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Implications of negative interest rates for the net interest margin and lending of euro area banks*

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Abstract

This paper explores the impact of low (but) positive and negative market interest rates on euro area banks' net interest margin (NIM) and its components, retail lending and retail deposit rates. Using two proprietary bank-level data sets, I find a positive impact of the level of the short-term rate on the NIM, which increases substantially at negative market rates. As low profitability could hamper the ability of banks to expand lending, I also investigate the impact of the NIM on new lending to the non-financial private sector. In general, the NIM is positively related to lending: When lending is less profitable, banks cut lending. However, at negative rates this effect vanishes. This finding suggests that banks adjusted their business practices when servicing new loans, thereby contributing to higher new lending in the euro area since 2014.

Keywords: net interest margin, monetary policy, negative interest rates, bank profitability, lending

JEL classification: G21; E43; E52.

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1 Introduction

In the wake of the financial and sovereign debt crises, monetary policymakers in the euro area responded by adopting a wide range of easing measures. Since then policy rates have been reduced to extremely low levels, with the deposit facility rate (DFR) even having been in negative territory since June 2014. A negative DFR means that banks have to pay for excess liquidity held at the central bank. This is a direct cost for banks which reduces their interest income. Short-term rates in the euro area closely followed the downward movements of the DFR. As a consequence, the interest rate level in the euro area has remained on a very low level for several years and has fuelled the discussion on the impact of monetary policy on banks' business models and profitability.

Against this background, banks' interest earnings are historically low. European banks still earn around 60% of their total net profits from interest-bearing assets and liabilities (European Central Bank (2017)). During the crisis and post-crisis years, the reliance on interest income even increased, as larger banks, too, shifted their focus more to retail businesses (CGFS (2018b)). Additionally, Detragiache, Tressel, and Turk-Ariss (2018) find that the share of fee and commission income to total income has not played a role in increasing the overall profitability of European banks since 2000. The authors also show that cross-sectional differences in profits of European banks reflected mainly temporary factors and not systematic and persistent differences in profitability. Their findings point to an intense competition in the European banking market. In particular, the scope of business model adjustments to potentially offset lower interest earnings, for instance reducing costs and/or raising non-interest income, depends on the level of competition in the banking (financial) market.

From a macro (welfare and monetary policy) perspective, low net interest margins (NIM) are not necessarily bad. They can be a sign of a relatively competitive banking sector and of lower funding costs for the non-financial private sector. Banks' individual interest rate-setting abilities in highly competitive markets should be limited, potentially resulting in a more complete interest rate pass-through (see Van Leuvensteijn, Kok Sørensen, Bikker, and van Rixtel (2013), CGFS (2018a)). However, from a financial stability perspective, lower margins imply *ceteris paribus* a weaker ability of banks to build up capital through retained earnings, decreasing their shock absorbing capacity.

Besides competition, the quantitative impact of the interest rate level on a bank's profitability also depends on its business model (Demiralp, Eisenschmidt, and Vlassopoulos (2017)). Banks with more diversified portfolios and more wholesale funded, like universal or larger commercial banks, have been less affected by the low and partly negative interest rate environment (Lopez, Rose, and Spiegel (2018)). There are mainly two reasons for this. First, larger banks are more capable of increasing their net non-interest income, for example through cross-selling activities. Second, in general, banks with a more diversified portfolio have managed to earn a nearly constant NIM during the low interest rate environment, albeit on a much lower level than, for example, retail lenders (Deutsche Bundesbank (2017) comparing different bank business models for Germany, European Central Bank (2019) showing results for 100 significant euro area banks).

In this article, I first investigate empirically the importance of the short-term interest rate level and the term spread for the NIM of banks located in the euro area. In contrast to the existing literature, the focus of this paper is on the NIM banks earn through lending, as this portfolio might be relatively more affected by the low level of market rates. For this purpose, I use two proprietary bank-level data sets on interest rates and balance sheet items for more than 200 euro area banks. The main advantage of using these data is their availability on a monthly basis, which is not common for profitability data of banks. A higher frequency is particularly preferable when analyzing the impact of the interest rate level on bank profitability. The estimation sample is representative for the euro area, as it covered around 55% of total outstanding loans to the non-financial private sector in December 2018.

This paper tries to contribute to the literature which suggests a non-linear relation between the NIM and the interest rate level. The empirical analyses follow different approaches to evaluate these potential non-linearities. First, I include squared terms of the short-term rate and the term spread in the regression model. Second, motivated by a strong indication of a non-linear relation - as the coefficient of the squared short-term rate is highly statistically significant - I substitute the squared terms by indicator variables for low but positive interest rates and negative interest rates and interact them with the interest rate level variables. I follow Claessens, Coleman, and Donnelly (2018) and define a low but positive interest rate environment when the 3-month OIS rate is between 0% and 1.25%. Furthermore, I decompose the NIM into the retail lending and retail deposit rates, as a different monetary policy transmission could result from an effective zero lower bound of the latter.

Since the beginning of the negative interest rate policy (NIRP) in the euro area in June 2014, credit growth has increased steadily (Figure 6 in the Appendix). As banks could adjust to shrinking profits by expanding their loan supply, I am interested in the isolated effect of the NIM on new lending. Therefore, I regress the quarterly loan growth rate on the NIM besides a wide set of bank specific control variables. I also simultaneously control for all country-specific time-varying macroeconomic factors (e.g. business cycle) by using time*country fixed effects.

I find that the short-term market rate is positively related with euro area banks' margins, but only up to an interest rate level of 2%. Furthermore, the impact is increasingly non-linear with declining interest rates. The effect is not only statistically significant but also economically relevant. In particular, at negative market rates, a 1 percentage point decrease in the short-term interest rate would suggest a reduction in the monhtly NIM of 3.2% relative to the sample mean, compared with 1.2% at low but positive rates.[1]

I also find a positive impact of the NIM on new lending. Thus, when lending is, on average, less profitable, banks cut lending. A falling margin might signal to the bank a lower covering of the operating costs when servicing a new loan. This finding applies especially to more profitable banks and retail lenders of the estimation sample. In particular, following a 1 percentage point decrease in the quarterly NIM banks reduce new lending to the non-financial private sector by 27.4% relative to the sample mean.[2] However, at negative rates this effect vanishes and is no longer statistically different from zero, suggesting that, as most banks face downward pressure on the interest income, banks supplement their income by granting more loans regardless of the average margin they earn. This change in banks' business practices when servicing new loans has contributed

[1] At negative (low but positive) rates one standard deviation of the short-term rate is equivalent to 0.12 (0.34) pp.

[2] A 1 standard deviation of the NIM over the whole sample period is equivalent to 1.13 pp.

ceteris paribus to higher new lending in the euro area since 2014. My findings therefore indicate that the NIRP of the Eurosystem has adverse effects on banks' NIM but the eroding margins have not so far adversely affected new lending.

The remainder of the paper is organised as follows. Section 2 gives a short overview of the related literature. Section 3 shows descriptive analyses of the profitability and balance sheet adjustments of euro area banks. Section 4 illustrates the identification and data I use. Section 5 explains my empirical approach, discusses the results and Section 6 concludes.

2 Related literature

Most of the related literature regarding the impact of the interest rate level on bank profitability focuses on US banks or on a worldwide sample of larger banks. In addition to the NIM, other profitability indicators, like the net operating income margin, the loan loss provisions margin, or broader profitability measures, like return on assets (ROA), are commonly used. In one of the first empirical studies, Flannery (1981) shows that market rates have no statistically significant long-run impact on the net operating earnings of 15 large US banks. Expanding the cross section and controlling for bank specific and macro variables, English, Van den Heuvel, and Zakrajšek (2012) and Alessandri and Nelson (2015), among others, find that a decrease in the short-term market rate and in the term spread have a negative effect on the NIM and ROA. In the first paper focusing on euro area banks, Altavilla, Boucinha, and Peydró (2017) document the same result for the NIM, but no significant effects on ROA.

A strand of the literature also analyses bank profitability under low positive interest rates. Consistent evidence is found that low-for-long interest rates erode banks' margins over time (Borio, Gambacorta, and Hofmann (2017), Claessens et al. (2018), Altavilla et al. (2017), Bikker and Vervliet (2017), CGFS (2018a)). One factor which can mitigate the effect on the NIM is the typically positive development of loan loss provisions when the interest rate level is low. Altavilla et al. (2017) find that the positive effect on provisions compensates entirely for the negative effect on the NIM. Investigating the composition of loan loss provisions, Huizinga and Laeven (2019) find stronger income smoothing through loan loss provisions and higher procyclicality with regard to GDP of banks in the euro area compared with banks in non-euro area countries. Bikker and Vervliet (2017) express financial stability concerns when banks mainly use provisions for future (expected) losses to boost their overall income in a low interest rate environment.

