LOST IN NEGATIVE TERRITORY? SEARCH FOR YIELD!

MATTIA GIROTTI, GUILLAUME HORNY, AND JEAN-GUILLAUME SAHUC

ABSTRACT. We study how negative interest rate policy (NIRP) affects banks' loan pricing. Using contract-level data from France, we show that NIRP affects bank lending rates to firms primarily through a portfolio rebalancing channel: banks holding a one standard deviation more of cash and central bank reserves offer a 8.6 basis points lower loan rate after NIRP is introduced. The impact concentrates on medium-term loans (with maturity comprised between three and six years) but not on loans to opaque or speculative grade firms, indicating that banks conduct a search for yield focused on term spreads. These findings suggest that NIRP complements quantitative easing policies.

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1. INTRODUCTION

Several central banks around the world have by now introduced a negative interest rate policy (NIRP).[1] This policy belongs to the class of unconventional monetary policies that a central bank may consider to improve financing conditions in a context characterized by historically low levels of the natural rate of interest.[2] In practice, NIRP means that a central bank sets its target interest rate in negative territory. Whether this policy is ultimately capable of reducing bank lending rates to firms and households is theoretically uncertain (Brunnermeier & Koby, 2018; Eggertsson et al., 2019), and empirical analyses have not yet fully clarified whether and how NIRP affects bank loan pricing.

In this paper, we bring novel evidence to this debate by focusing on the introduction of NIRP by the European Central Bank (ECB) on June 11, 2014 and by analyzing its effects on bank lending rates. To this end, we consider contract-level data on 120,905 loans lent by 77 banks to 84,041 firms in France. Our empirical analysis starts from the argument that NIRP may reduce banks' revenue: this is because

December 2021. M. Girotti: Banque de France, 31 rue Croix des Petits Champs, 75049 Paris, France (e-mail: mattia.girotti@banque-france.fr); G. Horny: Banque de France, 31 rue Croix des Petits Champs, 75049 Paris, France (e-mail: guillaume.horny@banque-france.fr); J.-G. Sahuc: Banque de France, 31 rue Croix des Petits Champs, 75049 Paris, France, and University Paris-Nanterre (e-mail: jean-guillaume.sahuc@banque-france.fr). The views expressed in this paper are those of the authors and do not necessarily reflect those of the Banque de France or the Eurosystem.

[1] These central banks include the Danmarks Nationalbank, the European Central Bank, the Bank of Japan, the Sveriges Riksbank, and the Swiss National Bank.

[2] Laubach & Williams (2016) define the real natural rate of interest as "the real short-term interest rate consistent with the economy operating at its full potential once transitory shocks to aggregate supply or demand have abated."

NIRP makes the reserves that banks hold in excess of minimum requirements costly to hold and may lead to a reduction in the remuneration offered by financial assets. In an effort to offset the contraction in revenue and maintain profitability, two mechanisms can then determine how banks modify their loan pricing in response to NIRP. The first hinges on the downward rigidity of deposit rates: because they may not pass negative rates on depositors, banks react to NIRP by not fully transmitting the interest rate cut on borrowers. That is, banks obtaining a larger fraction of funding in the form of deposits offer loans at relatively higher interest rates when NIRP is introduced. The second mechanism works through portfolio rebalancing: since excess reserves become costly to hold and cash does not bring any revenue, banks aim to substitute away from those assets. Thus, banks holding more cash and reserves become more aggressive in pricing loans when NIRP is implemented.

We test which of these mechanisms explains how banks respond to NIRP by using a difference-in-differences approach: we measure the difference in lending rates before and after the introduction of NIRP depending on the lending banks' deposit ratio and cash and reserve ratio. The granularity of the data allows us to absorb the effects of loan-, firm- and bank-level factors. Specifically, we absorb the effects related to contract characteristics such as loan maturity and loan purpose. We control for loan demand using firm location $\times$ sector $\times$ size $\times$ time fixed effects, in line with the approach developed by Degryse et al. (2019), and for time-varying impact of credit risk using firm credit rating $\times$ time fixed effects. Finally, we control for the amount of central bank refinancing received by each bank group: since the ECB launched a series of targeted longer-term refinancing operations (TLTROs) simultaneously to NIRP, failing to control for the TLTROs obtained by a bank may result in a biased assessment of the impact of NIRP.

Our results provide evidence in favor of the portfolio rebalancing mechanism. The more a bank holds cash and reserves, the more it reduces lending rates when NIRP is implemented. The magnitude of the effect is economically relevant. According to our preferred and most saturated specification, a one standard deviation difference in the cash and reserve ratio leads a bank to offer a 8.6 basis points lower loan rate, that is a 3.6% lower loan rate relative to the sample median. This result indicates that NIRP leads banks to substitute cash and reserves, which yield zero or negative remuneration, with corporate loans, which yield positive remuneration. Thus, NIRP incentivizes banks to search for yield. In conducting this search, banks having greater substitution needs are more aggressive in pricing loans relative to competitors, precisely because they need to attract more corporate borrowers. Since they may need to compensate for a larger loss in revenue induced by NIRP, the remaining question is whether these banks have also more appetite for risk. Hence, we test whether they react to NIRP by

targeting borrowers at longer maturities—so to earn the corresponding term spread—or borrowers with higher credit risk—so to earn the related credit risk spread.

Following a triple difference-in-differences approach, we decompose the portfolio rebalancing effect induced by NIRP by loan maturity. We find that the effect peaks in magnitude and is statistically and economically significant primarily on medium-term loans: a one standard deviation difference in the cash and reserve ratio leads a bank to offer a 16 basis points lower loan rate after the implementation of NIRP if the maturity of a loan is comprised between three and six years, and a statistically insignificant 2.6 basis points lower loan rate if the loan maturity is up to one year. Instead, when we decompose the effect by firm credit risk (as measured by the firm credit rating), we find that investment grade, speculative grade and unrated (i.e., opaque) firms all enjoy lower loan rates. Taken together, these results indicate that when NIRP is introduced, banks holding more cash and reserves target primarily borrowers at intermediate maturities. While motivated by the greater term spread inherent in such loans, the consequence is that these banks offer medium-term loans at relatively lower rates. That is, they associate medium-term loans with a lower price of risk relative to competitors. An implication of our results is thus that NIRP flattens the middle of the corporate loan yield curve.

This paper primarily relates to the burgeoning literature on the effects of NIRP on bank lending.[3] Most of the existing analyses concentrate on lending volumes and ignore lending rates (see, e.g., Heider et al., 2019, Demiralp et al., 2021, Grandi & Guille, 2021). However, assessing whether and how NIRP alters lending rates is key to determine whether this policy can be useful to improve financing conditions for firms and households. The few studies that focus on lending rates find mixed evidence. Eggertsson et al. (2019), using bank-level data from Sweden, and Amzallag et al. (2019), using contract-level from Italy, find that banks relying more on deposit funding charge relatively higher mortgage rates after the introduction of NIRP.[4] Conversely, using Swiss contract-level data, Schelling & Towbin (2020) show that banks relying more on deposit funding offer looser lending terms to corporations. Similar evidence is found by Tan (2019) for mortgage lending using bank-level data from the euro area. Basten & Mariathasan (2018) use bank-level data from Switzerland to show that when NIRP is introduced, banks holding more reserves reduce mortgage rates less. Instead, in line with what we document, Bottero et al. (forth) use bank-firm-level data from Italy to show that banks having more liquid balance sheets rebalance towards corporate lending and charge firms relatively lower interest rates.

[3] See Brandao-Marques et al. (2021) for a survey of the literature on the effects of NIRP on cash usage, households, non-financial firms, banks, and money market funds as well as output and inflation.

[4] Amzallag et al. (2019) find this effect only for fixed-rate mortgages.

Our contribution to this literature is twofold. First, we assess how NIRP affects bank loan pricing using data that allow to control for confounders along the loan, firm, and bank dimensions. In this way, we overcome an important limit of studies that use less granular data, which is the inability of dissociating the effect of NIRP from that of loan characteristics, such as loan maturity. Second, and perhaps most importantly, we are to our knowledge the first to evaluate how NIRP affects the corporate loan yield curve exploiting this degree of data granularity. Our result that NIRP triggers a flattening of the middle of the yield curve adds to existing works addressing the complementarity among unconventional monetary policies (see, e.g., Rostagno et al., 2019 and Bottero et al., forth). The evidence presented here suggests that NIRP acts as a complement to asset purchase programs, which rather affect the longer end of the yield curve. Moreover, the result that banks search for yield by targeting borrowers at longer maturities and not necessarily borrowers with higher credit risk offers a novel perspective on the risk-taking channel of monetary policy (Jiménez et al., 2014; Ioannidou et al., 2014).

The remainder of the paper is organized as follows. Section 2 presents mechanisms on how NIRP may affect bank lending rates, while Section 3 describe the data we exploit. Section 4 outlines the empirical strategy and presents the results. Finally, Section 5 concludes.

2. Mechanisms: How NIRP Affects Bank Lending Rates

On June 11, 2014, the ECB brought its deposit facility rate (i.e., the key policy rate in the euro area since the ECB has been operating in a large balance sheet regime) to -0.10%. A negative deposit facility rate means that banks pay—rather than receive—interest for holding reserves in excess of minimum requirements with the Eurosystem. Since that time, the ECB has implemented additional interest rate cuts in negative territory, eventually bringing the deposit facility rate to -0.5% in September 2019.

