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Bank Profits and Margins in a World of Negative Rates

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Abstract

This paper investigates the influence of negative interest rate policy (NIRP) on bank margins and profitability. Using a dataset comprising 7242 banks from 33 OECD member countries over 2012-2016 and a difference-in-differences methodology, we find that bank margins and profits fell in NIRP-adopter countries compared to countries that did not adopt the policy. The results are robust to a variety of checks. This adverse NIRP effect appears to have been stronger for banks that were small, operating in competitive system as well as in countries where floating loan rates predominate.

JEL: E43, E44, E52, G21, F34

Keywords: Negative interest rates, bank profitability, NIMs, difference-in-differences estimation

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Bank Profits and Margins in a World of Negative rates

Introduction

Since the Global Financial Crisis (GFC), policy-makers have been facing a challenging economic situation dominated by economic stagnation, high unemployment and deflation. As a first monetary policy response, central banks cut interest rates aggressively through conventional accommodative monetary policies. However, when interest rates approached the zero lower bound (ZLB) without producing the hoped for effects on nominal spending and inflation, many central banks implemented a range of unconventional monetary policies (UMPs) including large scale asset purchase (LSAPs), in the form of quantitative easing, as well as policy rate forward guidance². UMP took a step further from 2012 onwards when several countries/regions (Denmark, the Euro Area, Hungary, Norway, Sweden, Switzerland and Japan) implemented negative interest rates policy (NIRP) in order to provide further economic stimulus to constantly weak economies³. The aim of NIRP (see Couere', 2016) is to increase the cost to banks of holding excess reserves at the central bank encouraging them to take them back on the balance sheet. This should lead to beneficial outcomes for the real economy coming mostly from a greater supply and demand for loans due to the decline in funding costs for both banks and borrowers. Nevertheless, going beyond the barrier determined by the ZLB and pushing rates⁴ into "uncharted" negative territory deserves serious consideration and analyses. In this regard, the "how low for how long" question has raised concern about the long-term effect of this policy on financial intermediaries' performance and on the economy as a whole (see, McAndrews., 2015)⁵. A cut in interest rates into negative territory may increase bank profitability if there is significant loan growth and margins are unaffected, or/and if banks boost fee and commission income on the back of greater lending. However, if banks are unable to reduce deposit rates to the same extent as loan rates then margins will be compressed, and if there is limited loan growth and/or cross-selling of fee and commission services then profits will likely fall. If the latter is the case, the decline in profits can erode bank capital bases and further limit credit growth thus stifling NIRP monetary transmission effects. This influence of NIRP on bank performance may further be aggravated in the European context where banks have been struggling to maintain (respectable) levels of profitability because of a slow economic recovery, historically high levels of non-performing loans, and a post GFC and European sovereign debt crisis deleveraging phase.

We contribute to the existing literature, which focuses on low and/or more 'normal' interest rate environments by evaluating the impact of an unexplored monetary policy instrument as the NIRP on net interest margins (NIMs) and bank profitability. We employ a bank-level database comprising 7242 banks in 33 OECD countries for the period 2012-2016 and a difference-in-differences methodology. This methodology allows us to draw conclusion as to whether banks' NIMs and profitability in NIRP adopter countries were impacted differently than countries that did not adopt the policy. Moreover, it permits us to analyse both macroeconomic and bank-level factors that

² See Reifschneider and Williams (2000) and Chung et al. (2012) for the impact of the zero lower bound constraint and Gambacorta et al. (2014), Borio and Zabai (2016) and Hamilton et al. (2012) for the effectiveness of unconventional monetary policies.

³ See Bech and Malkhozov (2015) for a discussion of the implementation mechanisms of NIRP in adopting countries. The time of introduction of NIRP is noted in Table A1 in the appendix.

⁴ \$12 trillion of bonds in 2016 were traded at negative yield (see Kunz, 2016).

⁵ There has been discussion that negative rates promote bubbles in the bond and housing markets. In our analysis, we will focus on the performance of the banking sector.

affect performance in the uncharted territory of NIRP. We find that NIM and return-on-assets (RoAs) show a strong contraction after NIRP implementation. Our results highlight that NIM contraction reduces banks' profitability, despite the case that lower rates can boost bank profits through valuation gains on fixed-income securities (direct) and a reduced cost of non-performing loans (indirect). Finally, the negative effect on profits and margins appears to have been stronger for banks that are small, operating in countries where markets are more competitive and floating interest rates predominate.

The paper proceeds as follow. Section 2 reviews the academic literature on the impact of interest rates on bank profitability and margins. Section 3 introduces our data and methodology. Section 4 presents our results along with several robustness checks and the final section concludes.

Literature Review

Our study is based on the literature that analyses the effects of interest rates on bank performance. While there is an extensive literature on the determinants of bank margins and profits that follow the pioneering work of Ho and Saunders (1981), the literature evaluating interest rates, monetary policy and bank performance is still somewhat limited⁶. One of the first empirical papers dates back to the early 1980s, in which the switch from low to high interest rates determined by the “Volcker doctrine”⁷ raised concerns about the soundness and stability of commercial banks and saving and loans associations (“thrift” institutions) that “borrow short and lend long”. In this context, Flannery (1981) finds that, while drastic interest rate changes can threaten bank stability, large U.S banks mitigate these risks by hedging against interest rate risk modifying assets and liabilities in order to have similar average maturities. Hancock (1985) notes that if monetary policy does not affect the spread between interest earning assets and liabilities, an increase in interest rates tends to boost bank profits. Demirgüç-Kunt and Huizinga (1999) were among the first to investigate the effect of real interest rates on bank margins and profitability. Using cross-country and bank-specific data on margins, they find that high real interest rates are associated with higher NIMs and profitability - especially in emerging economies where deposit rates are frequently targeted by policymakers to be below-market rates. English (2002), studying the link between interest rate risk exposure and bank margins in ten OECD countries over the period 1979-1999, points out that the average yield on bank assets is more closely related to long-term rates than the average yield on liabilities, hence a steep yield curve should be associated with higher NIMs. In a similar fashion, Albertazzi and Gambacorta (2009) also use data of ten OECD countries over 1981-2003 and aggregate income statement data to show that short-term and long-term rates have a differential influence on bank margins⁸. While short-term rate seems to have no impact on margins, a 1% increase in long-term rates increases NIMs from 1% after a year to up to 4% in the long-run, hence margins react mainly to the slope of the yield curve. The relation between the slope of the yield curve and bank profitability has been evidenced also by Alessandri and Nelson (2014) with reference to the UK banking sector. Again, their findings suggest that in the long-run (measured using ten-year government bond yields) higher interest rates have an unambiguous positive effect on bank profitability and margins.

Size and specialness appear to be key factors that enable banks to hedge against interest rate risk avoiding excessive NIMs and profit volatility in ‘normal’ operating environments. In this regard, Angbazo (1997) finds that U.S banks with assets size greater than \$1 billion have net interest income that is not sensitive to interest risk volatility, while the opposite is found for small regional banks. Specialness, assets composition and size are also found to be important by Hanweck and Ryu (2005). Using a sample of U.S banks, they underline how small regional banks and mortgage specialists are particularly affected by the volatility of interest rates.