Banks' reluctance to charge negative interest rates on retail deposits implies a *de facto* zero lower bound, through which a negative interest rate level could have an even stronger downward effect on the NIM than low but positive rates. Nucera, Lucas, Schaumburg, and Schwaab (2017) find that, in an environment of negative interest rates, smaller banks that follow more traditional business models are perceived as relatively more risky.[3] A recent study by Lopez et al. (2018) finds that the overall profitability of banks which are funded at more than 75% through customer deposits is declining at negative rates; a finding that stands in contrast to large, small and low-deposit banks. In particular,

[3] Nucera et al. (2017) use the SRisk-measure, i.e. bank's propensity to become under-capitalized in a financial crisis.

the increased net non-interest income is not able to offset the declining effect on the net interest income. One consequence of this finding is that retail banks, which are often not listed on the stock exchange, are less able to boost their capital through retained earnings. Demiralp et al. (2017), using the same data as I do, find that balance sheet adjustments at negative rates differ by bank characteristics. High-deposit banks try to stabilise their interest income by granting more loans, which, in turn, may raise the overall riskiness of their loan portfolio. In fact, there is a growing literature for the euro area, too, finding that a prolonged period of low interest rates decreases risk perception and increases risk-tolerance by banks (Jiménez, Ongena, Peydró, and Saurina (2014), Neuenkrich and Nöckel (2018)). However, such findings are not specific to negative rates and certain business models of banks.

Regarding the effectiveness of monetary policy at negative interest rates, the empirical findings in the literature referring to the bank lending channel are ambiguous. For instance, Arce, García-Posada, Mayordomo, and Ongena (2018) and Jobst and Lin (2016) find no contractionary effect of NIRP on banks' credit supply. In contrast, Heider, Saidi, and Schepens (2018) show that, in the syndicated loan market, monetary policy is less effective when interest rates are negative. With a focus on the interest rate pass-through, Eggertsson, Juelsrud, and Wold (2017) find that the pass-through from market rates to deposit and lending rates collapses once the policy rate turns negative. Based on their theoretical macro-model, Eggertsson et al. (2017) show that, due to reduced bank profits, the total effect of a policy rate cut on aggregate output can be contractionary instead of expansionary. Describing a similar mechanism, Brunnermeier and Koby (2018) show theoretically that an interest rate level exists at which accommodative monetary policy "reverses" its intended effect. However, this reversal interest rate is not necessarily negative.

3 Stylised Facts

Evidence from the euro area bank lending survey (BLS) suggests that monetary policy measures taken in the euro area since 2014 have had a negative impact on bank profitability, but an expansionary effect on banks' balance sheets. The euro area BLS comprises two questions about the (positive or negative) effects of the Expanded Asset Purchase Programme (EAPP)[4] and the negative DFR[5]. The Public Sector Purchase Programme (PSPP), as the main part of the EAPP aimed at lowering particularly longer-term government bond yields, also puts downward pressure also on the country-specific term spreads. In contrast, the DFR constitutes a reference rate for short-term market rates, which crossed the zero line soon after the DFR (see Figure 5 in the Appendix).

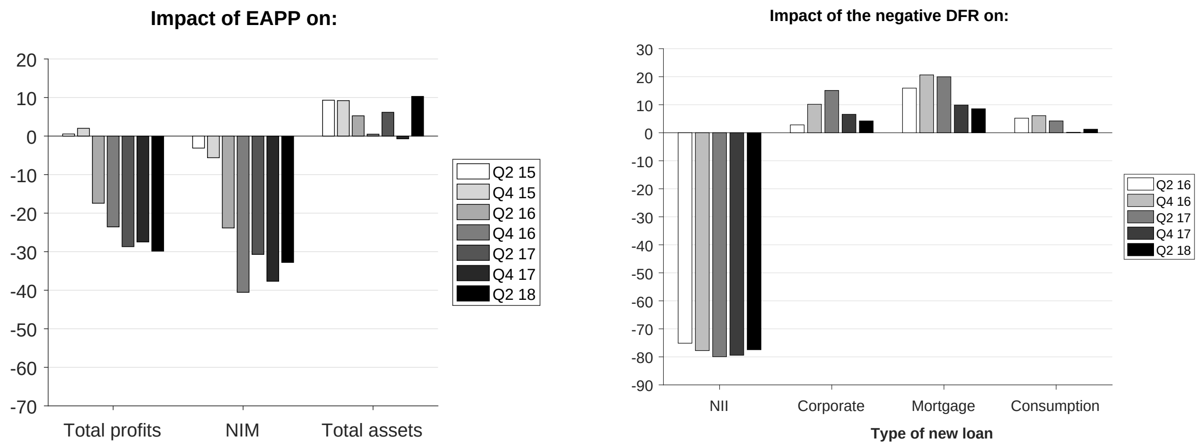
Banks' answers indicate that the DFR made a significantly negative contribution to their net interest income (NII); a homogeneous answer across countries (Figure 1, right-hand side). However, banks also report an expansionary impulse of the negative DFR on new lending. A similar picture emerges regarding the question on the effects of the

[4]The EAPP was announced by the ECB's Governing Council in January 2015. See: https://www.ecb.europa.eu/mopo/implement/omt/html/index.en.html#pspp.

[5]The ECB's Governing Council decided in June 2014 to enter negative territory with one of their policy rates. Since then, the DFR has been lowered four times between 2014 and 2018 and reached -40 BP in March 2016.

EAPP (Figure 1, left-hand side). However, in contrast to the DFR question, the negative impact on overall profitability driven by the net interest income is mainly reported by countries with a high share of long-term fixed rate contracts (see Figure 7 in the Appendix for a comparison of interest rate fixation periods between euro area countries). At the individual bank-level, Arce et al. (2018) find that those banks in the BLS which report that their net interest income is adversely affected by the negative DFR are concurrently lowly capitalized, take less risk and adjust loan terms and conditions to shore up their risk-weighted assets and capital ratios. However, the authors do not find differences in banks' credit supply.

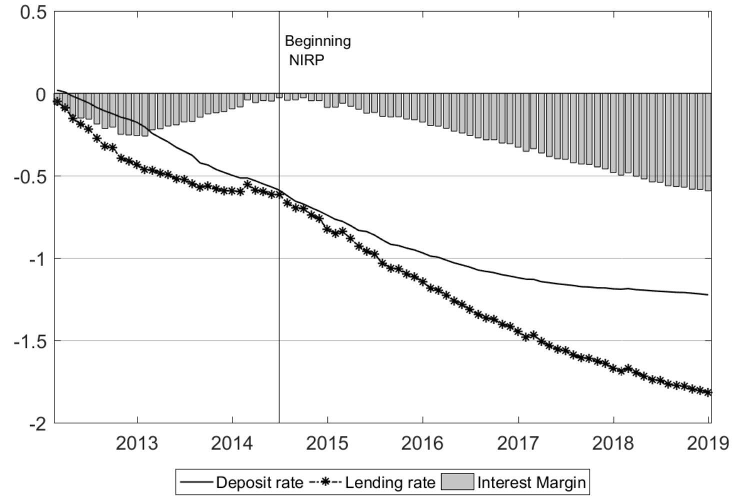
Figure 1: Impact of ECB's monetary policy measures on euro area banks



Source: Euro Area Bank Lending Survey.
Note: As a percentage. NII = Net interest income. EAPP = Extended Asset Purchase Programme. Question for the left-hand side graph: "Over the past six months, has the ECB's EAPP affected (either directly or indirectly) your bank?" Question for the right-hand side graph: "Given the ECB's negative deposit facility rate, did (*over the past six months*) this measure, contribute to ...?" Negative/positive sign = Contributed to a decrease/ increase.

Figure 2 plots the cumulative changes of the lending and deposit rates and their difference for euro area banks. In particular, since the beginning of the NIRP in the Eurosystem in June 2014 the aggregated lending rate has been decreasing more strongly than the deposit rate, exerting downward pressure on the NIM. The level effect of interest rates implies that banks' earnings on lending falls until all old contracts are repriced according to the low interest rate level. Banks could offset some of the downward pressure on the NIM by a reduced pass-through of the low market rates to their borrowers (Eggertsson et al. (2017)). However, intense competition in the euro area banking market and a strategy to boost earnings by acquiring more loans may circumvent a broad disruption of the interest rate pass-through. If a zero lower bound of deposit rates prevents banks from stabilizing their NIM, they could adjust their funding structure towards a higher share of wholesale funding. Yet, banking regulation increases the incentives for banks to hold retail deposits, as, in particular, the Liquidity Coverage Ratio (LCR) and the Net Stable Funding Ratio (NSFR) treat retail deposits as the most stable funding source. Traditional banks, for instance, low diversified lenders, are still able to comply with the LCR when their share of retail deposits in total funding is sufficiently high (Deutsche Bundesbank (2015)).

