WORKING paper

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Lost in Negative Territory? Search for Yield![1]

Mattia Girotti[2], Guillaume Horny[3] & Jean-Guillaume Sahuc[4]

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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 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 risky firms, indicating that banks conduct a search for yield focused on term spreads. These findings suggest that NIRP complements quantitative easing policies.

Keywords: Negative Interest Rates, Portfolio Rebalancing, Search for Yield, term spreads, Banks

JEL classification: E43; E58; G21

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[2] Banque de France, 31 rue Croix des Petits Champs, 75049 Paris, France (e-mail: mattia.girotti@banque-france.fr).

[3] Banque de France, 31 rue Croix des Petits Champs, 75049 Paris, France (e-mail: guillaume.horny@banque-france.fr).

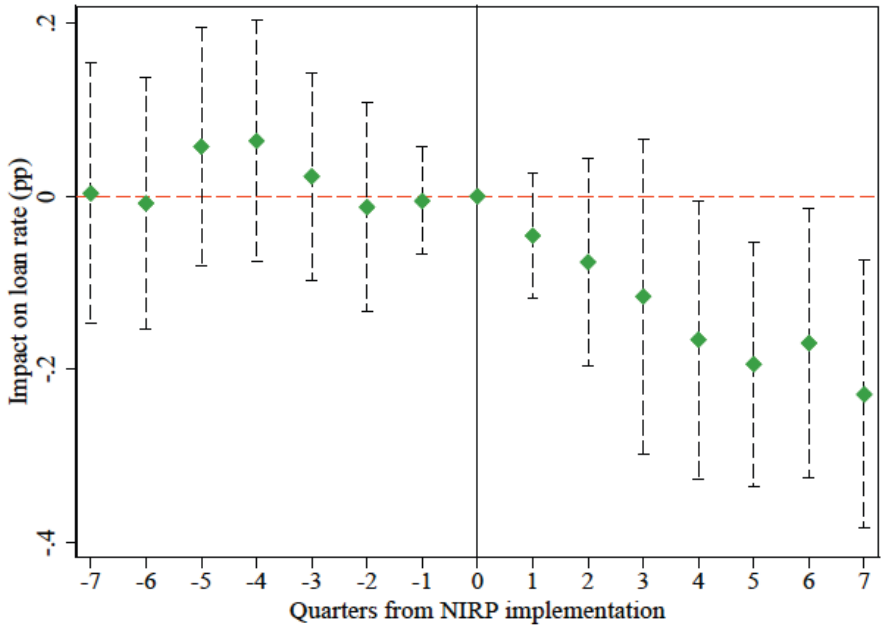
[4] Banque de France, 31 rue Croix des Petits Champs, 75049 Paris, France (e-mail: jean-guillaume.sahuc@banque-france.fr) and University Paris-Nanterre.

NON-TECHNICAL SUMMARY

When a central bank sets its target interest rate in negative territory, the reserves that banks hold in excess of minimum requirements become costly to hold, and banks' revenue may reduce. In an effort to offset the contraction in revenue, two mechanisms may determine how banks modify their loan pricing in response to NIRP. The first mechanism 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 relying more on deposit funding offer loans at relatively higher interest rates. The second mechanism works through portfolio rebalancing: since the opportunity cost of holding cash and reserves increases, banks aim to substitute away from those assets. Hence, banks holding more cash and reserves become more competitive in pricing loans.

We test which of these mechanisms explains banks' reaction to NIRP by focusing on the introduction of this policy by the European Central Bank (ECB) on June 11, 2014. We exploit contract-level data on 121,519 loans lent by 77 banks to 84,048 firms from France. Considering French data is a distinctive element of our analysis: The French banking system is a priori amongst those most affected by the reduction in revenue caused by NIRP, being one of the main excess reserves holders in the euro area. Our approach employs difference-in-differences: 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.

Impact of the introduction of negative interest rate policy on corporate loan rates



Notes: Time 0 is the last quarter before the implementation of negative interest rate policy and is taken as the reference quarter. The sample period is 2012Q3 – 2016Q1. Confidence intervals are obtained by two-way clustering standard errors by bank and firm cluster (i.e., French region × sector × size).