There are also a limited number of studies that focus specifically on bank profitability and margins in a low interest rate environment. Genay and Podjasek (2014) indicate that U.S banks face decreasing NIMs and returns during

⁶The literature on the determinants of net interest margins and profits is extensive. We refer to section 3 for a select overview of studies on the determinants of bank margins and profits.

⁷ Paul Volcker, Chairman of the Federal Reserve during the period 1979-1987, is credited with ending the high level of inflation in the United States by using tight monetary policies and high interest rates.

⁸ In their model Albertazzi and Gambacorta (2009) define short-term and long-term interest rate using the 3-month interbank rate and the rate on long term government bonds, respectively.

periods of low interest rates – and (again) the effect is particularly strong for small institutions. However, they also suggest that the benefits of low rates (in terms of boosting economic activity) outweigh the costs. Opposing findings have been reported by Covas et al. (2015) who show that, during a period of low interest rates (2010-2015 in their sample), NIMs decline more markedly for large U.S banks (70 basis points against 20 for small banks⁹) because small banks benefit more from a fall in deposit costs. Claessens et al. (2017), investigating 47 countries, find that low interest rates have a significantly greater impact on bank ROAs and NIMs than high rates. Although profitability appears to be less affected than margins, persistently low interest rates also reduce the ability of banks to be profitable. Hence, while a cut in interest rates has the short-term effect of negatively impacting NIMs, in the long-term there is an adverse pass through to profitability. Busch and Memmel (2015), studying the German market during ‘normal’ and low interest rate periods, find a small but positive effect of long-term rates on bank margins. However, they state that, during periods of low interest rates, the ZLB constraint on deposit products puts additional stress on banks’ margins.

Empirical analysis of the influence of NIRP on bank margins and profits links to the unconventional monetary policy (UMP) literature. NIRP is one type of UMP together with Quantitative Easing (QE) (large-scale asset purchases) and policy guidance that manages down long-term interest rate expectations. These policies not only reduce market interest rates but expand and modify the size and composition¹⁰ of both central bank’s and commercial bank’s balance sheets that can impact margins and profitability. In this regard, Lambert and Ueda (2014), using a sample of U.S banks over 2007-2012 report a negative relation between the size of central bank’s assets and NIMs. When central banks expand their balance sheets this helps push down interest rates reducing bank funding costs but the influence is offset by reduced revenues from new loans. Deposit rates are more ‘sticky-downward’ than loan rates and compresses margins reducing profits. Similar results have been displayed by Alessandri and Nelson (2014) who show that Bank of England balance sheet expansion has a negative influence on NIMs¹¹.

Our contribution to the literature is important in three respects. First, as outlined in the aforementioned studies, persistently low interest rates are found to adversely impact bank profits and margins. If this is valid for low interest rates, breaking the ZLB with negative rates might even be more problematic given the reluctant attitude of banks to start charging customers for their deposits (“stickiness”). Secondly, the literature on NIRP is still small and generally comprises overviews of developments in key banking and other financial aggregates in the immediate pre- and post-NIRP periods rather than rigorous econometric analysis. Moreover, studies examining the effects of NIRP (see Jobst and Lin., 2016; Arteta et al., 2016; Bech and Malkhozov., 2015) point to the compression of NIMs as lending rates for new loans decline and existing (variable-rate) loans re-price while deposit rates remain sticky-downward¹², but they do not use bank-level data to explicitly test to see if this is actually the case. If this is indeed the case, all other things being equal, it will lead to a reduction in profitability and this may reduce the effectiveness of this new monetary policy tool if banks reduced profits curtails lending

⁹ Small banks are defined in this study as having assets less than \$50 billion.

¹⁰ See Bernanke and Reinhart (2004) for an explanation of unconventional monetary policies.

¹¹ Both studies apply panel regressions and GMM estimation.

¹² The relation between monetary policy changes and the stickiness of deposits has been extensively analysed (see Freixas and Rochet, (1997) for a review).

activity. Third, we perform various robustness checks to validate our results. These provide more information on specific type of banks and countries financial features that can influence the impact of NIRP.

Our paper adds to the aforementioned literature by examining the impact of NIRP on margins and profits using a dataset comprising 7242 banks in 33 OECD countries over 2012-2016 and a difference-in-differences methodology. Our main finding is that bank margins and profits fell in NIRP-adopter countries compared to countries that did not adopt the policy. The results are robust to a variety of checks. The adverse NIRP effect on bank performance appears to have been stronger for banks that were small, operating in competitive system as well as in countries where floating loan rates predominate.

Methodology and Data

Methodology

To capture the effect of NIRP on ROAs and NIMs we use a difference-in-differences methodology. This methodology has been widely used in the policy evaluation literature and more recently to banking and financial sector issues (Beck et al., 2010; Calderon and Schaeck., 2013; Berger et al., 2014; Fiordelisi et al., 2017). The advantage of this approach is that it allows to use a panel data set-up to compare a treated group of banks (those impacted by the policy change) with those that are not affected (the control group or untreated banks). The approach also helps to control for the ‘omitted variable bias’¹³. Our baseline specification takes the following form:

$$Y_{ijt} = \alpha + \beta_1 Treated_{ij} + \beta_2 Post_{jt} + \beta_3 (Treated_{ij} * Post_{jt}) + \varphi_t + \gamma_i + \varepsilon_{ijt} \quad (1)$$

Where Y_{ijt} is the NIM (or RoA)¹⁴ of bank i in country j at time t , $Treated_{ij}$ is a dummy variable that takes the value 1 if bank i in country j has been affected by NIRP and 0 otherwise, $Post_{jt}$ is a dummy variable that takes the value 1 after the period that country j at time t decided to implement NIRP and 0 before that period¹⁵, and β_3 represents the average difference in NIM and RoA between countries that switched to NIRP and countries that did not. We also include γ_i and φ_t to capture, respectively, bank and year fixed effects and limit the potential for bias in estimates of β_3 ¹⁶.

We introduce bank- and country-specific controls in a second specification that takes the form:

$$Y_{ijt} = \alpha + \beta_1 Treated_{ij} + \beta_2 Post_{jt} + \beta_3 (Treated_{ij} * Post_{jt}) + \beta_4 X_i + \varphi_t + \gamma_i + \varepsilon_{ijt} \quad (2)$$

where X_i is a vector of bank- and country-specific characteristics to capture cross-bank and cross-country heterogeneity over time that can affect NIMs and ROAs¹⁷. Bank-specific variables are a combination of balance

¹³ For example, regulatory changes (such as Basel III) may affect treated and untreated bank performance alike, regardless of the NIRP intervention. But as these changes may affect banks similarly, the difference-in-differences approach avoids this bias by differencing away common trends affecting both groups

¹⁴ Following Borio et al. (2015) and Claessens et al. (2017), we define bank net interest margins as the difference between interest earning assets and interest bearing liabilities divided by the amount of interest earning assets. Return on assets is calculated by dividing bank’s net income by its assets.

¹⁵ The vast majority of NIRP countries in our sample introduced NIRP in 2014, hence $Post_{jt}$ takes the value 1 from 2014. However, since Sweden, Norway and Switzerland introduced NIRP in 2015 so for these the $Post_{jt}$ dummy is set at 2015.

