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Negative interest rates, excess liquidity and retail deposits: Banks' reaction to unconventional monetary policy in the euro area

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Negative interest rates, excess
liquidity and retail deposits:
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Abstract

Negative monetary policy rates are associated with a particular friction because the remuneration of retail deposits tends to be floored at zero. We investigate whether this friction affects banks' reactions when the policy rate is lowered to negative levels, compared to a standard rate cut in the euro area. We exploit the cross-sectional variation in banks' funding structures jointly with that in their excess liquidity holdings. We find evidence that banks highly exposed to the policy tend to grant more loans. This confirms studies that point to higher risk taking by banks as a reaction to negative rates. It, however, contrasts some earlier research associating negative rates with a contraction in loans. We illustrate that the difference is likely driven by the broader coverage of our loan data, longer time span of our sample and, importantly, the explicit consideration of the role of excess liquidity in our analysis.

Keywords: negative rates, bank balance sheets, monetary transmission mechanism

JEL Classifications: E43, E52, G11, G21

Non-technical summary

In June 2014 the ECB became the first major central bank to lower one of its policy rates to negative territory. Other central banks have since followed suit and as monetary policy rates are expected to be closer to zero more often in the future, the practical relevance of this policy has increased in recent years. The academic debate, however, on how this policy operates and what its effects are on banks, the financial system and the economy at large is only starting and far from settled. Our paper contributes to this debate by analysing the effect of the negative interest rate policy (NIRP) of the ECB on euro area bank balance sheets.

We provide some conceptual considerations as to why the transmission of monetary policy under NIRP may be different and discuss several hypotheses regarding how banks could adjust their balance sheets under NIRP. We argue that the main friction associated with NIRP is that a part of banks' deposit base (retail deposits) does not reprice fully when policy rates are cut to a level below zero: the rate that banks pay to households and small firms for their deposits appears to be floored at zero, while most other rates paid or received by banks do adjust to rate cuts under NIRP. This suggests that banks that are particularly reliant on retail deposits for their funding should be particularly impacted by NIRP. We then turn to the empirical question of whether this friction gives rise to a change in bank balance sheets under NIRP that is different from banks' reaction to a rate cut under positive interest rates.

We use a confidential data set containing balance sheet information at a monthly frequency for a sample of 252 euro area banks and use standard panel econometric techniques. A crucial aspect of our empirical analysis is to ensure that we solely capture the effects of NIRP, given that a number of other monetary

policy measures were put in place simultaneously with NIRP. To do so, we note that banks that rely more heavily on retail deposits are likely more affected by NIRP and thereby more incentivised to adjust their balance sheets to reduce the indirect costs of negative rates. NIRP also implies a direct cost for banks as they are required to pay interest on their excess liquidity (EL) with the central bank (reserve holdings in excess of required reserves). The size of their EL captures banks' exposure to these direct costs – and their incentives to reduce these costs by reducing their EL. Banks' EL holdings also capture their scope to rebalance their portfolio away from a negative yielding asset and towards instruments that promise higher returns. In view of this, we exploit the variation in banks' reliance on retail deposit funding *jointly* with the variation in banks' EL holdings to capture both effects of NIRP. Exploiting the interaction between bank's retail deposit intensity and their EL holdings is a novel approach and distinguishes the paper from earlier studies that are based on the retail deposit intensity alone.

We find that euro area banks that are most reliant on retail deposits and who hold EL significantly increase their lending to households and enterprises under NIRP. Given this finding and its robustness when tested using a variety of standard robustness checks, we conclude that NIRP has acted as an empowerment to the ECB's asset purchase programme (APP). Banks most reliant on retail deposits have the strongest incentive to convert their EL, created by the APP, into loans - and our results document that they did so. NIRP catalysed the active use of EL by banks, also increasing the effectiveness of the APP. Both measures were instrumental in providing additional monetary policy accommodation in a situation in which the euro area faced subdued loan dynamics, low output growth and inflation rates well below those consistent with its mandate.

1. Introduction

In June 2014, the European Central Bank (ECB) cut its deposit facility rate (DFR) to negative territory, an unprecedented move as no other major central bank had used negative rates before.² The ECB's decision to introduce negative rates was part of a monetary stimulus package aimed at fending off deflationary risks in a situation in which policy rates had reached zero. More generally, decreasing levels of equilibrium interest rates all around the world and declining trend growth rates have elevated the practical relevance of this new monetary policy tool, as monetary policy is more likely than in the past to operate in the vicinity of the lower bound of policy rates. Kiley and Roberts (2017) note that the “zero lower bound” could, in the future, be binding up to 40 percent of the time. In view of this, the assessment of the effectiveness of negative interest rate policies (NIRP), which is the topic of this paper, is of high importance for policy makers and academics all around the world.

Rate cuts resulting in negative policy rates are unlikely to operate in the same fashion as conventional rate cuts because banks may not be able to charge their retail customers negative rates on their deposits. Banks' inability to adjust some of their funding costs may be due to the forces of competition – in combination with the high regulatory value of retail deposits due to their stability – as well as the existence of paper currency, which offers an alternative store of value with a yield of zero. This specific friction associated with NIRP should have an impact on banks' profitability as the remuneration of their assets declines as a consequence of NIRP while a significant part of their funding costs remain

² This followed a similar decision by the Danish central bank (Danmarks Nationalbank) in July 2012. Subsequently, the Swiss National Bank and the Swedish Riskbank introduced negative policy rates in December 2014 and February 2015, respectively, see Jackson (2015). The Bank of Japan followed in January 2016.

unchanged, leading to declining intermediation margins. In line with this argument, several papers in the literature (Brunnermeier and Koby; 2017, Eggertsson et al., 2017) come to the conclusion that negative rates are either contractionary or they could potentially be contractionary as they may induce banks to cut their lending, increase lending rates or both.

In principle, an alternative reaction to the compression of bank profitability is also possible. Banks may attempt to tilt the composition of their balance sheets towards higher-yielding assets in order to reinstate the average return they earn across their entire portfolio. This can be viewed as a particular version of the standard portfolio rebalancing mechanism that is typically associated with the operation of non-standard monetary policy measures, such as quantitative easing (e.g. Krishnamurthy and Vissing-Jorgensen, 2011). To the extent that this rebalancing results in the shifting of portfolios towards loans to the real economy, it will have expansionary effects. Whether this mechanism dominates the contractionary one described above is essentially an empirical question and this paper sets out to answer it for the euro area.

We contribute to the literature on the impact of NIRP on banks by employing a novel identification approach in our empirical analysis. Unlike most of the literature, which uses the variation in retail deposit intensity to identify the effects of NIRP, we exploit the interaction of the cross-sectional variation of retail deposit intensity *and* banks' holdings of central bank reserves in excess of their reserve requirements (excess liquidity, EL henceforth). Banks' EL holdings are a crucial element in our identification because the cost they imply for banks is uniquely related to NIRP and not to any other concurrent monetary policy measure. Thus, EL holdings not only capture the exposure to treatment as regards

the direct effect of NIRP, but also the scope for portfolio rebalancing that can be achieved by mobilising EL to acquire high-yielding assets and in particular by extending loans. Our approach therefore allows us to better isolate the effects of NIRP from other policy easing measures compared to studies that rely on retail deposit intensity alone.

Another way of looking at our identification is that it allows us to combine two crucial elements in banks' reaction to NIRP: the motive and the opportunity to react. Banks are primarily motivated by the squeeze in their intermediation margins – captured by their retail deposit intensity – and react according to their opportunity set captured by the availability of negative-yielding assets in the form of EL that can be redeployed towards higher-yielding uses. The joint presence of the two – motive and opportunity – is necessary for this transmission channel of the NIRP to be activated.

Using confidential bank-level data covering around 70% of main assets and 80% of total loans of euro area banks in a sample running until March 2018, we find that NIRP has been expansionary by inducing highly-exposed banks to increase their lending activity in an effort to mitigate the adverse impact of NIRP on their profitability. This contrasts some earlier papers, e.g. Heider et al. (2018) (hereafter, HSS), which find that banks that are more reliant on deposit funding reduce their syndicated loans during NIRP. Our different result partly reflects the much wider coverage of our sample: Syndicated loans account for only 3% of euro area loans, whereas our sample includes the vast majority of euro area bank loans, including syndicated loans. More importantly, our paper pays particular attention to the role of EL, which provides stronger incentives for banks to engage in portfolio rebalancing during NIRP, a channel that is not explicitly considered in

most of the earlier literature (an exception is Altavilla et al. (2018) who also use EL in one of their specifications with results similar to ours). In line with the bulk of the literature (HSS, Bubeck et al. 2019, Bottero et al., 2018), we find support for the result that banks highly exposed to NIRP take on more risk, as they effectively convert a risk-less asset – EL – into a risky one – bank loans.

We start the paper with a discussion of the particular friction associated with negative interest rates and why banks may operate differently under these circumstances. Section 3 discusses the channels that banks may use to adjust their balance sheets in the face of negative rates. Section 4 describes our empirical strategy and section 5 reports our results. In section 6, we consider several robustness checks, while Section 7 concludes.

2. Are negative rates special?

2.1. The pass-through of negative interest rates to financial market rates and retail deposit rates in the euro area

The ECB introduced negative rates in June 2014 by lowering the DFR to -0.10 percent. Further rate cuts followed (September 2014, December 2015 and March 2016) bringing the rate on the ECB's deposit facility to -0.40 percent.³

The initial transmission of DFR cuts to short-term money market rates took longer than usual, likely due to the time needed by financial market participants to adjust to the new environment (e.g. changes to IT systems, legal documentation). Nevertheless, all rate cuts after May 2015 did pass through immediately to short-term interest rates such as the EONIA (Figure 1). The

³ The negative rate is not only applied to recourse to the deposit facility but to all parts of banks' current accounts with the Eurosystem in excess of their reserve requirements. The same applies to other potential "loopholes", e.g. the remuneration of government deposits as well as deposits in the context of reserve management services offered by the ECB were also lowered in the process to (at least) -0.40%.

overnight index swap (OIS) curve was in negative territory for maturities of up to four years and short-term government bonds of the highest credit quality were trading at yields well below the DFR, demonstrating that the pass-through of negative rates to euro area financial market rates was eventually complete.

A different picture emerges when we look at rates paid by banks for deposits of households and non-financial corporations (NFC) (Figure 2). Comparing the distribution of deposit rates across a representative sample of euro area banks in June 2014 and October 2018, it is clear that both types of deposit rates have declined during the NIRP period, with both distributions having most of their mass at zero at the end of our sample period. This piling up of deposit rates at zero suggests the existence of a zero lower bound for bank deposits, although there are some banks that do report rates below zero for their household and, more prominently, NFC deposits. By further zooming in on the case of German banks, Eisenschmidt and Smets (2018) show that the zero lower bound on bank deposits only holds for retail deposits. Potential explanations for this friction associated with NIRP include the existence of paper currency that offers a way to avoid any negative rates on deposits, in combination with low switching costs of households who normally hold relatively small-sized deposits. From the banks' side, competition in the deposit market combined with the regulatory and commercial value of deposits due to their stickiness as well as costs associated with switching to a different business or funding model imply that they are reticent to lower retail deposits rates below zero (see Drechsler et al., 2017a and 2017b, for a discussion on the value of retail deposits for banks in the US).

2.2. The transmission mechanism of monetary policy under NIRP

Banks are important for the transmission of monetary policy to the economy, especially for bank-centred financial systems such as the one in the euro area. Changes in monetary policy rates trigger reactions in bank behaviour but the theoretical and empirical literature studying these reactions typically refers to environments where policy rates are adjusted (and remain) in positive territory. It is therefore *ex ante* unclear whether these mechanisms carry over when policy interest rates are reduced to levels below zero.

According to the standard *interest rate channel*, a change in the policy rate is transmitted to deposit and loan rates through the banking system. However, the effective zero lower bound on retail deposits implies that a significant part of banks' funding cannot be re-priced further once this threshold is reached, which could induce a change in the standard transmission mechanism.⁴ The presence of NIRP imparts some heterogeneity in the banking system as it prevents banks with high reliance on retail deposits from fully adjusting their funding costs. The resulting squeeze in profit margins may impair the standard interest rate channel because high deposit banks might start raising loan rates instead of lowering them in response to a policy easing to protect their profit margins. HSS investigate this possibility and note that there is no evidence of higher loan rates charged by high deposit banks in the Euro area. Meanwhile Basten and Mariathan (2018) and

⁴ The “specialness” of NIRP, at least in a temporary sense, may also derive from a range of institutional features of the financial system. In some jurisdictions there may be legal restrictions to the application of negative rates to bank customers or at least uncertainty regarding the legal standing of such an arrangement. Some financial contracts (e.g. money market funds or floating rate notes) may not foresee the possibility of payments from the lender to the borrower (see Witmer and Yang, 2015) and in any case the logistics of collecting interest payments from holders of securities can be intractable. Similarly, some IT systems may not be designed to cope with negative rates. Other examples of possible institutional restrictions include the tax treatment of negative interest rate income, which is often not symmetric to the treatment of positive interest rate income, e.g. payments triggered by negative interest rates may not be tax deductible, while positive interest rate income is generally taxable. Finally, internal risk management practices and rules in banks may in some cases prevent transactions that imply a loss on principal, such as holding negatively remunerated central bank reserves. While some of these institutional features may be adapted in light of the introduction of NIRP, such changes are typically implemented slowly.

Eggertsson et al. (2017) provide evidence of an increase in fees and lending rates following rate cuts into negative territory in Switzerland and Sweden. Lopez et al. (2018) find that banks that rely more on deposit funding are more vulnerable to losses in interest income when interest rates are negative because they are less capable of raising non-interest income.