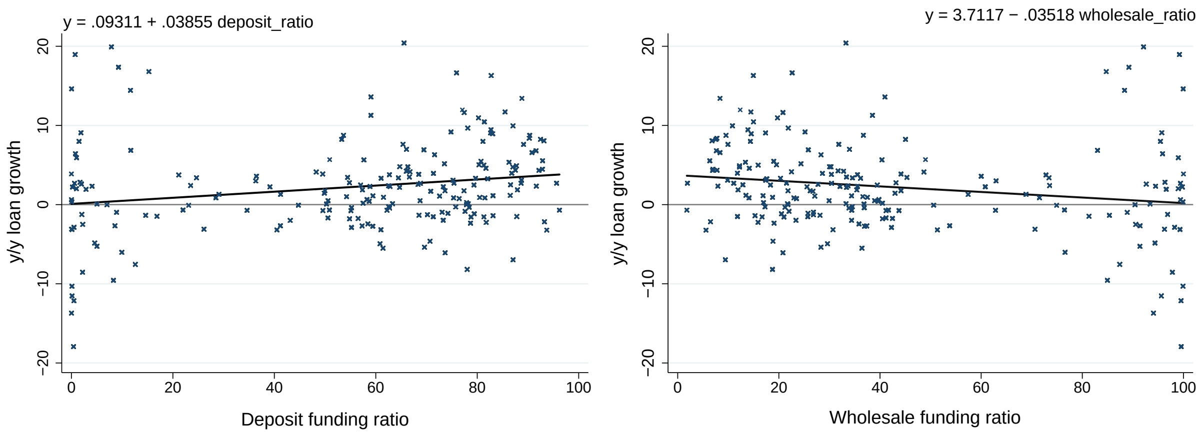
Figure 2: Cumulative changes in the lending rate and deposit rate



Source: ECB.
Note: In percentage points. Aggregated interest rates for loans and deposits to the non-financial private sector for the euro area weighted by outstanding volumes. The lending margin is the spread between the lending rate and the deposit rate. NIRP = Negative interest rate policy.

For monetary policy, identifying heterogeneous developments across different business models of banks is important for understanding the movement of the euro area aggregate. Figure 3 plots the raw data from the database for 213 euro area banks. Even though controls are missing, the descriptive plots highlight the importance of the funding structure on lending for the period since 2007 (Demiralp et al. (2017)). On the one hand, retail deposit funded banks have been the driving force for the loan growth in recent years. This result does not change when looking only at the period of the NIRP. On the other hand, the indirect effect of the NIRP on the NIM resulting from the very low level of short-term interest rates might also apply to retail banks in particular. For assessing the role of different bank business models, in the robustness section I perform the empirical analyses for universal banks, retail lenders and specialised lenders.

Figure 3: Funding structure and y/y loan growth



Note: As a percentage.

4 Data and Identification

I use two proprietary data sets of the euro area for the empirical analyses: the individual Balance Sheet Items (iBSI) microdatabase and the individual MFI Interest Rate (iMIR) microdatabase. The iBSI and iMIR database are collected at a monthly frequency at the individual bank level. I use the iBSI data to calculate bank-specific control variables. A detailed description of the variables used in the regressions are shown in Section A.5. Under the statistical framework of iBSI and iMIR, the definition of most balance sheet items is standard.

The definition of equity is a notable exception, as it deviates from what banks publish in their yearly statements. In particular, equity comprises specific and general provisions against loans and securities and other types of assets, besides retained earnings and issued equity. The calculation of the loan growth rate also deviates from publicly available individual bank data, as these are calculated using credit flows. Transaction flows are closer to real new lending of banks, as they do not reflect reclassifications and other breaks in series, changes in exchange rate, price fluctuations, and loan write-offs/write-downs. Calculating credit growth rate in this way is therefore a strong advantage compared with publicly available individual bank data.

I adjust the data in several ways with the aim of reducing the influence of outliers in the analyses. Government authorities responded to the financial and sovereign debt crisis with huge government rescue packages for the national banking sectors. Therefore, I add the affected banks to the estimation sample only after the recapitalisation took place.[6] Furthermore, I winsorize all bank-specific variables (namely, the NIM, the lending and deposit rate, the quarter on quarter loan growth rate, the retail funding ratio, size, the liquidity ratio, the equity ratio and the market share) at the 1st and 99th percentiles. Greek, Cypriot and Estonian banks were removed from the data set, either because no data on long-term government bond yields were available or they took on extreme values over a lengthy period owing to the sovereign debt crisis.[7] Furthermore, banks whose average NIM over the whole sample period is smaller than or equal to zero and with less than two years of observations of the NIM have been dropped. Overall, the final unbalanced estimation sample covered around 55% of total lending to the non-financial private sector in the euro area in December 2018. The estimation period runs from July 2007 to December 2018.

The main variables of interest in the empirical investigation are the NIM, calculated as in Equation 1, and its components. The numerator of Equation 1 is the net interest income of banks, which they can adjust either through prices or volumes. The definition in this paper deviates from the NIM based on the profit and loss accounts of banks, as it includes only outstanding loans and outstanding deposits from households and non-financial corporations. However, as, on aggregate, loans and deposits vis-à-vis the non-financial private sector account for around 40% of total assets of euro area banks, the interest earned and paid on this portfolio is a main indicator of their overall net interest income. Two key advantages of using this narrow definition of the NIM exist. First, data

[6] The time of recapitalisation was set using the European Commission's state aid database (see http://ec.europa.eu/competition/state_aid/register/).

[7] Latvia and Lithuania were also excluded from the analysis since both countries did not join the euro zone until 2015 and 2014, respectively.

are available on a monthly basis, which is not common for profitability data of banks. A higher frequency is preferable in particular when analyzing the impact of the interest rate level on bank profitability. Second, I am especially interested in the effect of the zero lower bound of deposit rates, which is better addressed when using this sub-portfolio of banks' interest-bearing assets and liabilities.

$$Net\ interest\ margin = \frac{((i_{loans} * loans) - (i_{deposits} * deposits))}{loans} \tag{1}$$

The dynamic development of new lending in the euro area coincides with the negative DFR and the launch of the EAPP in 2014/2015, suggesting an accommodative impulse of these monetary policy measures (see Figure 6 in the Appendix). However, the gross effect is not visible from a descriptive plot; i.e. the NIRP could have mitigated the expansionary effect of the EAPP on lending. I aim at disentangling the impact of negative rates on the NIM and new lending by different approaches. First, I compare in each specification the period of negative short-term interest rates with the period of low but positive short-term interest rates. I follow Claessens et al. (2018) and define a low but positive interest rate environment when the 3-month OIS rate is between 0% and 1.25%. This difference is important because banks were already pricing their deposits as a mark-up rather than a mark-down to short-term rates when interest rates were low but still positive. Second, I include a short-term rate and a term spread in the models, and assume that the EAPP mainly influenced the term spread, whereas the DFR had a stronger effect on the short-term rate.

One drawback of the used data set is availability, which first begins at the end of 2007. This implies that only monetary easing periods are covered by the data set (except for the few tightening steps in 2011). As the literature suggest an asymmetric interest rate pass-through (see, for example, Sander and Kleimeier (2004)), the results of the empirical findings of this paper might be biased and not generally valid for the behaviour of banks over the whole interest rate cycle.

5 Methodology and Findings

5.1 Net interest margin

The benchmark specification is related to a broad literature, such as Alessandri and Nelson (2015), Borio et al. (2017), Altavilla et al. (2017), and takes the following form:

$$\begin{aligned} Y_{i,j,t} = &\beta Y_{i,j,t-1} + \lambda X_{i,j,t-1} + \upsilon C_{j,t} + \gamma_1 \delta_t + \\ &\gamma_2 r_t + \gamma_3 r_t^2 + \gamma_4 \theta_{j,t} + \gamma_5 \theta_{j,t}^2 + \alpha_i + \epsilon_{i,j,t} \end{aligned} \tag{2}$$

where Y is either the NIM, the lending rate or the deposit rate of an individual bank "i" operating in country "j" at time "t". Monetary policy indicators are r, the three-month overnight index swap (OIS) rate, and θ, the country-specific term spread; calculated as the difference between the 10y government bond yield and r. Quadratic terms are included in order to capture a certain form of non-linearity, which allows for the effect of the short-term rate and the term spread to vary with the level of the respective variable (Borio et al.

(2017)). Bank- and country-specific controls are also included in the model. The vector X includes, at the individual bank level, the balance sheet equity ratio, liquid assets to total assets, retail funding to total funding, the bank-individual market share in the national credit market and size. Due to potential endogeneity between the dependent variable and the other bank-specific variables, the latter are lagged by one month. The vector C includes real GDP growth and inflation, which control for macroeconomic and demand effects at the country level.[8] δ is a volatility measure of the short-term interest rate, also included in the regressions, as suggested by Saunders and Schumacher (2000). α_i is the term for bank fixed effects which correct for individual, time-constant and unobserved factors. I am unable to control for time*country fixed effects, since these would be collinear with the interest rate variables. However, residuals in the estimation of a given month are probably correlated across different banks and countries. I address this crucial issue by clustering standard errors at the bank level and at the country*month level (see Petersen (2009)). The dynamic models were estimated using the within-group estimator with bank-fixed effects.[9]

In order to further analyse the effect of different levels of the short-term interest rate on banks' margin, lending rate and deposit rate, I substitute the quadratic terms in Equation 2 by two indicator variables and interact them with the interest rate level variables. $D^{<1.25}$ takes the value 1 when the short-term rate is lower than 1.25 % (Demiralp et al. (2017)) and $D^{<0}$ takes the value 1 when the short-term rate is lower than 0%. The model to be estimated is

$$\begin{aligned} Y_{i,j,t} =& \beta Y_{i,j,t-1} + \lambda X_{i,j,t-1} + \upsilon C_{j,t} + \gamma_1 \delta_t + \gamma_2 r_t + \gamma_3 r_t D^{<1.25} + \gamma_4 r_t D^{<0} + \\ & \gamma_5 \theta_{j,t} + \gamma_6 \theta_{j,t} D^{<1.25} + \gamma_7 \theta_{j,t} D^{<0} + \alpha_i + \epsilon_{i,j,t} \end{aligned} \tag{3}$$

Note that the overall effect at low but positive (negative) rates is the sum of γ_2 and γ_3 (γ_2 and γ_3 and γ_4) for the short-term rate and, respectively, γ_5 and γ_6 (γ_5 and γ_6 and γ_7) for the term spread.