The introduction of NIRP reduced money market interest rates. Figure 1.A shows that the Overnight Index Swap (OIS) forward curve—a market measure that encapsulates rate expectations—flattened, and the maximum forward rate reduction was at a five-year horizon. This reaction is markedly different from what typically realizes in correspondence of interest rate cuts in positive territory (Rostagno et al., 2019). For instance, when the ECB brought its deposit facility rate from 0.25% to 0% on July 11, 2012, most of the effect concentrated on OIS forward rates below the one-year horizon (Figure 1.B). The way the OIS forward curve reacted to the introduction of NIRP suggests that market investors interpreted it as indication that the level of interest rates would stay lower for more time than previously expected. In particular, as highlighted by Wu & Xia (2020), NIRP caused investors to revise their

beliefs about the location of the effective lower bound.[5] Hence, the signal implied by the introduction of NIRP reinforced ECB's forward guidance.

NIRP has two direct effects on banks. First, it reduces banks' revenue. This happens because it makes excess reserves costly to hold and because cash flows from financial assets may adjust for changes in market interest rates (for example, loan rates may be indexed to some market interest rate). Second, by reducing the discount rate applied to future cash flows, NIRP increases the value of fixed-income securities. To offset the contraction in revenue and maintain profitability, credit institutions have (at least) two margins of adjustment.

The first margin consists in reducing the funding cost, and thus passing the policy rate cut on depositors. In practice, however, banks may find impossible or may be unwilling to reduce deposit rates below 0% (Heider et al., 2019; Levieuge & Sahuc, 2021). One reason is that if deposit rates turned negative, firms and especially households might decide to substitute their deposit holdings with cash or switch to another bank. Another reason is that in several countries deposit rates cannot fall below 0% by law and/or there exist regulated deposit accounts whose interest rates are decided by the government. In France, which is the country we consider in our empirical analysis, regulated deposits account for 75% of the savings deposits held by households (Duquerroy et al., 2020). The downward rigidity of deposit rates may thus lead banks not to fully transmit the interest rate cut on borrowers of new loans (Eggertsson et al., 2019).

The second margin of adjustment consists in rebalancing the asset portfolio. Since NIRP makes excess reserves expensive to hold, banks may decide to substitute away from such costly reserves and allocate their resources in alternative investments yielding positive revenue. Such investments include, for example, corporate loans. Since cash does not bring any revenue, similar incentives for substitution away from cash may also be at play. Therefore, in an effort to attract borrowers and substitute away from cash and reserves, banks may become more aggressive in pricing loans.

We define the two following hypotheses, which will guide our empirical analysis:[6]

H1 (retail deposits channel): Because they cannot pass negative rates on depositors, banks react to NIRP by not fully transmitting the interest rate cut on borrowers of new loans. Hence, in the cross-section of banks, those obtaining a larger fraction of funding in the form of deposits offer loans at relatively higher interest rates.

[5] In line with this mechanics, Figure A1 in the Online Appendix signals that the impact on OIS forward rates of the subsequent interest rate cut of September 2014 peaked at even further horizons. Note that this interest rate cut was *(i)* unexpected by market participants and *(ii)* not announced in combination with other monetary policy measures.

[6] Of course, additional margins of adjustment of banks to NIRP may exist. For example, banks may respond to the reduction in revenue by charging higher fees on customers (Bottero et al., forth; Lopez et al., 2020).

H2 (portfolio rebalancing channel): Since excess reserves become costly to hold and cash does not bring any revenue, banks aim to substitute away from those assets and become more aggressive in pricing loans when NIRP is implemented. Therefore, in the cross-section of banks, those holding more cash and reserves offer loans at relatively lower interest rates.

Both mechanisms feature a search for yield, which however works differently. In H1, banks relying more on deposit funding may offer relatively higher rates especially to borrowers of lower yielding loans. By doing that, those banks would in fact neglect such borrowers and focus on portions of the loan market populated with higher yielding loans. In H2, instead, banks holding more cash and reserves may try to be more attractive especially in the higher yielding portions of the loan market, given their greater substitution needs and larger drop in revenue following NIRP. The question in both mechanisms is then *where* banks search for yield after the introduction of NIRP. There are indeed two distinct portions of the loan market in which yields are higher: *(i)* loans with longer maturities and *(ii)* loans to riskier borrowers.[7]

Identifying which of H1 or H2 better describes how banks react to NIRP needs to account for two additional factors affecting bank behavior. The first is the increase in the value of the fixed-income securities in banks' portfolio that realize after the introduction of NIRP. To the extent that these assets increase in value, banks incur in an implicit recapitalization, and may therefore experience an increase in their ability to lend. Note that in the setting we consider the possible increase in asset values may not only be caused by NIRP but also by the various asset purchase programmes that the Eurosystem implemented starting from October 2014.[8] The second factor affecting bank lending behavior is the launch by the ECB of a series of TLTROs on June 5, 2014. Through these operations, the Eurosystem provided long-term financing to credit institutions at attractive conditions.[9] Consequently, controlling for the volume of banks' bond portfolio and for the extent to which banks receive TLTROs is key to appropriately identify how NIRP affects bank lending rates.

[7] Building on the data that we describe in Section 3, Figure A2 in the Online Appendix shows that in the period before the introduction of NIRP (2012Q3–2014Q2), loan rates are on average higher for longer maturity loans and for loans to speculative grade or unrated firms. Note that we take the firm credit rating as a measure of firm credit risk, and that unrated firms—in particular if small-sized—are more opaque and thus globally riskier for a lender.

[8] Eurosystem's asset purchases are conducted according to four programmes: a covered bond purchase programme, an asset-backed securities purchase programme, a public sector purchase programme, and a corporate sector purchase programme.

[9] TLTROs contain an incentive scheme that aims to stimulate bank lending to non-financial corporations and households (excluding loans to households for house purchase).

3. DATA

Our study combines several proprietary data sets maintained by the Banque de France, the French central bank. The data cover the period from 2012Q3 to 2016Q1, which is a window of seven quarters before to seven quarters after the implementation of NIRP in June 2014. We choose to start exactly seven quarters before the introduction of NIRP because this is when the deposity facility rate was brought to zero, implying that no other cut in this policy rate realized in the seven quarters up to the introduction of NIRP. Note that by terminating the window of analysis in 2016Q1, we stop right before the first voluntary early repayment of TLTROs, happening in 2016Q2. Hence, the chosen period of analysis features a relatively homogeneous environment in the pre and post periods.

3.1. **Loan data.** The M-Contran data set includes granular information on new loans issued in France on the first calendar month of a quarter. This data set is maintained by the Banque de France in order to compute quarterly statistics on the interest rates of new loan contracts and to estimate usury interest rates. To our knowledge, this data set has been used for academic research purposes only by Mésonnier et al. (forth.). All main credit institutions report exhaustive information for all new individual loans from their reporting branches. Importantly, the M-Contran data set has no minimal reporting threshold on either loan size or borrower size.

For each loan, the data set reports the following information: interest rate, size, purpose (investment, treasury, leasing, etc.), maturity at issuance, and indication of whether the interest rate is fixed or adjustable. The M-Contran data set also includes the borrowing firm identifier (SIREN code) and the lending bank identifier (CIB code), which allow us to merge this data set with firm- and bank-level information, respectively.

3.2. **Firm data.** FIBEN (FIchier Bancaire des ENtreprises) is a database that includes rich firm-level information. We use it to collect data on firms' age, location of headquarters (French region), sector (NES 12 code), firm size (taille LME), and rating. The firm rating is an assessment of a firm's ability to meet its financial commitments at a 3-year horizon. It is attributed by Banque de France analysts to all firms with more than €0.75 million turnover or more than €0.38 million bank debt by combining hard information (from, for example, balance sheet data) with soft information, including information collected during the interviews with firm managers (Cahn et al., 2021). In the period we consider, the rating scale is composed of 12 notches. From the most favorable to the least favorable, these are: 3++, 3+, 3, 4+, 4, 5+, 5, 6, 7, 8, 9, and P. A rating 0 is attributed to unrated firms. In our analysis, we use the credit rating as a measure of firm credit risk and distinguish between unrated, investment grade, and

speculative grade firms. To determine if a firm is investment grade, we build on the fact that Banque de France credit ratings are used by the Eurosystem to determine the eligibility of banks' credit claims as collateral in monetary policy refinancing operations. Since February 2012, loans to firms rated 4 or above have been eligible. Hence, we define investment grade firms those rated 4 or above.

3.3. **Bank data.** The FINREP (FINancial REPorting) data set reports bank financial statement information and is collected by the French Supervisory Authority (ACPR - Autorité de Contrôle Prudentiel et de Résolution) at semi-annual frequency. For our baseline analysis, we consider information as of December 31, 2013.[10] The data set enables us to measure several bank-level aggregates, including cash and reserve holdings, bond holdings, deposits collected and total assets. Note that cash and reserve holdings include the volume of reserves (both minimum reserves and excess reserves) that a bank holds at the central bank together with the volume of cash held. For each bank, we compute the cash and reserve ratio (cash and reserve holdings divided by total assets), the bond ratio (bond holdings divided by total assets), and the deposit ratio (deposits collected divided by total assets).

We complement the FINREP data set with a data set reporting information on the liquidity obtained by French banks in Eurosystem's refinancing operations. This latter data set presents the outstanding liquidity position with the Eurosystem for each credit institution, at daily frequency. In line with what observed by Andrade et al. (2019), we note that in most cases only one entity per bank group bids in refinancing operations. This signals that central bank liquidity is obtained by that entity on behalf of all banks in the same bank group and then dispatched to each of the affiliates.

For this reason, we first determine the identity of the bank group (GEA code) to which each of the banks in the FINREP data set belongs using a mapping table constructed by the French Supervisory Authority. Next, we derive the TLTRO uptakes of the banks appearing in the central bank liquidity data set as the change in their liquidity position at each of the seven settlement dates of TLTROs in our sample period.[11] Finally, we associate these TLTRO uptakes and the volume of total assets of the bank group as a whole (derived from the FINREP data set) with each of the banks belonging to the same group. We define the TLTRO funding ratio as TLTRO uptake in a quarter divided by the bank group's total assets as of December 31, 2013.[12]

[10] For the placebo test in Section 4.4, we consider information as of December 31, 2011.