¹⁶ We include bank-specific dummies to control for time-invariant, unobservable bank characteristics that can shape bank NIMs and RoAs. We include year fixed effects to control for possible shocks over the sample period that can affect bank NIMs and RoAs such as other monetary policies and changes in regulation. All regressions are estimated with bank-level clustering, namely allowing for correlation in the error terms. We use robust standard errors to control for heteroscedasticity and dependence (see Bertrand et al, 2004; Petersen, 2009; Donald and Lang, 2007). We also estimate equation 2 substituting bank fixed effects with country fixed effects to control for differences among our sample of countries limiting the omitted variables bias.

¹⁷ The inclusion of covariates in a difference-in-differences framework presents advantages but also disadvantages (Lechner, 2010). On the one hand, introducing explanatory covariates can have the positive advantage of detecting cross-bank and cross-country heterogeneity that can potentially affect bank NIMs and RoAs independently by the introduction of NIRP. On the other hand, the introduction of covariates can cause two main problems. First, when banks are relatively homogeneous in both the treatment and control group, additional covariates can weaken, instead of strengthening, the likelihood that both groups maintain the parallel trend, hence violating our assumption. Second, time varying covariates can change or be influenced by the post-treatment period, leading to endogeneity problems. We assess this problem in several ways. First, we test the control variables for multicollinearity using the *variance inflation factor* (VIF). A mean VIF of 1.07 suggests that our controls are not highly correlated (a correlation matrix is provided in Table A2 in the appendix). Second, we provide

sheet and performance measures. Our control variables are in-line with the literature on the determinant of NIMs and profits. We include four bank-specific and two country-specific control variables that have been shown in the literature to explain banks' performance. The first variable is size (size) measured by the logarithm of bank total assets. According to Goddard et al. (2004) and Mirzaei et al. (2013) banks size affects profits positively through the realisation of economies of scale. However, as suggested by Demirgüç-Kunt and Huizinga (1999) and Demirgüç-Kunt et al. (2004) large efficient banks apply lower margins to customers through increasing returns to scale, hence we expect profits and margins to have the opposite signs in relation to size. Several studies (McShane and Sharpe, 1985; Saunders and Schumacher, 2000; Maudos and Fernandez de Guevara, 2004) use the ratio of equity to total assets (E/TA) as a proxy for bank risk aversion. A positive relation is expected between this variable and margins¹⁸. Risk averse banks will require higher margins to cover the greater cost of equity. A positive relation is expected also with reference to profitability as suggested by Berger (1995). Banks with higher franchise value and well-capitalised face lower expected bankruptcy and funding costs. We also use liquidity (Carbo and Fernandez, 2007) and a credit risk measure (Carbo and Fernandez., 2007; Poghosyan., 2012; Almarzoqi and Naceur, 2015) to explain bank margins. In this context, we use the ratio of liquid securities to total assets (liquidity) and the loan loss provision to gross loans ratio (credit risk), respectively. We expect that less liquid and credit riskier banks, apply a premium to margins.

The country-specific variables are broad measures of macroeconomic performance and include GDP growth (GDP growth) and consumer price inflation (inflation). Athanasoglou et al (2008) recognise a twofold GDP growth effect on bank performance. On one hand, GDP growth has a positive effect on bank profits coming from a greater demand for loans. In contrast, there may be a negative relationship if the supply of funds (deposits) declines due to a rise in consumption in-line with GDP growth. The extended literature (Molyneux and Thornton, 1992; Boyd et al, 2001; Demirgüç-Kunt et al, 2004; Gelos, 2006; Almarzoqi and Naceur, 2015) has also demonstrated a positive relationship between nominal inflation and bank margins and profits. The economic uncertainty induced by high inflation rates is compensated for by higher spreads.

The difference-in-differences approach requires that three assumptions hold. First, the control group must constitute a valid counterfactual for the treatment¹⁹. Second, assignment of the treatment has to be exogenous with respect to bank performance. In other words, the policy action ('intervention') should affect bank performance and not vice versa. As explained in the introduction, the aim of NIRP is to increase the cost to banks of holding excess reserves at the central bank encouraging them to take them back on the balance sheet and increase the supply of loans. Hence, influencing bank performance (profits and margins) is not the policy-makers main target but rather reflects a secondary effect. Moreover, figures 1 and 2 show that, prior to the introduction of NIRP, NIMs and RoAs moved in a similar direction but the relationship changed thereafter. This is confirmed when we

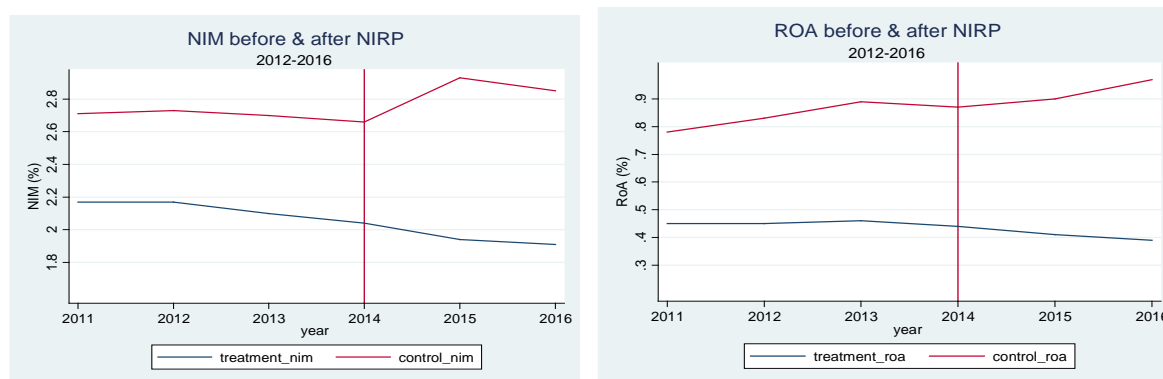
t-test statistics to show that the control variables are not homogenous among treated and untreated banks (see section 3.2 and Table 1). Finally, to avoid the possibility that time varying control variables can be influenced by the intervention (the NIRP introduction), we test the control variables as dependent variables in the difference-in-difference specification. As expected, the test (not reported) suggests that our control variables are not affected by the intervention.

¹⁸ Macroeconomic theorists such as Gertler and Kiyotaki (2011) suggest a negative relation. A higher net worth (equity) relative to the capital stock reduces the expected default probability (everything else equal). Thus, banks can charge lower margins to customers.

¹⁹ We provide evidence that this assumption holds in the next section.

examine the third requirement of a ‘parallel trend assumption’²⁰. Figure 1 depicts level of NIMs and RoAs from 2011 to 2016 for both NIRP adopter and non-adopter countries. Both NIM and RoA move in the same direction in the pre-treatment period, indicating that the parallel trend assumption holds. Since June 2014, when policy rates in most of the NIRP adopter countries turned negative, NIRP affected banks register the worst performance since 2011 with level falling below 2% for NIM in 2014-2015 and below 0.40% for RoA in 2015²¹.

Figure 1. Average NIM/ROA among treated banks (blue line) and non-treated banks (red line) from 2011 – 2016.



