LISBON SCHOOL OF ECONOMICS & MANAGEMENT
UNIVERSIDADE DE LISBOA

MASTER

MONETARY AND FINANCIAL ECONOMICS

MASTER'S FINAL WORK

DISSERTATION

NEGATIVE INTEREST RATE POLICY AND BANK RISK-TAKING: EVIDENCE FROM THE PORTUGUESE BANKING SECTOR

TELMA ALEXANDRA ALVES FRUTUOSO

NOVEMBER 2020

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SUPERVISION:

PROFESSOR DOUTOR JORGE BARROS LUÍS

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Negative Interest Rate Policy and Bank Risk-Taking: Evidence from the Portuguese Banking Sector

Telma Frutuoso

November 2020

Abstract:

This dissertation aims to assess the impact of the Negative Interest Rate Policy (NIRP), followed by the ECB, on the Portuguese banks' risk-taking, using a panel data approach. We studied an unbalanced panel data set Portuguese banks over the period spanning from 2010 to 2018 by using a dynamic model. To perform the analysis, we use as a *proxy* of bank risk-taking the Z-score and non-performing loans (NPLs). We found a reduction in the risk-taking, related to a decrease in the level of interest rates, i.e., a 1% decrease in the level of interest rates causes a decrease in the level of Z-score and NPLs, of 2.34% and 11.4%, respectively.

KEYWORDS: Unconventional Monetary Policy, Financial Stability, Negative Interest Rates Policy, Bank Risk-Taking.

JEL CODES: C33, E43, E52, E58, G21

Negative Interest Rate Policy and Bank Risk-Taking: Evidence from the Portuguese Banking Sector

Telma Frutuoso

Novembro 2020

Resumo:

Esta dissertação tem como objetivo avaliar o impacto da Política de Taxa de Juros Negativa (NIRP), seguida pelo BCE, na assunção de risco dos bancos portugueses, através de uma abordagem de dados em painel. Realizamos a análise através de uma abordagem de dados em painel desequilibrado, para os bancos Portugueses no período entre 2010 e 2018, através de um modelo dinâmico. Para realizar a análise, foi usado como *proxy* da assunção de risco bancário, a variável Z-score e non-*performing loans* (NPLs). Reportamos uma redução na assunção de riscos relacionada com a diminuição do nível de taxas de juro, i.e. 1% de diminuição no nível de taxas de juro, provoca uma descida no nível do Z-score e de NPLs de 2.34% e 11.4%, respetivamente.

PALAVRAS-CHAVE: Política Monetária não convencional, Estabilidade Financeira, Política Taxa Juros Negativa, Risco Bancário.

JEL CODES: C33, E43, E52, E58, G21

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> Negative (policy) rates were introduced for one specific reason: when interest rates reached the zero-lower bound, the expectations for the future rates in the long term are only that the rates can go up. So, with negative rates we were useful in taking these expectations down.
>
> In Draghi (2016)

1. INTRODUCTION

The 2007-2009 Global Financial Crisis (GFC) and the European sovereign debt crisis that followed have forced a growing number of central banks to implement a set of unconventional monetary policy measures. These unprecedented measures were aimed to restore economic growth and stabilize inflation expectations. On June 5, 2014, the Governing Council of the European Central Bank (ECB) have decided to cut one of the official interest rates, the deposit facility rate (DFR)[1] to -10 basis points[2]. Following other central banks as Danmarks Nationalbank (DNB), Swiss National Bank (SNB), and the Sveriges Riksbank (SR).

The adoption of negative rates, commonly labeled as Negative Interest Rate Policy (NIRP), along with other non-standard policy measures, as target long-term refinancing operations (TLROs), asset purchase programme (APP), and forward guidance, aims to provide additional monetary stimulus, due to the challenging macroeconomic environment.

Since the last decade, the ECB has been used the negative rates as an essential instrument of its unconventional monetary policy, aiming to promote the inflation target and boost economic growth. This new paradigm challenges the z*ero-lower bound* (ZLB) assumption, and so far, several questions remain unclear. What are the implications of negative rates for the banking system and financial stability?

In the last years, there was increasing literature exploring the existence of a different transmission mechanism of monetary policy, the so-called *risk-taking channel* (Borio & Zhu, 2008; Adrian & Shin 2008; 2010a and b). The reasoning behind the risk-

[1] The DFR is the rate that banks may use to the overnight deposits with the Euro system.

[2] The ECB monetary policy decision was to decrease the key interest rates, the interest rate on the main refinancing operations (MRO) by 10 basis points to 0,15%; the interest rate on the marginal lending facility by 35 basis points to 0,40%, and the DFR by 10 basis points to -0,10%, on 11th June of 2014. Then, other cuts followed on the DFR, on 10th September of 2014 to -0,20%, 09th December of 2015 to -0,30%, 16th March of 2016 to -0,40%, and 18th September of 2019 to -0,50%. Figure 11 illustrates the cuts on the DFR.

taking channel is that under low-interest rates, banks may have an incentive to increase their risk appetite.

Since the onset of the financial crisis that the relationship between monetary policy and the financial system, has been brought to the forefront of the academic debate. Understanding the transmission mechanisms of the monetary policy below the ZLB is essential to identify the potential side-effects of monetary policy and its impacts on financial stability.

Recently, some empirical studies have pointed out some of the implications of the NIRP on the banking system and financial stability, regarding the potential adverse effects of negative rates, namely on profitability and risk-taking (Scheiber *et al.* 2016). However, there is scant evidence that reflects the increase in risk-taking under negative rates (Bongiovanni *et al.* 2019; Boungou, 2019).

Following this, this dissertation aims at studying the effect of negative rates on Portuguese banks' risk-taking. We want to assess whether negative rates have encouraged the Portuguese banks to incur additional risk-taking. To do so, we studied an unbalanced panel data set of Portuguese banks over the period spanning from 2010 to 2018 by using a dynamic model. To perform our analysis, we use as a *proxy* of bank risk-taking the Z-score and Non-Performing Loans (NPLs).

In order to assess the impact of the level of interest rates on risk-taking, the present study uses the generalized method of moments (GMM) developed by Arellano & Bond (1991). According to our empirical results, we found that during the period under analysis the Portuguese banks experienced a decrease in risk-taking.

The remainder of the dissertation is organized as follows. Section 2 describes the background of monetary policy and bank risk-taking, and the institutional context of the Portuguese banking sector. Section 3 addresses the most relevant literature and a final remark of the contribution of this dissertation to the literature. Section 4 explains the methodology used to perform the analysis. Section 5 summarizes the data. Section 6 presents the empirical results. Section 7 concludes.

2. BACKGROUND

2.1. MONETARY POLICY AND BANK RISK-TAKING

In the aftermath of the GFC, several central banks have been forced to implement a set of unconventional monetary policy measures, adopted again to tackle the impacts of the pandemic Covid-19. Since the onset of the financial crisis that there has been an increased concern regarding financial stability issues and the nexus between monetary policy and financial stability was brought to the forefront of the academic debate.

The overly low-interest-rate environment experienced after the dotcom bubble in the late nineties, among other relevant factors, as financial innovation and the deregulation of the financial sector had been contributing to the build-up of the financial crisis. The accommodative monetary policy and the low-interest rates environment favored the increased leverage in the financial system.

One of the avenues of research in the literature has focused on the transmission mechanism of monetary policy through the banks' risk-taking behavior, the so-called risk-taking channel (Borio & Zhu, 2008; Adrian & Shin, 2008, 2010a and b). Borio & Zhu (2008), in their paper, draw attention to the relantionship between monetary policy and the perception and pricing or risk by economic agents, which they labeled as the risk-taking channel of monetary policy.

The literature on the risk-taking channel has flourished, with several empirical studies setting forth a negative relationship between the level of interest rates and bank risk-taking (Delis & Kouretas, 2010). The reasoning is that in a low-interest-rate environment, banks tend to increase their risk profile.