[11] That is, September 24, 2014, December 17, 2014, March 25, 2015, June 24, 2015, September 30, 2015, December 16, 2015, March 30, 2016.

[12] We follow this procedure for all banks in the sample except for those belonging to the Société Générale group. The reason is that the two banks of this group, Crédit du Nord and Société Générale, obtain TLTRO funding separately. Therefore, in their cases, the TLTRO funding ratio reflects their own TLTRO uptakes.

3.4. **Sample construction and summary statistics.** We construct our loan-level sample as follows. We start from the M-Contran data set and employ a cleaning strategy similar to that adopted by Mésonnier et al. (forth.). The raw data set reports tranches of multitranches loans as independent observations. These tranches are identical in terms of borrowing firm, lending bank, quarter of issuance, loan purpose, loan maturity, and indication of whether the loan rate is fixed or adjustable. We collapse these tranches into one unique observation: the interest rate of the resulting loan is a size-weighted average of the interest rate of the composing tranches, while its size is the sum of the tranches' size. Next, we keep only loans to firms based in mainland France and to firms other than property holding companies.[13] Finally, we keep standard (investment and treasury) non-subsidized loans, which are not borrowed for personal reasons by entrepreneurs.

We associate the firm-level information from FIBEN and the bank-level information described in Section 3.3 with the loans in the sample using the SIREN and CIB codes. We eliminate loans lent by credit institutions not based in mainland France, public sector banks, and specialized financial institutions. Finally, we drop loans whose size is below the 1st percentile or above the 99th percentile, or whose interest rate or maturity are above the 99th percentile.

This cleaning strategy leaves us with a total of 120,905 loans lent between 2012Q3 to 2016Q1 by 77 banks to 84,041 firms. Table 1 presents the summary statistics of the loans and banks in sample.[14] The median loan size is €30,850, indicating that our sample has extremely good representativity of loans to small- and medium-sized firms. The median loan rate is 2.4%, while median loan maturity is 4 years. Slightly more than two thirds of loans are for investment purposes, and the loan rate is adjustable in 27% of cases. In terms of corporate characteristics, the median firm age is slightly below 15 years. 74% of firms are not rated (i.e., they are too small to be rated), 17% of firms are investment grade, while 9% are speculative grade.

The 77 banks in the sample include all major credit institutions in France and account for 70% of the overall assets managed by monetary and financial institutions in France.[15] The average bank holds about €72 bn of total assets. On average, cash and reserves account for 1.5% of total assets, while bonds for 6.6%. As for funding sources, 44% of total assets are, on average, funded through deposits. When cumulated over quarters, the TLTRO uptakes amount to 1.4% of total assets on average. Table 1

[13] Property holding companies (*sociétés civiles immobilières*) are most often used by individuals as vehicles for holding wealth and reducing their tax burden. They are thus non-standard corporations.

[14] Table A1 in the Online Appendix provides variable definitions based on data item codes.

[15] Table A2 in the Online Appendix reports the list of banks in the sample, together with the identity of their bank group.

uncovers a significant heterogeneity across banks—specifically, for what concerns the cash and reserve ratio and the deposit ratio—which we exploit for the identification of the effects of interest.

4. Empirical Analysis

4.1. **Empirical Strategy.** Our empirical strategy exploits a standard difference-in-differences approach. We measure the difference in lending rates that depend on the lending banks' cash and reserve ratio and deposit ratio, before and after the introduction of NIRP:

$$\begin{aligned} loan\,rate_{l,f,b,t} = \beta \left(\frac{cash\,\&\,reserves_b}{total\,assets_b} \times after\,NIRP_t \right) + \gamma \left(\frac{deposits_b}{total\,assets_b} \times after\,NIRP_t \right) \\ + \phi\, X_{f,b} + \chi\, V_{b,t} + \psi\, W_{l,t} + \omega\, Z_{f,t} + \varepsilon_{l,f,b,t}, \end{aligned} \tag{1}$$

where $loan\,rate_{l,f,b,t}$ is the loan rate requested by bank b to firm f at time t in loan l, $after\,NIRP_t$ is a dummy $0/1$ denoting the period following the implementation of NIRP, and $\varepsilon_{l,f,b,t}$ is the idiosyncratic error term. As described in Section 3, both the cash and reserve ratio and the deposit ratio are measured as of December 31, 2013—that is, almost six months before the implementation of NIRP—and are thus time-invariant in the period.

The coefficients of interest in Equation (1) are β and γ. β measures the difference in loan rate due to a bank holding more cash and reserves when NIRP is introduced. Conversely, γ captures the difference in loan rate due to a bank relying to a greater extent on deposits as a funding source when NIRP is introduced. Therefore, by estimating β and γ, we are able to determine through which mechanism NIRP affects bank lending rates.[16] To properly identify β and γ, we saturate the specification with several control variables and fixed effects.

The first set of controls is at the firm-bank-level: $X_{f,b}$ are firm cluster $\times$ bank fixed effects, where firm cluster is defined as the interaction of geographical location (French region) of the firm's headquarters, firm sector (NES 12), and firm size (taille LME). The role of $X_{f,b}$ in Equation (1) is twofold. First, they control for every time-invariant element of a bank (including the cash and reserve ratio and the deposit ratio, since these characteristics are measured as of December 31, 2013). Second, they control for the characteristics of the relationship of a bank with a given firm cluster. For instance, it is possible that a bank holds more information than another bank in a given location, sector, firm size, or combination of the three, and this impacts its lending rates.

[16] Note that to make a parallel with a standard difference-in-differences setup, our setting features two treatments ($\frac{cash\,\&\,reserves_b}{total\,assets_b}$ and $\frac{deposits_b}{total\,assets_b}$) and the "after" period is identified by the dummy $after\,NIRP_t$.

Bank-time-level controls $V_{b,t}$ include the bond ratio (measured as of December 31, 2013) interacted with $after\,NIRP_t$ and the TLTRO funding ratio. The former variable controls for the impact of NIRP depending on the size of the bond portfolio. The latter variable controls for the effect of receiving central bank liquidity in the form of TLTROs. Note that not controlling for these two factors affecting bank behavior might lead to biased estimates of β and γ.

A key advantage of our empirical approach is to control for loan-level characteristics. $W_{l,t}$ include the log loan volume, a dummy 0/1 identifying if the loan rate is adjustable, a dummy 0/1 identifying if the loan is an investment loan (loan purpose) interacted with time fixed effects, and the log loan maturity interacted with time fixed effects. Note that loan purpose $\times$ time fixed effects capture the possibly time-varying loan demand for investment—rather than for liquidity—purposes. The log loan maturity $\times$ time fixed effects control, instead, for differences in the yield curve over time.

The last set of controls is at the firm-time-level. $Z_{f,t}$ include the age of the firm, firm cluster $\times$ time fixed effects and firm rating $\times$ time fixed effects. Firm cluster $\times$ time fixed effects control for all shocks that are common to firms that *(i)* are located in the same region, *(ii)* operate in the same sector, and *(iii)* are similar in size. The inclusion of these fixed effects permits us to control for loan demand, in line with the approach developed by Degryse et al. (2019). Finally, firm rating $\times$ time fixed effects absorb the possibly time-varying impact of credit risk on loan rates.

An important feature of the difference-in-differences approach in Equation (1) is that it is sufficiently flexible to permit us to identify whether there exists heterogeneity in the reaction of banks to NIRP depending on loan or borrower characteristics. It suffices to include in Equation (1) the triple interaction terms between each of the two treatment variables, the dummy $after\,NIRP_t$, and a variable identifying a given loan or borrower characteristic as well as cross terms.

4.2. **How Does NIRP Affect Bank Lending Rates?** We present the estimation results of the difference-in-differences in Table 2. Each column considers a different degree of saturation of the specification, with column (8) effectively corresponding to Equation (1). Standard errors are two-way clustered by bank and by firm cluster.

Columns (1) and (2) examine a parsimonious specification with only the firm age, firm cluster $\times$ time fixed effects, and loan purpose dummy included as control variables. Including only these variables is a minimalist way to control for firm risk and loan demand. The difference between the two columns is that in column (1) we study the impact of NIRP on lending rates depending on a bank's cash and reserve ratio, while in column (2) we study the impact depending on a bank's deposit ratio. We find that banks holding more cash and reserves reduce their lending rate significantly more when

NIRP is implemented (the parameter estimate is statistically significant at 5%). Importantly, the coefficient on the cash and reserve ratio not interacted with $after\ NIRP_t$ is not statistically significant. This indicates that in absence of NIRP, banks holding more cash and reserves do not show any significant difference in loan pricing relative to other banks. As for column (2), there does not appear any difference in lending rate depending on a bank's deposit ratio, both before and after the implementation of NIRP.

These results are confirmed when we have the cash and reserve ratio, the deposit ratio and their interactions with $after\ NIRP_t$ in the same regression (column (3)). They are also unaltered, and actually increase in statistical significance, when we introduce bank fixed effects (column (4)), firm cluster $\times$ bank fixed effects (column (5)), loan-time-level and firm-time-level controls (columns (6) and (7)), and finally bank-time-level controls (column (8)).

Overall, Table 2 provides evidence in favor of the portfolio rebalancing hypothesis, which posits that the more a bank's revenue is negatively impacted by NIRP given its asset composition, the more the bank reduces lending rates to attract corporate loan borrowers. That is, in an effort to substitute away from cash and reserves and maintain profitability after the introduction of NIRP, the bank searches for yield in the corporate loan market and is more competitive in pricing loans. The magnitude of the effect is economically significant: according to our preferred and most saturated specification (column (8)), a one standard deviation difference in the cash and reserve ratio leads a bank to offer a 8.6 basis points lower loan rate, that is a 3.6% lower loan rate relative to the sample median, after the introduction of NIRP. Note that this impact is net of the effect of loan and firm characteristics, loan demand shocks and other factors affecting bank behavior.