Data

We rely on Jobst and Lin (2016) for dating the adoption of NIRP regimes and construct a dataset combining information mostly from two main sources²². The macroeconomic series are from Thompson DataStream and the bank balance and performance data are from Orbis Bank Focus. Since Orbis comprises cross-country banks that operate in more than one country, balance sheet data can be either consolidated or unconsolidated. To avoid concerns regarding banks that operate in more than one country in both treated and not treated groups, we use bank account data that are either unconsolidated (U1 and U2 codes in Orbis) or consolidated but not with an unconsolidated subsidiary. Our sample covers 7242 financial institutions (commercial banks, savings banks, cooperative banks and bank holding companies) from 33 OECD countries over 2012 - 2016²³. The treated countries include those of the Euro Area, Hungary, Sweden and Switzerland.²⁴ Descriptive statistics for bank RoAs and NIMs, other bank balance sheet variables, and the macroeconomic series in the treatment and control groups of countries are shown in Table 1.²⁵

²⁰According to Bertrand et al. (2004) and Imbens and Wooldridge (2009) the difference-in-differences is valid only under the restrictive assumption that changes in the outcome variable (in our case bank profits and NIM) over time would have been exactly the same in both treatment (countries that experienced NIRP) and control groups (no NIRP) in the absence of the intervention (the introduction of NIRP).

²¹ A correlation table (Table A3 in the Appendix) of the average level of NIMs and RoAs pre- and post-NIRP confirms the inverse trend among the two groups following the intervention.

²² See Table A1 in the Appendix for the dating of NIRP.

²³ The sample period is intentionally short. According to Roberts and Whited (2013) and Bertrand et al. (2004) the change in the treatment group should be concentrated around the onset of the treatment. Moving away leads to unobservable and other factors that affect the treatment outcome leading to omitted variable bias threatening the validity of the model.

²⁴ We exclude Japan in our sample as the country only adopted NIRP in early 2016, which provides too short a period to examine the impact of NIRP on profits and margins.

²⁵ We also estimate Pearson correlation coefficients (table A4 in the appendix) for the macroeconomic variables in the treatment and control groups. The significance of coefficients suggests that the countries in the two groups experienced a similar macroeconomic environment validating the fact that the control group constitutes a valid counterfactual scenario for the treatment. This finding, together with the parallel trend assumption that we report in Figures 1 and 2, further supports our decision to choose a difference-in-differences methodology in our

Panel A and B of Table 1 presents summary statistics on the aforementioned balance sheet data. Panel C displays macroeconomic condition and monetary policy variables descriptive statistics²⁶. Bank profitability and margin may also be driven by other macroeconomic, market and monetary policy factors. Accordingly, we control for a wide range of potentially important explanatory control variables in the regression models. Following Carbo and Fernandez (2007), Maudos and Fernandez de Guevara (2004), Hawtrey and Liang (2008) Maudos and Solis (2009), Lepetit et al. (2008), Almarzoqi and Naceur (2015) and Entrop et al. (2015), we use the Lerner index (Lerner index) to control for competition in the banking sector²⁷. The Lerner index is the difference between the price and the total margin cost as a proportion of the price and has been taken from the World Bank Global Financial Development Database. It ranges between 0 (perfect competition) and 1 (monopoly). It is inversely proportional to banking competition. NIRP is expected to have a more marked impact in more competitive systems as changes in policy rates are likely to be passed on more effectively.

As other UMP policies, including central banks' asset purchase programs (Di Maggio et. al, 2016; Rodnyanski and Darmouni, 2016; Kandrac and Schulsche, 2016; Chakraborty et. al, 2017), were conducted at the same time as NIRP we include variables to account for these effects. In-line with Gambacorta et al. (2014), Lambert and Ueda (2014), and Alessandri and Nelson (2015) we employ the log growth rate of a country's central bank balance sheet (*CB_GR*). We also use the log growth rate of the monetary base (*MO_GR*) as further controls to isolate the impact of other UMP's on bank NIMs and RoAs. According to the aforementioned studies other UMP's are also expected to compress margins and therefore (we expect) bank profits. This is investigated in the robustness check section 4.2 of the paper.

Finally, we try to disentangle the impact of NIRP on bank margins and profitability in those countries that for historical or cultural reasons have a preference for lending at a floating or fixed rate basis. One would expect the impact of NIRP to be greater in countries where floating rates are more prevalent. Following Albertazzi and Gambacorta (2009) we address this issue by using the share of variable rate loans in total loans to households and non-financial corporations (floating-fixed rate) taken from the ECB Statistical Warehouse to identify countries where the bulk of lending is at a variable or fixed rate.

analysis. We arbitrarily chose a longer time period (in comparison with the sample period) to highlight that these macroeconomic indicators move together for several years after the GFC.

²⁶ Equality of means t-test is also performed.

²⁷ We prefer the non-structural Lerner index measure of competition over a concentration measure such as the Herfindahl-Hirschman Index (HHI). There are, in fact, different views about competition and concentration in the literature. Claessens and Laeven (2003), for example, point out that there are some countries, such as U.S, that show levels of monopolistic competition in banking despite the relatively low level of concentration and large number of banks, while countries like Canada are highly competitive, although the level of concentration is high and number of banks relatively small. Beck and Hesse (2009) suggest that concentration measures are not satisfactory measures of the degree of market competition in the banking industry.

Table 1. Descriptive Statistics Control and Treatment Group

Variable	I. Treatment group:					II. Control group				
	Obs.	Mean	Std. Dev.	Min	Max	Obs.	Mean	Std. Dev	Min	Max
Panel A: Bank Profitability and Margin										
NIM	16956	2.00%***	0.90%	0.52%	3.08%	9017	2.74%***	1.36%	0.39%	6.15%
ROA	17133	0.43%***	0.50%	0	1.26%	9268	0.91%***	0.75%	-0.10%	3.26%
Panel B: Bank Balance Sheet Data										
Size	17186	13.78***	1.59%	11.51	16.58	9658	14.35***	2.02%	11.21	17.63
E/TA	17182	10.14%***	4.75%	4.07%	21.76%	9654	16.55%***	13.91%	5.47%	51.27%
Liquidity	16444	21.49%***	15.04%	0.01%	46.68%	8715	22.23%***	20.00%	0.01%	64.85%
Credit risk	9888	5.88%***	5.47%	0.48%	17.25%	6081	2.69%***	2.62%	0.19%	8.46%
Panel C: Macroeconomic Conditions and Monetary Policy										
GDP growth	20456	0.25%***	0.56%	-0.19%	6.62%	46240	0.52%***	0.17%	-1.13%	1.89%
Inflation	20456	0.99%***	0.77%	-1.73%	4.39%	46244	1.51%***	1.17%	-1.73%	8.93%
CB_GR	15342	-7.34%***	14.22%	-22.06%	23.44%	25066	16.93%***	13.59%	-14.33%	37.80%
M0_GR	13448	8.35%***	12.78%	-7.89%	51.56%	44788	9.65%***	8.00%	-26.63%	18.77%
Deposit Rate	3486	0.69%***	1.01%	-0.18%	5.29%	3988	4.31%***	5.34%	0.03%	16.77%
Lending Rate	4788	4.02%***	1.24%	2.68%	9.00%	43385	3.25%***	0.78%	0.80%	9.26%
Lerner Index	20456	0.16***	0.78%	0.67	0.41	45400	0.32	0.04%	0.11	0.44
Floating-Fixed Rate	18208	71.39%	18.08%	32.95%	98.10%					

Note: NIM is the yearly difference between interest earning assets and interest bearing liabilities divided by total interest earning assets; ROA is the yearly net income to total asset ratio; Size is the natural logarithm of bank total asset; E/TA is the ratio of bank equity to total assets; Liquidity is the ratio of bank liquid securities to total assets; Credit risk is the ratio of loan loss reserve to gross loans; Lerner is the Lerner index; GDP_GR is the yearly growth rate of real GDP; Inflation is the yearly Consumer Price Index in percentage;; CB_GR is the monthly logarithm growth rate of central bank balance sheet size; M0_GR is the logarithm growth rate of the money supply M0; Deposit Rate is the country level aggregate deposit rate in percentage; Lending Rate is the country level aggregate of lending rate in percentage; Spread is the difference between lending and deposit rates; Floating-Fixed Rate is the share of variable loans in total loans to household and non-financial corporation taken from the ECB Statistical Warehouse Database. ***, ** and * indicate statistical significance at 1%, 5% and 10%, respectively.