Nicolò *et al.* (2010) suggest that risk measures are usually neglected in macroeconomic models since these usually focus on the quantity of credit rather than the quality of credit.

The existing literature on the risk-taking channel has been expanding over the past years, with several authors focusing on the transmission mechanisms through which the risk-taking channel operates. The empirical studies suggest two main channels. Firstly, due to the *search-for-yield* effect (Rajan, 2005; Taylor, 2009) that occurs through the asset side of the banks' balance sheet. The decrease in interest rates leads to a sticky rate of returns, and increases risk-taking behavior (Dell'Ariccia *et al.* 2010). Secondly, through the liability side of the balance sheet. The low-interest-rates environment affects

income, valuations, and cashflows. Lower interest rates boost asset and collateral valuations, as incomes and profits, resulting in a decrease in risk perception (Borio & Zhu, 2008; Altunbas *et al.* 2010).

There were relevant empirical contributions to the literature that evidence the existence of the risk-taking channel. Gambacorta (2009) studied an extensive database of European Union (EU) countries and the United States (US), whose results are consistent with the risk-taking channel. These results show that in a low-interest-rate environment over a prolonged period, asset and collateral valuations are affected, while the banks' expected default frequency (EDF) tends to increase.

Jiménez *et al.* (2014) analyzed an extensive database of Spanish credit institutions and concluded that when interest rates are lower, banks soften their lending standards and increasing their loans to *ex-ante* risky borrowers. The results are more acute for less capitalized banks. Bonfim & Soares (2014) use a unique loan-level of Portuguese banks dataset and found that banks are more willing to grant loans to riskier borrowers in periods of low interest rates, and those loans are more likely to default. In the medium term, higher risk-taking can cause a deterioration of banks' asset quality.

Using a Bolivian loan database, Ioannidou *et al.* (2009) concluded that a reduction in the level of interest rates caused excess risk-taking. The authors' main results show that under accommodative monetary policy rates, banks have raised their risk-appetite, but they did not seem to price it properly. The decrease in interest rates increased the probability of a default of the individual banks. Moreover, the spread applied to these loans surprisingly decreased in response to additional risk.

Altunbas *et al.* (2010) analyzed the link between short-term interest rates and bank risk by using quarterly balance sheet information for listed banks in the EU and the US, covering a total of sixteen countries. The results show that over an extended period of unusually low interest rates, there is an increase in bank risk-taking. Besides the effect of monetary policy transmission, they include other possible variables affecting the risk-taking behavior, as bank-specific characteristics (size, liquidity, level of capitalization, lending portfolios and profitability), macroeconomic factors, (GDP, housing and equity prices, the slope of the yield curve) and institutional characteristics at a national level, i.e. level of competition, risk appetite, and regulation requirements.

Maddaloni & Peydró (2011) used data from banking lending surveys (BLS) in the Euro Area and the US, concluding that low short-term interest rates are related to a softening in banks' lending standards. Moreover, the results are more pronounced in banks where there is higher securitization activity and weak bank capital supervision, being the results statistically more significant for short than long-term interest rates.

Paligorova & Jimenez (2012) show that banks apply lower spreads to riskier borrowers in an environment of lower short-term interest rates.

The concept of the risk-taking channel is broadly supported by the empirical studies in the existing literature. Under the new paradigm of low or even negative rates, the adverse effects of an accommodative monetary policy could pose significant risks to the soundness of the financial system. In which regards, the supervisory and macroprudential authorities should pay significant attention to the impacts of monetary policy transmissions mechanisms to mitigate the adverse effects on the real economy. "Understanding how negative nominal interest rates affect the economy is important in preparing for the next economic downturn" (Eggertsson *et al.* 2019).

2.2. PORTUGUESE BANKING SECTOR

> Financial intermediation is an important component of economic growth, a strong and resilient banking system is the foundation for sustainable economic growth, as banks are at the center of the credit intermediation process between savers and investors.
>
> In Bank for International Settlements (BIS, 2011)

The Portuguese banking sector environment presents some particularities, being relevant to analyze which events have contributed to its development over the past decades.

Overall, in June of 2019, according to the Portuguese Banking Association (APB), the principal representative of the Portuguese banking sector, representing over 90% of total assets, the banking system was composed of 152 credit institutions (CI), compressing 62 banks, 86 agriculture savings & loans institutions (*caixas de crédito agrícola mútuo*), and 4 savings and loans (*caixas económicas*).

The banking sector represents the total volume of assets of EUR 398.1 billion, representing 191.9% of the total GDP, with 4.023 branches and 46.339 employees. In

terms of total aggregate assets, the five largest institutions held 87.1% share of the total market. Based on the Herfindahl-Hirschman Index (HHI), which is a measure of market concentration and was calculated according to the ECB guideline on monetary and financial statistics (ECB/2014/15), [3] the Portuguese banking sector is moderately concentrated, with an index value of 1,477[4] (APB, 2018).

Over the past decades, several political and institutional events have shaped the development of the Portuguese banking sector. After the 1974 Revolution, the newly-elected government decided to nationalize all Portuguese banks and insurance companies through the Decree-Law no. 135-A/75 of 15th March. Only in 1986, as a result of the integration in the European Economic Community, the Portuguese economy experienced a process of intense economic liberalization. In the banking sector, several reprivatizations occurred (Lima & Soares de Pinho, 2008). This period of intense financial liberalization corresponded to the period where several nationalizations were reverted.

The banking sector was one of the most prosperous sectors of the Portuguese economy in the 1990s. Since 1990, we have seen an increase in the concentration of the banking sector, measured by the HHI. Particularly in the years of 1995 and 2000, when occurred the following acquisitions:

- 1995 - the acquisition of Banco Português do Atlântico by Banco Comercial Português (BCP);
- 2000 - the acquisitions of Banco Pinto & Sotto Mayor and Banco Mello by BCP, the Banco Totta & Açores (BTA) and Crédito Predial Português (CPP) by Santander, and Banco Chemical by Caixa Geral de Depósitos (CGD), (Banco de Portugal, 2019).

[3] The Herfindahl-Hirschman Index is obtained by summing up the squares of the market shares of all the CI in the banking sector, and is reported in accordance with the following formula:

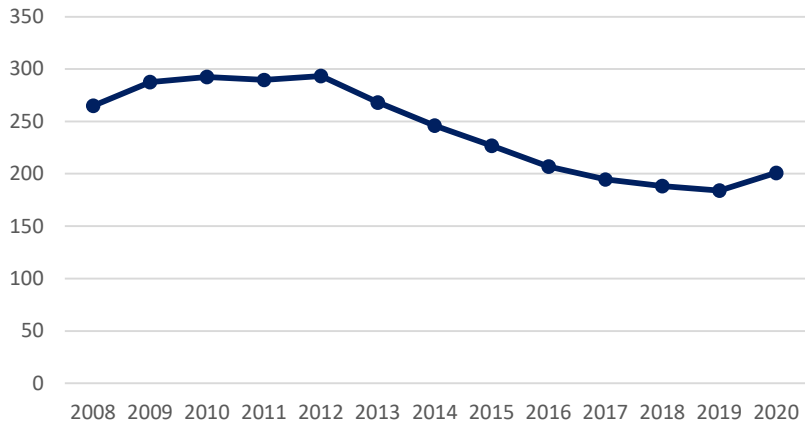
$HHI = \sum_{i=1}^{n} \left(\frac{X_i}{X}\right)^2$,

where n is the number of CIs in the country, X_i represents the total assets of CI_i and $X = \sum_{i=1}^{n}$ and represents the total assets of all CIs.

[4] Generally, the Index values below 1.000 denote low concentration, between 1.000 to 1.800 denote moderately concentrated, and above 1.800 is highly concentrated (APB, 2018).

The aforementioned acquisitions converted the Portuguese banking system into one of the most concentrated in the European Union, with three "big banks" owning over half of the market share (Boucinha & Ribeiro, 2007). In the period spanning from 2009 to 2012, the sector experienced an expressive growth, the total volume of assets representing almost 300% of GDP (Banco de Portugal, 2019). However, since 2012 that the total assets as a proportion of GDP have been steadily decreased, as illustrated in Figure 1.