According to the *bank lending channel*, expansionary monetary policy measures increase banks' willingness to provide loans (Bernanke and Blinder, 1998). Several papers support the notion that the bank-lending channel remains intact under NIRP (e.g. Albertazzi et al., 2017; Bräuning and Wu, 2017; Basten and Mariathasan, 2018) while others argue that the bank lending channel is less effective in a low interest rate environment (Borio and Gambacorta, 2017) or that it breaks down once the zero bound on deposits is reached (Eggertsson et al., 2017). We argue that this channel may in fact be strengthened by NIRP for two reasons. Firstly, the charge on reserves may motivate banks to extend more loans in an effort to reduce their reserve holdings and avoid it. Secondly, from the perspective of depositors, the zero lower bound on deposit rates leads to a decrease in the opportunity cost of holding retail deposits and increases the demand for such deposits. Banks may respond to this increased deposit funding by issuing more loans. Thus, while NIRP reduces the ability of banks to pass on lower rates to their borrowers and may thus reduce the effectiveness of the interest rate channel, the policy may amplify the bank lending channel by increasing the cost of holding EL, in particular for banks with a high share of retail deposit funding on their balance sheet. The identification strategy employed in this paper is based on this idea.

The exchange of very safe assets such as central bank reserves for riskier assets like loans and bonds can also be seen through the lens of the *risk-taking channel*, which emphasises the role of risk perceptions and risk tolerance (Borio and Zhu, 2008; Adrian and Shin, 2009; Jimenez et al., 2014; Dell’Ariccia et al., 2016). The increase in asset prices and collateral values prompted by lower policy rates can boost banks’ capacity and willingness to take on more risk. For instance, banks may rely on risk measures that are based on market equity prices, such as expected default frequencies, and make use of Value-at-Risk frameworks for their asset-liability management, all of which are likely to allow higher risk taking in an environment of lower rates. Moreover, “sticky” rate-of-return targets defined in nominal terms can prompt a “*search for yield*” effect when interest rates are reduced, which necessitates higher risk tolerance. In fact, the promotion of portfolio rebalancing by encouraging lenders to invest in riskier assets when the returns on safer assets decline is considered to be one objective of quantitative easing policies (Aramonte et al., 2015; HSS). This channel is likely to be further reinforced by the existence of negative rates.

While NIRP may stimulate bank balance sheet adjustment due to negative charges on EL and increased risk taking, there might be “tipping points” beyond which banks cannot tolerate further squeezes in their profits and adopt different strategies (Bech and Malkhozov, 2016). This argument is further taken up in Brunnermeier and Koby (2017) who argue that below some level of the policy rate (which is not necessarily zero) further reductions can in fact be contractionary owing to the financial instability they induce and the ensuing contractionary effects on bank lending. As the theory incorporates offsetting factors, determining

the net impact of NIRP on bank lending is ultimately an empirical question, to which we turn in section 4.

3. Strategies for bank balance sheet adjustments under NIRP

If banks reduce their EL holdings to avoid the additional costs during NIRP, this adjustment process normally involves changes to other items on the banks' balance sheets. The general adjustment channels that we consider are depicted in Figure 3. Starting from a stylized balance sheet illustrated on the upper left panel, we consider asset swaps in the form of loan creation (lower right) or the acquisition of other assets, such as securities (lower left), financed by lower EL holdings. In addition, banks may consider balance sheet reduction (non-roll over of bank funding) illustrated on the upper right panel. We test for the presence of these three channels in the empirical analysis.

There is one important caveat regarding the potential for banks' balance sheet adjustments to reduce their EL holdings: banks cannot change aggregate EL (in the short-run at least). While any individual bank can plausibly expect that a strategy to reduce its EL will be successful, it will not work for the system as a whole (see also section 4.2 in Ryan and Whelan, 2019). Some banks will inevitably end up with EL on their balance sheet. The system as a whole can only reduce EL by repaying borrowing from the Eurosystem or by acquiring banknotes. Typically, however, banks do not borrow from the Eurosystem in order to hold funds at the deposit facility and earn a negative spread.⁵ Instead, banks borrow to cover liquidity needs (e.g. in the weekly refinancing operations with a maturity of one week) or even funding needs (e.g. in the refinancing

⁵ An exception refers to episodes of acute turmoil in money markets, when banks may for precautionary reasons choose to simultaneously borrow from the central bank and hold the funds borrowed with the central bank as liquidity buffers. Such episodes were observed in the early stages of the financial crisis. Such a situation was not, however, observed during the NIRP period.

operations with long maturities like the long-term refinancing operations (TLTROs)). This implies that the funds borrowed are paid out to other banks within the closed system in which central bank reserves circulate. Moreover, in a context where the central bank is engaging in large-scale asset purchases, most of the EL in the system is not actively generated by banks' borrowing from the central bank but passively received when central bank asset purchases are settled. In both cases, the banks that end up holding the EL are different from the ones that have borrowed from the Eurosystem because banks that hold EL do so primarily for reasons that are linked to their role and position in the financial system.⁶ Overall, there is very limited scope for individual bank EL to be reduced by repaying funds borrowed from the central bank.⁷

4. Empirical strategy

In line with the conceptual discussion in the previous section, our empirical analysis focuses on tracing out three possible bank balance sheet adjustments triggered by the introduction of NIRP: loan extension, acquisition of other assets, and decline in wholesale funding.

4.1 Data

We make use of a confidential dataset containing balance sheet data for 252 euro area banks at the monthly frequency. Because monthly data may be subject to more random volatility, we report the empirical results obtained using quarterly averages. Nevertheless, the results are highly robust to using the

⁶ For example, a bank with high retail deposit intensity in its funding strategy will maintain some retail deposit generating infrastructure (a network of branches and offices) and it will be difficult for the bank to fully control the amount of retail deposits it takes in through this infrastructure.

⁷ Prudential regulation also imposes constraints on banks' adjustment space as is reflected in a multitude of regulations that govern the possible evolution of a bank's balance sheet (e.g. capital needed for loans, liquidity regulations constraining the funding strategy and leverage ratios limiting balance sheet size expansion stemming from particular items). For example, a bank may be constrained in its ability to extend lending by binding capital requirements or by liquidity regulation in which the exchange of a high-quality liquid asset for a loan that does not qualify as such would have adverse implications for regulatory liquidity ratios.

monthly frequency as well (not shown). The Eurosystem central banks collect the data with a view to reach a high degree of representativeness of the euro area banking sector, containing a broad range of banks of different sizes and business models from all euro area countries. Importantly, banks contained in the sample cover a large fraction of loans to the euro area economy (between 70% and 85% of all bank loans, depending on the country). We exclude banks from Cyprus and Greece because these banks were affected by domestic economic and banking crises. We also exclude banks that are particularly affected by the APP, such as banks that are directly exposed to the implementation of Eurosystem asset purchases,⁸ banks handling large amounts of euro liquidity on behalf of non-euro entities (see Eisenschmidt et al., 2017) or banks handling the cash leg of an APP transaction for non-euro area banks. For these banks, standard balance sheet adjustment channels described above are unlikely to be viable options, owing to their specific role in the implementation of the APP and the financial system architecture more broadly. This leaves us with 196 banks with balance sheet data from 2007.Q3 until 2018.Q1.

4.2 Identification

The introduction and further roll-out of NIRP occurred in tandem with the announcement of other non-standard monetary policy measures by the ECB. In particular, the first reduction of the DFR to negative territory in June 2014 coincided with the announcement of the first wave of TLTROs. The next reduction of the DFR to -0.20 percent was decided in September 2014, together with the announcement of the asset backed securities purchase programme

⁸ Banks affected by the APP typically display a strong co-movement of their main assets with their excess liquidity after March 2015, dwarfing other balance sheet changes. We exclude all those banks for which we observed an average EL ratio over main asset in excess of 10% over the APP period. In a second step, we manually checked all banks selected by that criterion to verify their close connection to the APP.

(ABSPP) and the third covered bond purchase programme (CBPP3). The rate cuts of December 2015 and March 2016 coincided with extensions of the ECB's expanded asset purchase programme (APP), which started in March 2015 and was broadly expected by financial markets as early as September 2014.

This confluence of various policy measures can have a bearing on banks' decisions and thus renders the identification of the effects of NIRP based purely on the timing of its introduction problematic. For example, it is plausible to expect the APP to have induced significant portfolio rebalancing effects (Albertazzi et al., 2018). The availability of long-term funding at an attractive price through the TLTRO can also be expected to incentivise the acquisition of assets and more generally changes to banks' balance sheets as the targeting elements of this measure would be expected to spur increased lending in particular.

Against this backdrop, our identification of the impact of NIRP relies on the cross-sectional variation of two characteristics of the banks in our sample: banks' retail deposit intensity and EL holdings. Considering the cross-sectional variation in these two characteristics jointly allows us to clearly identify effects that are exclusively linked to NIRP and not to any other concurrent monetary policy measure. The volume of EL held by each bank is different and changes through time. It is this volume (and banks' expectations of the additional volume that they will receive) that defines the direct cost of NIRP for banks and, therefore, the pressure to adjust their balance sheets. Moreover, for a given level of EL, banks' balance sheet adjustment to NIRP will differ depending on their exposure to retail deposit funding. In line with the discussion in section 2, we expect banks that rely on traditional retail deposit funding to be more responsive to NIRP compared to banks that exploit alternative funding options. To test this

argument formally, we classify banks into three business models: high, medium, and low retail deposit intensity, based on the size of their “retail deposits/ assets” ratios, using the 33rd and 66th percentiles to split the sample. We expect banks with high retail deposit intensity (“high deposit”) to attempt to reduce their EL more aggressively during NIRP as these banks are particularly exposed to the charges on EL holdings implied by negative policy rates.

We conceptualise our identification strategy and its links to the literature in Figure 4, which is key to understanding our empirical approach. Figure 4 compares the balance sheets of two stylized bank funding models, considering only the elements relevant for our research question. Bank A is entirely funded by retail deposits and hence faces a zero lower bound in passing the policy rate changes onto deposit rates. Meanwhile Bank B is entirely funded in the wholesale market with complete interest rate pass-through (r denotes the applicable interest rate). Under positive rates without EL (upper left panel of Figure 4) both banks can expect the same net present value (NPV) of their stream of profits, providing a general equilibrium rationale for the existence of both business models at the same time.⁹ In the presence of EL (upper right panel), both bank types earn a positive rate of return for their EL holdings (e.g. DFR) and, again, have equal NPVs, as the costs of holding EL in a positive rate environment are unrelated to banks’ funding structure. Note that the insight from the upper right panel of Figure 4, i.e. that EL does not change banks’ fundamental business prospects, is also backed by empirical research (see Ennis and Wollman (2015) for the case of the US).

⁹ The NPV is represented by the thickness of the red and black bars next to the balance sheets of both types of banks. NPV is used in this stylised illustration as a summary metric that allows us to compare the dynamic effects of different rate and asset/liability structure constellations.

Things change once policy rates are lowered below zero. The wholesale-funded bank is not affected as its liabilities fully reprice. The retail deposit-funded bank, however, is negatively affected as its liabilities cannot reprice fully and the NPV of its profits declines relative to the NPV of the profits of the wholesale-funded bank (lower left panel of Figure 4). This situation is worse when the banking system is forced to hold EL (e.g. due to asset purchases). The NPV of the profits of the retail deposit-funded bank further deteriorates relative to the one of the wholesale-funded bank because holding EL is more costly for the retail deposit-funded bank (lower right panel of Figure 4).

This classification of effects of NIRP on banks with and without EL also helps understanding the differences in the literature: Papers relying on retail deposit intensity (e.g. HHS; Eggertsson et al., 2017) base their identification on the channel described in the lower left panel of Figure 4. Meanwhile, our approach identifies the transmission channel described in the lower right panel of Figure 4. In this way, we are able to capture the incidence of the direct costs of the NIRP and the scope for portfolio adjustment through EL holdings while also capturing the exposure to the indirect effects associated with margin compression through the retail deposit funding intensity.

Based on this stylized discussion, we expect retail deposit-funded banks to have stronger incentives to reduce their EL holdings than banks without retail deposit funding. A more fundamental adjustment option for affected banks would be to change their funding models (i.e. to reduce their reliance on retail deposits). Such decisions, however, are of a more long-term nature and do need to be weighed against the fixed costs associated with switching to a new funding model as well as the benefits of the new funding model under positive interest rates. In

an environment where negative rates are considered temporary, we would rather expect the retail deposit-funded banks to adjust their EL holdings instead of changing their business models.

5. Empirical results

5.1. Bank loans

We start with the question whether NIRP prompts banks to use their EL to extend more loans, over and above the standard determinants of loan issuance. Determinants of bank loans have been heavily investigated in the literature. We specify an equation that is similar to the loan regression in Cornett et al. (2011), to estimate the impact of NIRP on bank loans.

$$\begin{aligned}
Y_{i,t} = & T_t + B_i + \beta_0 Y_{i,t-1} + \beta_1 EL_{i,t-1}(1 - D^{NIR}) + \beta_2 EL_{i,t-1} D^{NIR} \\
& + \beta_3 EL_{i,t-1}(1 - D^{NIR}) RR_{i,t-1} + \beta_4 EL_{i,t-1} D^{NIR} RR_{i,t-1} \\
& + \beta_5 (1 - D^{NIR}) RR_{i,t-1} + \beta_6 D^{NIR} RR_{i,t-1} + \beta_7 Liquidity\ ratio_{i,t-1} \\
& + \beta_8 Leverage\ ratio_{i,t-1} + \beta_9 BLS\ demand_t + \beta_{10} r_{i,t-1}^{Loan} \\
& + \beta_{11} Unemployment_{j,t-1} + \varepsilon_{i,t}
\end{aligned} \tag{1}$$

where $Y_{i,t} = Loan\ ratio_{i,t} = \frac{Loans_{i,t}}{Assets_{i,t-1}}$ is constructed from flow data on loans to

households and non-financial corporations, $EL\ ratio_{i,t} = \frac{Excess\ Liquidity_{i,t}}{Assets_{i,t}}$.

