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Negative Interest Rate: the banking channels of transmission across Europe

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Negative Interest Rate: the banking channels of transmission across Europe

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Abstract

We show that in the Euro area Negative Interest Rate Policy (NIRP) had an expansionary effect on credit supply. We document that the policy had its intended expansionary effect through a portfolio rebalancing channel, especially in Southern Europe. Low rates created incentives for banks to reduce liquid assets and expand credit, in particular towards smaller firms. The portfolio rebalancing channel translates into real effects in terms of firms' investment and wage bill growth. By contrast, we do not find any evidence suggesting that NIRP has detrimental effects on bank profitability.

1. Introduction

How does monetary policy transmit to the real sector once the policy rate goes below the so called Zero Lower Bound (ZLB)? Modern macroeconomics suggests that once we approach zero, monetary policy is no longer able to expand lending and aggregate demand by lowering short term rates (Keynes 1936; Krugman et al. 1998). Consequently, when rates are low the economy is expected to fall in a liquidity trap. This is the reason why negative nominal rates represent an important novelty in the monetary policy toolkit. Even though many advanced economies adopted Negative Interest Rates Policy (NIRP), its impact remains unclear. Today, understanding negative rates is even more important given that the Covid19 pandemic occurred in a low rates environment. While

it could stimulate aggregate demand through the removal of the ZLB (Bernanke 2017; Rogoff 2017), it could also be detrimental for bank profitability because of the impossibility to pass negative rates to depositors (Brunnermeier and Koby 2018; Eggertsson et al. 2019; Ulate 2019). The goal of this paper is to contribute to the understanding of the new transmission channels that are at work in a negative rates environment. Given that transmission mechanisms may depend on macroeconomic conditions (Brunnermeier and Koby 2018), we also explore the possibility that different channels may coexist in different countries. The Euro area is an optimal setting because of the heterogeneous economic and financing conditions of member States, which are subject to the same monetary policy.
Our firm level analysis exploits the introduction of NIRP by the European Central Bank (ECB) in mid-2014. We document that the policy had its intended expansionary effect through a portfolio rebalancing channel (Bottero et al. 2019), especially in Southern Europe. Low rates created incentives for banks to reduce liquid assets and expand credit, in particular towards smaller firms. We find that firms associated with more liquid banks will receive more credit after the introduction of negative rates. Furthermore, this channel translates into real effects in terms of wage bill growth and investment. Conversely, we do not observe any detrimental effect on bank profitability, even in countries where deposit rates approach zero. We provide evidences suggesting that banks which rely more on deposits preserve their profitability by raising fees. Finally, we find that the transmission mechanism seems unchanged when the policy rate becomes deeply negative.

The rest of the paper is organized as follows: Section 2 reviews the literature; Section 3 documents the negative interest rate policy at the ECB and discusses the hypotheses; Section 4 describes the data and the empirical strategy; Section 5 reports the results of our analysis; Section 6 extends the model to deep negative rates; Section 7 concludes.

2. Literature Review

Our paper contributes to the flourishing literature on bank lending in negative interest rates environment. Brunnermeier and Koby (2018) theoretically prove the existence of a "reversal rate" beyond which a further cut of the monetary policy rate loses its intended

expansionary effects and becomes contractionary. However, this threshold is not necessarily zero. Instead, Eggertsson, Juelsrud, Summers, and Wold (2019) and Ulate (2019) explicitly model negative rates. They both build on the assumption that negative rates cannot be passed to deposit rates, otherwise customers would switch to cash, which yields zero nominal return. While lending rates decline because of monetary policy, deposit rates are sticky at zero, consequently banks' profitabity declines due to the squeeze in intermediation margins. In Eggertsson et al. (2019) as soon as the policy turns negative the transmission of monetary policy through the banking sector breaks down. Instead, Ulate (2019) captures both the detrimental and the beneficial effects, embodied in increased aggregate demand. He concludes that when the policy rate is negative and small, monetary policy is less effective compared to the positive territory; but when the policy rate falls beyond a small and negative threshold, monetary policy becomes contractionary.

The empirical literature identified two banking channels of transmission. The first channel, in line with the theoretical models, suggests that banks with higher retail deposit ratio are more exposed to the profitability squeeze caused by the zero lower bound on deposits. As a consequence, banks that rely more on deposits lend less and take more risk (Heider et al. 2019). However, this channel may not be at work if banks set negative rates on depositors - as reported by Altavilla et al. (2019) - or if banks preserve profitability by charging higher fees (Lopez et al. 2020; Bottero et al. 2019).

The second channel, found by Bottero et al. (2019), has instead an expansionary effect. Negative interest rates penalize the holding of liquid, safer assets incentivizing banks to rebalance their portfolio from low-yield to high-yield assets, such as loans. They show that NIRP affects more banks with higher net interbank position or more broadly, with more liquid balance sheets.

Our paper is closely related to the literature on bank lending in negative rate environments. Heider et al. (2019) examines the impact of negative rates on syndicated lending, while Bottero et al. (2019) exploit the Italian Credit Register data. In our analysis we explore the effects of NIRP in different European countries without the constraint of focusing on a specific market sector. More importantly, we investigate whether the transmission is heterogeneous across countries. Previous literature suggests that transmission

mechanisms depend on macroeconomic conditions Brunnermeier and Koby (2018) and on the market structure Drechsler et al. (2017). The Eurozone provides a unique setup: a group of heterogeneous countries subject to the same monetary policy. Understanding whether the transmission mechanism is the same across Europe is dramatically important if the final goal is convergence.

In addition, our paper adds to a broader literature on bank lending channel by considering cuts below zero. Kashyap and Stein (2000) found that less liquid banks lend more after a conventional monetary policy cut, whereas we find that *more* liquid banks lend more when the cut is in the negative territory. Overall, our findings suggest that NIRP is expansionary but works differently.

We also reference to the new literature on the role of deposits in monetary policy transmission. Drechsler et al. (2017) showed that the intensity of transmission depends on the deposit market structure. With the introduction of NIRP, Altavilla et al. (2019) found evidence of a novel banking channel of transmission in which firms do not play the usual role of borrowers but are seen as depositors. After 2014, a subset of European banks passed negative rates to corporate depositors. This has generated a mechanism analogous to the portfolio rebalancing channel: firms decreased their cash holdings and invested more. We will examine more carefully this alternative channel in Appendix D.1.

Finally, we contribute to the study of unconventional monetary policies, where the existing literature focuses on large liquidity injections (Acharya et al. 2019; Rodnyansky and Darmouni 2017).

3. Institutional background and hypothesis development

Between 2012 and 2016, numerous central banks adopted negative interest rates for the first time in history. In particular, the European Central Bank (ECB) lowered the Deposit Facility Rate[1] from 0% to -0.10% in June 2014. In the following years the ECB made subsequent cuts, reaching - 0.50 % in September 2019. Following the introduction of NIRP, also interbank rates, which proxy the cost of holding excess liquidity, entered the

[1]The ECB requires credit institutions established in the euro area to hold deposits on accounts with their national central bank (minimum required reserves). The DFR is the rate that banks earn on reserves that exceed the required level (excess reserves).

negative territory (Figure 1).