Figure 1: Total assets to GDP (%)



Source: Banco de Portugal. Calculations by the author.

Following the GFC, the European sovereign debt crisis, has evidenced the vulnerabilities of the Portuguese economy, mostly due to the high level of indebtedness of both the public and the private sectors (Banco de Portugal, 2014). In 2011, the Portuguese banks, as well as the Portuguese government, could not access financing on the financial markets. Public and private financing was significantly restricted, because of an unbearable increase in the cost of debt. In May 2011, Portugal was "forced" to request external assistance, which gave origin to the Economic and Financial Assistance Programme (EFAP), signed between the Portuguese Government, the EU, and the International Monetary Fund (IMF). The EFAP were aimed at restoring the confidence of the financial markets and promote sustainable economic growth. The EFAP was based on three main pillars: structural adjustment of the Portuguese economy, fiscal

consolidation, and the stability of the financial system. Under the programme, Portugal got a total amount of financing of EUR 78 billion, in which EUR 12 billion was allocated to the Bank Solvency Support Facility (BSSF).

In the years before the EFAP, and during the programme, several institutions were intervened. In 2008, triggering a criminal investigation, Banco Português de Negócios was nationalized and integrated into the CGD group; in 2010, Bank of Portugal ordered the liquidation of the Banco Privado Português, also motivating several accusations of financial crimes. Under the EFAP, between 2011 and 2014, several recapitalizations occurred, namely, in CGD, BCP, BPI, and Banco Internacional do Funchal (Banif).

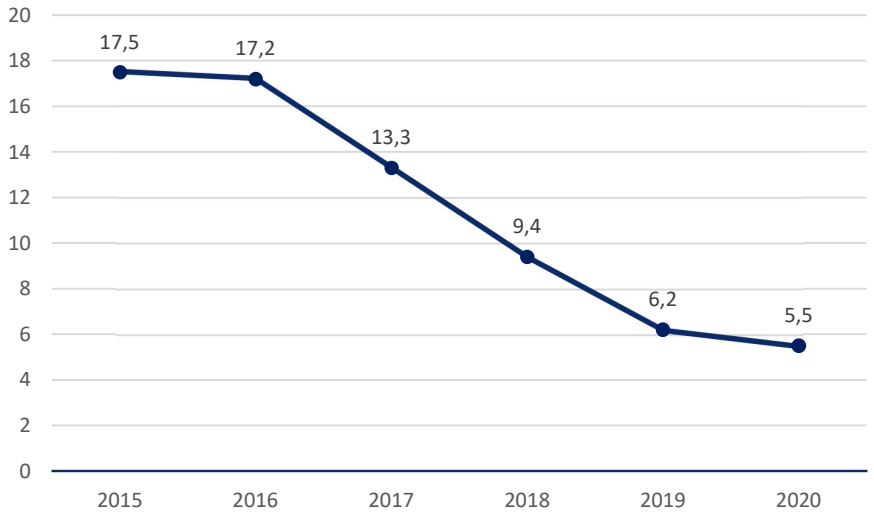
In 2014, the resolution of Banco Espírito Santo, classified by the ECB as a significant CI,[5] led to the creation of a transition bank, Novo Banco. In the following year, Banif's resolution and the acquisition of its commercial network by Santander Totta occurred. These two resolutions involved initial public funds injections of EUR 4.3 million and EUR 2.25 million, respectively.

The EFAP unleashed an intense adjustment process of the banking sector to correct the financial imbalances created in the years before the crisis. Thenceforth, the main financial indicators have shown a favorable evolution. The banking sector became more resilient by making significant improvements in terms of efficiency, liquidity, assets' quality, profitability, and solvency (APB, 2019).

In a nutshell, analyzing some financial indicators, the NPLs ratio has followed a downward trend, in line with the guidelines and plans for reducing non-performing assets submitted to the supervisory authorities. Figure 2 illustrates the NPLs ratio evolution.

[5] The significant credit institutions are directly supervised by the ECB. The Council Regulation (EU) No 1024/2013 of 15 October 2013 confers to the ECB specific tasks concerning the prudential supervision of credit institutions.

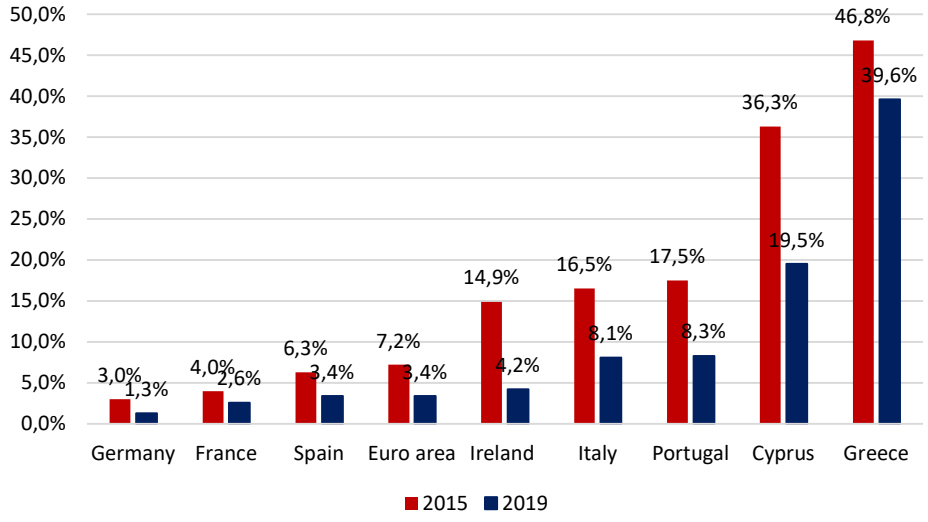
Figure 2: NPLs evolution (%)



Source: Banco de Portugal. Calculations by the author.

Since 2015, the reduction of NPLs reached EUR 27 billion, but despite the progress achieved, the ratio remains one of the highest when compared with the European countries (Banco de Portugal, 2019). Figure 3 shows the evolution of the NPLs ratio in the EU. From December 2015 to June 2019, the NPL ratio decreased by 3,8% in the EU and 9,2% in Portugal.

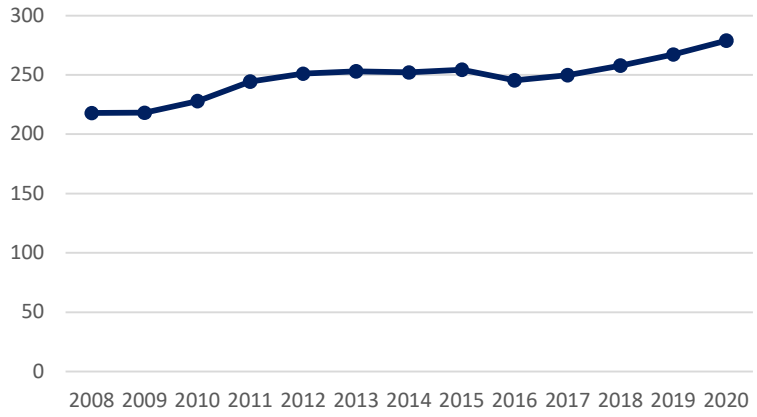
Figure 3: NPL evolution in the EU



Source: Banco de Portugal. Calculations by the author.

The funding obtained from the ECB has been decreasing steadily since 2012, with the increasing reliance on customers' deposits. Figure 4 shows the evolution of deposits from customers from 2008 until the second quarter of 2020, which represents EUR 279 billion.