$Liquidity\ ratio_{i,t} = \frac{Liquid\ assets_{i,t}}{Assets_{i,t}}$, $Leverage\ ratio_{i,t} = \frac{(Capital+Reserves)_{i,t}}{Assets_{i,t}}$,

$RR_{i,t} = \frac{Retail\ Deposits_{i,t}}{Assets_{i,t}}$, D^{NIR} is a dummy variable that is equal to 1 for NIRP

(after 2014.Q2). The following variables are scaled by 1/100 for comparable

coefficient estimates: $BLS\ demand_{j,t}$ is a proxy for loan demand measured from

the BLS survey,¹⁰ $r_{i,t-1}^{Loan}$ is composite loan rate, and $Unemployment_{j,t-1}$ is the unemployment rate. The subscript i denotes individual bank i , and j is the country where the bank is located in.

Liquid assets are defined as the sum of interbank lending, holdings of government bonds, holdings of debt securities issued by MFIs, holdings of debt securities issued by the private sector, and holdings of equity. Retail deposits are defined as deposits (of all maturities) of households and r_i^{Loan} is the composite lending rate of bank i . Summary descriptive statistics for the variables used in our empirical analysis are provided in Table A1 in Annex.

We control for the potential endogeneity between macroeconomic variables, bank balance sheet components and the dependent variable by lagging the right hand side variables, which is standard practice in the literature (see e.g. Cornett et al., 2011; Kashyap and Stein, 2000). Carpenter et al. (2014) provide further evidence of a lagged adjustment of loan demand to economic activity. In the robustness section, we also consider a “difference in differences” methodology to address endogeneity issues and illustrate that our results are robust under this approach.

Our strategy for identifying the effects of the NIRP period on bank loan issuance is operationalised in equation (1) by interacting the EL ratio with a dummy variable for the NIRP period and by interacting EL with Retail Ratio (RR), which is our measure of banks’ retail deposit intensity. If banks are indeed more motivated to turn their EL into loans during the NIRP period, we expect $\beta_2 > \beta_1$. Furthermore, if this response is proportional to their holdings of retail deposits, then we expect $\beta_2 + \beta_4 > \beta_1 + \beta_3$.

¹⁰ Note that country results for the BLS are used, which ensures cross-sectional variation across countries and therefore does not lead to collinearity problems with the time fixed effects.

Equation (1) is estimated as a panel fixed effects model. We include bank fixed effects (B_i) to control for unobservable time-invariant bank-specific factors that affect the decision to extend loans.¹¹ Moreover, our specifications include time fixed effects (T_t) to control for aggregate shocks. The errors are clustered at the bank level. The estimation sample covers the period from 2007.Q3 to 2018.Q1. The relatively long time dimension of our dataset with 43 quarters does not require the use of an Arellano and Bond (1991) type of estimator to address the dynamic structure.¹² To avoid that our results are unduly influenced by outliers, all bank-level flow data are winsorized at the 1 and 99 percent levels.

Banks that have more funding through retail deposits are more likely to issue loans ($\beta_5, \beta_6 > 0$). Banks that have more liquid balance sheets or higher capital ratios are expected to issue more loans as well ($\beta_7, \beta_8 > 0$). An increase in demand should increase the volume of loans ($\beta_9 > 0$). We also control for demand with the unemployment rate. An increase in the unemployment rate should lead to a decline in loan issuance ($\beta_{11} < 0$).

Table 1a shows the estimation results. We drop the i and j indices to simplify the notation. EL is lagged in order to avoid potential endogeneity. The flow nature of our dependent variable with minimal autocorrelation further helps in eliminating any remaining endogeneity that may arise in a dynamic set up.¹³

¹¹ Pooled OLS estimates without fixed effects (not reported in the paper) as well as a model that replaces bank fixed effects with country fixed effects give qualitatively similar results.

¹² The Arellano-Bond (1991) estimator is designed for short panels. In long panels, a shock to the cross-sectional fixed effect declines with time and the correlation of the lagged dependent variable with the error term becomes insignificant. Judson and Owen (1999) use Monte-Carlo simulations and show that the so-called “Nickell bias” is no longer significant for panels where the time dimension is larger than 30.

¹³ Endogeneity would arise if there is reverse causality from bank loans to EL. There is, however, no reason to expect that the flow of loans in period t would influence the stock of EL at the end of the previous period $t-1$. Our framework does indeed suggest that banks that extend more loans would, *ceteris paribus*, reduce their EL, which would induce a negative bias. To the extent that lagging EL and utilizing flow data for loans does not completely eliminate this bias, our results

The coefficient associated with EL (rows 2-3) shows the impact of EL on loans, evaluated when $RR=0$. The negative and significant coefficient for the high deposit banks (column 3, row 3) likely reflects the economic situation post crisis. This was an environment with parts of the euro area banking sector still deleveraging while monetary policy reacted to this situation with expansionary measures that led to rising EL while loans for some banks in some countries continued to decline.

As described in the previous section, however, there are differences among banks in terms of their exposure to EL. In particular, banks are exposed to a less favourable situation when $RR>0$, which should motivate them to convert their EL into loans, as reflected by the positive and significant coefficient associated with $EL \times RR$ during NIRP (column 3, row 5) for high deposit banks. This is consistent with the goal of NIRP and in line with our stylized description of cross sectional differences in Figure 4.

Table 1b displays the relevant hypothesis tests. To ascertain whether the NIRP effect is indeed special, it is necessary to jointly consider the coefficients on the double and triple interaction. The first row in Table 1b tests whether the joint EL effect is significant in the period before NIRP. The second row tests the same effect for NIRP. The one-sided hypothesis tests whether the joint effect is positive. We note that for the high deposit banks, there is a significant and positive impact such that higher values of EL are associated with more loan extensions. The third row compares the relative magnitudes of the coefficient estimates during the two periods. We observe that the observed response is indeed

will err on the conservative side and underestimate the transmission channel that we aim to identify.

different (two sided hypothesis) and the response during NIRP period is larger (one sided hypothesis) for medium and high deposit banks.

Based on the results presented in Table 1a, the NIRP effect corresponds on average to 8.1 percent of the quarterly lending by high retail banks and 2.8 percent of lending by medium retail banks during the NIRP period. There are approximately 70 banks in each group and this set of banks amounts to 88.6% percent of average non-financial private sector (NFPS) loans in our sample.¹⁴

The results for our control variables are generally in line with our expectations. Banks that have more retail deposit funding or more liquid balance sheets tend to issue more loans (rows 6-8). A decrease in demand, captured by the increase in the unemployment rate, leads to less loan extension as expected (row 12).

5.2. Security holdings

We follow the same logic as in the previous section to identify the effects of NIRP for bank security holdings in the framework of portfolio adjustment. We decompose total security holdings into domestic government bonds, non-domestic government bonds, private securities, and external assets, which are assets that are issued outside the euro area. We estimate the effect for each type of security separately to detect if there are any differences in adjustment among different security types.

Banks hold securities because of their safe return. In addition, a considerable body of literature argues that banks also hold sovereign bonds for reasons other than their expected return. Bernanke and Blinder (1992), Holmstrom

¹⁴ In order to calculate the economic significance of our results, we calculate the ratio: $\frac{ELratio_i(\beta_2 + \beta_4 RR_i)}{Loan\ flow_i}$ where $Loan\ flow_i$, RR_i and $EL\ ratio_i$ are the sample average values during NIRP and β_i is the coefficient estimate from equation (1).

and Tirole (1993), Gennaioli et al. (2013) suggest that banks hold government bonds as a buffer against the materialisation of liquidity shocks. Other authors, such as Bonner (2016) and Popov and van Horen (2013) highlight the relevance of the preferential treatment of government bonds in capital and liquidity regulation. With these considerations in mind, we use the following equation, similar to our loan equation in the previous section:

$$\begin{aligned}
Y_{i,t} = & T_t + B_i + \beta_0 Y_{i,t-1} + \beta_1 EL_{i,t-1} (1 - D^{NIR}) + \beta_2 EL_{i,t-1} D^{NIR} \\
& + \beta_3 EL_{i,t-1} (1 - D^{NIR}) RR_{i,t-1} + \beta_4 EL_{i,t-1} D^{NIR} RR_{i,t-1} + \beta_5 (1 - D^{NIR}) RR_{i,t-1} \\
& + \beta_6 D^{NIR} RR_{i,t-1} + \beta_7 Liquidity\ ratio_{i,t-1} + \beta_8 Leverage\ ratio_{i,t-1} \\
& + \beta_9 (r_{i,t-1}^{Loan} - r_{j,t-1}^{10y}) + \beta_{10} \Delta r_{j,t-1}^{10y} D^{2014} + \beta_{11} \log(Assets)_{i,t-1} \\
& + \beta_{12} Unemployment_{j,t-1} + \varepsilon_{it}
\end{aligned} \tag{2}$$

where $Y_{i,t} = Securities\ ratio_{i,t} = \frac{Securities_{i,t}}{Assets_{i,t-1}}$. $Securities_{i,t}$ is flow data on either domestic government bonds, non-domestic government bonds, private securities, or external assets. The variable r_j^{10y} denotes the yield on the 10-year government bonds issued in country j , i.e. the country in which the respective bank is located. We interact this variable with a dummy variable after the fourth quarter of 2014 in order to control for the negative interest rate environment. The loan rate as well as the spread of the loan rate with respect to 10-year government bond rate is scaled by 1/100.

Similar to our logic in the previous section, if banks are more motivated to buy bonds with their EL during NIRP, we expect $\beta_2 > \beta_1$. Furthermore, if this behaviour is more pronounced for higher levels of retail ratios, we expect $\beta_2 + \beta_4 > \beta_1 + \beta_3$.

Tables 2-5 report the estimation results for domestic government bonds, non-domestic government bonds, private securities and external assets. We do not observe a significant increase in any type of security holding on average during NIRP. This finding is consistent with Ennis and Wolman (2015) who find no evidence of substitution between excess reserves and other forms of liquid assets for the US (albeit for a period with positive interest rates).

Better capitalised banks (row 9) tend to be more inclined to acquire non-domestic bonds (Table 3a) and external assets (Table 5a). There is a significant reaction to the opportunity cost of holding non-domestic government bonds (Table 3a, row 11).

An improvement in the liquidity ratios prompt banks to hold less private securities (Table 4a, row 8). Similarly, a deterioration in general macroeconomic conditions as proxied by the unemployment rate seem to decrease their holdings of private securities purchases as well (Table 4a, row 13).

5.3. Wholesale funding

Wholesale funding refers to uninsured bank liabilities such as inter-bank loans and debt securities issued that provide additional funding opportunities beyond retail deposits. Wholesale funding, owing to its uninsured nature, tends to be costlier than retail deposits and can, in some cases, be adjusted flexibly. At the same time, in a NIRP environment it is not subject to an effective lower bound and can therefore become relatively less costly than retail deposits. As discussed in Section 3, one potential impact of NIRP could be to motivate banks to use their EL to pay back wholesale funding debt, but we would expect this channel, if anything, to be more muted than the others due to the potential beneficial impact wholesale funding can have on banks' funding cost under NIRP.

We consider an empirical specification that is similar to the earlier ones:

$$\begin{aligned}
Y_{i,t} = & T_t + B_i + \beta_0 Y_{i,t-1} + \beta_1 EL_{i,t-1}(1 - D^{NIR}) + \beta_2 EL_{i,t-1} D^{NIR} \\
& + \beta_3 EL_{i,t-1}(1 - D^{NIR}) RR_{i,t-1} + \beta_4 EL_{i,t-1} D^{NIR} RR_{i,t-1} \\
& + \beta_5 (1 - D^{NIR}) RR_{i,t-1} + \beta_6 D^{NIR} RR_{i,t-1} + \beta_7 \text{Liquidity ratio}_{i,t-1} \\
& + \beta_8 \text{Leverage ratio}_{i,t-1} + \beta_9 \text{BLS demand}_t + \beta_{10} (r_{j,t-1}^{2y} - r_{i,t-1}^{\text{Deposit}}) \\
& + \beta_{11} \text{Unemployment}_{j,t-1} + \varepsilon_{it}
\end{aligned} \tag{3}$$

where $Y_{i,t} = \text{Wholesale ratio}_{i,t} = \frac{\text{Wholesale funding}_{i,t}}{\text{Assets}_{i,t-1}}$, $r_{j,t-1}^{2y}$ is the yield on the respective two-year sovereign bond, $r_{i,t-1}^{\text{Deposit}}$ is the composite deposit rate of each bank. The spread is scaled by 1/100.

The spread between the two-year sovereign bond rate and the deposit rate is a proxy to capture the relative cost of wholesale funding. Billett and Garfinkel (2004) note that banks' choice between insured and uninsured funding depends on the differential rates charged in the two markets. An increase in this spread reflects an increase in the cost of wholesale funding and hence implies a negative coefficient: $\beta_{10} < 0$. If banks are more motivated to use their EL to pay back their wholesale borrowing during the NIRP period and if this motivation is further reinforced by the bank's business model, then we expect $\beta_2 < \beta_1$. Furthermore, if this behaviour is more pronounced for high deposit holders, we expect $\beta_2 + \beta_4 < \beta_1 + \beta_3$.

Variables such as the leverage ratio indirectly control for banks' unsecured funding costs (Babihuga and Spaltro, 2014) as banks with better capitalisation (i.e. a higher leverage ratio as defined here) should have lower wholesale funding costs and are, therefore, more likely to tap wholesale funding resources: $\beta_8 > 0$.

Table 6 shows the estimation results, which point to a decline in wholesale funding for high deposit banks when faced with increasing EL during the NIRP period, although the estimation is not very precise. This finding may be associated with broader deleveraging strategies followed by these groups of banks in this period, as they made efforts to have leaner balance sheets in the face of the introduction of the leverage ratio. Nevertheless, the estimated response is not statistically significant. Overall, our findings are in line with our expectation that the wholesale funding channel is an unlikely adjustment path for banks to reduce their EL holdings under NIRP as it potentially conveys a cost advantage to banks.