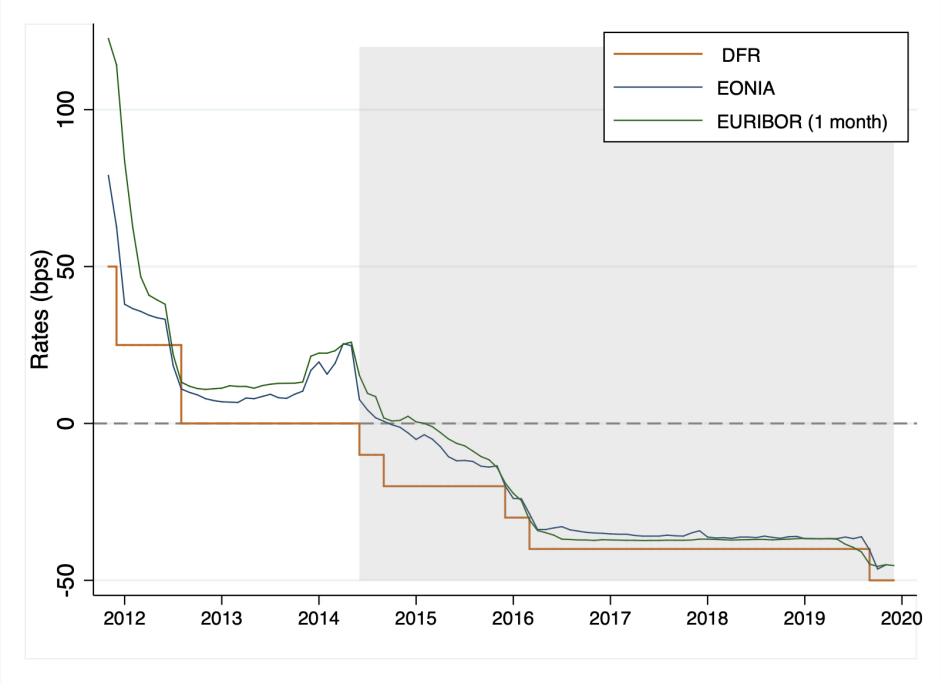

Figure 1: Deposit Facility Rate

The chart plots the ECB Deposit Facility rate at a monthly frequency, taking the end-month values. EONIA and EURIBOR (1 month) are reported at the monthly average. The gray area indicates the post NIRP period. *Source*: ECB Statistical Data Warehouse

By August 2014, the Euro OverNight Average Index (EONIA) and the one week Euro InterBank Offered Rate (EURIBOR) were already negative; at the beginning of 2015 also the one month EURIBOR broke the zero lower bound. *"Negative rates were introduced for one specific reason: when interest rates reached the zero lower bound, the expectations for the future rates in the long term are only that the rates can go up. So with negative rates we were successful in taking these expectations down"* (Draghi 2016). In fact, this change in expectations had relevant effects on the medium and long end of the yield curve. Negative interest rates have been peculiar because they shifted down and flattened the entire yield curve differently from the last cut in the positive territory, which mainly affected short term rates (Figure C1). Thanks to its impact on the yield curve, nominal negative interest rate was able to shift the risk-reward calculus of banks' portfolio allocation and make loans more attractive (Rostagno et al. 2016) .

On the other hand, some central banks, including the Federal Reserve and the Bank of England, are skeptical about the adoption of negative policy rates. Lowering the deposit

below zero is special because of the differential effect on the costs of funding. While during normal times an expansionary monetary policy translates into lower short term rates and lower deposit rates, when the policy rate turns negative short term rates fall but deposit rates are sticky at zero. The reason is that if banks start charging nominal negative rates on deposits, customers would switch to cash, which yields zero nominal return (Heider et al. 2019). Bank profitability has emerged as the main concern regarding NIRP. Cœuré (2016), who served the Executive Board of ECB until 2019, declared that *"A reduction in interest rates could harm interest margins, and this could be even more pronounced when rates enter negative territory, due to a potential zero lower bound for retail deposit rates"*. The profitability squeeze due to the decline intermediation margins, negatively impacts bank's net worth and leads to lower lending (Ulate (2019) Eggertsson et al. (2019)). What makes the Euro area an interesting case study are the different economic and

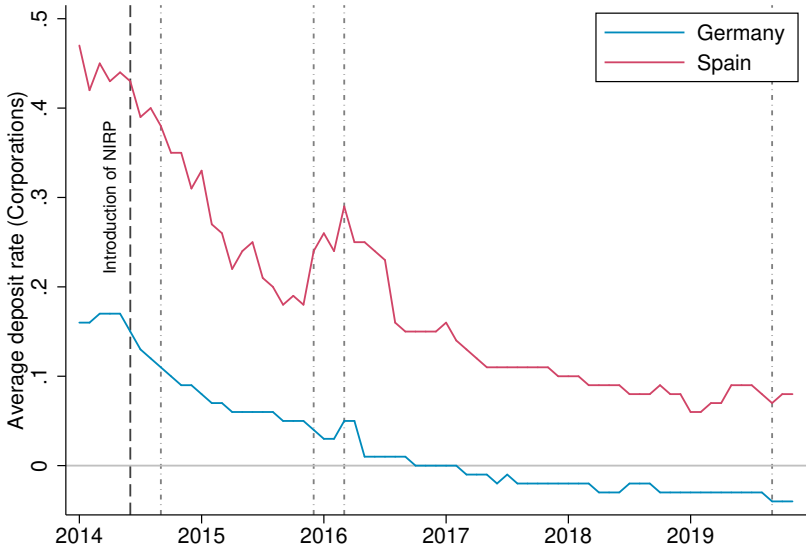

Figure 2: Average rate on corporate deposits

The figure describes average rate on corporate overnight deposits for Germany and Spain. The dashed line separates the pre-NIRP from the post-NIRP period. Dotted lines represent subsequent DFR cuts. *Source*: ECB Statistical Data Warehouse

financing conditions among member States following the sovereign debt crisis. Given the substantial cross-country heterogeneity, we should also consider the hypothesis that there are different channels at play in different areas of Europe. Figure 2 shows the evolution of overnight corporate deposit rates in Germany and Spain. The graph highlights two

facts. First, at the moment of the introduction of NIRP some countries are closer than others to the theoretical Zero Lower Bound. Where deposit rates are higher there is still room for the usual pass-through, therefore the retail deposit channel may not be active. Second, the ZLB may be just theoretical for corporate deposits. The cost of storage and the impossibility of carrying out operations just with cash, make it possible for banks to charge negative deposit rate on their corporate customers. However, this argument applies generally to sound Northern European banks (Altavilla et al. 2019). If we allow deposit rates to go below zero bank profitability can be preserved and the contractionary effects entailed by the retail deposit channel do not materialize.

Overall, even if the two channels may be simultaneously at work, on an aggregate level, the expansionary effect seems to have prevailed. As Figure 3 shows, in the first quarter of 2014 the growth of credit to non-financial corporations in the Euro area was -3.68 % . At the beginning of 2015, less than a year after the introduction of NIRP, credit growth was equal to 0.37%.