Regarding the factors that also affect bank behavior, two important results stand out in Table 2. The first is that banks do not react differently to NIRP depending on the size of their bond portfolio. This suggests that the bond portfolio revaluations possibly caused by NIRP, and later in the sample period by the asset purchase programmes, do not significantly affect a bank's loan pricing. The second is that the volume of central bank liquidity that a bank group receives in a quarter significantly alters the lending rate offered by a bank of the group. As expected, the greater the amount of TLTROs obtained, the lower is the lending rate.

To interpret the estimated effects as causal, it must be that the parallel trends assumption holds (Section 4.4 below addresses several additional identification concerns). In our case, this means that the difference in loan rates between banks holding more cash and reserves and banks holding less cash and reserves would be constant if NIRP were not implemented. This assumption cannot be tested,

but we can test whether such difference is constant before the implementation of NIRP. We create a dummy indicating if a bank's cash and reserve ratio is above the sample median and interact it with time dummies, one for each quarter in the sample period except 2014Q2, which we take as reference quarter.[17] We replace the interaction of the cash and reserve ratio with $after\ NIRP_t$ in Equation (1) by the created set of dummies. We run this regression and plot the coefficients on each of these dummies in Figure 2.A.

The estimated coefficients are useful to determine at what point in time banks holding cash and reserves above the sample median and banks holding cash and reserves below the sample median diverge in terms of lending rate. Since the estimated coefficients are not statistically different from zero before 2014Q2, it appears that the two groups of banks display a constant difference in lending rates up to the implementation of NIRP, that is they follow parallel trends. A difference materializes only after the implementation of NIRP, and increases in magnitude the more time passes. The results in Figure 2.A are thus consistent with the parallel trends assumption and provide ground for the causal interpretation of the estimated effects.

4.3. **Where Do Banks Search For Yield?** The more aggressive loan pricing by banks holding more cash and reserves is indicative of a greater willingness of these banks to substitute away from cash and reserves and attract corporate borrowers and, thus, to search for yield. The remaining question is where these banks conduct this search. As highlighted in Section 2, portions of the loan market in which yields are higher include loans with longer maturities and loans to riskier borrowers. We thus study whether the search for yield triggered by NIRP is conducted by banks by being more competitive in pricing longer maturity loans or loans to borrowers with higher credit risk.

We first focus on loan maturity. We create four dummy variables capturing whether the maturity of a loan is either below or equal to one year, above one year and below or equal to three years, above three years and below or equal to six years, or above six years.[18] We form triple interaction terms of the cash and reserve ratio with $after\ NIRP_t$ and each of these dummies. We construct similar triple interactions with the deposit ratio and the bond ratio. We include the created triple interactions as well as cross terms and the interaction of the TLTRO funding ratio with the four loan maturity dummies

[17] Note that since the M-Contran data set reports information as of the first calendar month of a quarter and NIRP was implemented in June 2014, in our data 2014Q2 is the last quarter before the introduction of NIRP.

[18] We choose these thresholds because they cut the sample in four portions of relatively similar size, as it appears from the summary statistics in Table 1.

in Equation (1) as regressors.[19] The primary objective is to decompose the effect of NIRP mediated by the cash and reserve ratio by loan maturity.

Table 3 presents the estimation results. Each column considers a different specification. In column (1), we decompose only the effect of NIRP mediated by the cash and reserve ratio by loan maturity. Column (2) decomposes all effects, while column (3) replicates column (2) by replacing the cash and reserve ratio by a dummy indicating whether a bank's ratio is above or below the sample median. All three columns indicate that the effect of NIRP mediated by the cash and reserve ratio peaks in magnitude and is statistically and economically significant primarily on medium-term loans. That is, banks holding more cash and reserves attract borrowers with significantly cheaper loans at intermediate maturies, while they do not offer cheaper loans at short maturities. According to column (2), a one standard deviation difference in the cash and reserve ratio leads a bank to offer a 16 basis points lower loan rate after NIRP is introduced if the maturity of the loan is comprised between three and six years, and a statistically insignificant 2.6 basis points lower loan rate if the loan maturity is up to one year. We visualize these results in Figure 2.B, which plots the coefficients on the triple interaction terms estimated in column (3). The graph clearly displays that most of the impact concentrates on intermediate-maturity loans.

These results suggest that following the introduction of NIRP, banks rebalance their portfolio mainly towards loans with intermediate maturity. Their search for yield is thus conducted not only by targeting corporate borrowers but also by specifically serving a portion of the loan market in which loan rates are higher given the longer maturity. Banks do that in an effort to boost their revenue by earning the higher term spread. Note that this reaction is in line with the shift of the OIS forward curve following the introduction of NIRP (see Figure 1): to the extent that short-term interest rates will be lower for more time, banks should prefer to lend at longer maturities. Consequently, given their greater desire of serving borrowers at intermediate maturities, banks holding more cash and reserves offer medium-term loans at cheaper interest rates. The results in Table 3 thus imply that NIRP causes a flattening of the middle of the corporate loan yield curve.

We proceed by studying whether banks' search for yield is also conducted by targeting riskier borrowers. As discussed in Section 3.2, we proxy for firm credit risk building on credit rating information.

[19] Note that these variables replace the interactions of the cash and reserve ratio, deposit ratio and bond ratio with $after\,NIRP_t$ and the TLTRO funding ratio. Also, in the modified Equation (1), the four dummies measuring loan maturity interacted with $after\,NIRP_t$ are (almost) redundant with the log loan maturity $\times$ time fixed effects. We therefore remove these latter fixed effects from the set of regressors.

We replicate the analysis just considered except that we form interaction terms with the three dummies measuring firm credit risk instead of with the dummies identifying loan maturity.[20] Similarly to before, the primary objective is to decompose the impact of NIRP mediated by the cash and reserve ratio by firm credit risk. We find that the reduction in lending rates by banks holding more cash and reserves appears for all borrowing firms, independently of their risk.[21] Therefore, we do not find evidence that the results in Table 2 depend on banks searching for yield by necessarily targeting riskier corporate borrowers.

4.4. **Identification Concerns.** We conclude our analysis by addressing several identification concerns.[22] We first replicate Equation (1) by replacing the cash and reserve ratio by the dummy indicating if that ratio is above the sample median. This is useful to dismiss the concern that the results in Table 2 are due to some observations at the extremes of the distribution for the cash and reserve ratio. We find that the coefficient on the interaction of this dummy with $after\,NIRP_t$ is negative and strongly statistically significant, in line with the results in Table 2. In this modified setting, however, it also appears that the coefficient on the interaction of the deposit ratio with $after\,NIRP_t$ is positive and mildly statistically significant (10% level). That is, according to this specification, banks obtaining more funding in the form of deposits charge relatively higher loan rates when NIRP is implemented. This result is in line with H1, and suggests that the two proposed mechanisms might actually coexist.

Second, although Figure 2.A times the impact of NIRP on lending rates depending on a bank's cash and reserve ratio, we repeat more formally that analysis. We consider the interactions of the dummy indicating if a bank's cash and reserve ratio is above the sample median with just four dummy variables: one identifying more than one year before the implementation of NIRP, one for the year preceding such event, one for the year following such event, and finally, one for more than one year following such event. These interactions replace the cash and reserve ratio with $after\,NIRP_t$ in Equation (1). We find that no significant differential trend appears before the implementation of NIRP, and a divergence materializes only after that point in time.

Third, a possible concern regarding our results is that banks might have acted strategically in anticipation of NIRP and modified their cash and reserve ratio, deposit ratio, and bond ratio back in 2013 to better cope with the implementation of the policy. If this were the case, our estimations would be

[20] In this modified Equation (1), the three dummies measuring firm credit risk interacted with $after\,NIRP_t$ are (almost) redundant with the firm rating $\times$ time fixed effects. We therefore remove these fixed effects from the set of regressors.

[21] The estimation results are reported in Table A3 in the Online Appendix.

[22] The estimation results discussed in this Section are reported in Table A4 in the Online Appendix.

plagued by endogeneity, and our coefficient estimates biased. We address this concern by first studying the persistence over time of banks' cash and reserve ratio, deposit ratio and bond ratio. Specifically, for each ratio, we can visualize the shape of the scatter plot of the levels as of December 31, 2013 against the levels as of December 31, 2011. In doing this, we obtain that most points (especially those for the deposit ratio and the bond ratio) lie over a 45 degree line, implying that the values observed for a bank in December 31, 2013 are very similar to those observed two years earlier. This strong time persistence partly dismisses the concern that banks acted strategically in anticipation of the implementation of NIRP.[23] However, we can go further and exploit this time persistence to check if our results stand if we measure the ratios as of December 31, 2011 and not as of December 31, 2013. Note that the resulting regression almost correspond to the reduced form of an instrumental variables estimation in which the cash and reserve ratio, the deposit ratio and the bond ratio (measured as of December 31, 2013) are instrumented by their past values. Carrying out this new regression confirms all previous results. If anything, the coefficient on the cash and reserve ratio, now measured as of December 31, 2011, implies a greater magnitude of the effect and keeps its strong statistical significance.

As a final check, we study whether the effects we uncover are special to NIRP or rather happen at any interest rate cut. As a placebo test, we consider the interest rate cut of July 5, 2012, which brought the deposit facility rate to 0% (from 0.25%). We estimate a modified Equation (1), in which instead of $after\,NIRP_t$ we have a dummy indicating if the deposit facility rate is equal to 0%, over a sample running from 2010Q3 to 2014Q1.[24] We do not find any significant effect related to either the cash and reserve ratio or the deposit ratio in conjunction with the deposit facility rate being brought to 0%. This suggests that the results obtained above can indeed be interpreted as specific to NIRP.