Looking at the other control variables, banks that have higher levels of liquid assets tend to rely on less wholesale funding as expected.

6. Robustness analysis

In the previous section, we documented that high deposit banks extend more loans during NIRP. We check the robustness of this result in several ways.

First, we consider alternative cut off points for various reductions in DFR to determine if the NIRP period is indeed special. Our goal is to understand whether other reductions in the DFR that took place in positive territory trigger reactions similar to the reductions in negative territory. To that end, we first consider two additional rate cut periods and construct dummy variables to capture them econometrically: D^{11-12} (2011.Q4 to 2012.Q2) and D^{2013} (2013.Q2 to 2013.Q4, when ECB lowered the MRO rate but not the DFR). D^{rem} captures the rest of pre-NIRP period. We interact these dummy variables with the EL ratio and add them to our specification.

Table 7 shows the results. We do not observe a significant response to EL by high deposit banks in the period before NIRP (rows 3-5). The dominance of insignificant coefficients (Table 7a) weakens the precision of the joint hypothesis tests (Table 7b). A similar situation emerges when we focus on the interaction terms: High deposit banks did not attempt to convert EL into loans when the DFR was in positive territory (rows 7-9). By contrast, the coefficient estimate associated with NIRP remains positive, as in our main specification, and significant (row 6).

Table 8 considers a second robustness check, analysing the impact of progressive steps into negative territory compared to the period when the DFR was positive. Accordingly, we split the NIRP period into four sub samples: D^{DFR1} (June 2014 to August 2014, $DFR=-0.10$), D^{DFR2} (September 2014 to November 2015, $DFR=-0.20$), D^{DFR3} (December 2015 to February 2016, $DFR=-0.30$) and D^{DFR4} (March 2016 to March 2018, $DFR=-0.40$).

The first period with a negative DFR (D^{DRF1}) was relatively short (3 months), left short-term money market rates largely above zero due to a sluggish pass-through, and was generally associated with lower levels of EL. In contrast, the cut in the DFR to -0.30 percent in December 2015 (D^{DRF3}) marks the point when financial markets revised their expectations regarding the future path of short rates because what was previously thought to be the lower bound (essentially because of previous communication by the ECB on the topic) had to be revised downwards.¹⁵ Thus, we would expect our results to be driven by the later NIRP sub-periods rather than the earlier sub-periods. In addition to

¹⁵ Grisse et al. (2017) note that if rate cuts below zero shifts the believed lower bound, this affects the long term rates and strengthens the transmission mechanism. Wu and Xia (2017) support this argument. Lemke and Vladu (2017) show evidence of a decline in the lower bound during NIRP.

determining which phase of NIRP was more influential, this robustness check also allows us to see whether the data contains any hint regarding a potential reversal rate. For example, while we might find an overall effect where banks expand their loan supply in the face of negative rates, this effect might get smaller and ultimately reverse, depending on the degree of negativity of the DFR.

Turning to our results, the two panels of Table 8 indicate that high deposit banks' loan expansion under negative rates is spread throughout the NIRP period, except for the third phase (column 3). Meanwhile, the impact is more pronounced for the third and fourth phases of NIRP for medium retail banks, consistent with our expectations (column 2). Most importantly, we find no indication of the banking system approaching a "reversal rate" which would have manifested itself in negative responses (coefficients) at the later stages of NIRP.

While we did not observe a significant change in banks' adjustment of securities holdings during NIRP in our baseline specification (Table 2), when we consider sub-sample analysis within NIRP, we note that high deposit banks purchase more domestic bonds associated with higher levels of EL during the first stage of NIRP (Table 9). This finding is consistent with Bubeck et al. (2019) who note that high deposit banks increase their securities holdings during NIRP. Similarly, Ryan and Whelan (2019) find that banks increase their holdings of securities in an attempt to reduce their costly EL during NIRP. However, our estimated response is short lived and once longer term loan contracts are adjusted, banks return back to their optimal securities holdings (Bernanke and Blinder, 1992). It should be noted that our estimate of the effects of NIRP is likely a conservative one that underestimates the true impact. This is because while NIRP encourages banks to convert their EL into bonds, APP encouraged banks to sell

their bond holdings to the ECB (Kojien et al.,2016). Even though we control for the APP period with time fixed effects, we do not have access to control variables at the bank level that would affect the bank's decision (e.g. the expected rate of return on alternative assets).

Table 10 considers another robustness check for bank loans by controlling for the APP period explicitly. The APP variable is constructed based on Blattner and Joyce (2016), which yields the probability of the ECB implementing APP based on survey evidence. The variable starts with a positive probability in September 2014 and increases gradually to 1 by January 2015. We note that the aggregate impact of EL is still significant for the high retail banks even after we control for APP according to Blattner and Joyce (2016).

6.1 Using standard business model classifications

In the empirical analysis testing the effectiveness of NIRP, we argued that banks' exposure to retail deposits is an important factor determining the adjustment of their balance sheets. As another line of robustness checks, we elaborate on this idea further and categorize banks into different business models based on clustering techniques. We group each bank in our sample into a category reflecting its business model, using standard hierarchical clustering methods (see Ayadi et al. (2011) for a general overview and description of the methodology and standard bank business models present in European bank data).

For the cluster analysis, we use balance sheet data prior to the introduction of NIRP during the period from 2013.Q2 through 2014.Q2, i.e. in the year before NIRP started to avoid endogeneity, assuming that bank balance sheets exogenously reflect strategic choices made by management with respect to activities and funding. In a first step, we determine instruments to identify banks in similar groups. These instruments are criteria to determine similarities or differences. In line with the literature, we use loan to asset, security to asset, wholesale funding to asset, derivative to asset and retail deposit to asset ratios to categorise banks into different business models. Next, we apply an algorithm to formally measure the similarities and differences between various business models. In line with Ayadi et al. (2011) we use Ward's (1963) methodology and form partitions in a hierarchical manner.

The algorithm first assigns each bank in a different cluster. It then merges clusters by minimizing the within cluster sum of squared deviations from the cluster mean for a given number of clusters. Statistical tests suggest that five different business models exist in our data. A variety of robustness checks, using

alternative clustering methods (Gaussian mixture models, k-means, harmonic k-means, see Hamerly and Elkan (2002) for a discussion on the potential alternatives and their advantages and disadvantages) confirm this overall number. Using dynamic clustering methods (dynamic k-means) and allowing for banks' switching business models, we establish, in line with the findings of Lucas et al. (2018), that banks in our sample are unlikely to change their business model, at least during the 9 years covered by our sample. Finally, we cross-check the results of our statistical exercise with bank business model classifications available from other sources: supervisory data, rating agencies, commercial providers of bank balance sheet data and banks' annual reports.

Table 11 illustrates the business models that are exploited in our empirical identification. By controlling for bank business models we are able to capture two aspects that are key for banks' reaction to negative rates: the difference in their costs of holding EL and in their ability to adjust to these costs. Both dimensions should be reflected in a bank's business model.

Looking at the balance sheet decompositions of different business models, the focused retail group holds the largest percentage of retail deposits, followed by the diversified retail group (Table 12). Consistent with our baseline results, we expect these banks to be more aggressive in adjusting their portfolios to reduce their EL during NIRP compared to other business models. In terms of EL ratios, investment banks are followed by focused retail and diversified retail groups.

Table 13 illustrates the estimation results using business models. The results for bank loans are consistent with Table 1 in that banks with higher retail ratios, in particular focused retail and diversified retail banks extend significantly more loans associated with higher levels of EL during NIRP. We do not detect a

significant adjustment in securities or wholesale funding, which is coherent with our baseline results.

6.2 Difference in Differences Methodology

The majority of the related papers that are cited in the earlier sections use a Difference in Differences (DD) methodology in the empirical analysis. As a final robustness check, we estimate our model using a DD approach. The methodology assumes that economic conditions affect low and high deposit banks in the same way. The advantage of this methodology is that it accounts for the potential endogeneity between the economic control variables and the dependent variable, if the underlying assumptions about the control group are correct. As a starting point, we estimate the following equation for bank loans:

$$Y_{it} = T_t + B_i + \beta_1 RR_i D^{NIR} + \varepsilon_{it} \quad (4)$$

where RR_i is the average retail deposit ratio in the year before NIRP, which captures the treatment intensity. In this specification, the coefficient β_1 associated with the interaction term that measures the effect of NIRP on the loan issuance of high deposit banks. The first column in Table 14 replicates equation (4) using $\log(\text{stock of NFPS loans})$ as the dependent variable. We obtain a positive β_1 coefficient that is highly significant.

The second column in Table 14 considers log differences of NFPS loans as the dependent variable. This is consistent with Eggertsson et al., 2017, who follow HSS's specification for Swedish banks and consider the log difference of loans instead of log levels. This way, the trend component of the stock variable can be eliminated and the dependent variable gets "closer" to the net flow variable that we use in the baseline analysis. The results in the second column show that once

the dependent variable is changed into log differences, the positive and significant interaction term disappears. However, a negative and significant coefficient as found in HSS and Eggertsson et al. 2017, cannot be replicated either. Extending the sample period until 2018.Q1 does not change this finding (Column 3).

The first three columns in Table 14 test the transmission channel that is described in the lower left panel of Figure 4, using DD. Starting with the fourth column, this time we test the channel described in the lower right panel with DD. Column four in Table 14 adds average EL ratio in the year before NIRP as an additional interaction term because we believe that exposure to treatment is further intensified by banks' EL holdings. Indeed, one of the key differences of our work compared to the earlier literature is that we identify a different transmission mechanism: while the earlier literature focuses on the role of NIRP through retail deposits, as summarized in columns 1-3, we focus on the activation of EL by extending loans in order to minimize the incidence of the charge on reserves, as summarized in columns 4-6. Our findings (row 2) show that the interaction term, $RR_t \times EL\ ratio_t \times D^{NIR}$, is positive and significant, suggesting that high deposit banks issue more loans during NIRP which is proportional to their EL holdings.

In column 5, we replace the dependent variable with the ratio of net flow of NFPS loans (as in our benchmark specification): $Y_{i,t} = Loan\ ratio_{i,t} = \frac{Loans_{i,t}}{Assets_{i,t-1}}$. We note that the interaction term is highly significant, confirming our earlier findings. The last column considers the full sample that we analyze starting from 2007. The interaction term is still significant although the marginal significance level declines, likely because the longer sample adds confounding factors which may reduce the precision of estimation.

The analysis in this section illustrates that our results are robust to applying a DD approach. This is not surprising because the triple differencing that we consider in our baseline regressions is rather similar in spirit to DD. One advantage of DD is that it allows us to test for the difference between banks that are more reliant on deposit funding vs. banks that are less reliant on deposit funding in a formal way. At the same time, the advantage of our baseline regressions is that it allows us to model the individual channels with more granularity.

7. Conclusions

The existing theoretical and empirical literature on banks' role in the monetary policy transmission mechanism is inconclusive on bank reactions to changes in policy rates when these changes take place in negative territory. Using confidential bank-level data for the euro area, covering a representative share of total euro area bank loans and a novel identification for the effect of NIRP on banks' balance sheets, we approach this question empirically. We jointly consider banks' exposure to the charge on EL and their reliance on retail deposit funding, as an essential identification mechanism for the impact of NIRP on banks. We find evidence that banks indeed operate differently under NIRP. Banks that are highly exposed to NIRP (i.e. funded by large amounts of retail deposits and are holders of EL) extend significantly more loans to the NFPS during NIRP compared to the pre-NIRP period. These results suggest that NIRP has acted as an empowerment to the ECB's large-scale asset purchases that were also launched during this period and injected large amounts of EL into the banking system. The charge on EL appears to encourage banks to take action to mitigate it, thereby catalysing more active portfolio rebalancing. Our results are coherent with results

in the literature on the impact of NIRP in that we do find evidence of higher risk taking by banks, as risk-free EL is converted into loans. However, in contrast to some of these contributions, we find that high retail deposit banks increase their lending during NIRP. The difference in the results stems from our use of a broader dataset for bank loans and the incorporation of the role of EL during NIRP.