Figure 4: Deposits from customers (€Bn)



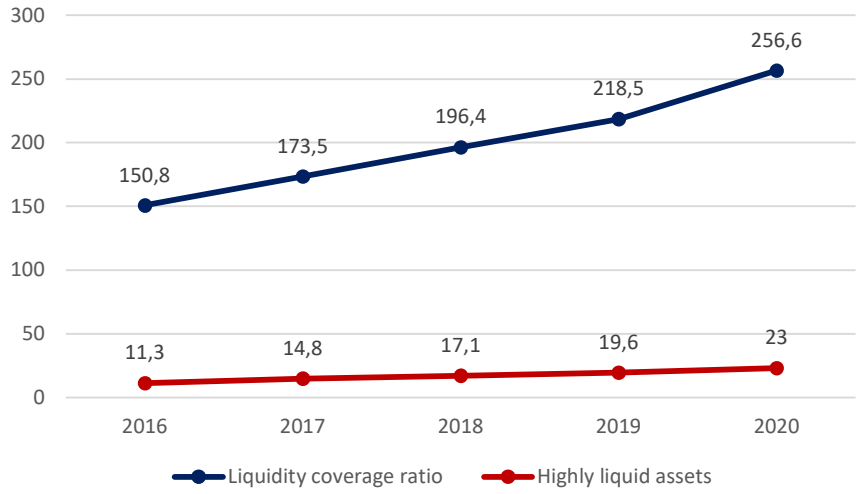
Source: Banco de Portugal. Calculations by the author.

The liquidity indicators also present comfortable levels, with the liquidity coverage ratio (LCR)[6] showing an upward trend, represents 256,6% in 2020, Figure 5 shows its evolution. Figure 5 also illustrates the evolution of high-quality liquid assets (HQLA)[7], which has been increasing since 2016.

[6] Calculated according to the stock of HQLA, divided by the total net cash outflows for a 30 days liquidity stress scenario (Banco de Portugal , 2020).

[7] Corresponds to the amount of liquid assets held by credit institutions that satisfy requirements set in the Commission Delegated Regulation (EU) 2015/61 of 10 October 2014, as a percentage of total assets (Banco de Portugal , 2020).

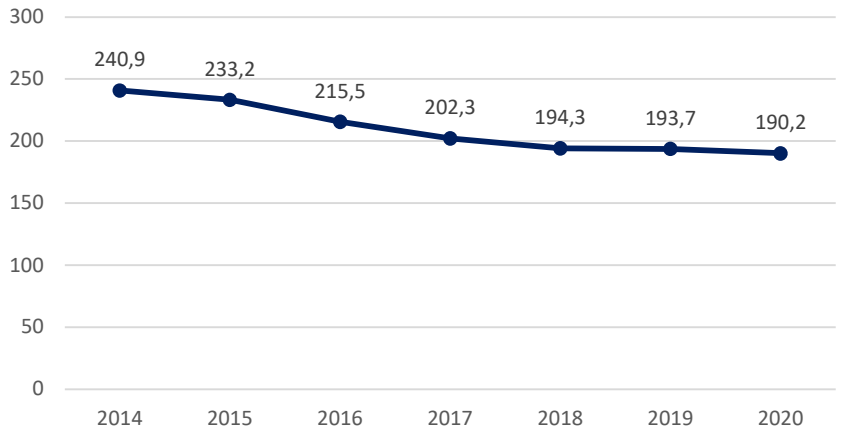
Figure 5: LCR and HQLA evolution (%)



Source: Banco de Portugal. Calculations by the author.

The risk-weighted assets (RWA) has been moderately decreasing since 2014, as illustrated in Figure 6.

Figure 6: RWA evolution (€Bn)

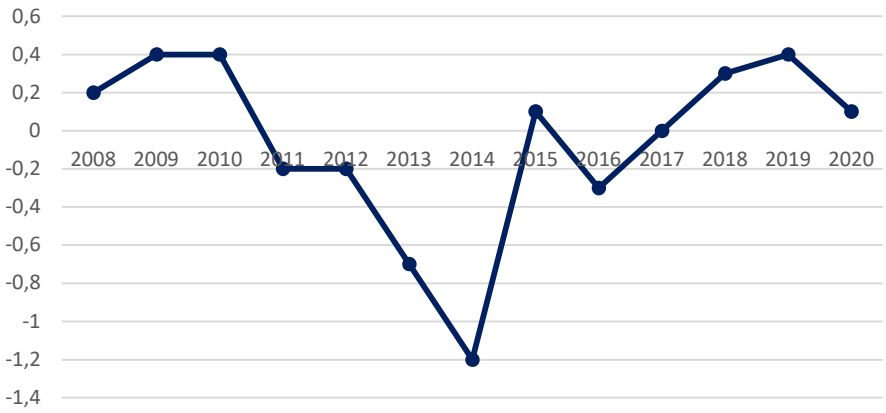


Source: Banco de Portugal. Calculations by the author.

In which regards to the profitability indicators, the return on assets (ROA) and return on equity (ROE) have recovered since 2016, except for a decline in 2019. Both indicators had an expressive decrease between 2012 and 2014, during the EFAP,

motivated by the deleveraging process initiated on the financial system. Figures 7 and 8 show its evolution.

Figure 7: ROA evolution (%)



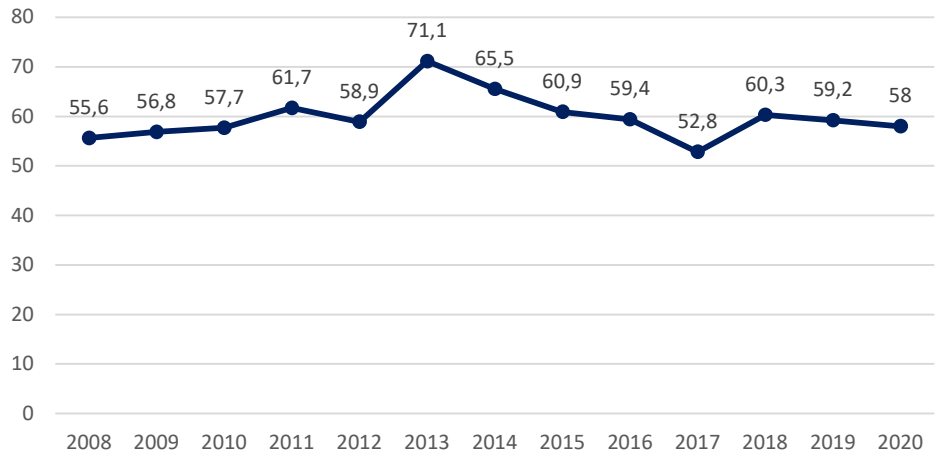
Source: Banco de Portugal. Calculations by the author.

Figure 8: ROE evolution (%)

Source: Banco de Portugal. Calculations by the author.

The cost-to-income ratio has remained relatively stable since 2008, as illustrated in Figure 9.

Figure 9: Cost-to-income (%)



Source: Banco de Portugal. Calculations by the author.

Following the GFC, several measures were decided within the new regulatory and supervisory framework. The development of the Single Supervisory Mechanism (SSM) [8] is an important step to ensure consistent supervision, increase financial integration, and to ensure the safety and soundness of the European banking system. Another relevant measure was Basel III, which imposed requirements on liquidity by setting two new metrics: LCR and the net stable funding ratio (NSFR)[9]. Moreover, a prudential requirement of a leverage ratio was introduced, complementary to the capital adequacy ratio based on RWA. The rules of Basel III were adopted in the EU, under the Capital Requirements Regulation (CRR)[10] and Capital Requirements Directive IV (CRD

[8] Regulation (EU) No 468/2014 of the ECB of 16 April 2014 establishing the framework for cooperation within the SSM between the ECB, and national competent authorities and with national designated authorities (SSM Framework Regulation).

[9] It is calculated according to the $\frac{Total\ available\ stab\quad funding}{Total\ required\ stable\ funding} \geq 100\%$. NSFR aims to promote resilience over a longer time horizon, creating additional incentives for banks to fund their activities with more stable sources of funding on an ongoing basis.

[10] Adopted in the EU through the Regulation (EU) No 575/2013 of the European Parliament and of the Council of 26 June.