5.2 Loan growth

As the theoretical literature (Brunnermeier and Koby (2018), Eggertsson et al. (2017)) suggests that the pressure on the NIM might have a contractionary impact on new lending, especially under negative rates, I regress the quarterly loan growth rate on the NIM besides a wide set of controls.

$$\Delta loan_{i,j,t} = \beta \Delta loan_{i,j,t-1} + \lambda X_{i,j,t-1} + \gamma NIM_{i,j,t-1} + \alpha_i + \alpha_{jt} + \epsilon_{i,j,t} \tag{4}$$

where Δloan is the quarterly growth rate of loans to the non-financial private sector of an individual bank "i" operating in country "j" at time "t". Besides the NIM, I regress

[8] These results are robust against including further country-specific macroeconomic variables, namely stock market growth rates and Herfindahl concentration indices.

[9] Estimating dynamic panel model by OLS will produce biased and inconsistent estimates. However, for panel estimations with a large time dimension - the average T of the estimation sample is 99 - the bias tends to be close to zero. See, for example Breitung (2015).

the dependent variable on the same bank-specific controls as in Equation 2.[10] In the baseline regression I estimate a dynamic model, adding to the regression the loan growth rate lagged by one quarter. However, since the average T of the quarterly sample is small and thus the estimates could be a biased, a static model is estimated for robustness. As the interest rate level variables are dropped from the regressions, I am able to control for country*time fixed effects denoted by α_{jt} (i.e., a dummy for each country-quarter pair). Including country*quarter fixed effects means that I control for all country-specific time-varying macroeconomic factors that influence loan policies (e.g. business cycle). Thus, the coefficients of the remaining variables can be interpreted as predominantly bank-side driven. Robust standard errors are again two-way clustered at the bank and country*quarter level. Models are estimated using the within group estimator with bank fixed effects. Following the estimation strategy in the previous section, two interaction terms between the indicator variables for low (short-term rate<1,25%) and negative short-term rates and the NIM are added to the regression:

$$\begin{aligned}\Delta loan_{i,j,t} =& \beta\Delta loan_{i,j,t-1} + \lambda X_{i,j,t-1} + \gamma_1 NIM_{i,j,t-1} + \\ & \gamma_2 NIM_{i,j,t-1} D^{<1.25} + \gamma_3 NIM_{i,j,t-1} D^{<0} + \alpha_i + \alpha_{jt} + \epsilon_{i,j,t}\end{aligned} \tag{5}$$

5.3 Findings

5.3.1 Net interest margin

The estimation results of Equation 2 show that the short-term interest rate is positively related to euro area banks' retail margins (see Table 6 in the Appendix). A 100 basis points (bp) decrease in the short-term rate leads to a reduction in the monthly NIM of 2.6 bp or by 1.1% relative to the sample mean.[11] These effects are similar to the ones reported in Borio et al. (2017) for internationally active banking groups. However, probably due to the focus on retail banking I find considerably stronger effects of the short-term rate on the NIM compared with most of the literature (see Table 14 in the Appendix).

I find a statistically insignificant effect of the term spread on the NIM, which might be surprising as maturity transformation should belong to the core of banks' activities. However, a broad finding of the existing literature is that the impact of the term spread is either very low or statistically not different from zero (see Table 14 in the Appendix). The importance of the term spread depends strongly on the dominant pricing strategy of banks. For example, in most countries in the euro area the majority of outstanding loans to the non-financial private sector are priced by short-term fixed rates or variable rates, implying a low maturity mismatch (regarding the interest rate fixation periods) between loans and deposits (Figure 7 in the Appendix).[12] Hence, the term spread should play a minor role in explaining the development of the NIM.

Decomposing the NIM into the lending and deposit rates explains the underlying mechanism for the depressed margin: Interest rates on outstanding loans react more strongly than interest rates on deposits to a change in the level of short-term market

[10] In a further specification, I substitute the NIM by the lending and deposit rate but the coefficients are not statistically significant regardless of the interest rate level. Results are not shown in this paper.

[11] A 1 standard deviation of the short-term rate over the whole sample period is equivalent to 100 bp (see Table 3 in the Appendix).

[12] Main exceptions are the banking systems in Belgium, Germany and France.

rates. Whereas the lending rate decreases by 8.8 bp following a 100 bp decrease in the short rate, the deposit rate falls by 6.1 bp. Claessens et al. (2018) report similar findings for a low interest rate environment.[13] Still, relative to the sample mean euro area banks lowered the deposit rate more strongly than the lending rate (2.6% compared with 5,8%).

Regarding the analysis of potential non-linearities, I find a statistically significant coefficient of the quadratic term of the short-term rate in the specification of the NIM and the lending rate.[14] The squared terms are negatively signed, meaning that the relationship between the short-term rate and the NIM or the lending rate behaves concave. Figure 4 gives a graphic representation of this relationship using the first derivatives with respect to the short-term rate. The left-hand graph shows that the positive relation between the short-term rate and the NIM only exists when the interest rate level is very low, i.e. smaller than 2% (e.g. Bikker and Vervliet (2017), CGFS (2018a)). In particular, a change in the short-term rate from 1% to 0% induces a falling NIM, by about 3.3 bp. In contrast, a change in the short-term rate level from 3% to 2% reduces the monthly NIM only by around 1 bp. As I include the level of the short-term rate, the estimated impact persists over time. A "low-for-long" interest rate level would therefore erode banks' NIM. However, there exists an effective lower bound of the NIM, which is the margin banks earn on new loans.

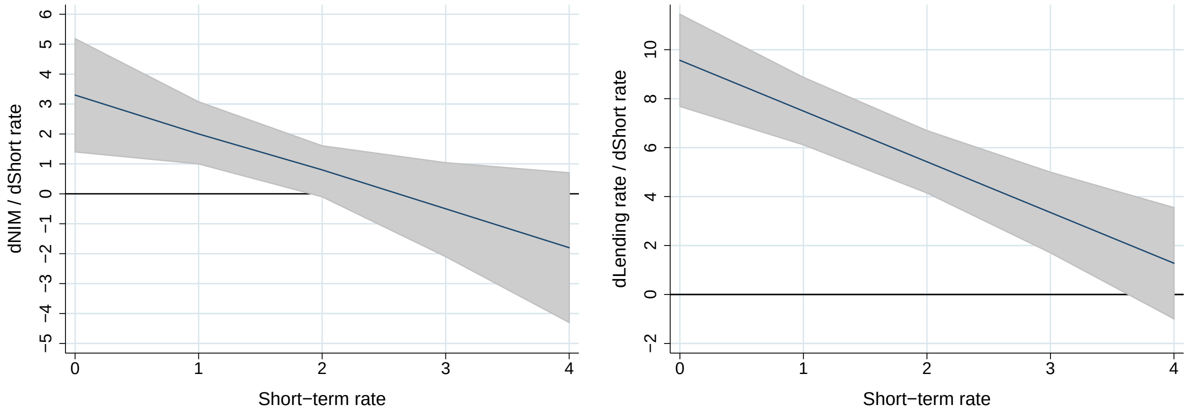
Concerning the lending rate specification, the response of the lending rate to a change in the short-term rate is mainly positive regardless of the prevailing interest rate level. Since the slope of the graph is considerably steep, when the short rate converges to zero the lending rate decreases much more strongly compared with a higher interest rate level. This finding can be explained by a duration effect: Besides new loans entering the balance sheet priced by the prevailing interest rate level, old contracts are also gradually repriced.[15] Depending on the duration of a low interest rate environment, the average interest rate of the loan portfolio on banks' balance sheets shrinks, successively reflecting more and more the low level of interest rates.

[13] A broad empirical finding in the literature is on the stickiness of deposit rates, meaning that the pass-through of changes in the market-rate to deposit rates is less complete compared with credit interest rates. Among others: Hannan and Berger (1991), Discroll and Judson (2013), Drechsler, Savov, and Schnabel (2017).

[14] Non-linearity may also exist in higher polynomials. However, I find that the shape of the fractional polynomial function fits the shape of the quadratic function very well. (see Figure 9 in the Appendix).

[15] In general, the interest rate fixation period is lower than the maturity of a loan.