Figures

Figure 1: Key policy-controlled interest rates and interbank overnight rates

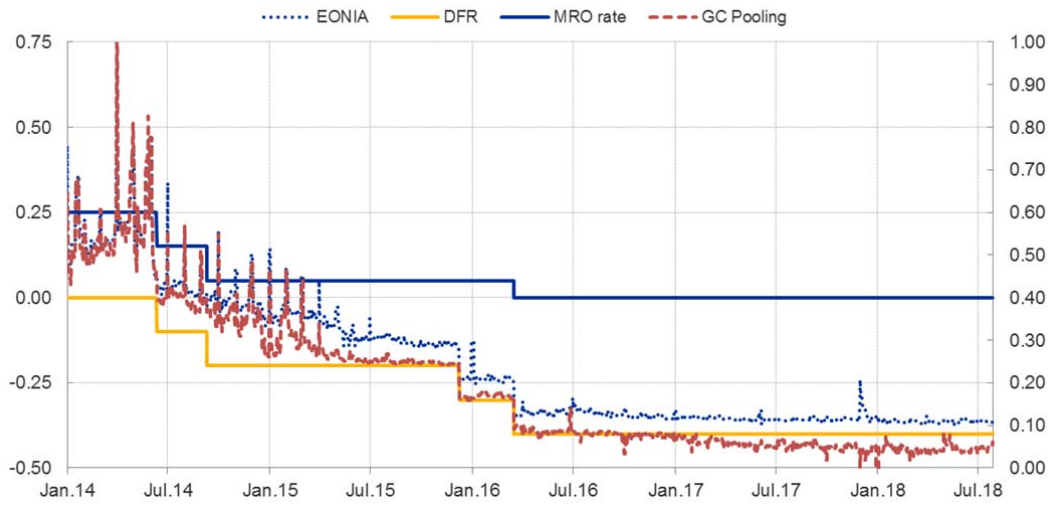
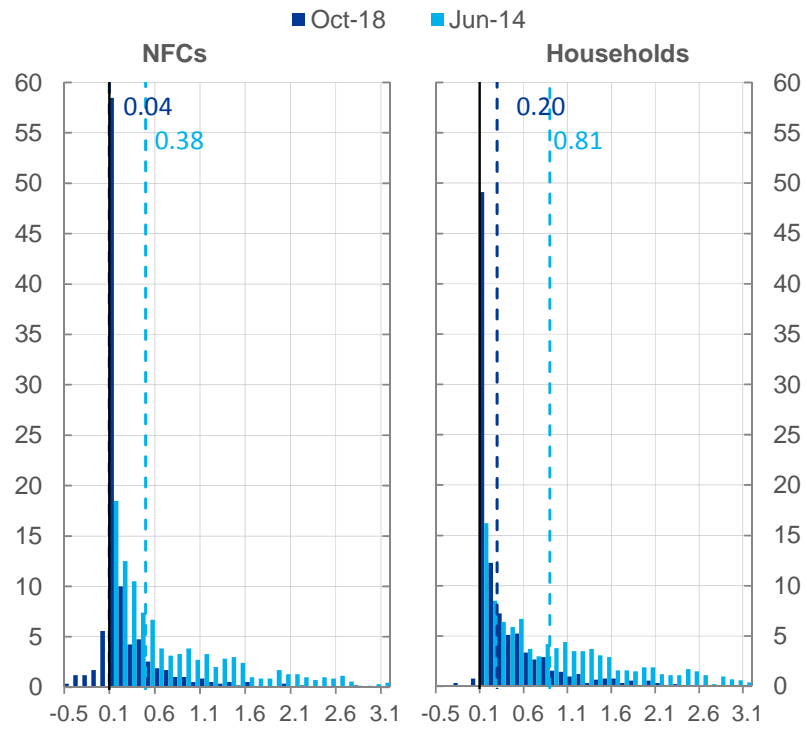


Figure 2: Distribution of the remuneration of household and NFC deposits across banks in the euro area



Source: ECB, dashed lines represent mean of distribution

Figure 3: Possible adjustment channels for banks to reduce their excess liquidity holdings



Figure 4: Comparison of two bank funding types under different interest rate environments

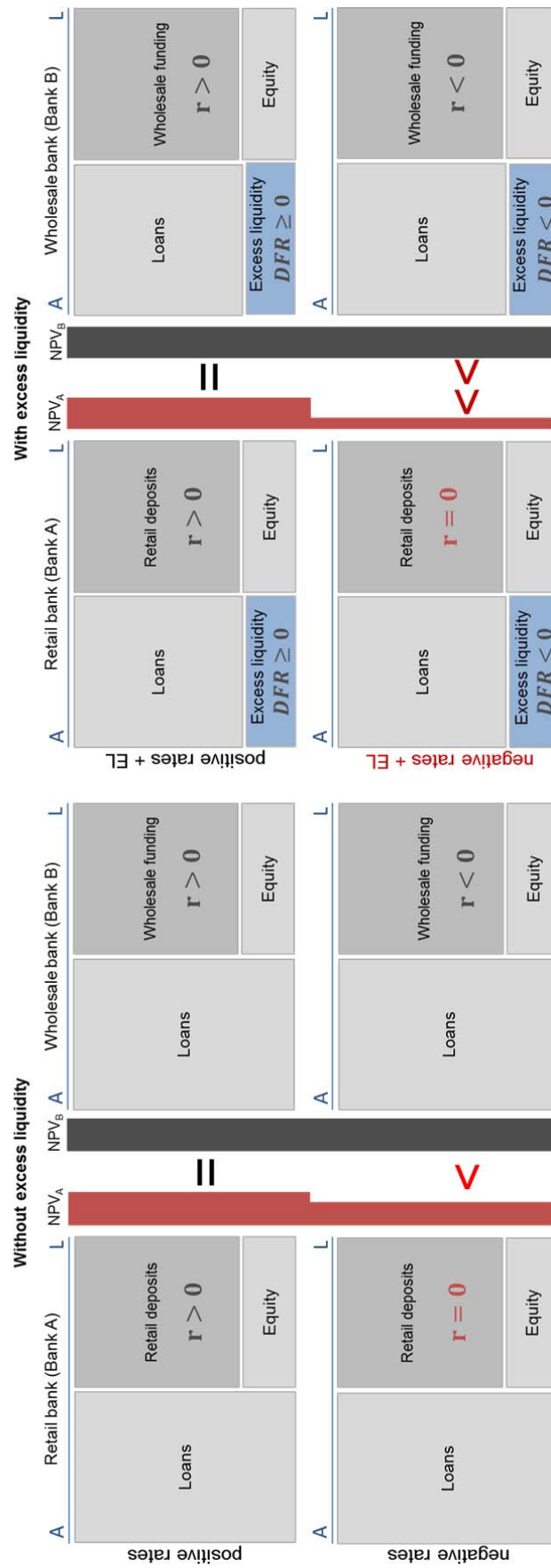


Table 1a: Effects of NIRP on Bank Loans

Dependent variable: Ratio of winsorized loan flow

VARIABLES	(1)	(2)	(3)
	Low retail	Medium retail	High retail
1. Lagged dependent variable	0.052 (0.076)	0.035 (0.038)	0.065** (0.030)
2. $EL\ ratio_{t-1} \times (1 - D^{NIR})$	-0.042*** (0.015)	0.159 (0.111)	-0.120 (0.122)
3. $EL\ ratio_{t-1} \times D^{NIR}$	-0.039** (0.018)	0.034* (0.020)	-0.174** (0.083)
4. $EL\ ratio_{t-1} \times (1 - D^{NIR}) \times RR_{t-1}$	-0.656 (1.568)	-1.003* (0.595)	0.221 (0.225)
5. $EL\ ratio_{t-1} D^{NIR} \times RR_{t-1}$	0.344 (0.321)	-0.120 (0.076)	0.371** (0.162)
6. $RR_{t-1} \times (1 - D^{NIR})$	0.172** (0.072)	0.020* (0.012)	-0.003 (0.012)
7. $RR_{t-1} \times D^{NIR}$	0.091* (0.049)	0.022** (0.011)	0.005 (0.011)
8. <i>Liquidity ratio</i> _{t-1}	0.026* (0.015)	-0.001 (0.008)	-0.009 (0.019)
9. <i>Leverage ratio</i> _{t-1}	0.005 (0.037)	-0.009 (0.016)	0.078 (0.096)
10. <i>BLS demand</i> _{t-1}	-0.002 (0.003)	0.001 (0.001)	0.006* (0.003)
11. r_{t-1}^{Loan}	0.031 (0.105)	-0.158*** (0.057)	-0.073 (0.072)
12. <i>Unemployment</i> _{t-1}	-0.062 (0.037)	-0.065*** (0.016)	-0.081*** (0.028)
13. <i>Constant</i>	-0.005 (0.008)	0.022*** (0.005)	0.018* (0.011)
Observations	1,953	2,438	2,512
R-squared	0.088	0.132	0.069
Number of ID	60	69	68

Robust standard errors in parentheses
 *** p<0.01, ** p<0.05, * p<0.1
 Regressions include cross section and period fixed effects.

Table 1b: Hypothesis testing

H0		(1)	(2)	(3)
		Low retail	Medium retail	High retail
1. $EL\ ratio_{t-1} \times (1 - D^{NIR}) + EL\ ratio_{t-1} \times (1 - D^{NIR}) \times RR_{t-1} = 0$	F statistic p-val (two sided)	3.44 0.0686	3.22 0.077	0.02 0.884
2. $EL\ ratio_{t-1} \times D^{NIR} + EL\ ratio_{t-1} \times D^{NIR} \times RR_{t-1} = 0$	F statistic p-val (two sided) p-val (one-sided)	4.51 0.038 0.981	0.01 0.929 0.464	3.52 0.065 0.032
3. $EL\ ratio_{t-1} \times (1 - D^{NIR}) + EL\ ratio_{t-1} \times (1 - D^{NIR}) \times RR_{t-1} = EL\ ratio_{t-1} \times D^{NIR} + EL\ ratio_{t-1} \times D^{NIR} \times RR_{t-1}$	F statistic p-val (two sided) p-val (one-sided)	0.40 0.529 0.265	3.31 0.073 0.037	2.13 0.149 0.074

Table 2a: Effects of NIRP on Domestic Bond Holdings

Dependent variable: Ratio of winsorized flow of domestic sovereign bonds

VARIABLES	(1)	(2)	(3)
	Low retail	Medium retail	High retail
1. Lagged dependent variable	0.016 (0.076)	-0.044 (0.035)	0.009 (0.035)
2. $EL\ ratio_{t-1} \times (1 - D^{NIR})$	-0.003 (0.004)	-0.020 (0.058)	0.167** (0.064)
3. $EL\ ratio_{t-1} \times D^{NIR}$	0.002 (0.006)	-0.056* (0.031)	0.063 (0.060)
4. $EL\ ratio_{t-1} \times (1 - D^{NIR}) \times RR_{t-1}$	0.089 (0.263)	0.194 (0.268)	-0.166** (0.076)
5. $EL\ ratio_{t-1} \times D^{NIR} \times RR_{t-1}$	0.001 (0.091)	0.461* (0.257)	-0.059 (0.102)
6. $RR_{t-1} \times (1 - D^{NIR})$	0.008 (0.014)	-0.003 (0.015)	0.000 (0.004)
7. $RR_{t-1} \times D^{NIR}$	0.010 (0.015)	-0.014 (0.014)	-0.005 (0.005)
8. $Liquidity\ ratio_{t-1}$	-0.002 (0.005)	-0.019*** (0.006)	-0.020** (0.008)
9. $Leverage\ ratio_{t-1}$	0.001 (0.008)	0.006 (0.011)	0.011 (0.015)
10. $r_{t-1}^{Loan} - r_{t-1}^{10y}$	0.025 (0.026)	-0.036 (0.023)	0.029 (0.070)
11. $\Delta r_{t-1}^{10y} \times D^{2014}$	0.161 (0.167)	0.240 (0.253)	-0.130 (0.381)
12. $\log(Assets)_{t-1}$	-0.119 (0.089)	-0.247 (0.293)	0.148 (0.159)
13. $Unemployment_{t-1}$	0.014 (0.011)	-0.020 (0.014)	0.019 (0.019)
14. <i>Constant</i>	0.013 (0.009)	0.034 (0.035)	-0.010 (0.016)
Observations	1,967	2,439	2,546
R-squared	0.044	0.073	0.046
Number of ID	60	69	68

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Regressions include cross section and period fixed effects.

Table 2b: Hypothesis testing

H0		(1)	(2)	(3)
		Low retail	Medium retail	High retail
1. $EL\ ratio_{t-1} \times (1 - D^{NIR}) + EL\ ratio_{t-1} \times (1 - D^{NIR}) \times RR_{t-1} = 0$	F statistic p-val (two sided)	0.05 0.825	1.26 0.266	6.82 0.011
2. $EL\ ratio_{t-1} \times D^{NIR} + EL\ ratio_{t-1} \times D^{NIR} \times RR_{t-1} = 0$	F statistic p-val (two sided) p-val (one-sided)	0.18 0.672 0.336	2.81 0.098 0.049	1.83 0.181 0.091
3. $EL\ ratio_{t-1} \times (1 - D^{NIR}) + EL\ ratio_{t-1} \times (1 - D^{NIR}) \times RR_{t-1} = EL\ ratio_{t-1} \times D^{NIR} + EL\ ratio_{t-1} \times D^{NIR} \times RR_{t-1}$	F statistic p-val (two sided) p-val (one-sided)	0.23 0.632 0.316	1.44 0.235 0.117	3.94 0.051 0.974

Table 3a: Effects of NIRP on Non-Domestic Bond Holdings

Dependent variable: Ratio of winsorized flow of non-domestic sovereign bonds

VARIABLES	(1)	(2)	(3)
	Low retail	Medium retail	High retail
1. Lagged dependent variable	-0.094 (0.060)	0.066 (0.066)	0.115** (0.056)
2. $EL\ ratio_{t-1} \times (1 - D^{NIR})$	-0.001 (0.002)	-0.029 (0.067)	0.025 (0.047)
3. $EL\ ratio_{t-1} \times D^{NIR}$	-0.002 (0.006)	0.008 (0.012)	0.008 (0.020)
4. $EL\ ratio_{t-1} \times (1 - D^{NIR}) \times RR_{t-1}$	0.260 (0.239)	0.289 (0.416)	-0.058 (0.101)
5. $EL\ ratio_{t-1} \times D^{NIR} \times RR_{t-1}$	-0.129 (0.200)	-0.034 (0.065)	-0.032 (0.040)
6. $RR_{t-1} \times (1 - D^{NIR})$	-0.012 (0.010)	0.003 (0.003)	0.001 (0.001)
7. $RR_{t-1} \times D^{NIR}$	-0.015** (0.007)	0.009** (0.004)	-0.000 (0.001)
8. $Liquidity\ ratio_{t-1}$	-0.001 (0.002)	-0.004 (0.002)	0.001 (0.003)
9. $Leverage\ ratio_{t-1}$	0.002 (0.004)	0.008** (0.003)	0.006 (0.006)
10. $r_{t-1}^{Loan} - r_{t-1}^{10y}$	0.015 (0.011)	0.004 (0.010)	0.016 (0.019)
11. $\Delta r_{t-1}^{10y} \times D^{2014}$	0.389* (0.204)	-0.020 (0.094)	0.094 (0.090)
12. $\log(Assets)_{t-1}$	0.014 (0.040)	0.007 (0.089)	-0.028 (0.046)
13. $Unemployment_{t-1}$	0.009 (0.007)	-0.004 (0.004)	-0.007 (0.005)
14. <i>Constant</i>	-0.002 (0.004)	-0.000 (0.011)	0.003 (0.004)
Observations	1,967	2,439	2,546
R-squared	0.052	0.038	0.036
Number of ID	60	69	68

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Regressions include cross section and period fixed effects.