5. Conclusion

This paper exploits contract-level data from France to analyze the impact of the ECB's negative interest rate policy on bank lending rates. We test which of the retail deposits channel or the portfolio rebalancing channel better explains how banks respond to NIRP by using a difference-in-differences approach: we measure the difference in lending rates before and after the introduction of NIRP depending on the lending banks' deposit ratio and cash and reserve ratio, while controlling for several loan-, firm- and bank-level determinants of lending rates, including the volume of central bank liquidity obtained by each bank.

[23] The scatter plots are displayed in Figure A3 in the Online Appendix.

[24] The M-Contran data set was set up in 2011. Hence, for this placebo test, we exploit the Sirius data set for the quarters prior to the M-Contran's creation. The Sirius data set provides most of the information included in the M-Contran data set.

Our results provide evidence in favor of the portfolio rebalancing channel. The more a bank holds cash and reserves, the more it reduces lending rates when NIRP is implemented, indicating that it aims to attract corporate borrowers and substitute away from cash and reserves. A one standard deviation difference in the cash and reserve ratio leads a bank to offer a 8.6 basis points lower loan rate, that is a 3.6% lower loan rate relative to the sample median. These results highlight that banks react to NIRP by searching for yield. When we investigate how this search is conducted, we find that banks holding more cash and reserves mainly target borrowers at intermediate maturities (between three and six years), but not necessarily borrowers with higher credit risk. This implies that banks' search for yield in response to NIRP is conducted by targeting term spreads.

Overall, our results suggest that NIRP proves useful in reducing financing costs for firms through banks, and is capable of flattening the middle of the corporate loan yield curve. Hence, a policy implication of this research is that NIRP complements quantitative easing policies, which rather flatten the longer end of the yield curve.

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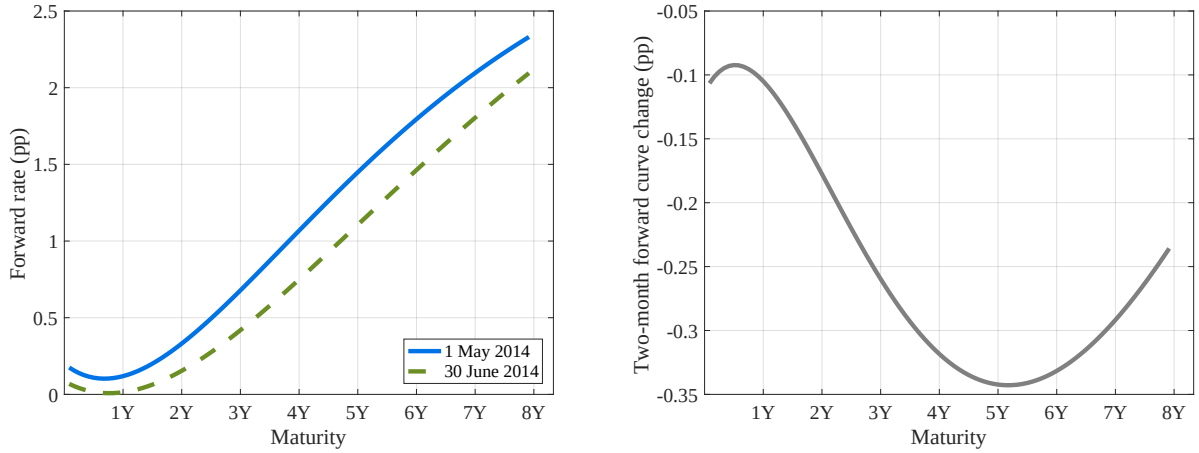
6. FIGURES

FIGURE 1. OIS forward curves and policy rate cuts in negative and positive territory

This figure plots the Overnight Indexed Swap (OIS) forward curves before and after two events: *(i)* the move into negative territory (from 0% to -0.1%) of ECB deposit facility rate on June 11, 2014 (panel A), and *(ii)* the 25 basis points cut of all ECB policy rates on July 11, 2012 (panel B). Since Wu & Xia (2020) show that several interest rate cuts, including the one of June 2014, were expected the month before, we focus on a two-month window centered around each event. For each event, we also plot the two-month forward curve change.

A. Introduction of NIRP (June 2014)



B. Interest rate cut in positive territory (July 2012)

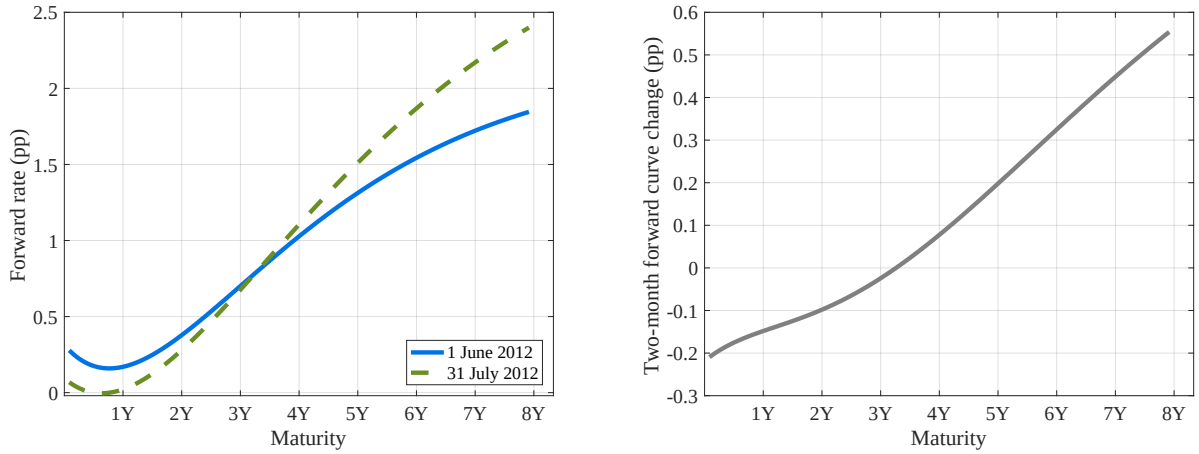
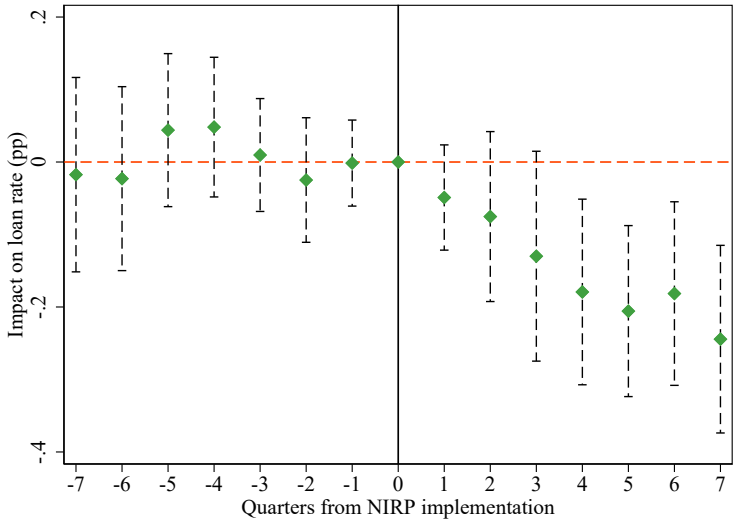


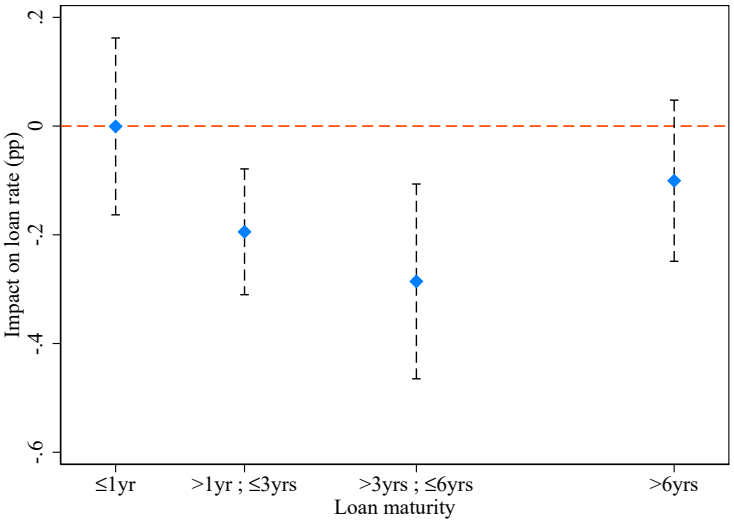
FIGURE 2. Impact of NIRP on bank lending rates

This figure studies the impact of NIRP on bank lending rates. Panel A focuses on the timing of the effect mediated by a bank's cash and reserve ratio. The specification is that of Equation (1), except that we replace a bank's cash and reserve ratio $\times$ $after\,NIRP_t$ by a set of dummy variables $\sum_t \mathbb{1}\left(\frac{cash\,\&\,reserves_b}{total\,assets_b} > median\right) \times \mathbb{1}_t$. $\mathbb{1}\left(\frac{cash\,\&\,reserves_b}{total\,assets_b} > median\right) \times \mathbb{1}_t$ is equal to one t quarter after (or before if t is negative) the implementation of NIRP if bank b's cash and reserve ratio is above the sample median. We plot the coefficients on each of these dummies for t between -7 and +7 (expressed in quarters), as well their 95% confidence intervals. Time 0 represents 2014Q2 and is taken as reference quarter. Panel B decomposes the impact of NIRP and mediated by a bank's cash and reserve ratio by loan maturity. The specification is that of Equation (1), except that we replace a bank's cash and reserve ratio $\times$ $after\,NIRP_t$ by a set of dummy variables $\sum_m \mathbb{1}\left(\frac{cash\,\&\,reserves_b}{total\,assets_b} > median\right) \times after\,NIRP_t \times \mathbb{1}_m$. $\mathbb{1}\left(\frac{cash\,\&\,reserves_b}{total\,assets_b} > median\right) \times after\,NIRP_t \times \mathbb{1}_m$ is equal to one after the implementation of NIRP if bank b's cash and reserve ratio is above the sample median and the maturity of the loan is equal to m. m can take four values: below or equal to one year, above one year and below or equal to three years, above three years and below or equal to six years, or above six years. We plot the coefficients on each of the four triple interactions, as well their 95% confidence intervals. Note that in the regression we also add the interactions of the deposit ratio and bond ratio with $after\,NIRP_t \times \mathbb{1}_m$ as well as all cross terms, and the interactions of the TLTRO funding ratio with $\mathbb{1}_m$. In both panels, confidence intervals are obtained by two-way clustering standard errors by bank and by firm cluster (i.e., French region $\times$ sector $\times$ size).