Figure 4: Effect of a change in the interest rate level on the NIM and on the interest rate of outstanding loans



Note: Y-axis: In basis points. X-axis: As a percentage. The chart is based on the regression results of the benchmark model. The vertical axis shows the first derivative of the NIM or the lending rate with respect to the 3-month OIS rate. The shaded area represents 95% confidence bands.

Motivated by the strong indication of non-linearities, I substitute the squared term in Equation 2 by two indicator variables for low and for negative interest rates and interact them with the interest level variables (see Equation 3). Table 1 summarises the main findings. Detailed regression results can be found in Table 6, Table 8 and Table 10 in the Appendix. Again, I find that, with a falling interest rate level its impact on the NIM increases. In addition, the higher impact under negative interest rates than in the period of low but positive rates is highly statistically different from zero. In particular, at negative rates a 100 bp decrease in the short-term rate would suggest a reduction in the monthly NIM by 3.2% relative to the sample mean, compared with 1.2% at low but positive rates.[16]

Regarding the components of the NIM, I find that, at negative rates, the estimated coefficient of the short-term rate especially in the lending rate regression increases substantially. Surprisingly, I do not find evidence for a slowdown of the pass-through from market rates to deposit rates, as the zero lower bound of retail deposit rates would suggest. However, the coefficients are estimated for the period of September 2014 until December 2018, while the slowdown in deposit rates is in particular observable first after 2017 (see Figure 6 in the Appendix). Nevertheless, relative to their sample means, banks in fact continued to lower their deposit rates more strongly than their lending rates (15% compared with 5.4%).

[16] At negative (low) interest rate a 1 standard deviation of the short-term rate is equivalent to 0.12 (0.34) pp (see Table 4 and Table 5).

Table 1: Overall impact of a change in the interest level on the NIM, the lending or deposit rate

Dependent variable:	*NIM*	*Lending rate*	*Deposit rate*
Short-term rate$_{whole\_sample}$	**0.9****	**5.5*****	**6.0*****
Short-term rate$_{low}$	**2.8*****	**7.7*****	**5.3*****
Short-term rate$_{negative}$	**6.9*****	**14.4*****	**6.9*****
Term spread$_{whole\_sample}$	0.1	**1.8*****	**1.9*****
Term spread$_{low}$	**-0.9*****	**0.8*****	**1.9*****
Term spread$_{negative}$	**-1.0****	0.3	**1.5*****
Bank controls	✓	✓	✓
Bank fixed effects	✓	✓	✓
SE clustered at bank-level	✓	✓	✓
SE clustered at country*month level	✓	✓	✓

***, **, * indicate significance at the 1%, 5% and 10% levels, respectively. Coefficients of Table 6, Table 7, Table 8, Table 9, Table 10 and Table 11, multiplied by 100.

To further investigate the importance of banks' funding structure for the development of the NIM, I include in a further regression two interaction terms, the short-term rate*deposit funding ratio and the short-term rate*deposit funding ratio*$D^{<0}$ (see column 4 in Table 6 in the Appendix). The baseline effect of the deposit funding ratio on the NIM is positive signed, meaning that mainly deposit-funded banks generated higher margins over the whole estimation period. However, independently of the short-term rate, banks with higher funding through retail deposits show relatively lower margins when interest rates are low. At negative rates, the lost advantage of deposit-funded banks compared to wholesale-funded banks is confirmed by the positively signed coefficient of the triple interaction term. These findings suggest that the zero lower bound for deposit rates plays a crucial role when evaluating the effect of the NIRP on banks.

5.3.2 Loan growth

An adjustment strategy by banks to continuously shrinking margins, which might signal a lower future net worth of banks, is designed to compensate for falling prices by increasing their lending activities. However, this strategy depends on banks' capital endowment and the average risk of its assets. The latter is positively correlated with intermediation costs, e.g. loan loss provisions. Thus, a very low level of profits might prevent banks from increasing their credit supply because they are not able to cover those costs associated with higher lending.[17] The impact of banks' profitability on new lending is therefore ambiguous.

Table 2 reports the main findings on the estimation of Equation 4. In Table 12 in the Appendix, detailed regression results can be found. In general, I find a positive impact of the NIM on new lending, meaning that when retail lending is on average less profitable, banks cut lending. In particular, a 100 bp decrease in the NIM reduces quarterly new lending by 14 bp or by 27.4% relative to the sample mean.[18] This effect is economically

[17] A similar mechanism is described in among others Brunnermeier and Koby (2018), Eggertsson et al. (2017).

[18] A 1 standard deviation of the NIM over the whole sample period is equivalent to 1.13 pp (see Table 3).

very important for new lending and robust throughout the various specifications. However, at negative rates the coefficient of the interaction term between the NIM and the negative interest rate dummy indicates a differential impact of the NIM on the quarterly loan growth rate. The overall effect (sum of γ_1 and γ_2 and γ_3 in Equation 5) turns statistically insignificant. This finding suggest that, as most banks face downward pressure on the NIM at negative rates, banks supplement their income by granting more loans regardless of the average margin they earn.

Table 2: Overall impact of the NIM on new lending

Dependent variable:	*q/q loan growth*
NIM_{whole_sample}	**14.0***
NIM_{low}	**14.5***
$NIM_{negative}$	-10.3
Bank controls	✓
Bank fixed effects	✓
(Country*quarter) fixed effects	✓
SE clustered at bank-level	✓
SE clustered at country*quarter level	✓

***, **, * indicate significance at the 1%, 5% and 10% levels, respectively.
Coefficients of Table 12 and Table 13, multiplied by 100.

To evaluate the economic importance of those findings, I conduct a counterfactual analysis aiming at comparing the actual quarterly loan growth rate with a hypothetical series for the period after June 2014, assuming the coefficient of the NIM does not render statistically insignificant. Figure 10 in the Appendix plots the results for the median bank of the estimation sample, indicating that the change in banks' business practices when servicing new loans have led to considerably higher new lending in the euro area since 2014. However, when assessing the importance of this effect for banks' net interest income, I only find a modest impact. Thus, banks would need to increase lending much more aggressively in order to offset the level effect of negative interest rates on the NIM (Jobst and Lin (2016) come to a similar conclusion).

5.4 Robustness

I performed several robustness analyses. I re-estimated Equation 4 and Equation 5 without the lagged dependent variable as regressor. The results can be found in Table 15 in the Appendix. They confirm the findings of the dynamic version of the model suggesting that the estimates are not biased.

In a further specification, the indicator variables in Equation 5 are substituted for the first difference of the short-term rate:

$$\begin{aligned}\Delta loan_{i,j,t} =& \beta \Delta loan_{i,j,t-1} + \lambda X_{i,j,t-1} + \upsilon C_{j,t} + \gamma_1 NIM_{i,j,t-1} + \\ & \gamma_2 \Delta short\_rate + \gamma_3 NIM_{i,j,t-1} \Delta short\_rate + \alpha_i + \epsilon_{i,j,t}\end{aligned} \tag{6}$$

As the first difference of the short-term rate is added to the regression, country*time fixed effects are replaced by the macroeconomic control variables. A positive signed coefficient of the interaction term indicates that, with decreasing interest rates, more profitable banks show a larger decrease in lending relative to less profitable banks. This might be the case because less profitable banks could try to compensate for the lower interest income resulting from decreasing interest rates by granting relatively more loans. Indeed, I find that the coefficient of the interaction term is positively signed. However, it is statistically significant only at the 10% level.

For analysing to what extent a certain bank's business model is driving the empirical findings, I distinguish between universal banks, retail lenders and specialised lenders.[19] The assignment of a bank to one of the clusters relies on an internal Eurosystem classification. In the estimation sample, specialised lenders is the most profitable business model. The median bank earned about 29% more relative to a retail lender and about 36% more than a universal bank (see Table 18 in the Appendix). Specialised lenders are mainly funded by bank bonds. The main funding source of universal banks and retail lenders is retail deposits. However, the share of wholesale funding is higher for universal banks.

The empirical results confirm the findings in the literature that traditional business models are more under pressure in a low interest rate environment (see Table 19 and Table 20 in the Appendix). With the increasing share of loans and deposits vis-à-vis the non-financial private sector on the balance sheet, the eroding effect of low interest rates on the NIM rises. Regarding the impact of the NIM on new lending, I find a statistically significant positive coefficient only for the retail lenders before the beginning of the NIRP. For the period of negative rates, the coefficient turns negative at the 10% significance level, meaning that the eroding margins have had an expansionary effect on lending and highlighting the role of those banks in the development in loan growth in the euro ares since 2014.

6 Concluding remarks

The findings of this article suggest that persistently low interest rates erode the net interest margin of euro area banks. Decomposing the NIM into the lending and deposit rate explains the underlying mechanism for the depressed margin: Interest rates on outstanding loans react more strongly to a change in the level of short-term market rates than interest rates on outstanding deposits. In contrast to the NIM and the lending rate, I do not find evidence either for a non-linear relation between the short-term rate and deposit rate or for a slowdown in the interest rate pass-through at negative market rates, as the zero lower bound of retail deposit rates would suggest.