Table 3b: Hypothesis testing

H0		(1)	(2)	(3)
		Low retail	Medium retail	High retail
1. $EL\ ratio_{t-1} \times (1 - D^{NIR}) + EL\ ratio_{t-1} \times (1 - D^{NIR}) \times RR_{t-1} = 0$	F statistic p-val (two sided)	0.84 0.362	1.18 0.281	0.24 0.626
2. $EL\ ratio_{t-1} \times D^{NIR} + EL\ ratio_{t-1} \times D^{NIR} \times RR_{t-1} = 0$	F statistic p-val (two sided) p-val (one-sided)	1.07 0.304 0.848	0.03 0.860 0.57	2.86 0.095 0.952
3. $EL\ ratio_{t-1} \times (1 - D^{NIR}) + EL\ ratio_{t-1} \times (1 - D^{NIR}) \times RR = EL\ ratio_{t-1} \times D^{NIR} + EL\ ratio_{t-1} \times D^{NIR} \times RR_{t-1}$	F statistic p-val (two sided) p-val (one-sided)	2.11 0.152 0.924	1.32 0.254 0.873	0.61 0.438 0.781

Table 4a: Effects of NIRP on Private Securities

Dependent variable: Ratio of winsorized flow of private securities

VARIABLES	(1)	(2)	(3)
	Low retail	Medium retail	High retail
1. Lagged dependent variable	-0.020 (0.029)	-0.050 (0.036)	-0.054 (0.033)
2. $EL\ ratio_{t-1} \times (1 - D^{NIR})$	-0.007 (0.005)	-0.120 (0.072)	0.079 (0.115)
3. $EL\ ratio_{t-1} \times D^{NIR}$	-0.006 (0.006)	-0.053 (0.037)	-0.020 (0.055)
4. $EL\ ratio_{t-1} \times (1 - D^{NIR}) \times RR_{t-1}$	0.448* (0.228)	0.210 (0.360)	-0.171 (0.190)
5. $EL\ ratio_{t-1} \times D^{NIR} \times RR_{t-1}$	0.017 (0.128)	0.010 (0.202)	-0.020 (0.098)
6. $RR_{t-1} \times (1 - D^{NIR})$	-0.026 (0.018)	-0.005 (0.010)	-0.007 (0.007)
7. $RR_{t-1} \times D^{NIR}$	-0.018 (0.019)	-0.011 (0.011)	-0.013* (0.007)
8. $Liquidity\ ratio_{t-1}$	-0.013* (0.007)	-0.029*** (0.007)	-0.029*** (0.008)
9. $Leverage\ ratio_{t-1}$	0.003 (0.010)	-0.044** (0.019)	0.017 (0.024)
10. $r_{t-1}^{Loan} - r_{t-1}^{10y}$	-0.054** (0.026)	0.083 (0.066)	0.036 (0.036)
11. $\Delta r_{t-1}^{10y} \times D^{2014}$	0.175 (0.446)	0.028 (0.168)	0.408* (0.225)
12. $\log(Assets)_{t-1}$	0.068 (0.174)	-0.008 (0.194)	0.027 (0.269)
13. $Unemployment_{t-1}$	-0.008 (0.014)	-0.016 (0.022)	-0.048* (0.026)
14. <i>Constant</i>	0.000 (0.018)	0.018 (0.023)	0.015 (0.030)
Observations	1,947	2,434	2,526
R-squared	0.034	0.083	0.092
Number of ID	60	69	68

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Regressions include cross section and period fixed effects.

Table 4b: Hypothesis testing

H0		(1)	(2)	(3)
		Low retail	Medium retail	High retail
1. $EL\ ratio_{t-1} \times (1 - D^{NIR}) + EL\ ratio_{t-1} \times (1 - D^{NIR}) \times RR_{t-1} = 0$	F statistic p-val (two sided)	0.01 0.931	2.85 0.096	0.07 0.788
2. $EL\ ratio_{t-1} \times D^{NIR} + EL\ ratio_{t-1} \times D^{NIR} \times RR_{t-1} = 0$	F statistic p-val (two sided) p-val (one-sided)	1.21 0.276 0.862	2.81 0.098 0.951	5.02 0.028 0.986
3. $EL\ ratio_{t-1} \times (1 - D^{NIR}) + EL\ ratio_{t-1} \times (1 - D^{NIR}) \times RR_{t-1} = EL\ ratio_{t-1} \times D^{NIR} + EL\ ratio_{t-1} \times D^{NIR} \times RR_{t-1}$	F statistic p-val (two sided) p-val (one-sided)	0.78 0.381 0.81	0.30 0.584 0.292	0.50 0.482 0.759

Table 5a: Effects of NIRP on External Assets

Dependent variable: Ratio of winsorized flow of external assets (outside euro area)

VARIABLES	(1)	(2)	(3)
	Low retail	Medium retail	High retail
1. Lagged dependent variable	-0.247*** (0.092)	-0.260*** (0.061)	-0.085*** (0.023)
2. $EL\ ratio_{t-1} \times (1 - D^{NIR})$	-0.034* (0.018)	-0.199 (0.159)	0.001 (0.095)
3. $EL\ ratio_{t-1} \times D^{NIR}$	0.021 (0.046)	0.024 (0.042)	-0.008 (0.041)
4. $EL\ ratio_{t-1} \times (1 - D^{NIR}) \times RR_{t-1}$	-1.247 (1.425)	1.195 (0.742)	0.043 (0.140)
5. $EL\ ratio_{t-1} \times D^{NIR} \times RR_{t-1}$	-1.117 (0.880)	0.003 (0.161)	0.000 (0.072)
6. $RR_{t-1} \times (1 - D^{NIR})$	0.214** (0.087)	0.005 (0.011)	0.007* (0.004)
7. $RR_{t-1} \times D^{NIR}$	0.208** (0.080)	0.026 (0.016)	0.012** (0.005)
8. $Liquidity\ ratio_{t-1}$	0.012 (0.018)	-0.008 (0.009)	0.010* (0.005)
9. $Leverage\ ratio_{t-1}$	-0.112 (0.085)	-0.030 (0.021)	0.038** (0.018)
10. $r_{t-1}^{Loan} - r_{t-1}^{10y}$	-0.102 (0.125)	0.058 (0.081)	0.054 (0.039)
11. $\Delta r_{t-1}^{10y} \times D^{2014}$	-1.873 (1.316)	-0.036 (0.546)	-0.055 (0.260)
12. $\log(Assets)_{t-1}$	-2.325* (1.339)	-0.288 (0.395)	-0.206** (0.082)
13. $Unemployment_{t-1}$	-0.054 (0.073)	0.021 (0.035)	-0.009 (0.009)
14. <i>Constant</i>	0.267* (0.156)	0.033 (0.042)	0.016* (0.009)
Observations	1,968	2,439	2,546
R-squared	0.131	0.108	0.045
Number of ID	60	69	68

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Regressions include cross section and period fixed effects.

Table 5b: Hypothesis testing

H0		(1)	(2)	(3)
		Low retail	Medium retail	High retail
1. $EL\ ratio_{t-1} \times (1 - D^{NIR}) + EL\ ratio_{t-1} \times (1 - D^{NIR}) \times RR_{t-1} = 0$	F statistic p-val (two sided)	3.85 0.054	1.02 0.316	0.48 0.489
2. $EL\ ratio_{t-1} \times D^{NIR} + EL\ ratio_{t-1} \times D^{NIR} \times RR_{t-1} = 0$	F statistic p-val (two sided) p-val (one-sided)	0.00 0.995 0.497	1.66 0.202 0.101	0.59 0.444 0.778
3. $EL\ ratio_{t-1} \times (1 - D^{NIR}) + EL\ ratio_{t-1} \times (1 - D^{NIR}) \times RR_{t-1} = EL\ ratio_{t-1} \times D^{NIR} + EL\ ratio_{t-1} \times D^{NIR} \times RR_{t-1}$	F statistic p-val (two sided) p-val (one-sided)	1.48 0.228 0.114	0.32 0.574 0.713	1.03 0.314 0.843

Table 6a: Effects of NIRP on Wholesale Funding

Dependent variable: Ratio of winsorized flow of wholesale funding

VARIABLES	(1)	(2)	(3)
	Low retail	Medium retail	High retail
1. Lagged dependent variable	-0.062 (0.044)	-0.061* (0.033)	-0.039 (0.042)
2. $EL\ ratio_{t-1} \times (1 - D^{NIR})$	-0.038* (0.020)	-0.343 (0.387)	-0.235*** (0.081)
3. $EL\ ratio_{t-1} \times D^{NIR}$	-0.306** (0.136)	0.039 (0.059)	0.286 (0.243)
4. $EL\ ratio_{t-1} \times (1 - D^{NIR}) \times RR_{t-1}$	5.399** (2.118)	1.300 (1.604)	0.393** (0.149)
5. $EL\ ratio_{t-1} \times D^{NIR} \times RR_{t-1}$	2.555 (1.833)	-0.179 (0.259)	-0.467 (0.343)
6. $RR_{t-1} \times (1 - D^{NIR})$	-0.106 (0.114)	0.068*** (0.019)	0.024* (0.013)
7. $RR_{t-1} \times D^{NIR}$	-0.089 (0.122)	0.067*** (0.020)	0.026 (0.016)
8. $Liquidity\ ratio_{t-1}$	-0.044 (0.030)	-0.018 (0.012)	-0.014 (0.015)
9. $Leverage\ ratio_{t-1}$	0.051 (0.062)	0.046 (0.038)	0.024 (0.058)
10. $BLS\ demand$	-0.009 (0.009)	-0.004 (0.003)	0.002 (0.003)
11. $r_{t-1}^{2y} - r_{t-1}^{Deposit}$	-0.051 (0.086)	-0.002 (0.062)	-0.012 (0.083)
12. $Unemployment_{t-1}$	-0.077 (0.118)	-0.029 (0.034)	-0.066* (0.039)
13. $Constant$	0.034** (0.017)	-0.009 (0.008)	0.001 (0.011)
Observations	1,377	2,437	2,444
R-squared	0.099	0.064	0.045
Number of ID	51	69	68

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Regressions include cross section and period fixed effects.

Table 6b: Hypothesis testing

H0		(1)	(2)	(3)
		Low retail	Medium retail	High retail
1. $EL\ ratio_{t-1} \times (1 - D^{NIR}) + EL\ ratio_{t-1} \times (1 - D^{NIR}) \times RR_{t-1} = 0$	F statistic p-val (two sided)	1.94 0.170	0.52 0.473	0.90 0.348
2. $EL\ ratio_{t-1} \times D^{NIR} + EL\ ratio_{t-1} \times D^{NIR} \times RR_{t-1} = 0$	F statistic p-val (two sided) p-val (one-sided)	5.13 0.028 0.014	0.08 0.772 0.386	0.05 0.823 0.588
3. $EL\ ratio_{t-1} \times (1 - D^{NIR}) + EL\ ratio_{t-1} \times (1 - D^{NIR}) \times RR_{t-1} = EL\ ratio_{t-1} \times D^{NIR} + EL\ ratio_{t-1} \times D^{NIR} \times RR_{t-1}$	F statistic p-val (two sided) p-val (one-sided)	7.24 0.010 0.014	0.33 0.569 0.715	0.84 0.361 0.819

Table 7a: Alternative Easing Periods vs. Full NIRP

VARIABLES	(1)	(2)	(3)
	Low retail	Medium retail	High retail
1. Lagged dependent variable	0.053 (0.076)	0.033 (0.038)	0.065** (0.030)
2. $EL\ ratio_{t-1} \times D^{NIR}$	-0.039** (0.018)	0.035* (0.019)	-0.174** (0.083)
3. $EL\ ratio_{t-1} \times D^{1112}$	-0.067*** (0.018)	-0.140 (0.257)	-0.162 (0.144)
4. $EL\ ratio_{t-1} \times D^{13}$	-0.031* (0.018)	0.342*** (0.093)	-0.135 (0.199)
5. $EL\ ratio_{t-1} \times D^{remaining}$	-0.031** (0.013)	0.192** (0.081)	-0.095 (0.109)
6. $EL\ ratio_{t-1} \times D^{NIR} \times RR_{t-1}$	0.343 (0.320)	-0.126* (0.075)	0.370** (0.163)
7. $EL\ ratio_{t-1} \times D^{1112} \times RR_{t-1}$	0.161 (0.922)	0.924 (1.615)	0.335 (0.329)
8. $EL\ ratio_{t-1} \times D^{13} \times RR_{t-1}$	-1.798 (2.258)	-1.953*** (0.359)	0.196 (0.356)
9. $EL\ ratio_{t-1} \times D^{remaining} \times RR_{t-1}$	-0.483 (1.460)	-1.146*** (0.402)	0.200 (0.209)
10. $RR_{t-1} \times (1 - D^{NIR})$	0.173** (0.073)	0.019 (0.012)	-0.003 (0.012)
11. $RR_{t-1} \times D^{NIR}$	0.092* (0.050)	0.023** (0.011)	0.005 (0.011)
12. $Liquidity\ ratio_{t-1}$	0.027* (0.015)	-0.001 (0.008)	-0.009 (0.019)
13. $Leverage\ ratio_{t-1}$	0.006 (0.037)	-0.009 (0.016)	0.078 (0.096)
14. $BLS\ demand_{t-1}$	-0.002 (0.003)	0.001 (0.001)	0.006* (0.003)
15. r_{t-1}^{Loan}	0.033 (0.107)	-0.150*** (0.056)	-0.073 (0.072)
16. $Unemployment_{t-1}$	-0.059 (0.036)	-0.065*** (0.016)	-0.080*** (0.028)
17. <i>Constant</i>	-0.005 (0.009)	0.022*** (0.005)	0.018* (0.011)
Observations	1,953	2,438	2,512
R-squared	0.089	0.135	0.069
Number of ID	60	69	68