Figure 3: Growth of credit to non-financial corporations

Year-on-year growth rates of outstanding loans at all euro area non- financial corporations. The dashed gray line separates the pre-NIRP and the post-NIRP period. *Source*: ECB Statistical Data Warehouse

4. Empirical Strategy & Data

4.1. The data

Our empirical analysis relies on two data sources. We obtained firm level data from Bureau Van Dijk's Orbis, which provides financial statement information for listed and unlisted companies. Importantly, Orbis provides information on the names of the main lenders of a firm for a subset of European countries. We selected Germany, France and the Netherlands for Northern Europe, and Greece, Spain and Portugal for Southern Europe. We matched lenders' name with bank's unconsolidated balance sheet information obtained from Moody's Bank Focus. For further details on the fuzzy matching procedure we remind the reader to Appendix A. We included in our analysis only commercial banks, saving banks and cooperative banks and we have been able to identify 32,667 bank firm relationships. After winsorizing the data between 1st and 99th percentile of firms' credit, our final firm level sample consists of an unbalanced panel of 18,449 firms for 9 years, from 2010 to 2018, 1,173 banks, 84 2-digit NACE2 core industry classifications, and 114 NUTS2[2] regions. Summary statistics are shown in Table B1.

The main limitation of the dataset is that we do not observe the single firm-bank loan exposure. However this setting allows us to bring an important novelty with respect to the previous literature: we are able study the effects of NIRP across different countries without focusing on a specific market segment.

4.2. Empirical Specification

In order to study the effect of negative rates on bank lending we exploit our matched firm bank data set, we estimate the following firm-level equation for a ±2 year time window around the introduction of NIRP:

$$\begin{aligned}\ln(Credit)_{ft+1} =& \alpha + \beta_0 \overline{Retail}_{bt} + \beta_1 \overline{Retail}_{bt} \times Post_t + \gamma_0 \overline{Liquidity}_{bt} \\ &+ \gamma_1 \overline{Liquidity}_{bt} \times Post_t + \bar{X}_{bt}\delta + F_{ft}\phi + \psi_{irt} + \epsilon_{ft}\end{aligned} \tag{1}$$

[2]Nomenclature of Territorial Units for Statistics established by Eurostat

where *Credit* is the total amount of loans of firm f in year $t+1$. *Post* is a dummy variable that takes value 1 from 2014 onwards. Bank level data are included as the simple average of all the banks that are associated to firm f. Our key variables of interest are *Retail*, measured as retail deposits over bank total assets, and *Liquidity*, measured as bank securities over bank total assets. We conjecture that firms associated with banks that have an *ex-ante* larger retail deposit ratio should face a larger drop in credit after the introduction of NIRP; whereas firms associated with *ex-ante* more liquid banks should experience a larger increase in credit because of bank portfolio rebalancing. Therefore, the coefficients β_1 and γ_1 identify respectively the retail deposit channel and portfolio rebalancing channel. The bank level controls (X_{bt}) include size (ln(Assets)), equity ratio, profitability (ROA) and gross loans ratio, defined as gross loans over total assets. All bank controls are included as standalone and interacted with the *Post* dummy variable, in this way we properly identify the channels of transmission. Firm level controls (F_{ft}) include ln(Assets), and ln(Current Assets), in order to control for firm's size and liquidity. We opted for a firm level model for two reasons. First, we are interested in the channels that transmit to the real economy. Second, this setting allows us to account for credit demand shocks. Following Acharya et al. (2018), we aggregate firm into clusters so that we are able to add firm cluster - year fixed effects (ψ_{irt}) to the regression. Firms clusters are based on firm's region r (NUTS2) and industry i (2-digit NACE2 core). Thus, the identifying assumption of our model is that firms belonging to the same cluster are subject to similar shocks. After excluding all clusters in which only one firm is present, we obtain 840 clusters, and each cluster is made on average of 6 firms. Standard errors are two-way clustered at the level of the region and the industry, following Huber (2018). As robustness checks, we run the same specification considering only the bank that the firm indicates as "main lender" and change the time window to ± 3 years and ± 1 year.

We also account for an alternative approach: in the spirit of Khwaja and Mian (2008) we collapse our data into a single pre-NIRP and a single post-NIRP period and we regress the change in total credit on pre-NIRP variables:

$$\Delta \ln(Credit)_f = \beta_0 + \beta_1 \overline{Retail}_b^{pre} + \beta_2 \overline{Liquidity}_b^{pre} + \beta_3 \overline{X}_b^{pre} + \beta_4 F_f^{pre} + \phi_{ir} + \epsilon_f \qquad (2)$$

where ϕ_{ir} are industry-region fixed effects. In the baseline we do not account for the possibility that after the introduction of NIRP, banks may change expectations about future rates and consequently change also their financing strategy. This model addresses this issue by fixing the exposure variables in 2013. Furthermore, it also sorts out the autocorrelation concerns raised by Bertrand, Duflo, and Mullainathan (2004).

One of our key research questions is whether channels of transmission are heterogeneous across countries. We test this hypothesis by extending the baseline model. We separate European countries in our sample into two categories (Northern vs Southern Europe) and we estimate the following model:

$$\begin{aligned}\ln(Credit)_{ft+1} =&\alpha + \beta_0\overline{Retail}_{bt} + \beta_1\overline{Retail}_{bt} \times Post_t + \beta_2\overline{Retail}_{bt} \times Post_t \times South_f + \\ &\gamma_0\overline{Liquidity}_{bt} + \gamma_1\overline{Liquidity}_{bt} \times Post_t + \gamma_2\overline{Liquidity}_{bt} \times Post_t \times South_f \\ &+ \bar{X}_{bt}\delta + F_{ft}\phi + \psi_{irt} + \epsilon_{ft}\end{aligned} \tag{3}$$

where $South_f$ is a dummy variable that takes value 1 if the firm is based in Greece, Portugal or Spain. The coefficients of this regression will reflect whether a channel is present only in one area or whether the intensity of transmission is different. We will also carry out an analogous heterogeneity analysis based on firm's size.

Finally, we investigate whether this transmission channels translate into real effects in terms of wage bill growth and net investment. The approach is analogous to the baseline specification:

$$\begin{aligned}\text{Firm's Outcome}_{ft+1} =&\alpha_f + \beta_0\overline{Retail}_{bt} + \beta_1\overline{Retail}_{bt} \times Post_t + \gamma_0\overline{Liquidity}_{bt} \\ &+ \gamma_1\overline{Liquidity}_{bt} \times Post_t + \bar{X}_{bt}\delta + F_{ft}\phi + \lambda_t + \epsilon_{ft}\end{aligned} \tag{4}$$

where all previously mentioned variables keep the same definition, α_f are firm fixed effects and λ_t are year fixed effects.

5. Results

This section is organized as follows: Section 5.1 reports the results of the baseline model and rationalizes them by examining the mechanisms underlying each channel; Section

5.2 provides robustness checks; Section 5.3 discusses possible heterogeneous effects; lastly Section 5.4 shows real effects.