Empirical results

Baseline results

The results from estimating equations (1) and (2) are presented in table 2 and 3. All the estimates include fixed bank and time effects. Table 2 and 3 report the estimates where the dependent variables are the NIMs (Table 2) and RoAs (Table 3), respectively. For both variables we incrementally introduce a set of bank and country control variables²⁸. Our main interest is the size, sign and statistical significance of the coefficient of β_3 that represents the average difference in the change of NIMs and RoAs between countries that adopted NIRP and those that did not, denoted in the table as the *NIRP-effect*. The baseline results reported in columns 1 of Tables 2 and 3 excludes all control variables. The coefficient of *NIRP-effect* is sizeable, negative and statistically significant at the 1% level for both dependent variables, indicating that countries where central banks implemented NIRP experienced a decline in NIMs and RoAs of around 12.60% and 6.27% respectively, relative to those countries where central banks did not follow the same policy²⁹. In-line with expectations the size of the coefficient on NIMs are nearly double that of RoA. This leads to two preliminary conclusions. First, NIRP directly causes a compression of banks' margins suggesting that they are unable to reduce deposit rates to the same extent as loan rates. Second, the contraction in NIMs (as a key component of bank profitability) indirectly drags down bank RoAs but to a lesser extent – a fall in margins reduces profits but not to the same extent as the overall effect is likely mitigated by lower/negative rates boosting non-interest income (via increased security valuations, trading income and such like)³⁰. The remaining columns of the tables present the results from adding bank- and country- specific controls sequentially. The baseline regression result holds up well in the face of all controls—though the size of the coefficient is diminished somewhat (with the marginal effect varying between 9.06% (column 8) and 13.10% (column 2) for NIM, and between 3.54% (column 7) and 6.20% (column 1) for RoA)³¹. The coefficients on the *NIRP-effect* remain negative and significant at the 1% level in all estimates. The covariates are mostly significant at conventional levels (although with small coefficients) with signs in-line with the literature on the determinants of NIMs and RoAs. The E/TA variable is positively correlated with NIMs suggesting that less leveraged and more profitable banks register higher margins. In contrast, liquidity, and credit risk are negatively related to NIM indicating that banks that are less liquid and with large non-performing assets apply higher margins to compensate for greater risks. Size and E/TA appear to be the main factors driving bank RoAs, while less liquid banks are the ones, in our sample, that show the largest profit reductions. Among the macroeconomic variables, the inflation

²⁸ In trying to avoid biased estimation, we remove credit risk in the RoAs regression as it causes an excessive variation in the NIRP-effect coefficient.

²⁹This has been known for a long time. Samuelson (1945) mentioned: "the banking system as a whole is immeasurably helped rather than hindered by an increase in interest rate".

³⁰We later test this to see whether NIRP resulted in an increase in non-interest income. For this exercise, we run two difference-in-differences baseline regressions (table A5 column 1 and 2 in the appendix) using the ratios of non-interest income to gross income and net fees and commission to total assets (according to Jobst and Lin (2016) and Arteta et al. (2016) banks should increase fees and commissions to compensate for the decline in interest earnings). The result suggests that NIRP-affected banks experienced an increase in non-interest income (NII), and fees and commissions (FEE), relative to those banks unaffected by the policy. This provides an explanation of the differences between NIMs and RoAs with the former declining more markedly than the latter.

³¹ As suggested by Roberts and Whited (2013), a large discrepancy of the treatment coefficient with and without controls should raise a 'red flag'. In our case, variation in the NIRP-Effect coefficient occurs when country control variables are introduced. To assess this problem we run (Table A6 and A7 in the Appendix) two additional regressions removing country control variables and bank fixed effects and introducing country fixed-effects. The NIRP-Effect coefficient is significant and displays smaller variation with the addition of country controls. This suggests that our country measures are not fully able to capture unobservable factors as country fixed effects.

rate displays a strong positive coefficient for both NIMs and RoAs suggesting that the low inflation decade since the GFC is another factor affecting banking sector performance³².

³² Similar tests (not reported) have been undertaken using another bank profitability measure (RoE). Although the NIRP-effect coefficient remains negative and is statistically significant, it does not hold-up well when the controls are introduced. This is not surprising. RoE is more variable and easy to manipulate by managers via share buy-backs, provisioning and other earnings management techniques. As our estimates also show, it is more strongly influenced by macroeconomic conditions. That is why the empirical banking literature has a strong preference for using RoA as a profits indicator. RoE results are not reported here but are available from the authors on request.

Table 2. NIRP and NIMs

	NIM(1)	NIM(2)	NIM(3)	NIM(4)	NIM(5)	NIM(6)	NIM(7)	NIM(8)
NIRP-Effect	-0.1260*** (0.0145)	-0.1310*** (0.0148)	-0.1250*** (0.0149)	-0.1138*** (0.0152)	-0.1177*** (0.0153)	-0.1160*** (0.0146)	-0.1070*** (0.0148)	-0.0856*** (0.0158)
Size		-0.0371 (0.0228)	0.0208 (0.0270)	0.0022 (0.0317)	-0.0952*** (0.0495)			-0.0698 (0.0509)
E/TA			0.0053*** (0.0013)	0.0057*** (0.0014)	0.0105*** (0.0029)			0.0108*** (0.0029)
Liquidity				-0.0010*** (0.0003)	-0.0023*** (0.0006)			-0.0024*** (0.0006)
Credit risk					-0.0056*** (0.0016)			-0.0041** (0.0017)
GDP growth						-0.0619*** (0.0137)	-0.0234* (0.0131)	-0.0029 (0.0195)
Inflation							0.0505*** (0.0061)	0.0416*** (0.0070)
Adj. R2	0.0553	0.0558	0.0603	0.0668	0.1109	0.0577	0.0636	0.1270
N.Banks	7242	7242	7241	6895	4895	7241	7241	4894
N.Obs	25973	25973	25965	24592	15474	25969	25969	15470

All regressions include fixed bank and time effects. Robust standard errors clustered by banks in parenthesis. ***, ** and * indicate statistical significance at 1%, 5% and 10%, respectively.