I find a positive relation between banks' NIM and new lending, indicating that when retail lending is, on average, less profitable, banks cut lending. This finding applies especially to more profitable banks in the estimation sample. However, at negative rates this finding does not hold, as the coefficient turns statistically insignificant. Thus, I cannot support evidence for the theoretical argument that low profitability stemming from the interest income has a contractionary impact on lending. One narrative which might explain this finding is that banks were able to compensate for the lower earnings by

[19]The business model categories G-SIB and corporate wholesale also exists, but for the empirical investigation the number of banks is too low.

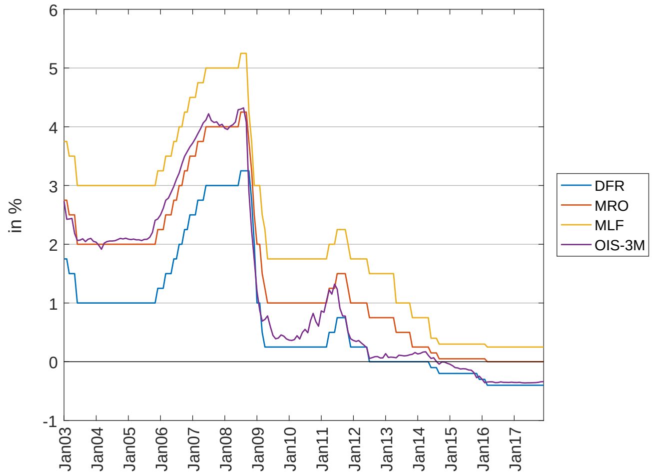
reducing their loan loss provisions for expected future losses. However, this compensatory effect may change under less favourable economic conditions.

For monetary policy, my findings suggest that the NIRP of the Eurosystem adversely affects the NIM of euro area banks, but has not had an effect on lending so far. In particular, I find evidence that banks try to reduce the downward pressure on the NIM by increasing their lending activities.

A Appendix

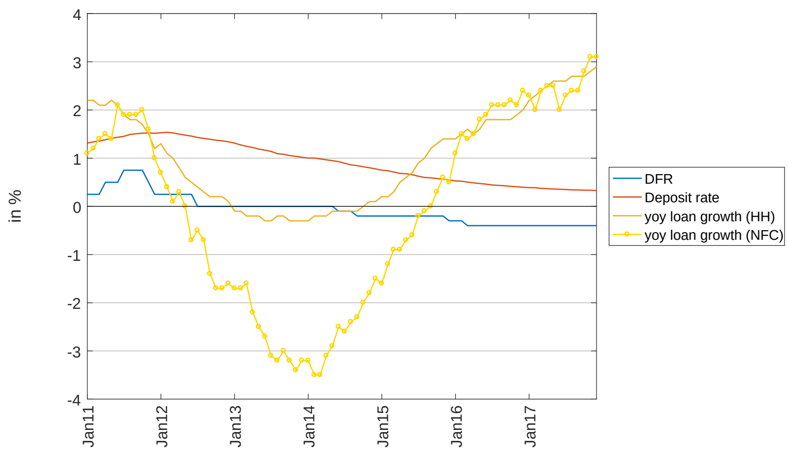
A.1 Descriptive figures

Figure 5: ECB policy rates and the 3-month OIS rate



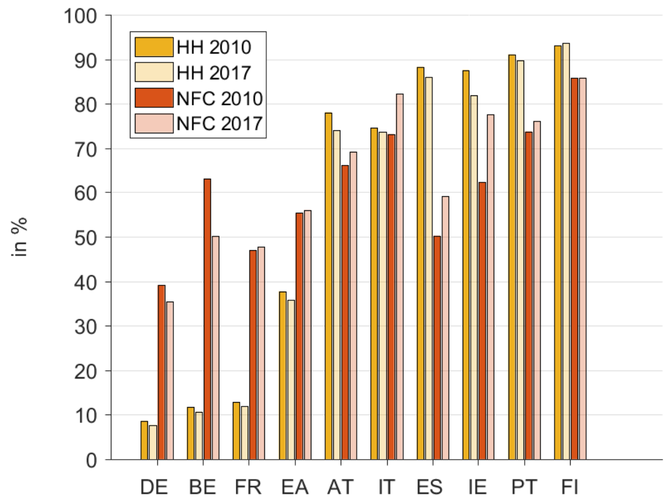
Source: ECB, Thomson Reuters Eikon - Datastream.
Note: MRO = Main refinancing operation rate, DFR = Deposit facility rate, MLF = Marginal lending facility rate, 3M-OIS = 3-month overnight index swap rate.

Figure 6: Loan growth and the deposit rate of euro area banks



Source: ECB.
Note: DFR = Deposit facility rate. Deposit rate is the volume-weighted interest rate for deposits of the non-financial private sector.

Figure 7: Share of flexible and short-term (up to 1 year) interest rate fixation in outstanding loans to the non-financial private sector



Source: Eurosystem MFI Balance sheet statistics.
Note: The figure shows data for Q4 2010 and Q4 2017. The graph shows a sub-sample of countries belonging to the euro area.

A.2 Characteristics of the estimation sample

	NIM	Lending rate	Deposit rate	q/q loan growth	Equity ratio	Retail funding/ total funding	Short-term market rate	Term spread
Mean	2.28	3.41	1.05	0.53	8.15	57.27	0.33	2.01
Median	2.27	3.32	0.86	0.45	7.58	66.02	0.08	1.68
SD	1.13	1.14	0.90	2.60	3.88	30.38	1.00	1.44
Min	-7.02	1.18	0	-10.34	0.34	0	-0.36	-0.21
Max	6.17	6.44	4.12	12.62	20	99.26	4.32	13.49

Table 3: **Descriptive statistics** (As a percentage.) Estimation period: July 2007 until December 2018.

	NIM	Lending rate	Deposit rate	q/q loan growth	Equity ratio	Retail funding/ total funding	Short-term market rate	Term spread
Mean	2.37	3.75	1.29	0.25	7.65	54.15	0.39	2.84
Median	2.39	3.77	1.21	0.20	7.15	62.32	0.35	2.51
SD	1.15	0.91	0.72	2.21	3.66	30.05	0.34	1.45
Min	-5.85	1.41	0	-10.32	0.34	0	0	0.94
Max	6.08	6.43	4.12	12.61	19.94	99.15	1.24	13.49

Table 4: **Descriptive statistics** (As a percentage.) For the period of low but positive rates (i.e. $0 \leqq$ 3-month OIS $< 1.25\%$).

	NIM	Lending rate	Deposit rate	q/q loan growth	Equity ratio	Retail funding/ total funding	Short-term market rate	Term spread
Mean	2.16	2.67	0.46	0.66	9.07	61.22	-0.27	1.21
Median	2.13	2.60	0.30	0.57	8.55	71.14	-0.35	1.02
SD	0.83	0.81	0.50	2.60	4.06	30.91	0.12	0.70
Min	-1.90	1.18	0	-10.34	0.39	0	-0.36	0.17
Max	6.14	6.44	3.99	12.62	20	99.26	-0.00	4.39

Table 5: **Descriptive statistics** (As a percentage.) For the period of negative rates (i.e. 3-month OIS<0).

A.3 Regression results

Dependent variable: NIM	I	II	III	IV
Short-term rate	0.009**	0.032***	0.001	0.038***
	(0.004)	(0.009)	(0.004)	(0.005)
Term spread	0.001	0.005	0.005	-0.006***
	(0.002)	(0.007)	(0.005)	(0.002)
Short-term rate^2		-0.006**		
		(0.003)		
Term spread^2		-0.001*		
		(0.001)		
Short-term rate$*D^{<1.25}$			0.027***	
			(0.009)	
Short-term rate$*D^{<0}$			0.042**	
			(0.019)	
Term Spread$*D^{<1.25}$			-0.014***	
			(0.005)	
Term Spread$*D^{<0}$			-0.001	
			(0.003)	
Retail deposits/ total $funding_{t-1}$	0.001***	0.001***	0.001***	0.001***
	(0.000)	(0.000)	(0.000)	(0.000)
*Short-term rate*Retail deposits/*				-0.001***
total $funding_{t-1}$				(0.000)
*Short-term rate*Retail deposits/*				0.001***
total $funding_{t-1}*D^{<0}$				(0.000)
N	21,013	21,013	21,013	21,013
Number of banks	213	213	213	213
Average T	99	99	99	99
Country-specific controls	YES	YES	YES	YES
Bank-specific controls	YES	YES	YES	YES
Bank fixed effects	YES	YES	YES	YES

Table 6: Estimation period: July 2007 - December 2018. Column 2 shows the results of Equation 2; column 3 shows the results of Equation 3. Standard errors are two-way clustered on the bank and (year-month)*country level. Robust standard errors in brackets. ***,** and * denote significance at the 1%, 5% and 10%-levels.

Overall effect at low but positive rates	
*Short-term rate+Short-term rate** $D^{<1.25}$	0.028***
	(0.010)
*Term Spread+Term Spread** $D^{<1.25}$	-0.009***
	(0.002)
Overall effect at negative rates	
*Short-term rate+Short-term rate** $D^{<1.25}$+*Short-term rate** $D^{<0}$	0.069***
	(0.013)
*Term Spread+Term Spread** $D^{<1.25}$+*Term Spread** $D^{<0}$	-0.010**
	(0.005)

Table 7: Overall effect of the interest rate level on the NIM for the low but positive and negative interest rate periods.