A. Timing the impact



B. Decomposing the impact by loan maturity



7. TABLES

TABLE 1. Summary statistics

This table displays the summary statistics of the samples considered in the analysis. Variable definitions are reported in Table A1 in the Online Appendix. Unless otherwise stated, bank-level information is taken as of December 31, 2013.

Loan-level information (unit of observation: loan)

	N	Mean	Median	St. dev.	5th pctile	95th pctile
Loan rate (in pp)	120,905	2.468	2.375	1.009	1.000	4.250
Loan volume (in €K)	120,905	319.003	30.850	1,285.524	5.340	1,253.320
Loan maturity (in months)	120,905	50.560	48.000	39.789	3.000	121.000
$\mathbb{1}$(loan maturity $\leq$ 1yr)	120,905	0.281	0.000	0.450	0.000	1.000
$\mathbb{1}$(1yr < loan maturity $\leq$ 3yrs)	120,905	0.156	0.000	0.363	0.000	1.000
$\mathbb{1}$(3yrs < loan maturity $\leq$ 6yrs)	120,905	0.305	0.000	0.460	0.000	1.000
$\mathbb{1}$(6yrs < loan maturity)	120,905	0.258	0.000	0.438	0.000	1.000
Adjustable-rate loan	120,905	0.271	0.000	0.445	0.000	1.000
Loan purpose ($\mathbb{1}$(loan is an investment loan))	120,905	0.686	1.000	0.464	0.000	1.000
Firm age (in years)	120,905	16.822	14.750	13.790	0.250	39.250
$\mathbb{1}$(firm is not rated)	120,905	0.736	1.000	0.441	0.000	1.000
$\mathbb{1}$(firm is investment grade)	120,905	0.171	0.000	0.376	0.000	1.000
$\mathbb{1}$(firm is speculative grade)	120,905	0.093	0.000	0.290	0.000	1.000

Bank-level information (unit of observation: bank)

	N	Mean	Median	St. dev.	5th pctile	95th pctile
Cash & reserve ratio	77	0.015	0.007	0.019	0.003	0.062
Deposit ratio	77	0.439	0.358	0.183	0.203	0.703
Bond ratio	77	0.066	0.054	0.059	0.002	0.229
TLTRO funding ratio (funding cumulated over quarters)	77	0.014	0.012	0.019	0.009	0.023
Bank assets (in €Bn)	77	71.911	13.725	234.029	5.305	433.694
Cash & reserve ratio (Dec 31, 2011)	76	0.009	0.007	0.008	0.003	0.029
Deposit ratio (Dec 31, 2011)	76	0.400	0.322	0.174	0.178	0.661
Bond ratio (Dec 31, 2011)	76	0.059	0.044	0.073	0.003	0.158

TABLE 2. Impact of NIRP on bank lending rates

In this table, we study the impact of NIRP on bank lending rates using Equation (1). The dependent variable is the loan rate (in pp). The effects of interest are those identified by the parameter on the cash and reserve ratio × after NIRP and the parameter on the deposit ratio × after NIRP. A firm cluster is defined as French region × sector × size. Standard errors are two-way clustered by bank and by firm cluster. *t*-statistics are in parentheses. Statistical significance at the 1%, 5%, and 10% level is indicated by **, *, and $^{+}$, respectively.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Cash & reserve ratio	0.0570		-0.0410					
	(0.02)		(-0.02)					
Cash & reserve ratio × after NIRP	-4.4447*		-4.0407*	-5.1241**	-5.3212**	-4.1435**	-3.9790**	-4.5438**
	(-2.15)		(-2.10)	(-3.00)	(-3.13)	(-3.13)	(-3.04)	(-3.51)
Deposit ratio		-0.0848	-0.0884					
		(-0.29)	(-0.32)					
Deposit ratio × after NIRP		-0.2374	-0.1638	-0.0091	-0.0652	0.1498	0.0596	0.1083
		(-1.07)	(-1.25)	(-0.07)	(-0.49)	(1.08)	(0.45)	(0.92)
Bond ratio × after NIRP								0.5122
								(1.08)
TLTRO funding ratio								-3.6395**
								(-4.06)
log Loan volume							-0.0882**	-0.0882**
							(-3.94)	(-3.94)
Adjustable-rate loan							-0.1238^{+}	-0.1238^{+}
							(-1.68)	(-1.68)
Firm age	-0.0041**	-0.0041**	-0.0042**	-0.0041**	-0.0038**	-0.0024**	-0.0022**	-0.0022**
	(-4.42)	(-4.25)	(-4.40)	(-4.52)	(-4.15)	(-3.17)	(-3.07)	(-3.08)
Firm cluster × Time FE	✓	✓	✓	✓	✓	✓	✓	✓
Bank FE				✓				
Bank × Firm cluster FE					✓	✓	✓	✓
Loan purpose FE	✓	✓	✓	✓	✓			
Loan purpose × Time FE						✓	✓	✓
Firm rating × Time FE						✓	✓	✓
log Loan maturity × Time FE							✓	✓
Observations	120,905	120,905	120,905	120,905	120,905	120,905	120,905	120,905
R^2	0.39	0.38	0.39	0.43	0.49	0.51	0.53	0.53

TABLE 3. Decomposing the impact by loan maturity

In this table, we study the impact of NIRP on bank lending rates depending on loan maturity. The dependent variable is the loan rate (in pp). The effects of interest are those identified by the parameters on the interaction of the cash and reserve ratio × after NIRP with the dummies describing loan maturity. A firm cluster is defined as French region × sector × size. Standard errors are two-way clustered by bank and by firm cluster. *t*-statistics are in parentheses. Statistical significance at the 1%, 5%, and 10% level is indicated by **, *, and $^{+}$, respectively.

	(1)	(2)	(3)
Cash & reserve ratio × after NIRP × 𝟙(loan maturity ≤ 1yr)	-2.6548*	-1.3600	
	(-2.24)	(-1.08)	
Cash & reserve ratio × after NIRP × 𝟙(1yr < loan maturity ≤ 3yrs)	-3.7004*	-4.9153**	
	(-2.64)	(-3.37)	
Cash & reserve ratio × after NIRP × 𝟙(3yrs < loan maturity ≤ 6yrs)	-6.9945**	-8.4399**	
	(-3.40)	(-4.64)	
Cash & reserve ratio × after NIRP × 𝟙(6yrs < loan maturity)	-4.4282*	-3.7904*	
	(-2.55)	(-2.43)	
𝟙(Cash & reserve ratio > median) × after NIRP × 𝟙(loan maturity ≤ 1yr)			-0.0006
			(-0.01)
𝟙(Cash & reserve ratio > median) × after NIRP × 𝟙(1yr < loan maturity ≤ 3yrs)			-0.1945**
			(-3.35)
𝟙(Cash & reserve ratio > median) × after NIRP × 𝟙(3yrs < loan maturity ≤ 6yrs)			-0.2857**
			(-3.18)
𝟙(Cash & reserve ratio > median) × after NIRP × 𝟙(6yrs < loan maturity)			-0.1006
			(-1.35)
TLTRO funding ratio	-3.4680**		
	(-4.56)		
TLTRO funding ratio × 𝟙(loan maturity ≤ 1yr)		5.3073	7.6993
		(0.84)	(1.31)
TLTRO funding ratio × 𝟙(1yr < loan maturity ≤ 3yrs)		-2.5009	-2.0699
		(-0.85)	(-0.72)
TLTRO funding ratio × 𝟙(3yrs < loan maturity ≤ 6yrs)		-3.0453*	-3.1320**
		(-2.60)	(-2.88)
TLTRO funding ratio × 𝟙(6yrs < loan maturity)		-6.0382**	-5.4450**
		(-3.11)	(-2.76)
Deposit ratio × after NIRP	0.1406		
	(1.27)		
Bond ratio × after NIRP	0.6025		
	(1.53)		
Additional interaction terms	✓	✓	✓
Deposit ratio interaction terms		✓	✓
Bond ratio interaction terms		✓	✓
Other firm & loan controls	✓	✓	✓
Firm cluster × Time FE	✓	✓	✓
Bank × Firm cluster FE	✓	✓	✓
Loan purpose × Time FE	✓	✓	✓
Firm rating × Time FE	✓	✓	✓
Observations	120,905	120,905	120,905
R^2	0.54	0.54	0.54

FIGURE A1. OIS forward curves and the interest rate cut of September 2014

This figure plots the Overnight Indexed Swap (OIS) forward curves before and after the 10 basis points cut (from -0.1% to -0.2%) of ECB deposit facility rate on September 4, 2014. Since Wu & Xia (2020) show that several interest rate cuts were expected the month before, we focus on a two-month window centered around the event. We also plot the two-month forward curve change.