Table 3. NIRP and RoA

	ROA(1)	ROA(2)	ROA(3)	ROA(5)	ROA(6)	ROA(7)	ROA(8)
NIRP-Effect	-0.0627*** (0.0119)	-0.0620*** (0.0120)	-0.0579*** (0.012)	-0.0374*** (0.0121)	-0.0611*** (0.0120)	-0.0576*** (0.0120)	-0.0312*** (0.0123)
Size		0.0060 (0.0158)	0.0437** (0.020)	0.0442* (0.0260)			0.0496* (0.0262)
E/TA			0.0033*** (0.0012)	0.0057*** (0.0017)			0.00584*** (0.0017)
Liquidity				-0.0000 (0.0000)			-0.0000 (0.0000)
GDP					-0.0104 (0.0130)	0.0058 (0.0143)	0.0074 (0.0153)
CPI						0.0227*** (0.0054)	0.0251*** (0.0054)
Adj. R2	0.008	0.008	0.014	0.0190	0.0086	0.0095	0.0210
N.Banks	7359	7358	7357	6939	7358	7358	6938
N.Obs	26401	26400	26394	24767	26397	26397	24763

All regressions include fixed bank and time effects. Robust standard errors clustered by banks in parenthesis. ***, ** and * indicate statistical significance at 1%, 5% and 10%, respectively.

Robustness checks

In this section, we report results from a range of robustness checks that offer variations from our choice of controls used in the baseline model. As previously described, the aim of NIRP is to induce further reductions in interest rates as banks run down their excess reserve balances. However, since deposits (may) have a “price floor” set at zero, a decline in lending rates can lead to a contraction of NIMs³³. We control for this effect by including in our analysis lending and deposit rates. The results are reported in panel A of table 4 (column 1-4). As expected, the NIRP coefficient becomes larger and is more significant. There is a strong positive relation between NIMs and the level of deposit rate and lending rate. It is interesting to note that lending rates have a larger impact on NIM than deposit rates - a 1% increase/decrease in lending rates leads to a 5.48% increase/decrease in NIM while for deposit rates the effect is a 1.45% change. This result suggests that, in a low and negative interest rates environment as in our sample, NIMs are more sensitive to changes in lending rather than deposit rates - confirming that deposits are downward ‘sticky’. Furthermore, the effect of deposit and loan rates on RoAs is insignificant³⁴.

NIRP was brought into the UMP mix by central banks several years after the adoption of other UMPs, and in particular the extensive use of outright asset purchases via QE. It is important to disentangle the effects of NIRP on profitability and margins from the effects of these policies. Outright asset purchases were aimed at expanding the central bank’s balance sheet to increase the level of the monetary base, encouraging banks to lend – in order (ultimately) to boost nominal spending (Bernanke and Reinhart., 2004). Accordingly, we proxy for the use of other UMPs by including, alternatively, variables that take into account the central bank balance sheet size and (alternatively) the size of the monetary base. The results are reported in panel B of table 4 (column 1-3) and are important for two reasons. First, they are in-line with the studies of Lambert and Ueda (2014) and Alessandri and Nelson (2014) underlining the possible negative effect of UMP on margins. The coefficients of central banks asset growth (CB_GR) and M0 growth (M0_GR) are negative and statistically significant (column 1 and 3). Second, the effect of UMP is diametrically the opposite for RoA (column 2 and 4). Hence, while UMP and NIRP play a complementary role in driving down NIMs, the latter appears to have cancelled out a substantial amount of the stimulus impact of central bank balance sheet expansion in terms of boosting bank profits³⁵.

As a further robustness check, we alter our country sample and focus only on European countries where the treatment group includes only European NIRP adopters and the control group includes only European non-NIRP adopters. These results are reported in panel C of the table 4 (column 1 and 2). The coefficients of NIRP in both

³³ However, in countries like Sweden and Denmark, where banks operate in a highly concentrated banking system and do not rely on retail deposit funding, banks can eventually decide to lower retail deposit rates below zero. In section 4.2, we test the role of market competition and bank funding structure on different bank behaviours in a negative interest rate setting.

³⁴ A similar test has been undertaken computing bank-level loan and deposit rates. Following Carbo and Fernandez (2007), we define the price of loans as the ratio of interest income on loans and the price of deposits as the ratio of interest expenses on deposits. The results (not reported) are in-line with our aggregate measures.

³⁵ It might be the case that both UMPs and NIRP have a positive impact on non-interest income that could offset the negative effects of declines in NIM on profitability. In table A5 (column 3) in the Appendix, we complement the analysis of the non-interest income baseline regression by adding M0_growth as a UMP control. The result shows that both NIRP and UMPs affect positively non-interest income. However, the overall negative effect on RoA displayed in table 3 indicates that the negative effects of NIMs on bank profits outweigh the positive effect of greater non-interest income and profitability still falls. This last point is further examined in section 4.3 of the paper.

cases remains negative and statistically significant (in the case of NIM the relationship is stronger than in the baseline regression)³⁶.

As a final robustness check, we try to eliminate the possibility that bank margins and profitability in the treatment group may have altered prior to the introduction of NIRP—for example, in anticipation of the adverse effects of NIRP, or for some bank-specific reasons—thereby invalidating our choice of difference-in-differences estimation. If the estimated coefficients on the ‘false’ NIRP are not statistically significant, we can be more confident that our baseline coefficient is capturing a genuine monetary policy shock. In panel D of the table we report results from estimates in which we extend our sample to the period from 2011 – 2014 setting the introduction of a “fake” NIRP in 2013. The coefficient on the NIRP variable is still negative but smaller and not statistically significant adding further support to the validity of our baseline estimation.

³⁶ We follow the studies conducted by Bertrand and Mullainathan (2003) and Jayaratne and Strahan (1996) that use different control groups, as a further test to control for the omitted variables problem. Multiple control and treatment groups reduce biases and unobservable variables associated with just one comparison.

Table 4. Robustness checks

	NIM (1)	ROA(2)	NIM (3)	ROA (4)
a. Lending and deposit rates				
NIRP-effect	-0.1993*** (0.0163)	-0.0792*** (0.0131)	-0.1493*** (0.0288)	-0.0436*** (0.0218)
lending rate	0.0548*** (0.0163)	0.0156 (0.0121)		
deposit rate			0.0145*** (0.0198)	0.0090 (0.0161)
Adj. R2	0.0440	0.0058	0.0396	0.0103
N.Obs	10901	11112	5678	5738
N.Banks	3142	3210	1719	1737
b. Unconventional Monetary Policy (UMP)				
NIRP-effect	-0.1520*** (0.0144)	-0.0584*** (0.0108)	-0.1620*** (0.0142)	-0.0842*** (0.0105)
CB_GR	-0.0393* (0.0209)	0.0733*** (0.0196)		
M0_GR			-0.0012*** (0.0003)	0.0005* (0.0003)
Adj. R2	0.0723	0.0090	0.0612	0.0121
N.Banks	7238	7354	5335	5422
N.Obs	25212	25627	19486	19809
c. NIRP and the EU				
NIRP-effect	-0.179*** (0.0267)	-0.0507*** (0.0175)		
Adj. R2	0.0950	0.0119		
N.Banks	5527	5623		
N.Obs	19897	20244		
d. fake-NIRP				
NIRP-effect	-0.0173	-0.0080		
Adj. R2	0.0000	0.0001		
N.Banks	7183	7307		
N.Obs	20123	20472		