Our first finding is that the more a bank holds cash and reserves, the more it reduces lending rates when NIRP is implemented, in line with the portfolio-rebalancing channel. According to our preferred 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. Banks holding more cash and reserves are more competitive in pricing loans as a means to attract more corporate borrowers and compensate for otherwise larger drops in revenue.

NIRP incentivizes banks to substitute cash and reserves, which yield zero or negative remuneration, with corporate loans, which yield positive remuneration. That is, NIRP pushes banks to search for yield by taking more risk to increase return. To characterize the search for yield at play, we examine whether banks target borrowers at longer maturities–to earn the corresponding term spread–or borrowers with higher credit risk–to earn the related credit risk spread. We show that the impact peaks in magnitude 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 3 basis points lower loan rate if the loan maturity is up to one year. Conversely, we obtain no heterogeneous effect depending on firm credit risk (as measured by the firm credit rating). These results indicate that when NIRP is introduced, banks holding more cash and reserves target primarily borrowers at intermediate maturities with the purpose of earning term spreads. Those banks offer medium-term loans at relatively lower interest rates, suggesting that they associate such loans with a lower price of risk. Overall, these findings imply that NIRP flattens the middle of the corporate loan yield curve and can act as a complement to asset purchase programmes, which rather affect the longer end of the yield curve.

Perdu en territoire négatif ? Cherchez le rendement !

RÉSUMÉ

Cet article étudie comment la politique de taux d'intérêt négatifs influence la tarification des prêts bancaires. En utilisant des données au niveau des contrats en France, nous montrons que cette politique affecte les taux des prêts bancaires aux entreprises par le biais d'un canal de rééquilibrage des portefeuilles : les banques détenant un écart type de plus de liquidités et de réserves auprès de la banque centrale offrent un taux de prêt inférieur de 8,6 points de base, après l'introduction de la politique de taux d'intérêt négatifs. L'effet se concentre sur les prêts à moyen terme (dont la maturité est comprise entre trois et six ans) mais pas sur les prêts aux entreprises risquées, ce qui indique que les banques mènent une quête de rendement centrée sur les spreads de terme. Ces résultats suggèrent que les taux négatifs complètent les politiques d'assouplissement quantitatif.

Mots-clés : taux d'intérêt négatifs, rééquilibrage des portefeuilles, quête de rendement, spreads de terme, banques.

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1. INTRODUCTION

We bring novel empirical evidence on whether and how negative interest rate policy (NIRP) affects bank lending rates. When a central bank sets its target interest rate in negative territory, the reserves that banks hold in excess of minimum requirements become costly to hold, and banks' revenue may reduce. In an effort to offset the contraction in revenue, two mechanisms may determine how banks modify their loan pricing in response to NIRP. The first mechanism 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 relying more on deposit funding offer loans at relatively higher interest rates. The second mechanism works through portfolio rebalancing: since the opportunity cost of holding cash and reserves increases, banks aim to substitute away from those assets. Hence, banks holding more cash and reserves become more competitive in pricing loans.

We test which of these mechanisms explains banks' reaction to NIRP by focusing on the introduction of this policy by the European Central Bank (ECB) on June 11, 2014. We exploit contract-level data on 121,519 loans lent by 77 banks to 84,048 firms from France. Considering French data is a distinctive element of our analysis: The French banking system is a priori amongst those most affected by the reduction in revenue caused by NIRP, being one of the main excess reserves holders in the euro area. Our approach employs difference-in-differences: 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 maturity and presence of collateral. We control for loan demand using firm location $\times$ sector $\times$ size $\times$ time fixed effects, in line with Degryse et al. (2019), and for the time-varying impact of credit risk using firm credit rating $\times$ time fixed effects. Finally, since the ECB launched a series of targeted longer-term refinancing operations (TLTROs) simultaneously to NIRP, we control for the amount of such central bank refinancing obtained by each bank group.