IV)[11]. In Portugal, CRD IV was transposed through the Decree-Law no. 157/2014.

Summing up, the deleveraging process started during the EFAP period was instrumental to improve the behavior of banks' main financial indicators. The financial sector still faces several challenges, namely after the current Covid-19 pandemic, with a sharp slowdown of the economic activity, and an even more prolonged period of low-interest rates, besides the business model challenges, with the increasing competition by the new operators and the digitalization trends, in addition to the regulatory requirements.

[11] Directive 2013/36/UE, of the European Parliament and of the Council of 26 June.

3. LITERATURE REVIEW

The effects of NIRP have not been largely studied in the existing literature, mostly due to its recent adoption. However, the NIRP adoption in June of 2014, by the Governing Council of the ECB, has already been the subject of several academic papers. The ECB unconventional monetary policy measures were aimed at restoring economic growth and stabilize inflation expectations, to achieve the ECB target inflation rate of below, but close to, 2% over the medium term.

The NIRP along with other unconventional monetary policy tools were designed to provide additional monetary stimulus to boost the real economy. The reasoning behind negative rates is to charge commercial banks for their excess reserves at the central banks, encouraging them to boost lending and thus, improving economic growth (Coeuré , 2016).

In the last few years, the academic research focused on the NIRP has intensified, caused an enriching debate about the potential unintended effects on the effectiveness of the negative rates (Brunnermeier & Koby (2018)). Since the adoption of the NIRP, some of its critics have drawn attention to the possible unintended consequences of negative rates (Scheiber *et al.* (2016)). The transmission of the monetary policy below the ZLB became a recent avenue of research, once that several central banks have been adopted negative rates over the past decade. Nonetheless, how are negative rates transmitted to the banking sector?

The existing literature providing empirical evidence on NIRP effects is still quite limited even though it is growing. Recent studies have highlighted the possible side-effects under negative rates on financial stability, notably if negative rates remain *lower-for-longer*. Some of these effects may include the deterioration of profitability and excessive risk-taking. In papers like Hannoun (2015), Arteta *et al*. (2016), and Heider *et al.* (2018) it is argued that banks may be willing to increase their risk profile of their investments in a search-for-yields.

Recent literature has been assessing how negative rates are transmitted through the transmissions mechanisms of monetary policy to the banking sector. These mechanisms are conceptually analogous to those under conventional monetary policies. Nevertheless, negative rates can pose some limitations on the traditional channels and could limit monetary policy effectiveness (Arteta *et al.* 2016).

Hannoun (2015) presented a comprehensive analysis describing the main transmission channels in which low-interest rates are expected to affect growth in the short-term. The main channels are the credit channel, asset valuations channel, portfolio rebalancing and risk-taking channel, the exchange rate channel, and the reflation channel. From a long-term perspective, a prolonged period of negative nominal interest rates may be counterproductive to policy effectiveness, causing some unintended effects as disincentive, distraction, distortion, disruption, and disillusion Hannoun (2015).

Under negative rates, the transmission mechanisms on interest rate channel and portfolio reallocation channel assume especially relevance. In the interest rate channel, lowering interest rates affects the rates at which banks conduct their lending and borrowing activities (Arteta *et al.* 2016). Additionally, lower interest rates over a prolonged period can lead to lowering the spreads earned by the financial intermediaries. There is another constraint under negative rates, due to the stickiness of the retail deposits, once that banks may be reluctant to pass on negative rates to their depositors to avoid shift to cash. Heider *et al.* 2018; Eggertsson *et al.* 2017 argued that negative rates limit the pass-through effect of monetary policy to deposit and lending rates. In the Portuguese context, according to Banco de Portugal notice 6/2009, article 3, there is a legal constraint to impose negative rates on retail deposits.

In the portfolio reallocation channel and risk-taking channel, negative short-term interest rates should support the demand for longer duration and higher-yielding assets once the safe assets become less attractive. Nonetheless, under negative rates, if they are extended for a prolonged period, it can distort asset valuations and lead to asset price bubbles (Arteta *et al.* 2016). This is in close spirit with the concept of distortion presented by Hannoun (2015) which argued that prices in global financial markets are driven mainly by central banks' monetary policy instead of the market functioning, leading to distortions in asset prices. The prices of the financial assets become artificially inflated as investors are encouraged into increasingly risky assets. In case of a generalized loss of confidence in the financial markets could lead to a severe financial crisis, especially under artificially inflated asset prices. In line with this theoretical point of view, the Federal Reserve System (Fed) has pointed out the possible trade-off between a lower-for-longer policy stance and the ability to handle asset price bubbles, especially when the pandemic ends. The question is whether the same interest rates levels achieve the central banks' main

objectives, plus a third one, financial stability. There are some costs to keeping interest rates at zero for a protracted period, and the question is if in the near-future central banks may be in front of a dilemma between inflation and financial stability objectives.

The effects of ultra-low or negative rates can be mitigated to some extent with macroprudential policies, even though the regulatory reforms and its effectiveness are still under discussion.

The empirical studies which analyze the impacts of NIRP on bank risk-taking are still scant. The literature has been focusing mainly on the impacts of negative rates on profitability. We aim to contribute to the increasing literature on the nexus between NIRP and bank risk-taking.

When analyzing the effect of negative rates on bank risk-taking, using a difference-in-differences (DiD)[12] method for a large unbalanced panel dataset, from 2009 to 2018, Boungou (2020) concluded that the increase in risk-taking has been lower among banks located in countries that have adopted negative rates. Furthermore, the author also analyzes the impact of banks' characteristics on the transmission of negative rates on risk-taking, concluding that the effects are more robust for small and well-capitalized banks, in line with the results of Altunbas *et al.* (2012).

Bongiovanni *et al.* (2019) studied the impact of the negative rates in 33, Organisation for Economic Cooperation and Development (OECD) countries over the period between 2012 to 2016 using a DiD method. The results show a 10 percent decrease in risky assets on banks' balance sheets among countries that adopt negative rates when compared to non-adopters. Beyond that, the results suggest that risk-taking is sensitive to banks' characteristics, i.e. capitalization, funding structure, and diversification, and the feature of the national banking institutional context, as the level of competition. Additionally, results evidenced that risk-taking increases in better-capitalized banks or banks that benefit from market power in less competitive markets. Moreover, they found an inverse relationship between risk-taking and size and liquidity. Therefore suggesting that less liquid banks are more likely to invest in riskier assets. The variable, funding structure, was found to be non-significant. However, coefficients are large, suggesting

[12] The difference-in-differences (DiD) analysis is a method for inferring causality from observational data. It involves analyzing the differential effect of a "treatment" on two groups, the treatment group versus the control group.

that banks with less stable sources of funding are more willing to increase the risk-taking. The funding structure affects the sensibility of banks to the interest rates levels. Lower interest rates can lead to an increase in risk-taking in a way to protect profitability if the retail deposits are rigid (and if banks have a higher funding cost).

Boungou (2019) analyzed the impact of negative rates in two strands of literature, on profitability and risk-taking. The study was conducted in 28 EU countries, and conlcudes for the existence of a threshold effect of negative rates on profitability and a reduction in risk-taking. The results show that the impact of negative rates is higher when compared to non-negative rates. Moreover, under negative rates, banks improve the quality of their balance sheet in which results in a decrease in risk-taking. Furthermore, negative rates have a negative impact on banks' net interest margins (NIM), i.e. a 1% decrease in interest rates results in a 0,43 percentage points reduction in NIM, and the effects are higher under negative rates than low but non-negative rates. A more detailed analysis found that NIM related to negative rates are positively correlated with risk-taking, concluding that under negative rates, a reduction in NIM implies a decrease in risk-taking.

