annual average index, 2015=100	Eurostat; OECD
$hicp$	Harmonised index of consumer prices; inflation	Annual average index, 2015=100	Eurostat; OECD
$unemployment$	Unemployment rate. Ratio between the number of unemployed people and the labour force.	%	Eurostat; OECD
$capitaladq$	Capital adequacy ratio. Ratio between the sum of Tier 1 and Tier 2 capital and risk weighted assets.	%	BankFocus database

divpayout	Dividend pay-out ratio. Ratio between dividends and net income	%	BankFocus database
leverage	Leverage ratio. Ratio between total liabilities and total assets	%	BankFocus database
tassets	Total assets	Million EUR	BankFocus database