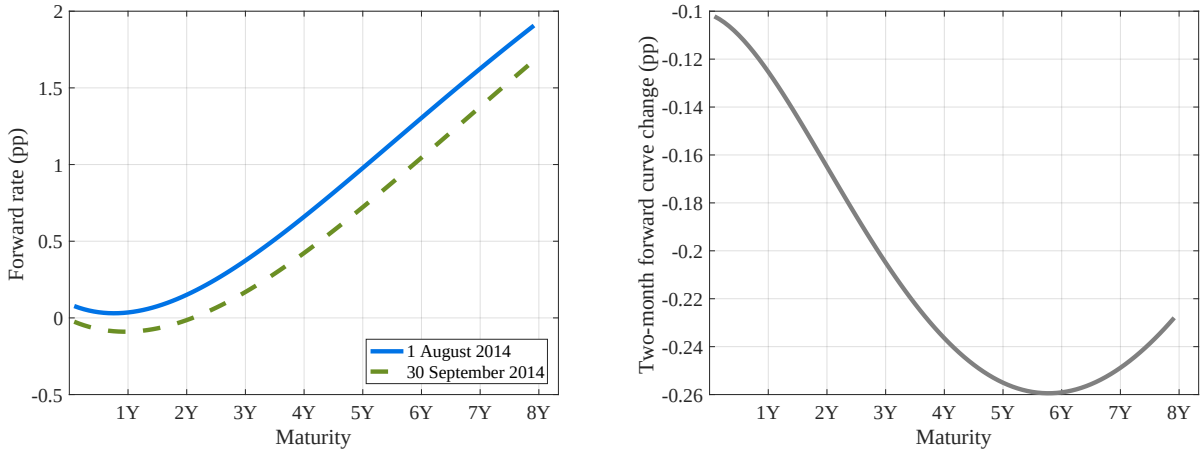


FIGURE A2. Relation between loan rate and either loan maturity or firm credit rating

This figure plots the relation between loan rate and either loan maturity (panel A) or firm credit rating (panel B) for the loans in sample granted before the introduction of NIRP, between 2012Q3 and 2014Q2.

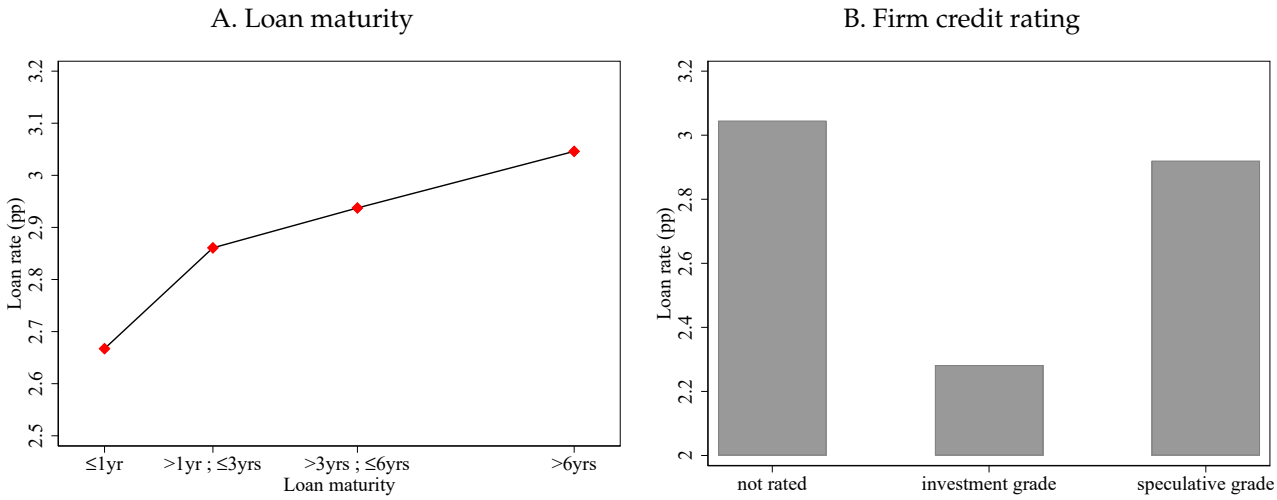
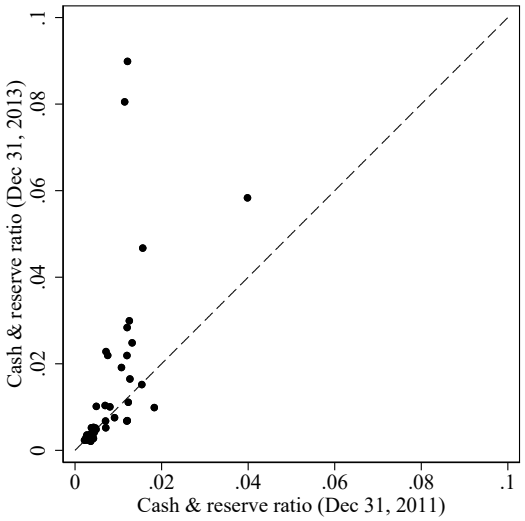


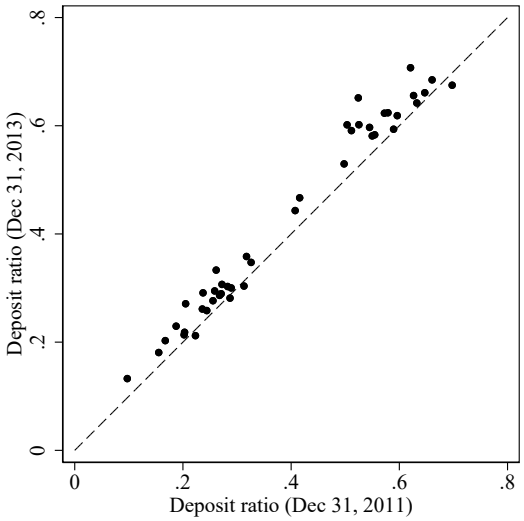
FIGURE A3. Persistence of banks' financial ratios

This figure studies the persistence of financial ratios for the banks in the sample between December 31, 2011 and December 31, 2013. Panel A focuses on the cash & reserve ratio, Panel B on the deposit ratio, and Panel C on the bond ratio. The dashed line represents the 45-degree line.

A. Cash & reserve ratio



B. Deposit ratio



C. Bond ratio

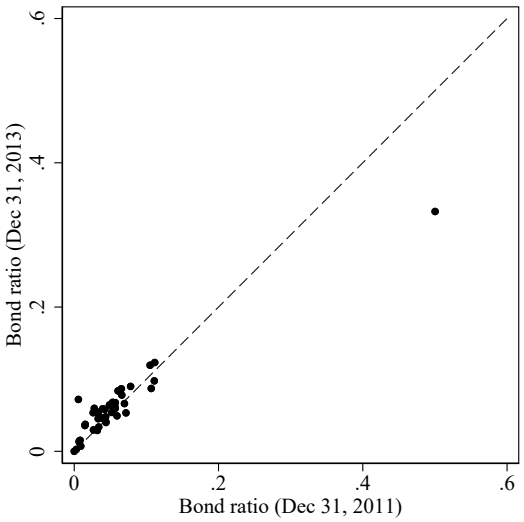


TABLE A1. Variable definitions

This table defines the variables used in the analysis and specifies their source.

Variable	Definition	Source
Loan-level variables		
Loan rate	Narrowly defined effective loan rate (item *taux effectif au sens étroit corrigé*). It is expressed in pp	BdF (M_CONTRAN)
Loan volume	Initial volume of loan lent (item *montant flux initial corrigé*). It is expressed in €K	BdF (M_CONTRAN)
Loan maturity	Loan maturity at creation (item *maturité du crédit*). It is expressed in months	BdF (M_CONTRAN)
Adjustable-rate loan	Dummy 0/1 indicating whether the loan rate is adjustable over time (item *nature de l'index de référence* takes the value "variable")	BdF (M_CONTRAN)
Loan purpose ($\mathbb{1}$(loan is an investment loan))	Dummy 0/1 indicating whether the loan is an investment loan (item *code poste financier* takes the values "500" or "510" and not the values "410", "420" or "440")	BdF (M_CONTRAN)
Firm age	Firm age at loan creation. It is derived from the firm's date of creation (item *date de création de l'entité juridique*). It is expressed in years	BdF (FIBEN)
$\mathbb{1}$(firm is not rated)	Dummy 0/1 indicating whether the firm is not rated (item *code cote crédit* is 0). It is expressed in years	BdF (FIBEN)
$\mathbb{1}$(firm is investment grade)	Dummy 0/1 indicating whether the firm is rated between 4 and 3++ (item *code cote crédit* identifies the firm rating)	BdF (FIBEN)
$\mathbb{1}$(firm is speculative grade)	Dummy 0/1 indicating whether the firm is rated between P and 5+ (item *code cote crédit* identifies the firm rating)	BdF (FIBEN)
Bank-level variables		
Cash and reserve ratio	Cash and balances with central bank (item *F1.10010*) divided by total assets (item *F1.10400*)	BdF (FINREP)
Deposit ratio	Deposits owed to non-financial agents (item *F50.0140*) divided by total assets (item *F1.10400*)	BdF (FINREP)
Bond ratio	Other debt instruments (item *F1.10050* + item *F1.10090* + item *F05.0070* + item *F06.0200*) divided by total assets (item *F1.10400*)	BdF (FINREP)
TLTRO funding ratio	Central bank liquidity obtained in the form of TLTROs during a quarter by the head of the group divided by the total assets (item *F1.10400*) of the head of the group as of 2013Q4	BdF (TLTRO data, FINREP)
Bank assets	Bank total assets (item *F1.10400*)	BdF (TLTRO data, FINREP)

TABLE A2. List of banks in the sample

This table lists the banks in the sample and the bank group to which they belong.