5.1. Baseline model

Table 1 reports the coefficients of interest of the baseline model (1). We show the results

ln(Credit)	(1)	(2)	(3)	(4)
Retail x Post	-0.0637	-0.146	0.582	1.464
	(0.382)	(0.462)	(0.872)	(1.292)
Liquidity x Post	2.433*	2.294*	3.644***	3.847**
	(1.341)	(1.374)	(1.331)	(1.480)
Industry-region-year FE	No	Yes	No	Yes
Region-year FE	Yes	No	Yes	No
Bank Controls	No	No	Yes	Yes
Firm Controls	Yes	Yes	Yes	Yes
Observations	13,499	11,640	13,499	11,640
R^2	0.374	0.483	0.374	0.483

Table 1: Baseline model

The table presents the estimates of model 1. Retail is measured as retail deposits over bank's total assets. Liquidity is measured as securities over bank's total assets. Observations are winsorized around the 1st and 99th percentile of credit. Bank and firm controls are those specified in Section 4.2. Bank controls are included as standalone and interacted with the Post dummy variable. Standard errors are two way clustered at region and industry level *** p<0.01, ** p<0.05, * p<0.1

of our baseline for two types of firm clusters: one accounts for firm's region, the other considers both firm's region and industry. In each case we report the basic regression and the one with bank controls. We find that the coefficient of the retail deposit channel is never significant, whereas the coefficient of the portfolio rebalancing channel is positive and robust to all the specifications. In particular, the coefficient does not change much when we consider different clusters, while it increases sensibly when we add bank controls. Bank controls are of particular importance: by controlling for size, profitability, leverage and gross loans ratio we implicitly control for the bank business model. Specification (4), which includes bank controls and considers the narrowest firm cluster, implies that one percentage point increase in liquidity ratio raises credit by 3.8%. The effect is economically

sizable if we consider that in 2013 average credit growth in our sample was equal to -5.3%. Overall, Table 1 provide evidence that Negative Interest Rate Policy has an expansionary effect through the portfolio rebalancing channel. In order to rationalize our results, next paragraphs analyze in detail the mechanisms underlying the two channels.

Retail deposit channel Despite theory suggests that negative rates should have a detrimental effect on bank profitability via deposit, we find no evidence of the retail deposit channel. One concern may be that firms are able to identify banks that will lend less and substitute across lenders. In this way we would not be able to see any effect at the firm level. In order to partially address this issue, we carry out a bank level analysis which mirrors the baseline (see Table B2) and we find that after the introduction of NIRP there is no correlation between retail deposit ratio and gross loans granted by the bank. Furthermore, the key mechanism driving the retail deposit channel implies that banks which rely more on deposits should suffer a larger profitability squeeze, which in turn leads to lower net worth and lower lending. However, Figure 4 shows that if we compare profitability across retail deposit ratio percentiles, we are not able to identify any downward trend. Therefore, data do not confirm the first step of the process that causes negative rates to be contractionary. There are three reasons to believe that negative interest rates are not a threat for banks' profitability. First, in some countries deposit rates were on average far from zero, therefore there was still room for the usual pass-through (see Figure 2) and consequently the retail deposit channel was not triggered. Second, the zero lower bound may not be binding. For instance, the ZLB may not be effective for corporate deposits given the impossibility of carrying out operations entirely with cash. As a matter of fact, a subset of banks has set negative deposit rates to corporations and large depositors (Altavilla et al. (2019), see also Figure 2). Third, banks may have started charging higher fees to preserve their profitability.

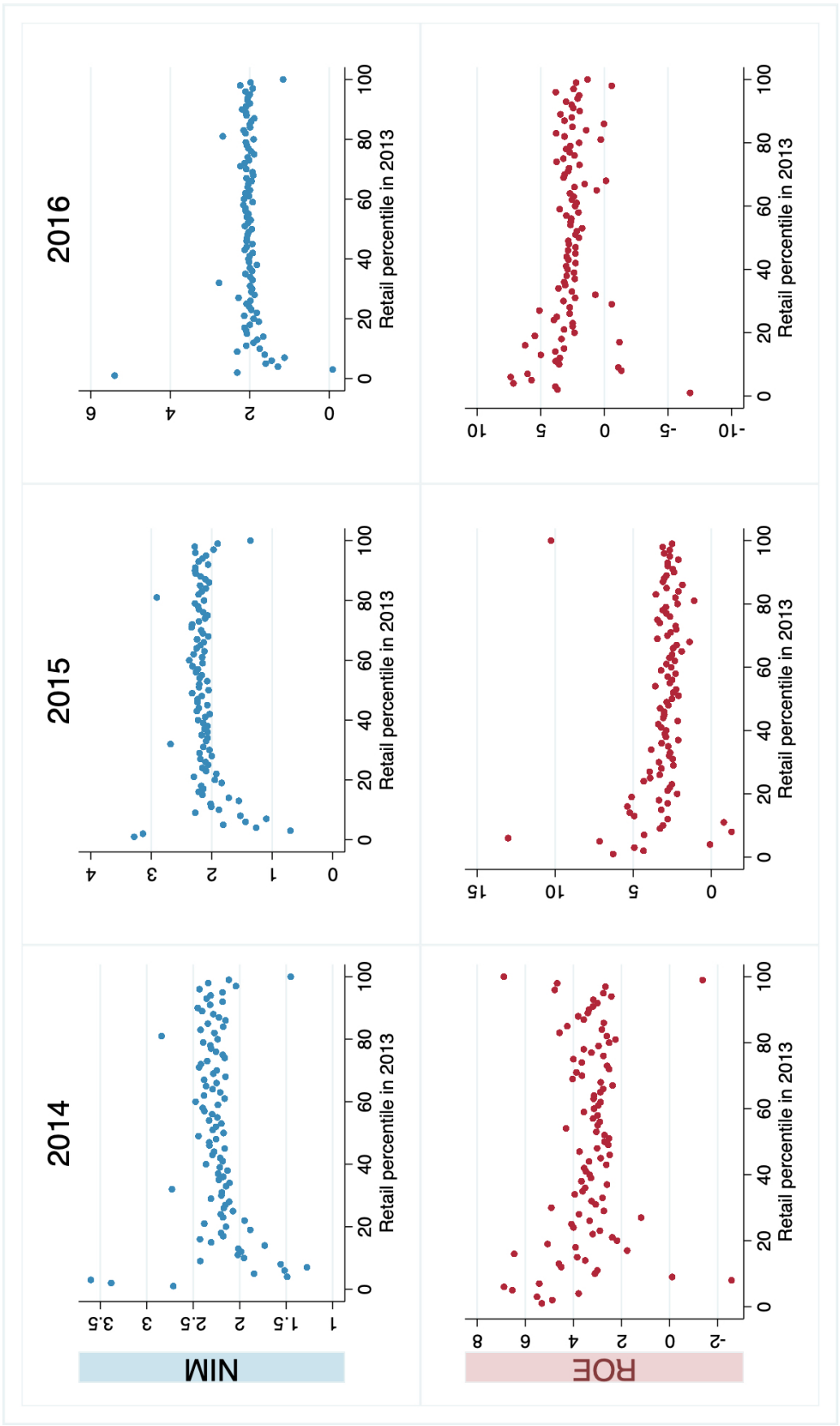

Figure 4: Bank profitability

We are able to test this last hypothesis. The first column of Table B3 shows that banks that had higher retail deposit ratios increased their fees more relative to those who relied less on deposits. The remaining columns report that the effect of NIRP on profitability was not heterogeneous across banks with different deposit ratios. Overall our findings suggest that negative interest rates are not a threat to bank profitability.