Table 7b: Hypothesis testing

H0		(1)	(2)	(3)
		Low retail	Medium retail	High retail
1. $EL\ ratio_{t-1} \times D^{NIR} + EL\ ratio_{t-1} \times D^{NIR} \times RR_{t-1} = 0$	F statistic	4.40	0.00	3.47
	p-val (two sided)	0.040	0.965	0.067
	p-val (one-sided)	0.98	0.483	0.033
2. $EL\ ratio_{t-1} \times D^{1112} + EL\ ratio_{t-1} \times D^{1112} \times RR_{t-1} = 0$	F statistic	7.79	0.36	0.05
	p-val (two sided)	0.007	0.548	0.820
	p-val (one-sided)	0.996	0.274	0.41
3. $EL\ ratio_{t-1} D^{NIR} \times EL\ ratio_{t-1} \times D^{NIR} \times RR_{t-1} = EL\ ratio_{t-1} \times D^{1112} + EL\ ratio_{t-1} \times D^{1112} \times RR_{t-1}$	F statistic	1.38	0.35	0.43
	p-val (two sided)	0.245	0.555	0.512
	p-val (one-sided)	0.122	0.723	0.256
4. $EL\ ratio_{t-1} \times D^{13} + EL\ ratio_{t-1} \times D^{13} \times RR_{t-1} = 0$	F statistic	2.37	16.59	0.12
	p-val (two sided)	0.129	0.000	0.730
	p-val (one-sided)	0.935	1.000	0.637
5. $EL\ ratio_{t-1} D^{NIR} \times EL\ ratio_{t-1} \times D^{NIR} \times RR_{t-1} = EL\ ratio_{t-1} \times D^{13} + EL\ ratio_{t-1} \times D^{13} \times RR_{t-1}$	F statistic	0.51	15.16	0.97
	p-val (two sided)	0.480	0.000	0.329
	p-val (one-sided)	0.24	0.000	0.164
6. $EL\ ratio_{t-1} \times D^{rem} + EL\ ratio_{t-1} \times D^{rem} \times RR_{t-1} = 0$	F statistic	2.12	1.93	0.03
	p-val (two sided)	0.151	0.170	0.855
	p-val (one-sided)	0.925	0.915	0.427
7. $EL\ ratio_{t-1} D^{NIR} \times EL\ ratio_{t-1} \times D^{NIR} \times RR_{t-1} = EL\ ratio_{t-1} \times D^{rem} + EL\ ratio_{t-1} \times D^{rem} \times RR_{t-1}$	F statistic	0.04	2.16	0.89
	p-val (two sided)	0.839	0.146	0.348
	p-val (one-sided)	0.419	0.073	0.174

Table 8a: Fully Split NIRP

VARIABLES	(1)	(2)	(3)
	Low retail	Medium retail	High retail
1. Lagged dependent variable	0.052 (0.076)	0.024 (0.042)	0.065** (0.030)
2. $EL\ ratio_{t-1} \times (1 - D^{NIR})$	-0.043*** (0.014)	0.158 (0.114)	-0.103 (0.129)
3. $EL\ ratio_{t-1} \times D^{DFR1}$	-0.006 (0.034)	0.192 (0.229)	-1.664*** (0.417)
4. $EL\ ratio_{t-1} \times D^{DFR2}$	-0.136* (0.079)	0.259*** (0.054)	0.191 (0.210)
5. $EL\ ratio_{t-1} \times D^{DFR3}$	-0.046 (0.052)	-1.343** (0.639)	0.111 (0.082)
6. $EL\ ratio_{t-1} \times D^{DFR4}$	-0.037** (0.018)	0.056** (0.028)	-0.196** (0.088)
7. $EL\ ratio_{t-1} \times (1 - D^{NIR}) \times RR_{t-1}$	-0.638 (1.621)	-1.014 (0.621)	0.183 (0.238)
8. $EL\ ratio_{t-1} \times D^{DFR1} \times RR_{t-1}$	0.590 (2.537)	-1.978** (0.938)	2.318*** (0.636)
9. $EL\ ratio_{t-1} \times D^{DFR2} \times RR_{t-1}$	1.872 (2.842)	-2.013*** (0.239)	-0.266 (0.356)
10. $EL\ ratio_{t-1} \times D^{DFR3} \times RR_{t-1}$	1.438 (1.366)	9.585** (4.193)	-0.275 (0.171)
11. $EL\ ratio_{t-1} \times D^{DFR4} \times RR_{t-1}$	0.336 (0.337)	-0.252* (0.139)	0.414** (0.173)
12. $RR_{t-1} \times (1 - D^{NIR})$	0.172** (0.073)	0.020* (0.012)	-0.004 (0.012)
13. $RR_{t-1} \times D^{NIR}$	0.089* (0.051)	0.022** (0.011)	0.005 (0.011)
14. $Liquidity\ ratio_{t-1}$	0.026* (0.015)	-0.004 (0.005)	-0.010 (0.019)
15. $Leverage\ ratio_{t-1}$	0.005 (0.037)	-0.011 (0.016)	0.079 (0.096)
16. $BLS\ demand_{t-1}$	-0.002 (0.003)	0.001 (0.001)	0.006* (0.003)
17. r_{t-1}^{Loan}	0.031 (0.106)	-0.153*** (0.052)	-0.060 (0.069)
18. $Unemployment_{t-1}$	-0.057 (0.036)	-0.066*** (0.016)	-0.082*** (0.028)
19. <i>Constant</i>	-0.005 (0.008)	0.023*** (0.005)	0.018* (0.011)
Observations	1,953	2,438	2,512
R-squared	0.088	0.317	0.071
Number of ID	60	69	68

Robust standard errors in parentheses
 *** p<0.01, ** p<0.05, * p<0.1
 Regressions include cross section and period fixed effects.

Table 8b: Hypothesis testing

HO		(1)	(2)	(3)
		Low retail	Medium retail	High retail
1. $EL\ ratio_{t-1} \times (1 - D^{NIR}) + EL\ ratio_{t-1} \times (1 - D^{NIR}) \times RR_{t-1} = 0$	F statistic p-val (two sided)	3.27 0.076	2.92 0.092	0.05 0.830
2. $EL\ ratio_{t-1} \times D^{DFR1} + EL\ ratio_{t-1} \times D^{DFR1} \times RR_{t-1} = 0$	F statistic p-val (two sided) p-val (one-sided)	0.00 0.947 0.473	5.77 0.019 0.990	12.23 0.001 1.000
3. $EL\ ratio_{t-1} \times (1 - D^{NIR}) + EL\ ratio_{t-1} \times (1 - D^{NIR}) \times RR_{t-1} = EL\ ratio_{t-1} \times D^{DFR1} + EL\ ratio_{t-1} \times D^{DFR1} \times RR_{t-1}$	F statistic p-val (two sided) p-val (one-sided)	1.80 0.184 0.092	4.75 0.033 0.984	12.09 0.001 0.000
4. $EL\ ratio_{t-1} \times D^{DFR2} + EL\ ratio_{t-1} \times D^{DFR2} \times RR_{t-1} = 0$	F statistic p-val (two sided) p-val (one-sided)	1.84 0.180 0.910	12.69 0.000 1.000	1.27 0.264 0.132
5. $EL\ ratio_{t-1} \times (1 - D^{NIR}) + EL\ ratio_{t-1} \times (1 - D^{NIR}) \times RR_{t-1} = EL\ ratio_{t-1} \times D^{DFR2} + EL\ ratio_{t-1} \times D^{DFR2} \times RR_{t-1}$	F statistic p-val (two sided) p-val (one-sided)	0.51 0.476 0.762	11.78 0.001 1.000	4.28 0.042 0.021
6. $EL\ ratio_{t-1} \times D^{DFR3} + EL\ ratio_{t-1} \times D^{DFR3} \times RR_{t-1} = 0$	F statistic p-val (two sided) p-val (one-sided)	0.17 0.681 0.66	5.14 0.026 0.013	2.55 0.115 0.943
7. $EL\ ratio_{t-1} \times (1 - D^{NIR}) + EL\ ratio_{t-1} \times (1 - D^{NIR}) \times RR_{t-1} = EL\ ratio_{t-1} \times D^{DFR3} + EL\ ratio_{t-1} \times D^{DFR3} \times RR_{t-1}$	F statistic p-val (two sided) p-val (one-sided)	0.48 0.491 0.246	5.41 0.023 0.011	0.90 0.346 0.827
8. $EL\ ratio_{t-1} \times D^{DFR4} + EL\ ratio_{t-1} \times D^{DFR4} \times RR_{t-1} = 0$	F statistic p-val (two sided) p-val (one-sided)	3.63 0.062 0.969	0.91 0.342 0.829	4.21 0.044 0.022
9. $EL\ ratio_{t-1} \times (1 - D^{NIR}) + EL\ ratio_{t-1} \times (1 - D^{NIR}) \times RR_{t-1} = EL\ ratio_{t-1} \times D^{DFR4} + EL\ ratio_{t-1} \times D^{DFR4} \times RR_{t-1}$	F statistic p-val (two sided) p-val (one-sided)	0.46 0.498 0.249	1.78 0.187 0.094	2.07 0.155 0.077

Table 9a: Fully Split NIRP

Dependent variable: Ratio of winsorized flow of non-domestic sovereign bonds

VARIABLES	(1)	(2)	(3)
	Low retail	Medium retail	High retail
1. Lagged dependent variable	0.015 (0.076)	-0.060* (0.034)	0.007 (0.038)
2. $EL\ ratio_{t-1} \times (1 - D^{NIR})$	-0.003 (0.004)	-0.072 (0.062)	0.153** (0.066)
3. $EL\ ratio_{t-1} \times D^{DFR1}$	-0.012 (0.027)	0.265 (0.549)	1.366 (1.329)
4. $EL\ ratio_{t-1} \times D^{DFR2}$	0.027* (0.015)	-0.319*** (0.055)	-0.120 (0.133)
5. $EL\ ratio_{t-1} \times D^{DFR3}$	0.034 (0.033)	-0.717** (0.303)	-0.089 (0.109)
6. $EL\ ratio_{t-1} \times D^{DFR4}$	0.001 (0.006)	-0.033* (0.017)	0.085 (0.068)
7. $EL\ ratio_{t-1} \times (1 - D^{NIR}) \times RR_{t-1}$	0.097 (0.249)	0.579* (0.319)	-0.131 (0.081)
8. $EL\ ratio_{t-1} \times D^{DFR1} \times RR_{t-1}$	0.288 (1.356)	-0.725 (1.980)	-1.042 (2.105)
9. $EL\ ratio_{t-1} \times D^{DFR2} \times RR_{t-1}$	0.327 (0.797)	2.881*** (0.237)	0.171 (0.261)
10. $EL\ ratio_{t-1} \times D^{DFR3} \times RR_{t-1}$	-1.401** (0.583)	4.873** (1.908)	0.286 (0.226)
11. $EL\ ratio_{t-1} \times D^{DFR4} \times RR_{t-1}$	0.011 (0.094)	0.139* (0.074)	-0.100 (0.114)
12. $RR_{t-1} \times (1 - D^{NIR})$	0.008 (0.014)	0.003 (0.012)	0.001 (0.004)
13. $RR_{t-1} \times D^{NIR}$	0.010 (0.016)	-0.014 (0.012)	-0.005 (0.005)
14. $Liquidity\ ratio_{t-1}$	-0.002 (0.005)	-0.022*** (0.007)	-0.020** (0.008)
15. $Leverage\ ratio_{t-1}$	0.001 (0.008)	0.007 (0.010)	0.012 (0.015)
16. $r_{t-1}^{Loan} - r_{t-1}^{10y}$	0.025 (0.026)	-0.027 (0.024)	0.023 (0.071)
17. $\Delta r_{t-1}^{10y} \times D^{2014}$	0.161 (0.167)	0.222 (0.244)	-0.067 (0.354)
18. $\log(Assets)_{t-1}$	-0.116 (0.090)	-0.059 (0.163)	0.154 (0.154)
19. $Unemployment_{t-1}$	0.014 (0.011)	-0.018 (0.013)	0.019 (0.019)
20. <i>Constant</i>	0.013 (0.009)	0.013 (0.020)	-0.011 (0.015)
Observations	1,967	2,439	2,546
R-squared	0.045	0.144	0.053
Number of ID	60	69	68

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Regressions include cross section and period fixed effects.