Nucera *et al.* (2017) analyzed the impact on the risk-taking of three consecutive cuts on the DFR (in June and September 2014 and in December 2015). Banks' risk is measured by the variable *SRisk*[13], which is a systemic risk measure and captures the propensity for a bank to become undercapitalized in a financial stress scenario. The reported results suggested that following a rate cut, some banks are perceived as riskier, and the impact depends on banks' business models. Moreover, the results evidenced some heterogeneity, suggesting that banks' characteristics are a relevant driver in the transmission mechanism of monetary policy under negative rates.

Bubek *et al.* (2020) studied the impact of negative rates on search-for-yield behavior in large banking groups in the euro area. The authors' empirical strategy relies on the analysis of the securities register portfolio. The results show that banks with more retail deposits invest relatively more in securities, especially in those securities yielding higher returns. Moreover, the results are acute for banks with a lower level of

[13] *"SRisk is a measured of the estimated capital shortfall of a bank, conditional on a 40% drop in a world equity index over a six month-ahead horizon"* (Nucera et al. 2017). The estimates of SRisk are publicly available at a monthly frequency for the Euro area.

capitalization.

The study developed by Heider *et al.* (2018) estimated the transmission of negative rates to the real economy via credit supply and conclude that banks with a high level of retail deposits decrease their lending amounts and increase their risk-taking.

The contribution of this dissertation to the literature is twofold, by adding to the empirical studies focusing on the impacts of NIRP on bank risk-taking, with an empirical analysis based on the Portuguese banking sector, notwithstanding the limitations imposed by the structural changes, in the last few years.

4. METHODOLOGY

4.1. VARIABLES

4.1.1. DEPENDENT VARIABLES

Risk is part of the bank's business model and measuring risk can be a challenging empirical task. In our model, to assess the impact of negative rates on risk-taking, we will use two measures of bank risk-taking which are widely used in the literature: Z-score[14] and the NPLs.

The Z-score can be interpreted as an accounting-based measure of the distance to default (Li et al. 2017). This variable takes into account the volatility of returns and the banks' leverage. In line with the literature, the Z-score is commonly used as a *proxy* for risk-adjusted performance and a *proxy* for bank risk-taking. The Z-score is inversely related to the probability of bank insolvency (Roy, 1952)[15], hence higher values indicate a lower probability of insolvency and thus, lower risk-taking. The Z-score[16] is calculated as the sum of return on asstes (ROA) and equity to total asstes ratio (ETA), divided by the standard deviation of ROA (σROA). Similarly to Laeven & Levine (2009), we use the natural logarithm of the Z-score, as its distribution is highly skewed.

[14] The presented Z-score should not be confused with the (Altman, 1968) Z-score, which is used as a measure to predict the probability of a company will go to bankruptcy.

[15] The concept of Z-score was subsequently developed by (Boyd & Graham, 1986; Hannan & Hanweck, 1988; Boyd et al., 1993)

[16] Z-Score is calculated according to the formula $\frac{(\mathrm{ROA}+\mathrm{ETA})}{\sigma\mathrm{ROA}}$.

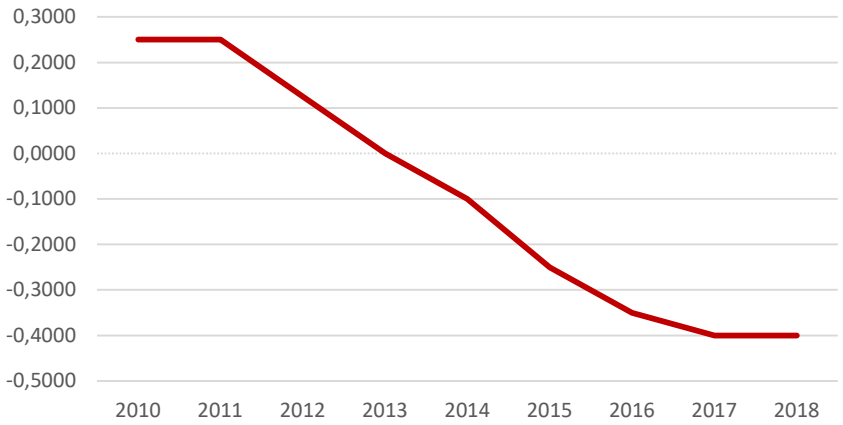
The NPLs are a usual indicator that reflects the asset quality of a given portfolio (Andries *et al.* 2016). Moreover, NPLs are usually used in credit risk models as a measure of risk (Beck *et al.* 2013). On the one hand, high levels of NPLs negatively affect the profitability of banks and in the long run can limit the capacity to grant new loans. On the other hand, high levels of NPLs are considered harmful to financial stability. Lower interest rates might trigger banks to lower their lending standards, which in the medium-term causes a deterioration in the loan portfolios (Bikker & Vervliet, 2018). Due to its importance, the ECB monitors the levels of NPLs under the Supervisory Review and Evaluation Process (SREP). Higher NPLs volumes could indicate that banks are accumulating *ex-post* debts in their balance sheet (Boungou, 2019). In line with the guidelines and plans submitted to the supervisory authorities, the total volume of NPLs in Portugal has been steadily decreased since 2015.

4.1.2. EXPLANATORY VARIABLES

We include, in our model, two main measures as explanatory variables related to monetary policy and bank-specific control measures.

A measure of monetary policy (interest rates), we will use the DFR . To do so, we compute the annual average of the DFR under the period of analysis, which is denotes by i. Figure 10 shows its evolution from 2010 to 2018.

Figure 10: DFR (annual average) evolution



Source: Banco de Portugal. Calculations by the author.

Furthermore, to capture the existence of the threshold effect at zero, we introduce an interaction term, defined as $(i * D_{NIRP})$. Where [D_{NIRP}] is a dummy variable, equal to 1 when t correspond to year i (i =2014, 2015, 2016, 2017, 2018) and 0, otherwise. We consider the adoption of negative rates in 2014, following the ECB decision to cut the official interest rates below zero for the first time.

Following prior studies, banks' individual characteristics are one of the main drivers that influence a banks' risk behavior (Altunbas *et al.* 2012; Boungou, 2020). To estimate this impact on our model, we incorporate some control variables concerning banks' individual characteristics. Our bank control variables are size, equity, liquidity, and efficiency.

The variable size, is measured by the natural logarithm of total assets, is an important variable, as "larger" banks can be perceived as *too-big-to-fail*, which is commonly associated with more systemic riskier banks. It is expected a positive effect between size and risk-taking, however, the literature suggests an ambiguous relationship.

We control for the ratio between ETA, a measure of equity. The variable equity is expected to have a positive effect on risk-taking (Bikker & Vervliet, 2018). We also control for the ratio between liquid assets to total assets, to measure liquidity. A higher liquidity ratio implies that banks are less vulnerable to a bankruptcy event. Effective liquidity risk management helps to ensure the banks' ability to meet future cash-flows obligations, which are uncertain and can be affected by exogenous events and by other economic agents (BIS, 2008). Liquidity plays a crucial role in the well-functioning of the sector by promoting the soundness of the banking sector. The variable equity is expected to have a positive effect on risk-taking (Bikker & Vervliet, 2018).

We also control for efficiency, measured by the cost-to-income ratio. Table I summarizes the description of all variables and the expected effect on our dependent variables, in line with the literature.

TABLE I: OVERALL DESCRIPTION OF ALL VARIABLES

Variable	*Description*	*Expected Effect*
	Dependent Variables	
Z-score	Natural logarithm of Z-score	
NPLs	Impaired loans to gross loans	
	Explanatory variables	
	Monetary policy measures	
$\boldsymbol{i}$	Annual average of the deposit facility rate (DFR)	+/-
D_{NIRP}	Dummy variable, equal 1 when t corresponds to the years i (i =2014, 2015, 2016, 2017, 2018) and 0, otherwise	+/-
$\boldsymbol{i} * D_{NIRP}$	Interaction term variable	+/-
	Bank-specific controls	
Size	Natural logarithm of total assets	+
Equity	Equity to total assets	+/-
Liquidity	Liquid assets to total assets ratio	+/-
Efficiency	Cost-to-income ratio	+/-

4.2 EMPIRICAL STRATEGY

To analyze the data, we used a panel data-approach. We construct an annual unbalanced panel for 35 banks, between 2010 to 2018. The panel-data approach has several advantages, more information, more variability, less collinearity, more degrees of freedom, and more efficiency (Balgati, 2005).