Portfolio rebalancing channel We found evidence that firm rebalance their portfolios towards credit, but which assets do they rebalance? We define IB Loans ratio as interbank loans over total assets. We want to test whether more liquid banks reduced the share of interbank loans in their portfolios. We run a bank level model which mirrors our baseline specification, Table B4 reports the results. We find that banks with higher liquidity ratio significantly reduced their share of interbank assets after the introduction of NIRP. This confirms the mechanism underlying the portfolio rebalancing channel: short term interbank rates are directly affected by monetary policy and turned negative few weeks after the DFR (Figure 1), therefore banks reduced very low yield assets in favor of loans. One concern regarding this result is that we are not controlling for possible interbank loans demand shocks. That being the case, our findings may be rationalized by an alternative explanation. The cut of the Deposit Facility Rate in June 2014 was accompanied by a cut of 35 basis points of the Marginal Lending Facility [3]. This could have made loans by the central bank relatively cheaper than interbank loans, causing a negative demand shock in the market. Therefore it may be that more liquid banks were forced to rebalance their portfolios from interbank loans to corporate loans. However this explanation does not seem plausible for at least two reasons. First, our measure of liquidity does not include interbank loans, thus the banks that lend more after the introduction of NIRP are not necessarily those who had ex-ante higher interbank loans ratios [4]. Second, banks lend more especially to smaller firms (see Section 5.3), which typically pay higher loan rates. This points out that banks are not pouring liquidity into the credit market because they cannot lend to other banks, but because they are looking for higher yields.

[3] The rate at which the ECB lends to Euro area banks overnight

[4] The correlation between IB ratio and Liquidity ratio is very close to zero in 2013.

5.2. Robustness checks

We test the robustness of our baseline specification. First, given that we cannot observe the single bank-firm loan exposure, we took as bank level variables the simple average of all banks associated to the firm. This creates some noise in our data, therefore we repeat the same exercise considering only the main bank associated to the firm. The first column of Table 2 reports the estimates for the firm-main bank model. The results confirm what we found in the baseline model: the retail deposit channel seems not to be active, whereas the portfolio rebalancing channel has a positive and significant effect. Second, we consider

ln(Credit)	Main Bank	Different Time Window	
		± 3 years	± 1 year
Retail x Post	1.875	1.712	1.051
	(1.133)	(1.231)	(0.850)
Liquidity x Post	4.333***	4.030***	3.382**
	(1.411)	(1.435)	(1.359)
Industry-region-year FE	Yes	Yes	Yes
Bank controls	Yes	Yes	Yes
Firm controls	Yes	Yes	Yes
Observations	6,004	15,895	6,599
R^2	0.511	0.479	0.486

Table 2: Robustness checks

The table presents the estimates of model 1. Retail is measured as retail deposits over bank's total assets. Liquidity is measured as securities over bank's total assets. Observations are winsorized around the 1st and 99th percentile of credit. Bank and firm controls are those specified in Section 4.2. Bank controls are included as standalone and interacted with the Post dummy variable. Standard errors are two way clustered at region and industry level *** p<0.01, ** p<0.05, * p<0.1

a different time horizon for our benchmark. The second and the third column of Table 2 report the estimates of the baseline for different time windows. Again, we find no evidence of the retail deposit channel, while the coefficient on liquidity increases as we widen the time window.

Lastly, we specify an alternative model in the spirit of Khwaja and Mian (2008). We collapse the data into a single pre-NIRP and a single post-NIRP period, with a window

of ±2 years around 2014. We compute the difference of firm's credit and we regress it on pre-NIRP variables. Following Acharya et al. (2018) we capture the shift of credit demand with industry-region fixed effects. The standard error produced by this model are robust to the concerns of autocorrelation raised by Bertrand, Duflo, and Mullainathan (2004). In addition, standard errors are double clustered at region and industry level. Table 3 shows the coefficients for the collapsed model. Again, we observe evidences in favor of the portfolio rebalancing channel only.

Δln(Credit)	(1)	(2)
Retail^{pre}	-0.0689	0.615
	(0.114)	(0.472)
Liquidity^{pre}	1.008**	1.056**
	(0.392)	(0.433)
Industry-region FE	Yes	Yes
Bank controls	No	Yes
Firm controls	Yes	Yes
Observations	968	968
R^2	0.253	0.256

Table 3: Pre-post collapse

The table reports the estimates of model 2. Retail is measured as retail deposits over bank's total assets. Liquidity is measured as securities over bank's total assets. Bank and firm controls are those specified in Section 4.2. Retail, Liquidity, and bank controls are measured as of 2013. We consider firms that had a change in logarithm of credit between -2.5 and 2.5. Standard errors are two way clustered at region and industry level *** p<0.01, ** p<0.05, * p<0.1

5.3. Heterogeneity analysis

Our findings suggest that banks' lending behavior is not affected by their deposit ratio and that they rebalance their portfolio from liquid low-yield assets to higher yields assets, such as loans. The next step is to understand whether these effects are homogeneous across countries and across firms. Firstly, we investigate the geographical dimension. In order to do so, we include a triple interaction with the dummy variable *South* which takes value 1 if the firm is based in Greece, Spain or Portugal. Given that bank level variables are included as the average of all banks associated to the firm, we cannot use bank's country.

However, more than 98% of bank-firm relationship in our sample are within the same macro region (see Figure C2). As discussed in previous sections, Northern Europe and Southern Europe at the moment of introduction of NIRP, experienced different economic and financing conditions. Therefore, we might expect that the transmission mechanisms of monetary policy are different. The first column of Table 4 reports the coefficients of interest. We find that the retail deposit channel is not active neither in Southern Europe,

ln(Credit)	(1)	(2)
Retail x Post	-0.243	-0.926
	(1.058)	(0.507)
Retail x Post x South	-0.441	
	(0.479)	
Retail x Post x Small		-0.144
		(0.418)
Liquidity x Post	2.736**	5.964***
	(1.166)	(0.989)
Liquidity x Post x South	4.356**	
	(1.666)	
Liquidity x Post x Small		6.724***
		(1.122)
Industry-region-year FE	Yes	Yes
Bank controls	Yes	Yes
Firm controls	Yes	Yes
Observations	11,640	11,640
R^2	0.485	0.487

Table 4: Firm Heterogeneity

Retail is measured as retail deposits over bank's total assets. Liquidity is measured as securities over bank's total assets. Bank and firm controls are those specified in Section 4.2, they are included as standalone, interacted with Post, South and Small dummy variables, and triple interacted with Post x South and Post x Small in the respective regressions. South is a dummy variable equal to 1 if firm's country is Greece, Spain or Portugal. Small is a dummy variable equal to 1 if a firm has assets below its country median in 2013. Double interactions with Liquidity, Retail and Post are included. Observations are winsorized around the 1st and 99th percentile of credit. Standard errors are two way clustered at region and industry level *** p<0.01, ** p<0.05, * p<0.1

nor in Northern Europe where deposit rates are closer to the zero lower bound. On the other hand, the portfolio rebalancing channel not only is present across all Europe, but

it has an enhanced impact in the South. We make two hypotheses to rationalize the differential lending behavior. Firstly, North and South may be intrinsically different and there is no observable that explains the heterogeneous effect. Secondly, there may be differences in the composition of the portfolios between Northern and Southern European banks, which leads to differential rebalancing incentives.