Our first finding is that the more a bank holds cash and reserves, the more it reduces lending rates when NIRP is implemented, in line with the portfolio rebalancing channel. According to our preferred 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. Banks holding more cash and reserves are more competitive in pricing loans as a means to attract more corporate borrowers and compensate for otherwise larger drops in revenue. NIRP thus incentivizes banks to substitute cash and reserves, which yield zero or negative remuneration, with corporate loans, which yield positive remuneration. That is, NIRP pushes banks to *search for yield* by taking more risk to increase return (Rajan, 2006). To characterize the search for yield at play, we examine whether banks target borrowers at longer maturities—to earn the corresponding term spread—or borrowers with higher credit risk—to earn the related credit risk spread.

Following a triple difference-in-differences approach, we show that the impact peaks in magnitude 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 3 basis points lower loan rate if the loan maturity is up to one year. Conversely, we obtain no heterogeneous effect depending on firm credit risk (as measured by the firm credit rating). These results indicate that when NIRP is introduced, banks holding more cash and reserves target primarily borrowers at intermediate maturities with the purpose of earning term spreads. Those banks offer medium-term loans at relatively lower interest rates, suggesting that they associate such loans with a lower price of risk. Targeting medium-term loans is a way for those banks to maximize returns without deviating too much from the initial maturity—i.e., risk—profile of their portfolio. Overall, these findings imply 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 (Brandao-Marques et al., 2021). Most of the existing empirical 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 if this policy improves financing conditions for firms and households. The

effect on lending rates is theoretically uncertain (Brunnermeier & Koby, 2018; Ulate, 2021a,b) and the few empirical studies find mixed evidence. Eggertsson et al. (2019), using Swedish bank-level data, and Amzallag et al. (2019), using Italian contract-level data, find that banks relying more on deposit funding charge relatively higher mortgage rates after the introduction of NIRP.[1] 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 euro-area bank-level data. Basten & Mariathasan (2018) use Swiss bank-level data 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 Italian bank-firm-level data to show that banks having more liquid balance sheets rebalance towards corporate lending and charge firms relatively lower interest rates.

Our contribution to this literature is twofold. First, we overcome an important limit of most of existing studies, which cannot determine the direct impact of NIRP on the loan rate separately from the effect of other loan attributes.[2] Indeed, thanks to the granularity of the data we exploit, we explicitly control for confounders along the loan, firm, and bank dimensions. Second, and perhaps most importantly, we are to our knowledge the first to evaluate how NIRP affects the corporate loan yield curve by exploiting this degree of data granularity. Our result that NIRP triggers a flattening of the middle of the yield curve adds to existing works studying the complementarity among unconventional monetary policies (see, e.g., Rostagno et al., 2019, Bottero et al., forth and Sims & Wu, 2021). The evidence presented here suggests that NIRP acts as a complement to asset purchase programmes, 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; Bubeck et al., 2020).

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

[2] For instance, an empirical analysis that fails to control for loan maturity and considers less granular data might lead to the wrong conclusion that banks holding more cash and reserves react to NIRP by charging relatively *higher* loan rates. This would happen even if those banks are more competitive in the medium-term loan segment, but the corporate loan yield curve is upward sloping.

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 central bank. Since that time, the ECB has implemented additional interest rate cuts in negative territory.

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). As the reaction of the OIS forward curve suggests, what is special about NIRP is that market investors interpreted it as indication that the level of interest rates would stay lower for more time than previously expected. Indeed, as highlighted by Wu & Xia (2020), NIRP caused investors to revise their beliefs about the location of the effective lower bound.[3]

NIRP has two direct effects on banks. First, it reduces banks' revenue. This happens because excess reserves become costly to hold and because cash flows from financial assets may adjust to changes in market interest rates. Clearly, the more banks hold excess reserves, the stronger is this effect: The French banking system, which is our focus, is a priori amongst the most affected in the euro area since it holds a large share (about 20%) of the overall volume of excess reserves.[4] Second, by reducing the discount rate applied to future cash flows, NIRP increases the value of banks' fixed-income portfolio. To offset the contraction in revenue and maintain profitability, banks 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

[3] In line with this mechanics, Figure OA1 in the Online Appendix suggests that the impact on OIS forward rates of the interest rate cut of September 2014 peaked at even further horizons.