We will follow a similar approach developed by Boungou (2019) regarding the analysis of risk-taking. We include in the model one-period lag for the dependent variables (Z-score and NPLs), once that risk-taking tends to have a persistent character, the level of risk in the previous period can influence the level of risk in the current period, this in line with the results of Delis & Kouretas (2010).

Therefore, preliminary, we estimate the following Ordinary Least Squares (OLS) empirical regression:

(1) $Risk_{b,t} = c + \alpha_0\, Risk_{b,t-1} + \alpha_1 MP_t + \alpha_2\, X_{b,t} + \varphi_t + \theta_b + \varepsilon_{b,t}$,

where, $Risk_{b,t}$ are the risk-taking measures, Z-score and NPLs, for bank b at time t, $Risk_{b,t-1}$, is a lagged dependent variable (of the risk-taking measures), the coefficient α_0 will capture the level of persistence in the risk-taking, MP_t is defined as the monetary policy measures, i.e. the annual average of the DFR (i), a dummy variable [D_{NIRP}], equal to 1 when t correspond to year i (i =2014, 2015, 2016, 2017, 2018) and 0, otherwise; and an interaction term, defined as ($i * D_{NIRP}$), at time t, φ_t are time fixed effects and θ_b are bank fixed effects, and $\varepsilon_{b,t}$ is an error term. Complementary to these variables, we add some control variables deemed relevant, as each bank has its own individual characteristics affecting the dependent variable, in line with (Altunbas *et al.* 2012).

Hence, $X_{b,t}$ are bank controls of bank b at time t, specifically the natural logarithm of total assets (size), equity to total assets (equity), liquidity assets to total assets (liquidity), and cost-to-income ratio (efficiency).

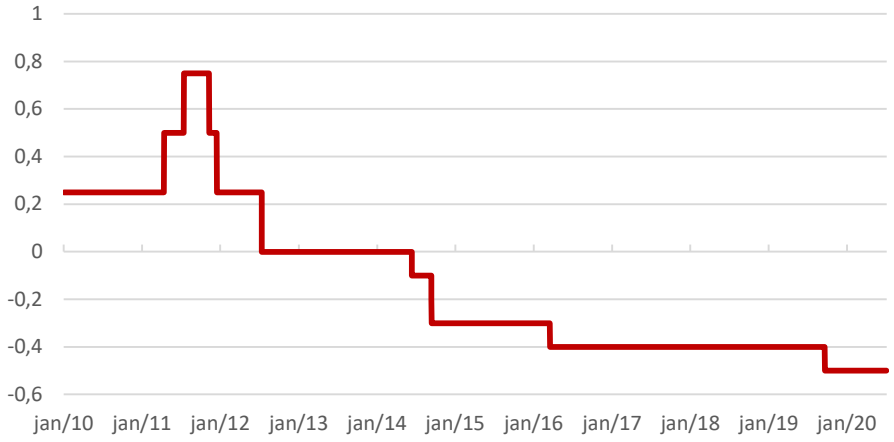
We have started to estimate our model by regressing the equation with the OLS estimator. Nonetheless, once that we use a dynamic model, by including the lagged dependent variable, we can face some endogeneity issues. In this case, the OLS estimator will be biased and inconsistent. To overcome the potential endogeneity issues, we re-estimate our model by using the GMM estimator, developed by Arellano & Bond (1991), and further developed by Arellano & Bover (1995) and Blundell & Bond (1998), which gives a consistent estimation in models with lagged dependent variables. This method provides a consistent and efficient estimation of our model, AR (1) and AR (2) tests ensure that residuals are not autocorrelated, and the Hansen test ensures that instruments used are valid. Following Boungou (2019), we compute robust standard errors and two-step estimator applying the Windmeijer (2005) finite-sample correction.

5. DATA

To perform our analysis, we use an unbalanced panel dataset of 35 Portuguese banks. These data consist of individual bank information over the period spanning from 2010 to 2018. We choose this period for our study to consider the introduction of negative rates after 2014. Moreover, the period under analysis was notably eventful, including the aftermath of the GFC, the Euro sovereign debt crisis, and the EFAP, which triggered the financial adjustments of the banking sector.

Our primary source of data is the APB (2018, 2019), which aggregates individual and consolidated data concerning the balance sheet and income statements for over ninety percent of the assets in the financial system. Initially, our dataset included 41 banks. However, six were removed due to problems with data availability. Furthermore, some of the data is not available on APB reports and has been collected directly from the individual annual financial reports. To compute the yearly average of the DFR, between the period under analysis, we have consulted the ECB Statistical Data Warehouse. Figure 11 illustrated the evolution of the DRF from January of 2010 to January of 2020.

Figure 11: DFR evolution



Source: Banco de Portugal. Calculations by the author.

The final data set includes 35 banks and 224 observations, except for Z-score with 215 observations. One of the limitations in our analysis is to deal with an unbalanced panel data set due to problems with data availability. Table II shows the descriptive statistics of all variables included in the data set.

TABLE II: DESCRIPTIVE STATISTICS

Variables	Mean	Std. Dev.	Min	Max
Size	994.475	789.218	198.418	3142.282
Size (ln)	6.6	0.781	5.29	8.053
Equity (%)	0.115	0.138	-0.005	0.928
Liquidity (%)	6.984	22.259	0.078	265.396
Efficiency (%)	0.575	0.62	-4.999	4.622
Z-score	1.634	0.768	0.25	4.793
Z-score (ln)	0.382	0.482	-1.388	1.567
NPL (%)	0.599	6.72	0	100.54

Source: APB. Calculations by the author.

Before estimating the model, to further describe the data, we estimate the pairwise correlation between the main variables included in the model and their significance level. Table III reports the results. This is a simple method to find multicollinearity issues. For the analysis, we do not report multicollinearity issues between the variables, the stronger correlation is between the coefficients of the variable equity and the natural logarithm of Z-Score, which is positive 0,595. The coefficients of the dependent variable, Z-score, is positively correlated with the variable equity and negatively with size, liquidity, and efficiency. While provisions are negatively correlated with equity and liquidity, and positively with size and efficiency; the NPL coefficients are negatively correlated with size, liquidity, and efficiency, and positively with equity.

TABLE III: CORRELATION MATRIX

Variables	(Size ln)	(Equity)	(Liquidity)	(Efficiency)	(Z-score ln)	(NPL)
Size (ln)	1.000					
Equity (%)	-0.461***	1.000				
Liquidity (%)	0.062	-0.130*	1.000			
Efficiency (%)	-0.061	-0.118*	0.024	1.000		
Z-score (ln)	-0.394***	0.595***	-0.140**	-0.082	1.000	
NPL (%)	0.123*	-0.026	-0.016	0.014	-0.127*	1.000

Note: *, ** and *** represent statistical significance at 10%, 5% and 1% levels, respectively.

6. EMPIRICAL RESULTS

Table IV shows the results of regressing the equation (1) for our dependent variable Z-score and controlling for banks-specific characteristics. The first set of empirical results identifies a negative correlation between the level of Z-score and the level of interest rates.

In Table IV, we report the results for regressing the equation (1) by using the OLS estimator, system GMM, and the GMM with Windmeijer (2005) sample correction. Column (1) presents the results for the OLS estimator. The OLS regression is useful in providing a first (and biased) estimate for the coefficients. Nevertheless, with dynamic models, the OLS estimator is biased and inconsistent, so, the results will not be interpreted.