Furthermore, we want to test whether the transmission channels are different across firms' size. Smaller firms are more vulnerable to bank shocks since they cannot easily substitute across banks (Gertler and Gilchrist 1993), while large firms may be able to substitute across lenders. Therefore it is possible that we are able to observe the retail deposit channel at firm level only for smaller firms. As to the portfolio rebalancing channel, we expect a larger effect for smaller firms. Given that the credit expansion is driven by portfolio rebalancing incentives, banks should rebalance their portfolios especially toward higher yield loans (Bottero et al. 2019). We define a firm as small if it has assets below the median of its country in 2013. The second column of Table 4 shows the results. We observe that the retail deposit channel is not significant even for smaller firms. Instead, we find that the effect of the liquidity ratio is more than doubled for smaller firms. This result confirms the key driving mechanism of the portfolio rebalancing channel.

5.4. Real Effects

Lastly, we are interested in the transmission mechanisms that not only lead to higher credit, but also translate into real effects. We want to test the impact of the two channels on wage bill growth and on investment (measured as yearly growth of fixed assets), which are relevant components of aggregate output. We modify the baseline specification by changing the dependent variable. Table 5 shows the results for a 2-year time window around 2014. As expected, all the coefficients that refer to the retail deposit channel are not significant. On the other hand, we find that the portfolio rebalancing channel is not only expansionary in terms of firm's credit, but also in terms of firm's outcomes. A one standard deviation increase in liquidity ratio increases wage bill growth by 2 percentage points and investment by 3.4 percentage points. These effects are economically significant considering that average wage bill growth and investment were respectively equal to 3%

	Wage bill growth		Investment	
	(1)	(2)	(3)	(4)
Retail x Post	0.049	0.036	-0.061	-0.054
	(0.0759)	(0.078)	(0.082)	(0.083)
Liquidity x Post	0.173**	0.163**	0.247**	0.264**
	(0.076)	(0.076)	(0.124)	(0.124)
Firm FE	Yes	Yes	Yes	Yes
Year FE	No	Yes	No	Yes
Bank controls	Yes	Yes	Yes	Yes
Firm controls	Yes	Yes	Yes	Yes
Observations	22,513	22,513	24,707	24,707
R^2	0.503	0.504	0.531	0.531

Table 5: Real Effects

The first two columns have as dependent variable the yearly wage bill growth. The last two columns have as dependent variable investment, measured as yearly growth of fixed assets. Retail is measured as retail deposits over bank's total assets. Liquidity is measured as securities over bank's total assets. Bank and firm controls are those specified in Section 4.2. Observations are winsorized around the 1st and 99th percentile of the dependent variable. Standard errors are clustered at region level *** p<0.01, ** p<0.05, * p<0.1

and -1% in the sample period.

6. Deep Rates

The DSGE model proposed by Ulate (2019) implies the existence of a small and negative rate beyond which monetary policy becomes contractionary. Also the reversal rate suggested by Brunnermeier and Koby (2018), may be negative. Therefore the level of the DFR may matter for the channels of transmission at play. It may happen that banks can preserve their profitability only with small negative rates; or it may be that only the first announcement of NIRP lowered expectations and induced portfolio rebalancing incentives. On 16th March 2016 the European Central Bank set the Deposit Facility Rate to -0.40%, entering in what it is generally called the deep negative territory. In order to investigate the impact of the deep negative rates on bank lending we repeat the same exercise of the baseline model modifying the time dummy variables. The dummy variable

PostNIR is switched on only in 2014 and 2015, while the dummy variable Deep takes value 1 from 2016 onwards. The time window taken into account is 2012-2018. Table 6 shows

ln(Credit)	(1)	(2)
Retail x PostNIR	-0.553	1.674
	(0.674)	(1.951)
Retail x Deep	0.179	2.732
	(0.908)	(1.964)
Liquidity x PostNIR	5.355***	7.806***
	(1.509)	(1.716)
Liquidity x Deep	5.002***	7.648***
	(1.442)	(1.607)
Industry-region-year FE	Yes	Yes
Bank Controls	No	Yes
Observations	19,380	19,380
R^2	0.247	0.249

Table 6: Deep Negative rates

Retail is measured as retail deposits over bank's total assets. Liquidity is measured as securities over bank's total assets. Post is a dummy variable that takes value 1 in 2014 and 2015, Deep is a dummy variable that takes value 1 from 2016 onwards. Observations are winsorized around the 1st and 99th percentile of credit. Bank controls are those specified in Section 4.2. Bank controls are included as standalone and interacted with the Post dummy variable. Standard errors are two way clustered at region and industry level *** p<0.01, ** p<0.05, * p<0.1

the results. The retail deposit ratio does not affect the amount of credit granted even in deep negative rates. Finally, we find that the portfolio rebalancing channel is at work also with deep negative rates. With bank controls, the effect seems to be weaker with respect to small negative rates, but the two coefficients are not statistically different. However this analysis provides just suggestive evidences since it does not take into account that banks may expected even lower rates and may have changed their financing strategy.

7. Conclusion

Despite many developed economies adopted negative policy rates, there is still scarce evidence on the transmission mechanism through the banking sector. Today, understanding whether Negative Interest Rate Policy has its intended expansionary effects is even more important. The Covid19 pandemic occurred in a low rates environment and negative rates may be adopted by some central banks in the attempt of providing the necessary stimulus. We document that NIRP has expansionary effects through the portfolio rebalancing channel. Thanks to their impact on expectations, negative rates flattened and shifted down the entire yield curve, creating incentive for banks to reduce the shares of low assets in their portfolios in favor of loans. We conjecture that more liquid banks are more exposed to these rebalancing incentives and consequently lend more. Exploiting a matched firm-bank dataset from six Eurozone countries, we find that a 1% increase in liquidity ratio increases credit by 3.8%. We also show that banks rebalance their portfolio especially towards smaller firms, confirming that banks look for higher yield assets. Furthermore, we find that the rebalancing effect is enhanced in Southern Europe. Even though this heterogeneous impact may be due to differences in the portfolio structure between Northern and Southern European banks, we cannot exclude that the two regions are intrinsically different and react differently to monetary policy shocks. The portfolio rebalancing channel has sizable real effects: a one standard deviation increase in liquidity ratio increases wage bill growth by 2 percentage points and investment by 3.4 percentage points. By contrast, we do not find any detrimental effect on banks' margins. Banks that have an *ex-ante* higher retail deposit ratio keep their profitability high by increasing their income from fees. We find that the contractionary retail deposit channel is active nowhere, even in Northern Europe where deposit rates are close to the theoretical ZLB. Finally, we provide evidences suggesting that the transmission mechanism is unchanged when policy rates are negative and large.

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Appendix

A. Data

Our empirical analysis relies on two data sources. We obtained firm level data from Bureau Van Dijk's Orbis, which provides financial statement information for listed and unlisted companies; and bank's unconsolidated balance sheet information from Moody's Bank Focus. We selected firms and banks from six European countries: Germany, Greece, France, Netherlands, Portugal and Spain.