Dependent variable: Lending rate			
	I	**II**	**III**
Short-term rate	0.055***	0.099***	0.052***
	(0.007)	(0.010)	(0.007)
Short-term rate^2		-0.011***	
		(0.002)	
Term spread	0.018***	0.015***	0.024***
	(0.002)	(0.005)	(0.005)
Term spread^2		-0.001	
		(0.000)	
*Short-term rate** $D^{<1.25}$			0.025***
			(0.008)
*Short-term rate** $D^{<0}$			0.067**
			(0.026)
*Term Spread** $D^{<1.25}$			-0.015***
			(0.005)
*Term Spread** $D^{<0}$			-0.006**
			(0.003)
N	21,013	21,013	21,013
Number of banks	213	213	213
Average T	99	99	99
Country-specific controls	YES	YES	YES
Bank-specific controls	YES	YES	YES
Bank fixed effects	YES	YES	YES

Table 8: Estimation period: July 2007 - December 2018. Column 2 shows the results of Equation 2; column 3 shows the results of Equation 3. Standard errors are two-way clustered on the bank and (year-month)*country level. Robust standard errors in brackets. ***,** and * denote significance at the 1%, 5% and 10%-levels.

Overall effect at low but positive rates	
Short-term rate+*Short-term rate** $D^{<1.25}$	0.077***
	(0.010)
Term Spread+*Term Spread** $D^{<1.25}$	0.008***
	(0.002)
Overall effect at negative rates	
Short-term rate+*Short-term rate** $D^{<1.25}$+*Short-term rate** $D^{<0}$	0.144***
	(0.013)
Term Spread+*Term Spread** $D^{<1.25}$+*Term Spread** $D^{<0}$	0.003
	(0.005)

Table 9: Overall effect of the interest rate level on the lending rate for the low but positive and negative interest rate periods.

Dependent variable: Deposit rate	I	II	III
Short-term rate	0.0599***	0.0609***	0.0601***
	(0.0066)	(0.0098)	(0.0065)
Short-term rate^2		-0.0005	
		(0.0021)	
Term spread	0.0192***	0.0143***	0.0088
	(0.0023)	(0.0052)	(0.0054)
Term spread^2		0.0007	
		(0.0005)	
Short-term rate$*D^{<1.25}$			-0.0067
			(0.0092)
Short-term rate$*D^{<0}$			0.0154
			(0.0225)
Term Spread$*D^{<1.25}$			0.0100*
			(0.0057)
Term Spread$*D^{<0}$			-0.0033
			(0.0027)
N	21,013	21,013	21,013
Number of banks	213	213	213
Average T	99	99	99
Country-specific controls	YES	YES	YES
Bank-specific controls	YES	YES	YES
Bank fixed effects	YES	YES	YES

Table 10: Estimation period: July 2007 - December 2018. Column 2 shows the results of Equation 2; column 3 shows the results of Equation 3. Standard errors are two-way clustered on the bank and (year-month)*country level. Robust standard errors in brackets. ***,** and * denote significance at the 1%, 5% and 10%-levels.

Overall effect at low but positive rates	
Short-term rate+*Short-term rate*$*\ D^{<1.25}$	0.053***
	(0.010)
Term Spread+*Term Spread*$*\ D^{<1.25}$	0.019***
	(0.002)
Overall effect at negative rates	
Short-term rate+*Short-term rate*$*\ D^{<1.25}$+*Short-term rate*$*\ D^{<0}$	0.069***
	(0.013)
Term Spread+*Term Spread*$*\ D^{<1.25}$+*Term Spread*$*\ D^{<0}$	0.015***
	(0.005)

Table 11: Overall effect of the interest rate level on the deposit rate for the low but positive and negative interest rate periods.

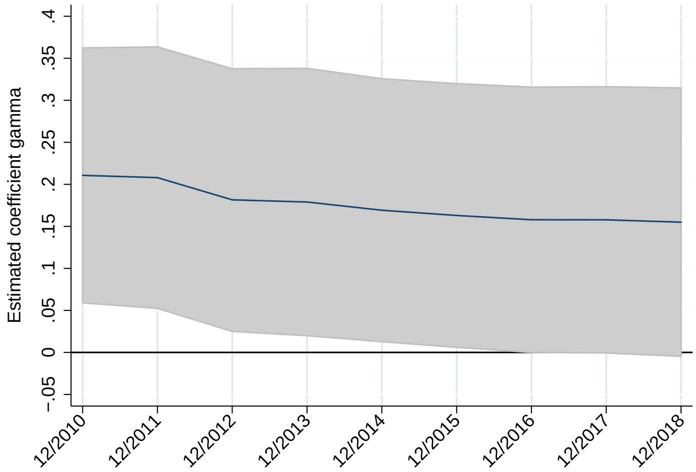
Dependent variable: q/q loan growth		
	I	**II**
$Loan\ growth_{t-1}$	0.089***	0.087***
	(0.031)	(0.031)
$Liquid\ assets/\ total\ assets_{t-1}$	0.007	0.006
	(0.012)	(0.012)
$Size_{t-1}$	-0.005	-0.005
	(0.004)	(0.004)
$Retail\ deposits/\ total\ funding_{t-1}$	0.025***	0.024***
	(0.009)	(0.009)
$Market\ share_{t-1}$	-0.152**	-0.145**
	(0.063)	(0.063)
$Equity\ ratio_{t-1}$	-0.061*	-0.059*
	(0.034)	(0.034)
NIM_{t-1}	0.140*	0.179**
	(0.074)	(0.085)
$NIM_{t-1}*D^{<1.25}$		-0.034
		(0.096)
$NIM_{t-1}*D^{<0}$		-0.248**
		(0.119)
N	6,818	6,818
Number of banks	211	211
Average T	32	32
Bank Fixed Effects	YES	YES
[(Year-quarter)*country] Fixed Effects	YES	YES
SE clustered at bank-level	YES	YES
SE clustered at [(year-quarter)*country] level	YES	YES

Table 12: Estimation period: 2007Q3 - 2018Q4. Column 1 shows the results on the baseline regression of Equation 4; column 2 shows the regression results of Equation 5. Robust standard errors in brackets. ***,** and * denote significance at the 1%, 5% and 10%-levels.

Overall effect at low but positive rates	
$NIM_{t-1}+NIM_{t-1}*D^{<1.25}$	0.145*
	(0.010)
Overall effect at negative rates	
$NIM_{t-1}+NIM_{t-1}*D^{<1.25}+NIM_{t-1}*D^{<0}$	-0.103
	(0.013)

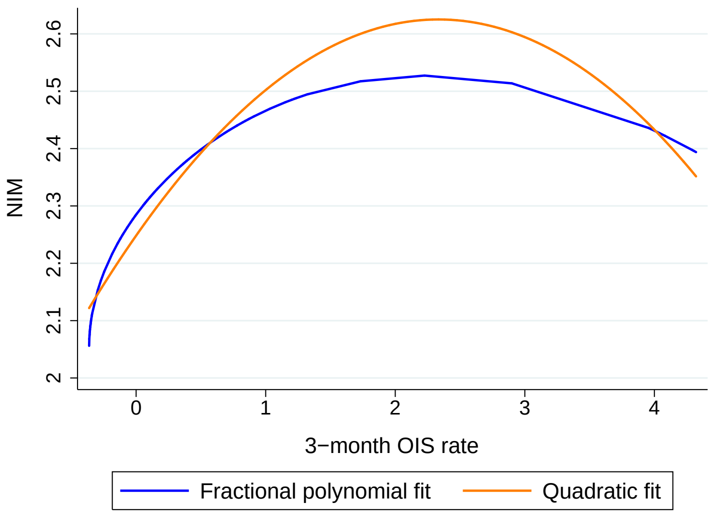
Table 13: Overall effect of the NIM on new lending for the low but positive and negative interest rate periods.

Figure 8: Estimated impact of the NIM on new lending since 2010



Note: In percentage points. Recursive estimation of the coefficient gamma in Equation 4 starting with the sample July 2007 until December 2010 and adding 12 months at a time.

Figure 9: Prediction plot for the estimation sample

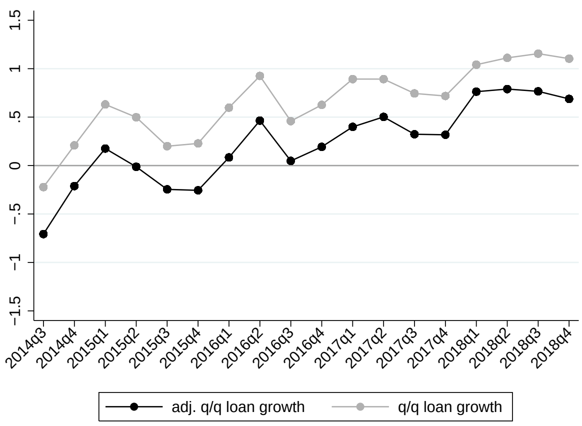


Note: As a percentage. Fitted values from the regression of Model II in Table 6.