The results suggest a negative correlation between the level of Z-score and the level of interest rates, statistically significant at the 1% level. Our first empirical results are presented in column (2) and are obtained by estimate the equation (1) using the GMM estimator developed by Blundell and Bond (1998). A decrease in the level of interest rates, captured by the coefficient of i causes an increase in the level of Z-score, thus we can infer that a decrease in interest rates improves the level of the Z-score. This result is in line with Boungou (2019). The results suggest an increase in the level of Z-score, associated with a decrease in the risk-taking, i.e., a 1% decrease in the interest rates, caused an approximately, 2,34% increase in the level of Z-score. We find that during the implementation of negative rates, captured by the coefficient of the variable of D_{NIRP}, Portuguese banks have experienced a decrease in the Z-score by, approximately, 0,12%, which means a better Z-score, and a lower probability of default. Nonetheless, the existence of a threshold effect is captured by the coefficient of ($i * D_{NIRP}$). The results might suggest that *ceteris paribus,* the effects of interest rates are higher under negative rates rather than positive rates, as the coefficients are greater, suggesting the existence of a threshold effect. Moreover, the variables are positively correlated.

The reported results, controlling for bank-specific characteristics are consistent with the existing literature, as risk-taking is sensitive to banks' individual characteristics, in line with the results of Altunbas et al. (2012).

Additionally, to this first result, we re-estimate the empirical regression including the Windmeijer (2005) correction for the variance of two-step GMM estimator,

to ensure robust standard errors. Column (3) reports the results. The results suggest a negative correlation between the level of Z-score and the level of interest rates, as described in our previous results and the coefficients are the same. However, the variable D_{NIRP} is found not statically significant.

A possible explanation for our results might be related to increasing regulation faced by the European banks during the period under analysis (2010-2018). The regulatory pressures followed after the GFC, have put in place strict prudential requirements. Consequently, banks have been discouraged in increasing their risk-taking.

TABLE IV: REGRESSION FOR Z-SCORE

Variable: Z-score			
	OLS (1)	**GMM (2)**	**GMM (3)**
i	- 2.667***	-2.338***	-2.338***
	(0.222)	(0.077)	(0.275)
D_{NIRP}	-0.16	-0.124***	-0.124
	(0.101)	(0.02)	(0.097)
$i * D_{NIRP}$	1.846***	1.412***	1.412***
	(0.308)	(0.088)	(0.357)
Lag. Z-score (ln)	0.104**	-0.013	-0.013
	(0.042)	(0.011)	(0.033)
Size (ln)	-0.091***	-0.094***	-0.094***
	(0.023)	(0.014)	(0.035)
Equity (%)	1.592***	1.794***	1.794***
	(0.314)	(0.077)	(0.428)
Liquidity (%)	- 0.003***	-0.004***	-0.004***
	(0.000)	(0.000)	(0.001)
Efficiency (%)	0.04	0.05***	0.05
	(0.057)	(0.007)	(0.038)
Observations	172	172	172
R-squared	0.785		
AR (1)		- 1.92	- 1.73
AR (2)		- 0.55	- 0.66
Hansen		0.882	0.020

Standard errors in parentheses.
AR (1) and AR (2) are the test for first and second-order autocorrelation.
Note: *, ** and *** represent statistical significance at 10%, 5% and 1% levels, respectively.

Table V shows the results of regressing the equation (1) for our dependent variable NPL and controlling for banks-specific characteristics. The first set of empirical results suggest a positive correlation between the level of interest rates and the level of NLPs. Moreover, the coefficients associated with the level of interest rates are very large.

Following a similar analysis performed for the variable Z-score, we have regressed the equation (1) using the OLS estimator, system GMM, and the GMM with Windmeijer (2005) sample correction. According to column (5), the results suggest that a 1% decrease in interest rates leads to an 11,4% decrease in the amount of NPLs, in line with Boungou (2019).

The results suggest that during the implementation of negative rates, captured by the coefficient of the variable of D_{NIRP}, Portuguese banks have decreased the amount of NPLs. Nevertheless, these results might be related to the obligation of the Portuguese banks to decrease the amount of NPLs under the guidelines and plans submitted to the supervisory authorities, after the EFAP. Indeed, as can be seen in figure 2, the NPLs ratio has been steadily decreasing since 2015.

The bank-specific characteristics are deemed relevant, except for liquidity. The variables Size (ln), Equity, and Efficiency are positively correlated with the level of NPL. Column (6) reports the results for regression the equation (1), including the Windmeijer (2005) correction. The results suggest a positive correlation between the level of NPLs and the level of interest rates, as described in our previous results, but the variables are not statistically significant. For bank-specific characteristics, Size (ln), Equity, and Liquidity, the coefficients are positive, as described previously, but also not statistically significant.

All in all, our results maybe, somehow, inflated by the obligation of Portuguese banks to decrease the level of NPLs under the SREP monitored by the ECB.

TABLE V: REGRESSION FOR NPL

Variable: NPL			
	OLS (4)	**GMM (5)**	**GMM (6)**
i	15.452	11.442***	11.442
	(15.894)	(1.132)	(12.689)
D_{NIRP}	0.606	0.363***	0.363
	(0.72)	(0.019)	(0.372)
$i * D_{NIRP}$	-16.402	-11.929***	-11.929
	(16.134)	(1.231)	(13.076)
Lag. NPL	-0.029	-0.026***	-0.026
	(0.031)	(0.001)	(0.026)
Size (ln)	1.602	1.435***	1.435
	(1.45)	(0.088)	(1.236)
Equity (%)	3.217	2.873***	2.873
	(2.849)	(0.568)	(2.618)
Liquidity (%)	-0.007	-0.001	-0.001
	(0.009)	(0.002)	(0.008)
Efficiency (%)	0.407	0.147**	0.147
	(0.493)	(0.058)	(0.355)
Observations	185	185	185
R-squared	0.046		
AR (1)		1.26	-0.57
AR (2)		0.51	0.37
Hansen		0.971	0.699

Standard errors in parentheses.
AR (1) and AR (2) are the test for first and second-order autocorrelation.
Note: *, ** and *** represent statistical significance at 10%, 5% and 1% levels, respectively.

7. CONCLUSIONS

The existing literature focusing on the impact of negative rates on bank risk-taking is still scant, even though it is growing. So far, little attention has been given to the possible effects of negative on the level of banks' risk-taking. Nonetheless, in the last few years, some empirical studies were exploring this new avenue of research. Following this, this dissertation aims to ascertain whether negative rates have been encouraged the risk-banking behavior by Portuguese banks.

To assess the impact of interest rates on risk-taking, the study uses the GMM estimator developed by Arellano & Bond (1991). We carried out our estimation for an unbalanced panel da set of 35 Portuguese banks over the period spanning from 2010 to 2018. The results suggest a reduction in risk-taking as a result of a decrease in the level of interest rates. In the case of Z-score, the variable is negatively correlated with the level of interest rates, which means that a decrease in interest rates causes an increase in the level of Z-score, and thus, less risk-taking. Specifically, the results suggest that a 1% decrease in interest rates leads to an increase, by approximately, 2.34% in Z-score. On the other hand, the level of NPLs responds positively to a decrease in the level of interest rates. During the period of introduction of negative rates, we verify a decrease in the level of NPLs. The 1% decrease in interest rates causes a decrease, by approximately, 11.4% on NPLs.

Following the aforementioned, we can conclude that in the Portuguese banking context, there is no evidence of an increase in bank risk-taking in response to an overly low-interest-rate environment. Our results are in line with (Boungou 2019; 2020).

Nevertheless, our study faces several limitations. Firstly, due to the institutional context of the Portuguese banking sector, which was notably eventful during the period under analysis, which took place several mergers and acquisitions, and recapitalizations. Secondly, the period under analysis was especially eventful, including the aftermath of the GFC and the Euro sovereign debt crisis, and the EFAP, which poses significant challenges to correctly identify the effects of NIRP.

As a follow-up, an interesting avenue for future research is the analysis of the impact of NIRP on the profitability of Portuguese banks', and a more detailed analysis on the impact of profitability on risk-taking, in line with the other strand on the literature related to the NIRP.

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