Bank	Bank group
BNP Paribas	BNP Paribas
Banque Palatine	BPCE
Banque Populaire Aquitaine Centre Atlantique	BPCE
Banque Populaire Atlantique	BPCE
Banque Populaire Bourgogne Franche-Comté	BPCE
Banque Populaire Côte d'Azur	BPCE
Banque Populaire d'Alsace	BPCE
Banque Populaire de l'Ouest	BPCE
Banque Populaire des Alpes	BPCE
Banque Populaire du Massif Central	BPCE
Banque Populaire du Nord	BPCE
Banque Populaire du Sud	BPCE
Banque Populaire Loire et Lyonnais	BPCE
Banque Populaire Lorraine Champagne	BPCE
Banque Populaire Occitane	BPCE
Banque Populaire Provençale et Corse	BPCE
Banque Populaire Rives de Paris	BPCE
Banque Populaire Val de France	BPCE
BRED Banque Populaire	BPCE
Caisse d'Epargne Bretagne Pays De Loire	BPCE
Caisse d'Epargne d'Auvergne et du Limousin	BPCE
Caisse d'Epargne Midi-Pyrenees	BPCE
Caisse d'Epargne Ile-de-France	BPCE
Caisse d'Epargne Lorraine Champagne Ardenne	BPCE
Caisse d'Epargne Aquitaine Poitou Charentes	BPCE
Caisse d'Epargne Bourgogne Franche-Comté	BPCE
Crédit Cooperatif	BPCE
Natixis	BPCE
Crcam Alsace Vosges	Crédit Agricole
Crcam Atlantique Vendée	Crédit Agricole
Crcam Brie Picardie	Crédit Agricole
Crcam Centre France	Crédit Agricole
Crcam Centre Loire	Crédit Agricole
Crcam Centre-Est	Crédit Agricole
Crcam Charente-Maritime Deux-Sevres	Crédit Agricole
Crcam Charente-Perigord	Crédit Agricole
	(*continued*)

Crcam d'Ille et Vilaine	Crédit Agricole
Crcam d'Alpes Provence	Crédit Agricole
Crcam d'Aquitaine	Crédit Agricole
Crcam de Champagne-Bourgogne	Crédit Agricole
Crcam de l'Anjou et du Maine	Crédit Agricole
Crcam de la Corse	Crédit Agricole
Crcam de la Touraine et du Poitou	Crédit Agricole
Crcam de Lorraine	Crédit Agricole
Crcam de Normandie	Crédit Agricole
Crcam de Paris et d'Ile de France	Crédit Agricole
Crcam des Côtes d'Armor	Crédit Agricole
Crcam des Savoie	Crédit Agricole
Crcam du Centre Ouest	Crédit Agricole
Crcam du Finistere	Crédit Agricole
Crcam du Languedoc	Crédit Agricole
Crcam du Morbihan	Crédit Agricole
Crcam du Nord Est	Crédit Agricole
Crcam Franche-Comté	Crédit Agricole
Crcam Loire Haute-Loire	Crédit Agricole
Crcam Nord de France	Crédit Agricole
Crcam Nord Midi-Pyrenees	Crédit Agricole
Crcam Normandie-Seine	Crédit Agricole
Crcam Provence-Côte d'Azur	Crédit Agricole
Crcam Pyrenees-Gascogne	Crédit Agricole
Crcam Sud Rhone-Alpes	Crédit Agricole
Crcam Sud Mediterranee	Crédit Agricole
Crcam Toulouse	Crédit Agricole
Crcam Val de France	Crédit Agricole
Crédit Lyonnais	Crédit Agricole
Banque Commerciale du Marché Nord Europe	Crédit Mutuel
Caisse Federale du Crédit Mutuel de Maine Anjou et Basse Normandie	Crédit Mutuel
Caisse Fédérale du Crédit Mutuel Nord Europe	Crédit Mutuel
Caisse Fédérale du Crédit Mutuel Océan	Crédit Mutuel
Caisse Federale du Crédit Mutuel	Crédit Mutuel
Crédit Industriel et Commercial	Crédit Mutuel
Crédit Mutuel Arkea	Crédit Mutuel
Groupama Banque	Groupama
HSBC France	HSBC Holdings
La Banque Postale	La Poste
Crédit Du Nord	Société Générale
Société Générale	Société Générale

TABLE A3. Decomposing the impact by firm credit risk

In this table, we study the impact of NIRP on bank lending rates depending on firm credit risk. The dependent variable is the loan rate (in pp). The effects of interest are those identified by the parameters on the interaction of the cash and reserve ratio × after NIRP with the dummies identifying firm credit risk and derived from firm credit rating. A firm cluster is defined as French region × sector × size. Standard errors are two-way clustered by bank and by firm cluster. *t*-statistics are in parentheses. Statistical significance at the 1%, 5%, and 10% level is indicated by **, *, and $^{+}$, respectively.

	(1)	(2)	(3)
Cash & reserve ratio × after NIRP × 𝟙(firm is not rated)	-4.8150**	-5.0548**	
	(-2.98)	(-3.04)	
Cash & reserve ratio × after NIRP × 𝟙(firm is investment grade)	-4.8626**	-3.9176**	
	(-4.56)	(-3.72)	
Cash & reserve ratio × after NIRP × 𝟙(firm is speculative grade)	-3.1776^{+}	-4.4459*	
	(-1.85)	(-2.05)	
𝟙(Cash & reserve ratio > median) × after NIRP × 𝟙(firm is not rated)			-0.1734**
			(-2.90)
𝟙(Cash & reserve ratio > median) × after NIRP × 𝟙(firm is investment grade)			-0.1359**
			(-3.11)
𝟙(Cash & reserve ratio > median) × after NIRP × 𝟙(firm is speculative grade)			-0.1589^{+}
			(-1.91)
TLTRO funding ratio	-3.6823**		
	(-4.17)		
TLTRO funding ratio × 𝟙(firm is not rated)		-3.3899**	-3.2741**
		(-3.56)	(-3.25)
TLTRO funding ratio × 𝟙(firm is investment grade)		-4.2640	-4.1156
		(-1.14)	(-1.17)
TLTRO funding ratio × 𝟙(firm is speculative grade)		-13.5187^{+}	-13.5217^{+}
		(-1.86)	(-1.85)
Deposit ratio × after NIRP	0.1236		
	(1.00)		
Bond ratio × after NIRP	0.5606		
	(1.26)		
Additional interaction terms	✓	✓	✓
Deposit ratio interaction terms		✓	✓
Bond ratio interaction terms		✓	✓
Other firm & loan controls	✓	✓	✓
Firm cluster × Time FE	✓	✓	✓
Bank × Firm cluster FE	✓	✓	✓
Loan purpose × Time FE	✓	✓	✓
log Loan maturity × Time FE	✓	✓	✓
Observations	120,905	120,905	120,905
R^2	0.52	0.52	0.52

TABLE A4. Identification concerns

In this table, we address several identification concerns. In all columns, the dependent variable is the loan rate (in pp). Column (1) replaces the bank's cash & reserve ratio by a dummy 0/1 indicating whether the bank's cash & reserve ratio is above the sample median. Column (2) decomposes the effect depending on the time distance from the implementation of NIRP (happening at date t). Column (3) considers the bank's cash & reserve ratio, deposit ratio, and bond ratio as of December 31, 2011. Finally, column (4) presents a placebo test where instead of NIRP we consider the case of the deposit facility rate being brought to zero in 2012Q3. In this case, the period of observation is 2010Q3–2014Q1. A firm cluster is defined as French region × sector × size. Standard errors are two-way clustered by bank and by firm cluster. t-statistics are in parentheses. Statistical significance at the 1%, 5%, and 10% level is indicated by **, *, and $^{+}$, respectively.

	(1)	(2)	(3)	(4)
$\mathbb{1}$(Cash & reserve ratio > median) × after NIRP	-0.1638**			
	(-3.22)			
$\mathbb{1}$(Cash & reserve ratio > median) × NIRP (< t - 1yr)		0.0001		
		(0.00)		
$\mathbb{1}$(Cash & reserve ratio > median) × NIRP (t - 1yr ; t)		0.0095		
		(0.31)		
$\mathbb{1}$(Cash & reserve ratio > median) × NIRP (t ; t + 1yr)		-0.1169*		
		(-2.21)		
$\mathbb{1}$(Cash & reserve ratio > median) × NIRP (> t + 1yr)		-0.2068**		
		(-3.56)		
Cash & reserve ratio (Dec 31, 2011) × after NIRP			-8.3110**	
			(-4.29)	
Cash & reserve ratio (Dec 31, 2011) × after deposit facility rate = 0				2.9178
				(1.38)
Deposit ratio × after NIRP	0.2682^{+}	0.2726^{+}		
	(1.78)	(1.79)		
Deposit ratio (Dec 31, 2011) × after NIRP			0.1199	
			(0.99)	
Deposit ratio (Dec 31, 2011) × after deposit facility rate = 0				0.0003
				(0.00)
Bond ratio × after NIRP	-0.2071	-0.2095		
	(-0.44)	(-0.44)		
Bond ratio (Dec 31, 2011) × after NIRP			0.3273	
			(0.83)	
Bond ratio (Dec 31, 2011) × after deposit facility rate = 0				-1.4204*
				(-2.19)
TLTRO funding ratio	-3.5218**	-4.7141**	-3.6013**	
	(-3.79)	(-5.07)	(-3.72)	
Other controls	✓	✓	✓	✓
Firm cluster × Time FE	✓	✓	✓	✓
Bank × Firm cluster FE	✓	✓	✓	✓
Loan purpose × Time FE	✓	✓	✓	✓
Firm rating × Time FE	✓	✓	✓	✓
log Loan maturity × Time FE	✓	✓	✓	✓
Observations	120,905	120,905	120,656	91,765
R^2	0.53	0.53	0.53	0.53