A.1. Fuzzy matching

The Bureau Van Dijk's Orbis database provides the name of firm's main lenders for a subset of European countries. However, it provides main lenders' names so that we do not have any identification number to make an exact matching with Moody's BankFocus database. Therefore, in order to obtain the matched bank-firm dataset, we perform a fuzzy matching based on bank's name.In order to improve performance, we make the bank name variable lower case and we remove non alphabetic characters. We match the datasets with the function *reclink*[5], which generates a score based on the similarity of the matched strings. Figure A1 reports the distribution of the matching score. The matching performed well, almost 60% of the observations found an exact match. We decide to drop all the observations that have a matching score below 0.9, which represent less than the 20% of our initial sample.

[5]Michael Blasnik, 2007. "RECLINK: Stata module to probabilistically match records," Statistical Software Components S456876, Boston College Department of Economics, revised 18 Jan 2010. <https://ideas.repec.org/c/boc/bocode/s456876.html>

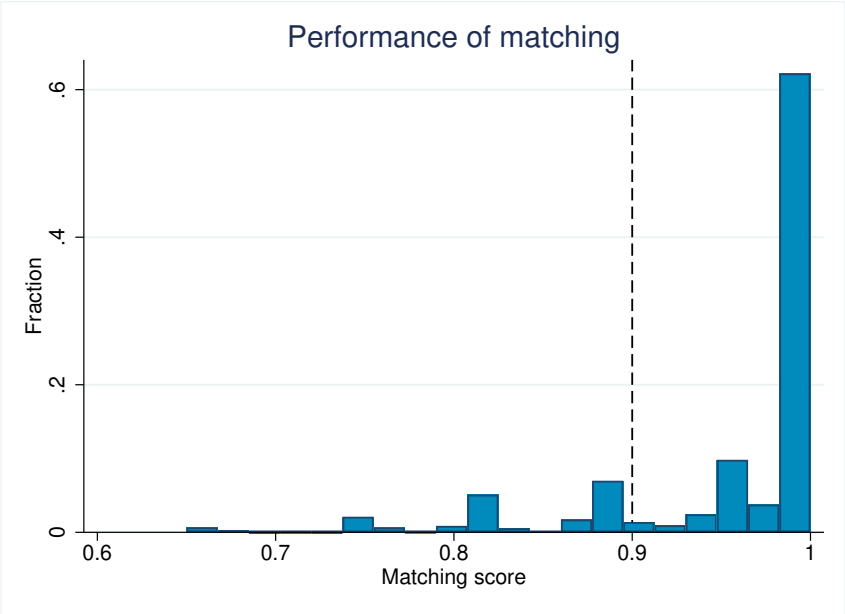


Figure A1: Matching performance

The figure reports the distribution of the matching score generated by the function reclink. The dashed line is the threshold below which we drop the observations

A.2. Variables definition

Table A1 reports variables definition.

Variable	**Definition**
ln(Credit)	Logarithm of total loans received by the firm
Retail	Bank's retail deposit over bank's total assets
Liquidity	Bank's total securities over bank's total assets
Post	Time dummy variable that takes value equal to 1 from 2014 onward
PostNIR	Time dummy variable that takes value equal to 1 in 2014-2015
Deep	Time dummy variable that takes value equal to 1 in 2016-2018
Investment	Yearly growth of firm's fixed assets
Wage bill growth	Yearly growth of firm's wage bill
ln(F. Assets)	Logarithm of firm's total assets

ln(Curr.Assets)	Logarithm of firm's current assets
ln(Loans)	Logarithm of bank's gross loans
IB Ratio	Interbank loans over bank's total assets
ln(Assets)	Logarithm of bank's total assets
ROA	Bank's return on assets
Equity ratio	Bank's total equity over total assets
Gross Loans ratio	Bank's gross loans over total assets
Industry	2-digit NACE2 core industry classification
Region	NUTS2 region classifications
Small	Dummy variable equal to 1 if the firm is below the own country median of total assets
South	Dummy variable equal to 1 if the firm is based in Greece, Portugal or Spain

Table A1: Definitions

B. Additional Tables

Panel A: Firm Level Variables					
	Mean	Std Dev	p50	p25	p75
Credit (M €)	0.77	2.29	0.10	0.02	0.42
Total Assets (M €)	7.02	22.56	1.14	0.45	3.44
ROE	0.10	0.25	0.07	0.01	0.19
Turnover (M €)	8.35	27.36	1.36	0.47	4.08
Current Assets (M €)	3.58	10.88	0.71	0.28	2.08
Investment	-0.01	0.29	-0.04	-0.14	0.05
Wage bill growth	0.03	0.20	0.01	-0.05	0.09
Observations	57,385				

Panel B: Bank Level Variables					
	Mean	Std Dev	p50	p25	p75
Gross Loans (B €)	2.16	7.84	0.41	0.14	1.17
Liquidity Ratio	0.12	0.13	0.08	0.03	0.17
Retail Deposit Ratio	0.72	0.15	0.75	0.69	0.81
Total Assets (B €)	3.91	16.46	0.71	0.26	1.95
Equity Ratio	0.09	0.05	0.09	0.07	0.10
ROA	0.27	0.21	0.23	0.14	0.36
Observations	5,603				

Table B1: Summary statistics

All summary statistics refer to the time window 2012 - 2015 .Panel A refers to firm level variables. Each variable is winsorized between 1st and 99th percentile of firm's credit. Investment is computed as the yearly growth of fixed assets. Wage bill growth is the yearly growth rate of wage bill. Panel B refers to bank level variables. Observations are winsorized between the 1st and 99th percentile of bank's gross loans. Liquidity ratio is measured as securities over total assets. Retail deposit ratio is measured as retail deposits over total assets.

Table B2: Bank level model

The table reports the estimates of the bank level model

$$\ln(Loans)_{bt+1} = \alpha + \beta_0 Retail_{bt} + \beta_1 Retail_{bt} \times Post_t + \gamma_0 Liquidity_{bt} + \gamma_1 Liquidity_{bt} \times Post_t + X_{bt}\delta + \epsilon_{bt}$$

The dependent variable is logarithm of bank gross loans. Retail is measured as retail deposits over bank's total assets. Liquidity is measured as securities over bank's total assets. Bank controls are bank's total assets, bank's roa and bank's equity ratio. Observations are windsorized around the 1st and the 99th percentile of gross loans. Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

ln(Loans)	(1)	(2)
Retail x Post	0.588	0.333
	(0.586)	(0.389)
Liquidity x Post	2.371*	1.490***
	(1.303)	(0.556)
Bank controls	No	Yes
Country -Year FE	Yes	Yes
vspace4pt		
Observations	819	813
R^2	0.273	0.883

Table B3: Bank profitability

The table shows the results of a cross sectional bank level analysis. We collapsed the dataset into a single pre-NIRP and a single post-NIRP period. We regressed the difference of firm outcomes on pre-shock variables. The time window taken into account is 2012-2015. Δ Fees is computed as the difference of logarithm of income from fees. Bank controls are bank's total assets, bank's ROA and bank's equity ratio and liquidity. Retail and bank controls are measured as of 2013. Standard errors are heteroskedastic robust *** p<0.01, ** p<0.05, * p<0.1