[4] Figure OA2 in the Online Appendix plots the shares held by national banking systems around the introduction of NIRP.

reduce deposit rates below 0%, especially in the case of household deposits (Heider et al., 2019; Altavilla et al., forth.; Levieuge & Sahuc, 2021; Heider et al., 2021). If deposit rates turned negative, firms and households might decide to substitute their deposit holdings with cash. The downward rigidity of deposit rates may be further reinforced by regulation or law (Duquerroy et al., 2020). Overall, this may 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 and lowers expected future interest rates, banks may decide to substitute away from assets yielding negative or zero remuneration (i.e., cash and reserves) and allocate their resources to investments yielding higher revenue (e.g., corporate loans). Therefore, in an effort to attract borrowers, banks may become more aggressive in pricing loans.

We define two testable hypotheses:

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 relying more on deposit funding offer loans at relatively higher interest rates.

H2 (portfolio rebalancing channel): Since the opportunity cost of holding cash and reserves increases, banks aim to substitute away from those assets and become more competitive in pricing loans when NIRP is implemented. Therefore, in the banks' cross-section, those holding more cash and reserves offer loans at relatively lower interest rates.

The two mechanisms feature differences in the way they impact the cross-section of loans. Under H1, banks relying more on deposit funding offer loans at relatively higher interest rates especially to borrowers of low-yield loans. Indeed, given that their funding cost is higher, those banks find serving such loans less attractive unless they can charge a premium. Under H2, banks holding more cash and reserves search for yield and consequently offer relatively lower loan rates especially in the case of high-yield loans. Such portions offer higher

returns and help those banks to compensate for the larger drops in revenue they may otherwise experience following NIRP. Understanding which portions of the loan market is more affected is therefore important to characterize the mechanism behind banks' reaction to NIRP.

A proper identification needs to account for two additional factors affecting bank behavior. The first is the increase in value of banks' fixed-income portfolio. The increase in asset values may not only be caused by NIRP but also by the asset purchase programmes implemented by the ECB after October 2014 (Rostagno et al., 2019). To the extent that the fixed-income portfolio is worth more, banks incur in an implicit recapitalization, and can thus lend more. The second factor affecting bank behavior is the launch by the ECB of a series of TLTROs on June 5, 2014. Through these operations, the ECB provided long-term financing to credit institutions at attractive conditions with the objective to stimulate bank lending to firms and households.

3. Data

Our study combines several proprietary data sets maintained by the Banque de France. The data cover the period 2012Q3–2016Q1, that is, from seven quarters before to seven quarters after the implementation of NIRP in June 2014. We choose to start exactly in 2012Q3 because that is when the deposity facility rate was brought to zero, and no other cut in this policy rate realized in the seven quarters up to the introduction of NIRP. By terminating the analysis in 2016Q1, we stop right before the first voluntary early repayment of TLTROs. Hence, the chosen window 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. The Banque de France uses it 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. (2022). 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 interest rate, size, purpose (investment, treasury, leasing, etc.), maturity at issuance, indication of whether the interest rate is fixed or adjustable,

and presence of collateral, together with the borrowing firm identifier (SIREN code) and the lending bank identifier (CIB code).

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 firm age, headquarters location (French region), sector (NES 12 code), 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 (Cahn et al., 2021). We use the credit rating as a measure of firm credit risk and distinguish between unrated, investment grade, and speculative grade firms. We define investment grade the firms whose debt is eligible as collateral in ECB refinancing operations.

3.3. **Bank Data.** The FINREP (FINancial REPorting) data set reports bank financial statement information and is collected by the French Supervisory Authority (Autorité de Contrôle Prudentiel et de Résolution, ACPR) at semi-annual frequency. We consider information as of December 31, 2013. The data set reports the cash and central bank reserve holdings, bond holdings, deposits collected, total equity and total assets, for each bank. We derive the cash and reserve ratio (cash and central bank reserves divided by total assets, CRR), the bond ratio (bonds divided by total assets), the deposit ratio (deposits divided by total assets, DR), and the capital ratio (total equity divided by total assets).