All regressions include fixed bank and time effects. Robust standard errors clustered by banks in parenthesis. ***,

** and * indicate statistical significance at 1%, 5% and 10%, respectively

Size, Competition and Asset Composition

As suggested by Jobst and Lin (2016), Brunnermeier and Koby (2016) and Bech and Malkhozov (2015), the contraction in NIMs and erosion of profitability should be more marked for small banks operating in competitive markets and with floating rate assets. In this section, using the difference-in-differences framework, we create NIRP-adopter treatment groups and non-adopter control groups according to various bank-specific factors that the literature on NIRP suggest might affect bank behaviour in a negative interest rate setting. Specifically, we focus on bank size, market competition and asset interest rate composition. First, we examine the impact of NIRP on NIMs and RoAs by running percentile regressions based on size. The results reported in Tables 5 are important in two respects. First, the largest banks show a significantly smaller contraction in margins (4.1% compared to 21.1% for the smallest (panel A in columns 1 and 4) and statistically insignificant influence on profitability (column 2). Following dell’Ariccia et al. (2010), this result suggests that NIRP enables large wholesale funded banks to take greater advantage of a declining funding costs partially offsetting pressure on margins and profitability. Second, the coefficients get larger in magnitude as banks size shrinks. This is in-line with the literature mentioned in section 1 indicating that large banks, through hedging and diversification, are better able to protect themselves against interest rate risk³⁷.

As a second test, we assess the impact of NIRP in the context of competitive conditions in banking markets. In this case, we use the Lerner index as a proxy for competition conditions³⁸. Sørensen and Werner (2006) argue that banks operating in a less competitive environment make slower adjustments to interest rates (and therefore to NIMs), which slows the transmission of monetary policy. Brunnermeier and Koby (2016) present a “reversal interest rate” hypothesis according to which there is a rate of interest at which accommodative monetary policy “reverses” its effect and becomes contractionary. They show that low interest policy is likely to have a more limiting effect on bank lending in competitive markets because of the associated pressure on NIMs. As the Lerner index varies between 0 and 1, we define a competitive market as those banking markets with a Lerner index smaller than 0.50, vice versa for non-competitive. The results, reported in panels A and B of table 6, support the aforementioned studies: namely that the impact of NIRP on bank profits and margins in competitive markets is negative and statistically significant. In less competitive markets in contrast, the impact of NIRP is negative but statistically insignificant for NIM while positive and statistically significant for RoA suggesting that banks here are better able to maintain profitability and margins.

³⁷ If small banks do not increase non-interest income from NIRP, we can more confidently say that the policy has a larger impact on reducing their RoA. In Table A8 (Panel A and Panel B) in the Appendix, we provide percentile regressions based on bank size for the impact on non-interest income and fees and commissions. The results confirm our hypothesis that small banks are the most affected (negatively) by NIRP in term of NIMs and RoAs as well as the least affected (positively) by NIRP in respect of non-interest income. Regressions (not reported) that include *MO_growth* as a control for UMPs also suggest a similar positive effect of UMPs on non-interest income and fees and commissions for large banks, while small banks are just marginally affected.

³⁸ For this exercise, similar tests were also undertaken using the Boone index and the Herfindahl-Hirschman Index (HHI). The results obtained (table A9 in the Appendix) are in-line with the Lerner index.

Table 5. Bank size, NIM and RoA

	Bank Size>75th percentile		Bank Size>50th & <75th percentile		Bank Size>25th & <50th percentile		Bank Size<25th percentile	
	NIM(1)	RoA(2)	NIM(3)	RoA(4)	NIM(5)	RoA(6)	NIM(7)	RoA(8)
Panel a.								
NIRP-effect	-0.0410**		-0.1460***		-0.1830***		-0.2110***	
	(0.0191)		(0.0229)		(0.0267)		(0.0437)	
Panel b.								
NIRP-effect		0.0261		-0.0519***		-0.0709***		-0.108***
		(0.0162)		(0.0188)		(0.0227)		(0.0279)
Adjusted R2	0.0324	0.00418	0.0820	0.0142	0.105	0.0138	0.102	0.0212
N.banks	1944	1855	2064	2115	2164	2195	2090	2159
N.Obs	6145	6514	6222	6637	6389	6629	6226	6621

All the percentile regressions include fixed bank and time effects. Robust standard errors clustered by banks in parenthesis. ***, ** and * indicate statistical significance at 1%, 5% and 10%, respectively.

Table 6. Banking sector competition and interest rate asset composition

	NIM	ROA	NIM	ROA
	<i>Panel A. Competitive</i>		<i>Panel B. Non-competitive</i>	
NIRP-effect	-0.0798*** (0.0372)	-0.0695*** (0.0248)	-0.0327 (0.0205)	0.0680*** (0.0207)
r2_a	0.0964	0.0039	0.0187	0.0030
N.Banks	4559	4640	3361	3443
N.Obs	15096	15259	10877	11142
	<i>Panel C. Fixed-rate</i>		<i>Panel D. Floating-rate</i>	
NIRP-effect	0.0222 (0.0155)	0.0286* (0.0141)	-0.0368** (0.0141)	0.0031 (0.0107)
r2_a	0.0058	0.0017	0.0244	0.0008
N.Banks	3689	3773	6436	6543
N.Obs	13095	13411	23066	23454

All regressions include fixed bank and time effects. Robust standard errors clustered by banks in parenthesis.

***, ** and * indicate statistical significance at 1%, 5% and 10%, respectively.

As a final test, we try to disentangle the effect of NIRP for floating-rate and fixed-rate countries³⁹. According to Jobst and Lin (2016), Brunnermeier and Koby (2016) and Albertazzi and Gambacorta (2009), the impact of NIRP should have a greater effect on variable-rate loans and on new loans. Hence, banks having a higher proportion of outstanding floating rate loans/assets should be strongly adversely impacted by the new monetary regime compared to those that rely more on fixed rate assets. The ECB's Statistical Warehouse provides data on the share of variable rate loans in total loans to household and non-financial corporations. Again, we split the sample dividing the treatment group into floating and fixed rate countries. For this exercise, we consider a floating rate country as having a share of variable rate loans to total loans greater than 50%, and vice versa for fixed-rate countries⁴⁰. The results are presented in panel C and D of table 6. While it is noticeable that there is a reduction in NIMs in floating rate countries (as expected), the results display also an increase in bank profits for floating rate countries as their margins are less affected by NIRP.

³⁹ As already mentioned in section 4.2, splitting control and treatment groups in different sub-groups allows us to reduce biases and unobservable variables associated with just one comparison, hence limiting the omitted variables bias.

⁴⁰ Germany, Austria, Estonia, Spain, Finland, Greece, Ireland, Italy, Luxembourg, Portugal, Sweden and Slovenia are, according to our computation, floating rate countries. Denmark, France, Hungary, Norway, Netherlands and Slovakia are fixed rate.