Table 9b: Hypothesis testing

H0		(1) Low retail	(2) Medium retail	(3) High retail
1. $EL\ ratio_{t-1} \times (1 - D^{NIR}) + EL\ ratio_{t-1} \times (1 - D^{NIR}) \times RR_{t-1} = 0$	F statistic p-val (two sided)	0.03 0.852	4.30 0.042	6.94 0.010
2. $EL\ ratio_{t-1} \times D^{DFR1} + EL\ ratio_{t-1} \times D^{DFR1} \times RR_{t-1} = 0$	F statistic p-val (two sided) p-val (one-sided)	0.06 0.810 0.595	0.45 0.507 0.253	5.77 0.019 0.010
3. $EL\ ratio_{t-1} \times (1 - D^{NIR}) + EL\ ratio_{t-1} \times (1 - D^{NIR}) \times RR_{t-1} = EL\ ratio_{t-1} \times D^{DFR1} + EL\ ratio_{t-1} \times D^{DFR1} \times RR_{t-1}$	F statistic p-val (two sided) p-val (one-sided)	0.04 0.843 0.578	0.07 0.792 0.396	5.03 0.028 0.014
4. $EL\ ratio_{t-1} \times D^{DFR2} + EL\ ratio_{t-1} \times D^{DFR2} \times RR_{t-1} = 0$	F statistic p-val (two sided) p-val (one-sided)	5.35 0.024 0.012	18.90 0.000 0.000	1.09 0.300 0.850
5. $EL\ ratio_{t-1} \times (1 - D^{NIR}) + EL\ ratio_{t-1} \times (1 - D^{NIR}) \times RS_{t-1} = EL\ ratio_{t-1} \times D^{DFR2} + EL\ ratio_{t-1} \times D^{DFR2} \times RR_{t-1}$	F statistic p-val (two sided) p-val (one-sided)	3.99 0.050 0.025	20.15 0.000 0.000	10.39 0.002 0.999
6. $EL\ ratio_{t-1} \times D^{DFR3} + EL\ ratio_{t-1} \times D^{DFR3} \times RR_{t-1} = 0$	F statistic p-val (two sided) p-val (one-sided)	0.08 0.783 0.392	6.29 0.015 0.007	2.39 0.127 0.063
7. $EL\ ratio_{t-1} \times (1 - D^{NIR}) + EL\ ratio_{t-1} \times (1 - D^{NIR}) \times RR_{t-1} = EL\ ratio_{t-1} \times D^{DFR3} + EL\ ratio_{t-1} \times D^{DFR3} \times RR_{t-1}$	F statistic p-val (two sided) p-val (one-sided)	0.11 0.744 0.372	5.93 0.018 0.009	0.104 0.844 0.578
8. $EL\ ratio_{t-1} \times D^{DFR4} + EL\ ratio_{t-1} \times D^{DFR4} \times RR_{t-1} = 0$	F statistic p-val (two sided) p-val (one-sided)	0.04 0.844 0.422	0.28 0.600 0.300	1.73 0.194 0.097
9. $EL\ ratio_{t-1} \times (1 - D^{NIR}) + EL\ ratio_{t-1} \times (1 - D^{NIR}) \times RR_{t-1} = EL\ ratio_{t-1} \times D^{DFR4} + EL\ ratio_{t-1} \times D^{DFR4} \times RR_{t-1}$	F statistic p-val (two sided) p-val (one-sided)	0.08 0.776 0.388	1.98 0.0164 0.918	3.82 0.055 0.973

Table 10a: Testing for APP

Dependent variable: Ratio of winsorized loan flow

VARIABLES	(1)	(2)	(3)
	Low retail	Medium retail	High retail
1. Lagged dependent variable	0.052 (0.076)	0.007 (0.049)	0.065** (0.030)
2. $EL\ ratio_{t-1} \times (1 - D^{NIR})$	-0.042*** (0.015)	0.184 (0.121)	-0.112 (0.124)
3. $EL\ ratio_{t-1} \times D^{NIR}$	-0.039** (0.018)	0.017 (0.021)	-0.174** (0.083)
4. $EL\ ratio_{t-1} \times D^{APP}$	-0.033 (0.070)	0.404 (0.548)	0.849 (0.659)
5. $EL\ ratio_{t-1} \times (1 - D^{NIR}) \times RR_{t-1}$	-0.667 (1.583)	-1.175* (0.662)	0.208 (0.227)
6. $EL\ ratio_{t-1} \times D^{NIR} \times RR_{t-1}$	0.335 (0.328)	0.061 (0.171)	0.372** (0.162)
7. $EL\ ratio_{t-1} \times D^{APP} \times RR_{t-1}$	-1.273 (5.525)	-3.750*** (1.152)	-1.249 (0.828)
8. $RR_{t-1} \times (1 - D^{NIR})$	0.172** (0.072)	0.020 (0.012)	-0.003 (0.012)
9. $RR_{t-1} \times D^{NIR}$	0.092* (0.050)	0.024** (0.011)	0.006 (0.011)
10. <i>Liquidity ratio</i> _{t-1}	0.026* (0.015)	-0.002 (0.007)	-0.010 (0.019)
11. <i>Leverage ratio</i> _{t-1}	0.005 (0.037)	-0.010 (0.016)	0.078 (0.096)
12. <i>BLS demand</i>	-0.002 (0.003)	0.001 (0.001)	0.006* (0.003)
13. r_{t-1}^{Loan}	0.031 (0.106)	-0.159*** (0.055)	-0.070 (0.071)
14. <i>Unemployment</i> _{t-1}	-0.058 (0.036)	-0.068*** (0.017)	-0.080*** (0.028)
15. <i>Constant</i>	-0.005 (0.008)	0.023*** (0.005)	0.018* (0.011)
Observations	1,953	2,438	2,512
R-squared	0.088	0.161	0.069
Number of ID	60	69	68

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Regressions include cross section and period fixed effects.

Table 10b: Hypothesis testing

H0		(1)	(2)	(3)
		Low retail	Medium retail	High retail
1. $EL\ ratio_{t-1} \times D^{NIR} + EL\ ratio_{t-1} \times D^{NIR} \times RR_{t-1} = 0$	F statistic p-val (two sided) p-val (one-sided)	4.43 0.040 0.980	1.04 0.312 0.156	3.63 0.061 0.031
2. $EL\ ratio_{t-1} \times D^{APP} + EL\ ratio_{t-1} \times D^{APP} \times RR_{t-1} = 0$	F statistic p-val (two sided)	0.21 0.645	4.39 0.040	0.47 0.495
3. $EL\ ratio_{t-1} \times (1 - D^{NIR}) + EL\ ratio_{t-1} \times (1 - D^{NIR}) \times RR_{t-1} = EL\ ratio_{t-1} \times D^{NIR} + EL\ ratio_{t-1} \times D^{NIR} \times RR_{t-1}$	F statistic p-val (two sided) p-val (one-sided)	0.41 0.522 0.261	3.13 0.081 0.041	2.03 0.159 0.08
4. $EL\ ratio_{t-1} \times D^{APP} + EL\ ratio_{t-1} \times D^{APP} \times RR_{t-1} = EL\ ratio_{t-1} \times D^{NIR} + EL\ ratio_{t-1} \times D^{NIR} \times RR_{t-1}$	F statistic p-val (two sided) p-val (one-sided)	0.03 0.860 0.43	3.99 0.050 0.025	0.26 0.612 0.306

Table 11: Business Models

Business Model	Description
Focused retail	Most active in traditional deposit loan intermediation.
Diversified retail	Deposit funded, moderate loan origination but also engaged in other activities.
Debt funded retail	Debt based market funding with moderate loan origination but also engaged in other activities, principally investment.
Investment	Mixed funding, high investment and trading activities.
Wholesale	High bank lending supported by debt funding.

Table 12: Median Shares of Selected Balance Sheet items by Business Model

Business Model	Assets			Liabilities		
	Loans to NFPS	Government bonds	Excess liquidity	Retail deposits	Interbank deposits	Securities issued
Focused retail	59.69%	5.33%	0.10%	43.05%	9.64%	3.77%
Diversified retail	36.11%	9.53%	0.12%	29.34%	13.07%	9.49%
Debt funded retail	35.18%	7.26%	0.02%	0.26%	31.21%	25.30%
Investment	20.00%	1.60%	2.41%	11.50%	20.60%	11.32%
Wholesale	5.91%	1.15%	0.08%	0.05%	22.65%	34.19%

Note: Median values are calculated over the NIRP.

Table 13a: Effects of NIRP on Bank Loans for Different Business Models

Dependent variable: Ratio of winsorized loan flow

	VARIABLES	(1) Debt funded retail	(2) Diversified retail	(3) Focused retail	(4) Investment	(5) Wholesale
1	Lagged dependent variable	0.159** (0.070)	0.031 (0.042)	0.029 (0.046)	0.133 (0.093)	-0.105 (0.117)
2	$EL\ ratio_{t-1} \times (1 - D^{NIR})$	0.079 (0.063)	-0.024 (0.041)	-0.070*** (0.006)	0.002 (0.037)	0.009 (0.030)
3	$EL\ ratio_{t-1} \times D^{NIR}$	-0.009 (0.024)	-0.021 (0.022)	-0.095*** (0.026)	-0.008 (0.018)	0.033*** (0.005)
4	$EL\ ratio_{t-1} \times (1 - D^{NIR}) \times RR_{t-1}$	-1.590** (0.625)	0.048 (0.076)	0.088 (0.111)	-0.300* (0.153)	0.513 (0.580)
5	$EL\ ratio_{t-1} D^{NIR} \times RR_{t-1}$	0.503** (0.215)	0.173** (0.070)	0.225*** (0.080)	0.075 (0.049)	0.273* (0.143)
6	$RR_{t-1} \times (1 - D^{NIR})$	0.091*** (0.032)	0.021*** (0.006)	0.018* (0.010)	0.028* (0.014)	0.154* (0.073)
7	$RR_{t-1} \times D^{NIR}$	0.027 (0.038)	0.023*** (0.005)	0.026** (0.011)	0.014 (0.012)	0.114 (0.079)
8	$Liquidity\ ratio_{t-1}$	0.048** (0.021)	-0.002 (0.006)	0.017* (0.009)	0.003 (0.008)	0.016 (0.010)
9	$Leverage\ ratio_{t-1}$	0.156 (0.118)	0.003 (0.015)	-0.018 (0.017)	-0.014 (0.022)	0.105*** (0.011)
10	$BLS\ demand$	0.000 0.048**	0.001 -0.002	0.002 0.017*	0.002 0.003	-0.002 0.016
11	τ_{t-1}^{Loan}	0.046 (0.130)	-0.232*** (0.063)	-0.072 (0.060)	0.053 (0.050)	-0.136 (0.140)
12	$Unemployment_{t-1}$	-0.115* (0.060)	-0.051*** (0.015)	-0.078*** (0.020)	-0.077** (0.030)	0.024 (0.059)
13	$Constant$	-0.021 (0.013)	0.016*** (0.004)	0.013** (0.006)	0.003 (0.004)	-0.000 (0.010)
	Observations	1,081	1,618	3,318	386	319
	R-squared	0.181	0.131	0.110	0.293	0.260
	Number of ID	32	45	91	10	11

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Regressions include cross section and period fixed effects.

Table 13b: Hypothesis testing

H0		(1) Low retail	(2) Medium retail	(3) High retail	(4) Investment	(5) Wholesale
$EL\ ratio_{t-1} \times (1 - D^{NIR}) +$ $EL\ ratio_{t-1} \times (1 - D^{NIR}) \times RR_{t-1} = 0$	F statistic p-val (two sided)	0.15 0.6978	0.20 0.6584	0.97 0.3280	1.20 0.3025	1.00 0.3411
$EL\ ratio_{t-1} \times D^{NIR} + EL\ ratio_{t-1} \times$ $D^{NIR} \times RR_{t-1} = 0$	F statistic p-val (two sided) p-val (one-sided)	0.54 0.4699 0.235	4.56 0.0383 0.019	0.02 0.8983 0.551	0.01 0.9266 0.463	14.90 0.0032 0.002
$EL\ ratio_{t-1} \times (1 - D^{NIR}) +$ $EL\ ratio_{t-1} \times (1 - D^{NIR}) \times RR_{t-1} =$ $EL\ ratio_{t-1} \times D^{NIR} + EL\ ratio_{t-1} \times$ $D^{NIR} \times RR_{t-1}$	F statistic p-val (two sided) p-val (one-sided)	0.02 0.8942 0.553	3.98 0.0524 0.026	1.35 0.2481 0.124	0.60 0.4583 0.229	0.00 0.9605 0.48

Table 14: Differences in Differences Framework

	(1)	(2)	(3)	(4)	(5)	(6)
	Ln(Loans)	Δ Ln(Loans)	Δ Ln(Loans)	Δ Ln(Loans)	Ratio of winsorized loan flow	Ratio of winsorized loan flow
	2011.Q1-2015.Q4	2011.Q1-2015.Q4	2011.Q1-2018.Q1	2011.Q1-2018.Q1	2011.Q1-2018.Q1	2007.Q3-2018.Q1
1. $RR_t \times D^{NIR}$	0.41**	0.01	0.03	--	--	--
	0.12	0.02	0.02			
2. $RR_t \times EL\ ratio_t \times D^{NIR}$	--	--	--	2.90*	0.32**	0.24*
				1.55	0.16	0.14
4. Cross section fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
5. Time fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
6. Observations	4110	4098	5657	5657	5997	8498
7. R-squared	0.95	0.08	0.08	0.08	0.14	0.12
8. Number of ID	211	211	211	211	214	214

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

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Annex : Summary statistics of regression variables

Table A1: Summary descriptive statistics

All Banks Excluding Cyprus, Greece and banks involved in APP (estimation sample)

	Mean	Median	Max	Min	Std.	Skewness
Loan ratio	0.32	0.13	89.45	-45.84	2.23	13.73
Domestic gov. bond ratio	0.03	0.00	22.11	-22.61	1.19	1.28
Non-domestic gov. bond ratio	0.00	0.00	11.78	-10.74	0.56	1.67
Wholesale ratio	-0.09	-0.14	717.04	-113.60	8.85	62.16
EL ratio	0.01	0.00	1.09	-0.01	0.04	10.07
log(Assets)	1051.40	1053.48	1372.02	618.54	137.79	-0.17
Retail ratio	0.28	0.25	0.87	0.00	0.24	0.54
Liquidity ratio	0.35	0.32	1.00	-0.82	0.19	0.81
Leverage ratio	0.09	0.07	1.05	-0.07	0.09	5.49
r^{Loan}	3.31	3.01	10.11	0.08	1.50	0.87
$r^{\text{Loan}} - r^{10y}$	0.68	0.88	8.53	-8.53	1.55	-0.29
BLS demand	-0.59	4.21	84.95	-100.00	30.73	-0.72
Unemployment rate	9.36	8.00	26.22	3.60	5.00	1.57

Note: *Loan ratio*, *Domestic Gov.Bond ratio*, *Non-Domestic Gov.Bond ratio* and *Wholesale ratio* are based on flow variables and have been multiplied by 100.

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