	(1) Δ ln(Fees)	(2) Δ ROE	(3) Δ NIM
Retail^{pre}	0.512***	-0.0275	0.157
	(0.176)	(0.0452)	(0.224)
Bank controls	Yes	Yes	Yes
Observations	254	259	256
R^2	0.176	0.300	0.019

Table B4: Interbank Loans

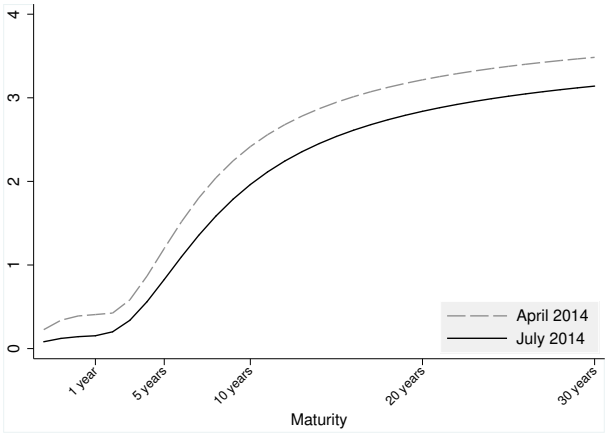
IB loans ratio is defined as interbank loans over total assets. Observations are winsorized around the 1st and 99th percentile of interbank loans ratio. Bank controls are Bank controls are bank's total assets, bank's roa and bank's equity ratio. Bank controls are included as standalone and interacted with the Post dummy variable. The time window considered is ± 2 years around 2014. Standard errors are two way clustered at region and industry level *** p<0.01, ** p<0.05, * p<0.1

IB Loans ratio	(1)	(2)
Liquidity x Post	-0.145**	-0.173***
	(0.0586)	(0.0657)
Bank controls	No	Yes
Country FE	Yes	Yes
Time FE	Yes	Yes
Observations	879	876
R^2	0.033	0.095

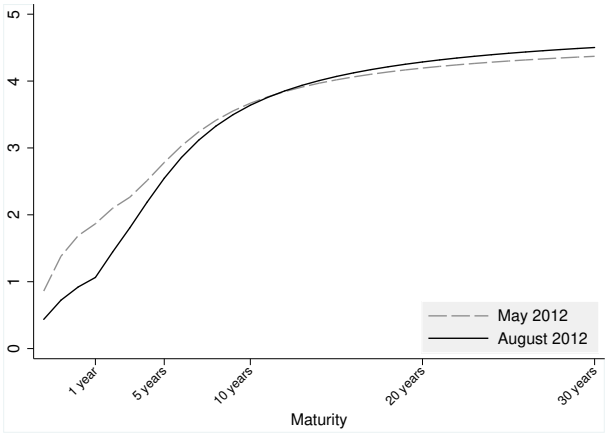
C. Additional Figures

Figure C1: Effect of monetary policy on the yield curve

The yield curve includes all central government bonds of the yield curve. Only fixed coupon bonds with a finite maturity and zero coupon bonds are selected, including STRIPS. Perpetual bonds and variable coupon bonds, including inflation-linked bonds, are not included. *Source*: ECB Statistical Data Warehouse



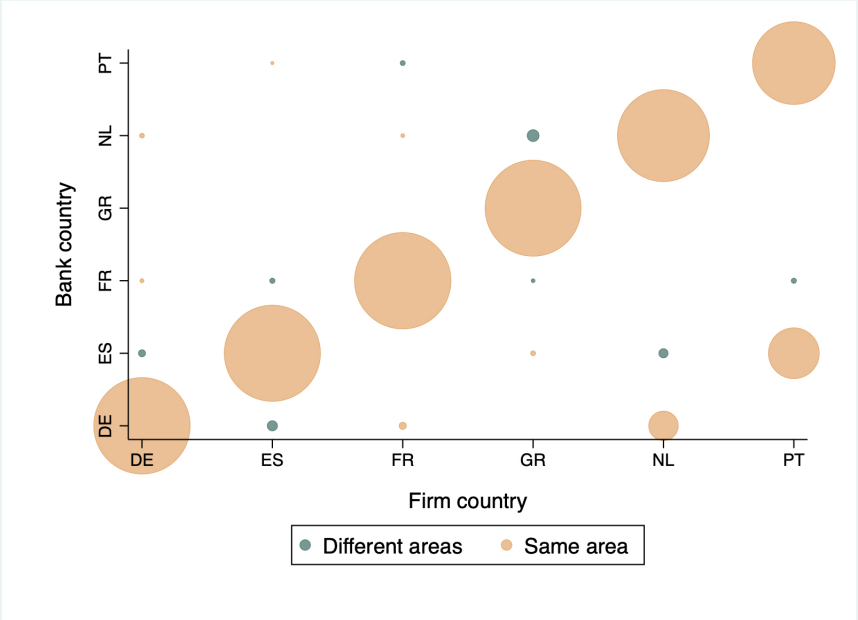
(a) NIRP



(b) Conventional MP

Figure C2: Cross country bank-firm relationships

The plot represents the cross country bank-firm relationship. The size of the dot is proportional to the relative presence of banks' nationality within the firm country. The macro areas taken into account are Northern Europe (France, Germany and Netherlands) and Southern Europe (Greece, Spain and Portugal).



D. Extentions

D.1. Firm level portfolio rebalancing channel

As reported by Altavilla et al. (2019), some banks started setting negative deposit rates. In particular they found that safer banks in Northern Europe are more likely to go below the zero lower bound. Furthermore they suggest that firms with high current asset associated with banks that offer negative rates invest more, implying a portfolio rebalancing channel at firm level. Given that we do not have access to deposit rates offered by banks, we proxy the probability that a bank is charging negative rates by its equity ratio. We use lagged current assets as a measure of exposure: more liquid firms have more incentives to reduce their cash holdings if they are charged a negative deposit rate.

Table D1 shows that the channel is not active everywhere in Europe. If we restrict the sample to Northern Europe, we find that more liquid firms associated with safer

	All Sample	North Only	
	Investment_t	Investment_t	Δ (%) Tangible_t
EquityRatio_t x ln(Curr.Assets_{t-1}) x Post	0.0149	0.0276*	0.0351**
	(0.00995)	(0.0160)	(0.0135)
Industry - region- year FE	Yes	Yes	Yes
Controls	Yes	Yes	Yes
Observations	33,835	14,924	14,413
R^2	0.170	0.216	0.212

Table D1: Firm-level portfolio rebalancing channel

The" "North Only" sample includes all firms based in Germany, France or the Netherlands. Investment is measured as the yearly growth of fixed assets between $t-1$ and t. In the last column we consider the yearly growth of only tangible fixed assets. Observations are winsorized around the 1st and the 99th percentile of the dependent variable. Controls include EquityRatio x ln(Curr.Assets_{t-1}) , ln(Curr.Assets_{t-1}) x Post, ln(Curr.Assets_{t-1}) and firm size, measured as the logarithm of total assets. Standard errors are two-way clustered at industry and region level *** p<0.01, ** p<0.05, * p<0.1

banks invest more after the introduction of NIRP. Differently from Altavilla et al. (2019), we find that the effect is stronger for investment in tangible fixed assets. These results suggest that NIRP may provide further stimulus to the economy through the existence of a portfolio rebalancing channel also at firm level.