Conclusions

Since 2012, several central banks have adopted NIRP aimed at boosting real spending by facilitating an increase in the supply of bank loans. The policy has generated controversy with skeptics pointing to several factors that might complicate the transmission from negative policy rates to higher bank lending. One factor that has been mentioned is that NIRP could compress NIMs and, therefore, bank profits, which may limit a bank's ability to lend. Empirical evidence on the impact of NIRP on bank behavior/performance is scant. In this paper, we provide new evidence that bank margins and profitability fared worse in NIRP-adopter countries than in countries that did not adopt the policy. Specifically, countries in which central banks implemented NIRP experienced a decline in NIMs and RoAs compared to those countries in which central banks did not follow this policy. This result holds and is robust to the inclusion of several bank-specific control variables. It also stands-up in the face of a wide array of robustness checks, including controlling for the effects of lending and deposit rates, other UMPs, for subsample analysis and to (possible) changes prior to the introduction of NIRP. Finally, our findings support recent discussion and preliminary analysis of the effect of NIRP on bank-specific factors (size, competition and interest rate asset composition) that make banks profitability more vulnerable in a negative interest rate environment.

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Appendix

Table.A1 Time of Adoption of NIRP.

Country	NIRP adoption date
Austria	June 2014
Belgium	June 2014
Denmark	July 2012
Estonia	June 2014
Finland	June 2014
France	June 2014
Germany	June 2014
Greece	June 2014
Hungary	March 2014
Ireland	June 2014
Italy	June 2014
Luxembourg	June 2014
Netherlands	June 2014
Norway	September 2015
Portugal	June 2014
Slovakia	June 2014
Slovenia	June 2014
Spain	June 2014
Sweden	February 2015
Switzerland	January 2015

Table A2. Correlation Matrix control variables

	size	E/TA	Liquidity	Credit risk	GDP growth	Inflation
Size	1.0000					
E/TA	-0.2015***	1.0000				
Liquidity	0.0706***	0.0097***	1.0000			
Credit risk	-0.0966***	0.2031***	0.0553***	1.0000		
GDP growth	0.1117***	0.1040***	-0.0745***	-0.1291***	1.0000	
Inflation	0.0102***	0.2022***	0.044***	0.0186***	-0.0174***	1.0000

Table A3. Correlation treatment and control group pre- and post-NIRP

	pre-NIRP	post-NIRP
NIM	0.94	-0.87
RoA	0.17	-0.94

Table A4. Descriptive Statistics Macroeconomics Indicators and Pearson Correlation Test in the Control and Treatment Group during the Period 2007-2015.

Variable	Mean Control	Mean Treatment	Std.Dev. Control	Std.Dev. Treatment	Pearson Corr.
Unemployment	7.38	7.54	1.86	3.70	0.6978*
GDP	0.35	0.19	0.47	0.64	0.9021***
Inflation	2.04	1.47	1.53	1.22	0.8659***

Table A5. NIRP, non-interest income, and fees and commissions

	NII (1)	FEE (2)	NII (3)
NIRP-effect	2.7970*** (0.2840)	0.0002*** (0.0001)	2.2760*** (0.2730)
M0_growth			0.0258*** (0.0048)
Adjusted R2	0.0276	0.0050	0.0193
N.banks	7360	6880	5050
N.Obs	25744	24701	18492

All regressions include fixed bank and time effects. Robust standard errors clustered by banks in parenthesis. ***, ** and * indicate statistical significance at 1%, 5% and 10%, respectively.

Table A6. NIRP and NIMs

	NIM(1)	NIM(2)	NIM(3)	NIM(4)	NIM(5)
NIRP-effect	-0.1261*** (0.0144)	-0.1370*** (-0.0144)	-0.1370*** (0.0145)	-0.1200*** (0.0144)	-0.123*** (0.0136)
Size		-0.1020*** (0.0081)	-0.0830*** (0.0086)	-0.0901*** (0.0084)	-0.124*** (0.0081)
E/TA			0.0078*** (0.0018)	0.0095*** (0.0019)	0.0222*** (0.0026)
Liquidity				-0.6590*** (0.0667)	-0.694*** (0.0748)
credit risk					-0.00321 (0.00197)
Year-FE	Y	Y	Y	Y	Y
Country-FE	Y	Y	Y	Y	Y
R2	0.0555	0.0540	0.0598	0.0676	0.118
N.banks	7242	7242	7241	6895	4895
N.Obs	25973	25973	25965	24592	15474

All regressions include fixed bank and time effects. Robust standard errors clustered by banks in parenthesis.
 ***, ** and * indicate statistical significance at 1%, 5% and 10%, respectively.

Table A7. NIRP and RoAs

	RoA(1)	RoA(2)	RoA(3)	RoA(4)
NIRP-effect	-0.0629*** (0.0118)	-0.0650*** (0.0118)	-0.0629*** (0.0118)	-0.0455*** (0.0119)
Size		-0.0218*** (0.0040)	0.0291*** (0.0037)	0.0344*** (0.0038)
E/TA			0.0246*** (0.0011)	0.0269*** (0.0012)
Liquidity				-0.136*** (0.0411)
Year-FE	Y	Y	Y	Y
Country-FE	Y	Y	Y	Y
R2	0.0081	0.0080	0.0241	0.0284
N.banks	7359	7358	7357	6939
N.Obs	26401	26400	26394	24767

All regressions include fixed bank and time effects. Robust standard errors clustered by banks in parenthesis. ***, ** and * indicate statistical significance at 1%, 5% and 10%, respectively.

Table A8. NIRP, non-interest income, and fees and commissions

	Bank Size>75th percentile		Bank Size>50th & <75th percentile		Bank Size>25th & <50th percentile		Bank Size<25th percentile	
	NII(1)	FEE(1)	NII(2)	FEE(2)	NII(3)	FEE(3)	NII(4)	FEE(4)
Panel A.								
NIRP-effect	2.507*** (0.443)		3.399*** (0.491)		3.219*** (0.606)		0.744 (0.842)	
Panel B								
NIRP-effect		0.0004*** (0.0001)		0.0003*** (0.0001)		0.0002 (0.0001)		-0.00004 (0.0001)
Adjusted R2	0.0157	0.0114	0.0345	0.00548	0.0669	0.00511	0.0174	0.0196
N.banks	1950	1765	2079	1970	2165	2076	2091	1945
N.Obs	6499	6197	6476	6234	6493	6309	6276	5961

All the percentile regressions include fixed bank and time effects. Robust standard errors clustered by banks in parenthesis. ***, ** and * indicate statistical significance at 1%, 5% and 10%, respectively.

Table A9. Banking sector competition and NIRP

	NIM	ROA		NIM	ROA
	<i>Panel a. HHI Non-concentrated</i>			<i>Panel b. HHI Concentrated</i>	
NIRP-effect	-0.0466*** (0.0200)	-0.0670 (0.0164)		-0.0078 (0.0343)	0.0346 (0.0265)
r2_a	0.0232	0.0039		0.0015	0.0089
N.Banks	5326	5406		1512	1546
N.Obs	18207	18501		4859	4953
	<i>Panel c. Boone Competitive</i>			<i>Panel D. Boone non-competitive</i>	
NIRP-effect	-0.0911** (0.0370)	-0.0037 (0.0272)		-0.0003 (0.0197)	0.0448** (0.0182)
r2_a	0.0232	0.0024		0.0290	0.0026
N.Banks	4325	4407		2753	2791
N.Obs	14760	15045		8306	8409

All regressions include fixed bank and time effects. Robust standard errors clustered by banks in parenthesis.

***, ** and * indicate statistical significance at 1%, 5% and 10%, respectively.