We complement the FINREP data set with information on the liquidity obtained by French banks through ECB refinancing operations at daily frequency. In line with what observed by Andrade et al. (2019), 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 group. 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 ACPR. Next, we derive the TLTRO uptakes for each bank group as the change in liquidity position at each of the seven settlement dates of TLTROs in our sample

period.[5] Finally, we associate these TLTRO uptakes and the volume of total assets of the bank group as a whole (from the FINREP data set) with each of the banks belonging to the 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.[6]

3.4. **Sample Construction and Summary Statistics.** We construct our loan-level sample employing a cleaning strategy similar to that adopted by Mésonnier et al. (2022). The raw M-Contran data set reports tranches of multitranches loans as independent observations. These tranches are identical in terms of borrowing firm, lending bank, issuance period, loan purpose, loan maturity, indication of whether the loan rate is fixed or adjustable, and presence of collateral. 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.[7] Also, 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. 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 121,519 loans lent between 2012Q3 to 2016Q1 by 77 banks to 84,048 firms. Table 1 presents the summary statistics of the loans and banks in sample.[8] The median loan size is €30,500, 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

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

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

[7] 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.

[8] Table OA1 in the Online Appendix provides variable definitions based on data item codes.

purposes, the loan rate is adjustable in 27% of cases, while one in three loans is collateralized. 17% of firms are investment grade, while 74% of firms are not rated (i.e., they are too small to be rated).

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.[9] 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, while 10% through equity. When cumulated through quarters, TLTRO uptakes amount to 1.4% of total assets on average. Table 1 uncovers a significant heterogeneity across banks—specifically, for what concerns CRR and DR—which we exploit for the identification of the effects of interest.

4. Empirical Analysis

4.1. **Empirical Strategy.** Our empirical strategy exploits a difference-in-difference approach. We measure the difference in loan rates that depends on the lending banks' CRR and DR, 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 CRR ($cash\,\&\,reserves_b/total\,assets_b$) and DR ($deposits_b/total\,assets_b$) 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 after NIRP is introduced. Conversely, γ captures the difference in loan rate due to a bank relying on deposit funding to a greater extent after NIRP is passed. Hence, by estimating β and γ, we can determine through which

[9] Table OA2 in the Online Appendix reports the list of banks in the sample, together with the identity of their bank group.

mechanism NIRP affects bank lending rates.[10] To properly identify these parameters, we saturate the specification with several control variables and fixed effects.

The first set of controls is at the firm-bank-level: $X_{f,b}$ includes firm cluster $\times$ bank fixed effects, where firm cluster is defined as the interaction of firm geographical location (French region), sector (NES 12), and size (taille LME). The role of $X_{f,b}$ in Equation (1) is twofold. First, it absorbs every time-invariant element of a bank (including CRR and DR, since these ratios are measured as of December 31, 2013). Second, it controls for the characteristics of the relationship between a bank and 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.

Bank-time-level controls, denoted by $V_{b,t}$, 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 increase in value of banks' fixed-income portfolio following the introduction of NIRP. 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. $W_{l,t}$ includes the log loan volume, a dummy 0/1 identifying if the loan rate is adjustable, a dummy 0/1 identifying if the loan is collateralized, a dummy 0/1 identifying loan purpose interacted with time fixed effects, and log loan maturity interacted with time fixed effects.[11] Loan purpose $\times$ time fixed effects capture the possibly time-varying loan demand for investment—rather than for liquidity—purposes. 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. $Z_{f,t}$ includes the age of the firm, firm cluster $\times$ time fixed effects and firm rating $\times$ time fixed effects. Firm cluster $\times$ time fixed effects capture all shocks that are common to firms that *(i)* are located in the same region, *(ii)* operate in the same sector, and *(iii)* have similar size. The inclusion of these fixed effects

[10] To make a parallel with a standard difference-in-differences setup, our setting features two treatments ($cash\,\&\,reserves_b/total\,assets_b$ and $deposits_b/total\,assets_b$) and the "after" period is identified by the dummy $after\,NIRP_t$.