	Yearly effect (in bp) on the NIM by a 100 BP increase of the		
	short-term rate	term spread	long-term rate
Altavilla et al. (2017) *Euro Area*	3.6	0.12	
Bikker and Vervliet (2017) *US*	1.5		0.03
Borio et al. (2017) *worldwide sample*	53	14	
CGFS (2018a) *worldwide sample*	21^{low}	7^{low}	
Claessens et al. (2018) *worldwide sample*	20^{low}	13^{low}	
Klein (2019) *Euro Area*	31 (83^{neg})		

Table 14: **Regression results compared with the related literature.** Effects marked by *low* are the effects in a low interest rate environment. *neg* stand for the estimated effect under negative interest rates.

Figure 10: The effect of the NIM on q/q loan growth



Note: As a percentage. Analysis based on the regression results in Table 12 column II. The plot shows the effect on the median bank of the estimation sample. The adjusted loan growth series is calculated by subtracting the estimated impact of the NIM at low but positive rates from the original series.

A.4 Robustness

Dependent variable: q/q loan growth	I	II
$Liquid\ assets/\ total\ assets_{t-1}$	0.006	0.006
	(0.013)	(0.013)
$Size_{t-1}$	-0.005	-0.006
	(0.004)	(0.004)
$Retail\ deposits/\ total\ funding_{t-1}$	0.028***	0.026***
	(0.009)	(0.010)
$Market\ share_{t-1}$	-0.147**	-0.139**
	(0.070)	(0.069)
$Equity\ ratio_{t-1}$	-0.070*	-0.068*
	(0.037)	(0.037)
NIM_{t-1}	0.155*	0.193**
	(0.081)	(0.094)
$NIM_{t-1}{*}D^{<1.25}$		-0.030
		(0.106)
$NIM_{t-1}{*}D^{<0}$		-0.270**
		(0.129)
N	6,818	6,818
Number of banks	211	211
Average T	32	32
Bank Fixed Effects	YES	YES
[(Year-quarter)*country] Fixed Effects	YES	YES
SE clustered at bank-level	YES	YES
SE clustered at [(year-quarter)*country] level	YES	YES

Table 15: **Estimation results of a static panel model.** Estimation period: 2007Q3 - 2018Q4. Regression are repeated from Table 12 without including the lagged dependent variable as regressor. Robust standard errors in brackets. ***,** and * denote significance at the 1%, 5% and 10%-levels.

Overall effect at low but positive rates	
$NIM_{t-1} + NIM_{t-1}{*}D^{<1.25}$	0.162*
	(0.010)
Overall effect at negative rates	
$NIM_{t-1} + NIM_{t-1}{*}D^{<1.25} + NIM_{t-1}{*}D^{<0}$	-0.107
	(0.013)

Table 16: Overall effect of the NIM on new lending for the low but positive and negative interest rate periods from Table 15.

Dependent variable: q/q loan growth		
	(I)	**(II)**
Loan growth$_{t-1}$	0.122***	
	(0.030)	
Liquid assets/ total assets$_{t-1}$	-0.004	-0.007
	(0.012)	(0.013)
Size$_{t-1}$	-0.006*	-0.006*
	(0.003)	(0.004)
Retail deposits/ total funding$_{t-1}$	0.024***	0.027***
	(0.007)	(0.008)
Market share$_{t-1}$	-0.177***	-0.180***
	(0.049)	(0.055)
Equity ratio$_{t-1}$	-0.082***	-0.097***
	(0.027)	(0.030)
NIM_{t-1}	0.171**	0.197**
	(0.071)	(0.081)
NIM_{t-1}*Δ*short rate*	0.064*	0.065
	(0.037)	(0.042)
Δ*Short-term rate*	-0.122	-0.208
	(0.203)	(0.210)
Δ *real GDP*	0.077***	0.087***
	(0.023)	(0.025)
Inflation	0.127***	0.154***
	(0.038)	(0.042)
N	6,830	6,830
Number of banks	212	212
Average T	32	32
Bank Fixed Effects	YES	YES
SE clustered at bank-level	YES	YES
SE clustered at [(year-quarter)*country] level	YES	YES

Table 17: Estimation period: 2007Q3 - 2018Q4. Table shows the regression results of Equation 6. Robust standard errors in brackets. ***,** and * denote significance at the 1%, 5% and 10%-levels.

	NIM	Securities held	Loans	Deposits from MFI	Securities issued	Retail deposits
Universal	2.07	12.55	51.56	15.95	10.95	66.17
Retail Lender	2.25	11.59	61.11	11.44	4.55	80.17
Specialised Lender	3.17	14.41	32.59	32.82	57.85	1.07

Table 18: **Descriptive statistics for different business models of banks.** (As a percentage.) Business model assessment based on Eurosystem's internal classification. MFI = Monetary Financial Institutions. Asset ratios as a percentage of total assets. Liability ratios in percent to total funding (excluding equity). Securities held vis-à-vis the MFI, private and domestic government sector. Loans vis-à-vis the non-financial private sector

Dependent variable: NIM	**Universal**	**Retail Lender**	**Specialised Lender**
Overall effect at low but positive rates			
Short-term rate+	0.015	0.039**	0.092**
*Short-term rate** $D^{<1.25}$	(0.017)	(0.016)	(0.012)
*Term Spread+Term Spread** $D^{<1.25}$	-0.002	-0.008*	0.002
	(0.002)	(0.005)	(0.007)
Overall effect at negative rates			
*Short-term rate+Short-term rate** $D^{<1.25}$	0.079***	0.089***	0.063
*+Short-term rate** $D^{<0}$	(0.017)	(0.023)	(0.053)
*Term Spread+Term Spread** $D^{<1.25}$	-0.012**	-0.009	-0.003
*+Term Spread** $D^{<0}$	(0.005)	(0.008)	(0.009)
Bank controls	YES	YES	YES
Macroeconomic controls	YES	YES	YES
Bank Fixed Effects	YES	YES	YES
SE clustered at bank-level	YES	YES	YES
SE clustered at [(year-month)*country] level	YES	YES	YES
N	8,971	7,178	2,584
Number of banks	94	65	29
Average T	95	110	89

Table 19: Estimation period: July 2007 - December 2018. The table shows the regression results of Equation 3 for different banks' business models. Standard errors in brackets. ***,** and * denote significance at the 1%, 5% and 10%-levels.

Dependent variable: q/q loan growth	**Universal**	**Retail Lender**	**Specialised Lender**
Overall effect at low but positive rates			
$NIM_{t-1} + NIM_{t-1} * D^{<1.25}$	0.189	**0.240****	-0.181
	(0.186)	(0.112)	(0.321)
Overall effect at negative rates			
$NIM_{t-1} + NIM_{t-1} * D^{<1.25} + NIM_{t-1} * D^{<0}$	-0.058	**-0.407***	-0.304
	(0.306)	(0.243)	(0.514)
Bank controls	YES	YES	YES
[(Year-quarter)*country] Fixed Effects	YES	YES	YES
Bank Fixed Effects	YES	YES	YES
SE clustered at bank-level	YES	YES	YES
SE clustered at [(year-month)*country] level	YES	YES	YES
N	2,883	2,222	684
Number of banks	91	61	26
Average T	31	36	26

Table 20: Estimation period: 2007Q3 - 2018Q4. The Table shows regression results of Equation 5 for different banks' business models. Due to the low average T static models are estimated. Robust standard errors in brackets. ***,** and * denote significance at the 1%, 5% and 10%-levels.

A.5 Data sources

Variable	Source	Description
Lending rate	iMIR (interest rates) and iBSI (volumes)	Volume-weighted interest rate on outstanding loans to the non-financial private sector (%).
Deposit rate	iMIR (interest rates) and iBSI (volumes)	Volume-weighted interest rate on outstanding deposits by the non-financial private sector (%).
Net interest margin	iMIR (interest rates) and iBSI (volumes)	(Interest income on outstanding loans - interest payment on outstanding deposits)/(outstanding loans) (%).
Liquidity ratio	iBSI	Cash + government securities + Euroystem deposits over main assets (%).
Retail funding ratio	iBSI	Deposits by the non-financial private sector over total liabilities (%).
Market share	iBSI and ECB-MFI Balance Sheet statistics	Ratio between a banks' total loans to the non-financial private sector and total loans to the non-financial private sector of the country's banking sector (%).
Size	iBSI	Logarithm of the bank's main assets.
Equity ratio	iBSI	Capital and reserves over main assets (%).
q/q loan growth	iBSI	Quarterly growth rate of loans to the non-financial private sector calculated by using an index of notional stocks based on credit flows (%).
10y government bond yield	ECB	-
3-month OIS rate	Thomson Reuters Eikon - Datastream	-
Volatility of the short-term rate	Author's calculation	12-month moving standard deviation of the 3-month OIS rate (%).
Real GDP	ECB	Calender and seasonally adjusted; quarterly data linearly interpolated to monthly data. Logarithmised.
Harmonised index of consumer prices	ECB	Calender and seasonally adjusted; yearly growth rates (%).

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