[11] For some loans, the M-Contran data set does not report information regarding collateral. We control for this by including in our regressions a dummy 0/1 identifying missing collateral information.

allows us to control for loan demand, in line with the approach developed by Degryse et al. (2019). Finally, firm rating × time fixed effects absorb the possibly time-varying impact of credit risk on loan rates.

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 both bank and firm cluster.

Columns (1) and (2) examine a parsimonious specification with only the firm age, firm cluster × time fixed effects, and loan purpose dummy included as control variables. While in column (1) we study the impact of NIRP on lending rates depending on a bank's CRR, in column (2) we focus on the impact depending on a bank's DR. We find that banks holding more cash and reserves reduce their lending rate significantly more following NIRP implementation (the parameter estimate is statistically significant at 5%). Importantly, the coefficient on CRR 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 is no difference in lending rate depending on a bank's DR, both before and after the implementation of NIRP.

These results are confirmed when CRR, DR and their interactions with $after\ NIRP_t$ are all included in the same regression (column (3)). They are also unaltered, and actually reach a higher level of statistical significance, when we introduce bank fixed effects (column (4)), firm cluster × 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 (H2). According to our preferred specification (column (8)), a one standard deviation difference in CRR 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 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.[12]

To interpret the estimated effects as causal, the parallel trends assumption must hold.[13] 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. We test whether such difference is constant before the implementation of NIRP. We create a dummy indicating if a bank's CRR 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.[14] We replace the interaction of CRR with $after\ NIRP_t$ in Equation (1) by the created dummies, run this regression and plot the coefficients on each of those dummies in Figure 2.A. The estimated coefficients are not statistically different from zero before 2014Q2, implying that the two groups of banks display a constant difference in lending rates up to the implementation of NIRP. That is, before 2014Q2, 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 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 competitive loan pricing by banks holding more cash and reserves is indicative of their greater willingness to substitute away from cash and reserves, attract corporate borrowers, and obtain higher returns. But to confirm that a search for yield is at play, we examine whether banks target especially borrowers at longer maturities—to earn the corresponding term spread—or borrowers with higher credit risk—to earn the related credit risk spread.[15]

[12] Another interesting result in Table 2 is that collateralized loans are associated with higher loan rates. This is in line with theories explaining collateral as a method of reducing ex-post frictions such as moral hazard, difficulties in enforcing contracts or costly state verification (see, e.g., Berger et al., 2011; Ioannidou et al., 2022).

[13] Additional identification concerns are addressed in the Online Appendix.

[14] 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.

[15] Figure OA3 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

We first focus on loan maturity. The objective is to decompose the effect of NIRP mediated by CRR by 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. 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. We form triple interaction terms of CRR with $after\,NIRP_t$ and each of these dummies. We construct similar triple interactions with DR 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 in Equation (1) as regressors.[16]

Table 3 presents estimation results. Each column considers a different specification. In column (1), we decompose only the effect of NIRP mediated by CRR by loan maturity. Column (2) decomposes all effects, while column (3) replicates column (2) by replacing CRR 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 CRR peaks in magnitude and is statistically significant primarily on medium-term loans. That is, banks holding more cash and reserves attract borrowers with significantly cheaper loans at intermediate maturities, while they do not offer cheaper loans at short maturities. According to column (2), a one standard deviation difference in CRR 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 3 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 after the introduction of NIRP, banks rebalance their portfolio mainly towards loans with intermediate maturity. Their search for yield is thus conducted

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.

[16]Note that these variables replace the interactions of CRR, DR and bond ratio with $after\,NIRP_t$ and the TLTRO funding ratio. Also, in this 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.

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. Targeting medium-term loans is a way for these banks to maximize returns without deviating too much from the initial maturity—i.e., risk—profile of their portfolio. Such a strategy allows them 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 (Figure 1). To the extent that short-term interest rates will be lower for more time, banks should prefer to lend at longer maturities. And, given their greater desire to serve 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. We replicate the analysis just considered except that we replace the dummies identifying loan maturity by the three dummies measuring firm credit risk derived from credit rating information. Like before, the objective is to decompose the impact of NIRP mediated by CRR by firm credit risk. We find that banks holding more cash and reserves are associated with lower lending rates, independently of borrower risk.[17] Therefore, we do not find evidence that the results in Table 2 depend on banks searching for yield by necessarily targeting riskier corporate borrowers.[18]

5. Conclusion

This paper exploits contract-level data from France to analyze the impact of the introduction of the ECB's negative interest rate policy on bank lending rates. Using difference-in-differences, we find that the more a bank holds cash and reserves, the more it reduces lending rates after NIRP is implemented, indicating that it aims to attract corporate borrowers and substitute away from cash and reserves. These results highlight that banks react to NIRP by searching for yield. When we investigate how this search is conducted, we find that banks

[17] Table OA3 in the Online Appendix reports the estimation results.

[18] As an additional test for the mechanism we highlight, Section 2 of the Online Appendix examines how our baseline results change with bank capitalization. We find that after NIRP is passed, mainly low-capital banks offer loans at lower interest rates the greater is their CRR. This corroborates the portfolio rebalancing mechanism, since it is in particular those banks that should aim to protect their profitability following NIRP and be willing to search for yield.

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 is conducted by targeting term spreads.

Our paper contributes to the policy debate on the interactions of unconventional monetary tools. By reducing financing costs for firms through banks and flattening the middle of the corporate loan yield curve, NIRP complements quantitative easing policies, which rather flatten the longer end of the yield curve. Our results are based on a period in which the ECB's NIRP and asset purchase programmes are at their inception, and the overall level of excess reserves is moderate. We leave for further research the question of whether NIRP exerts similar effects when in place for long time and when the level of excess reserves in the system is very high.

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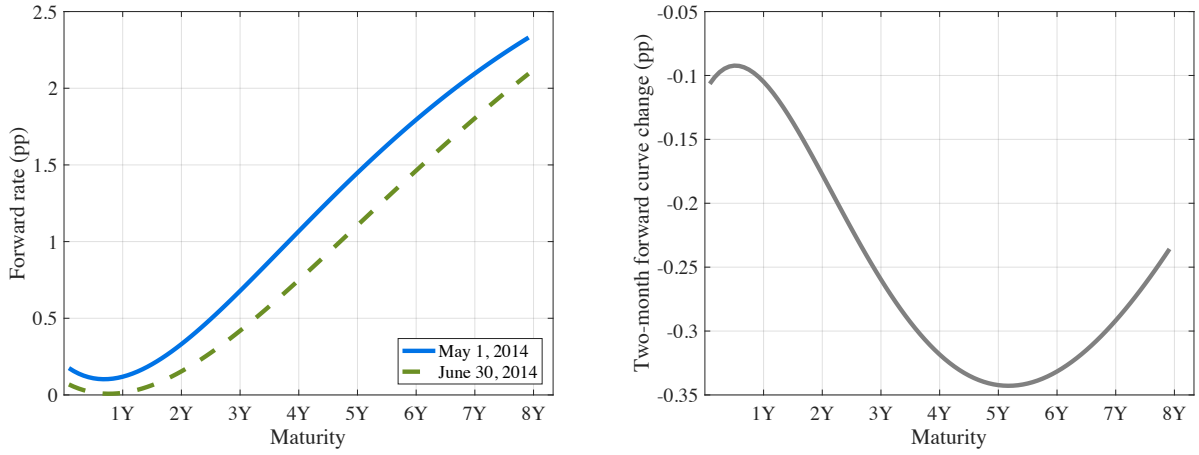
FIGURES

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

This figure plots the OIS forward curves before and after two events: *(i)* the move into negative territory (from 0% to -0.10%) 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)

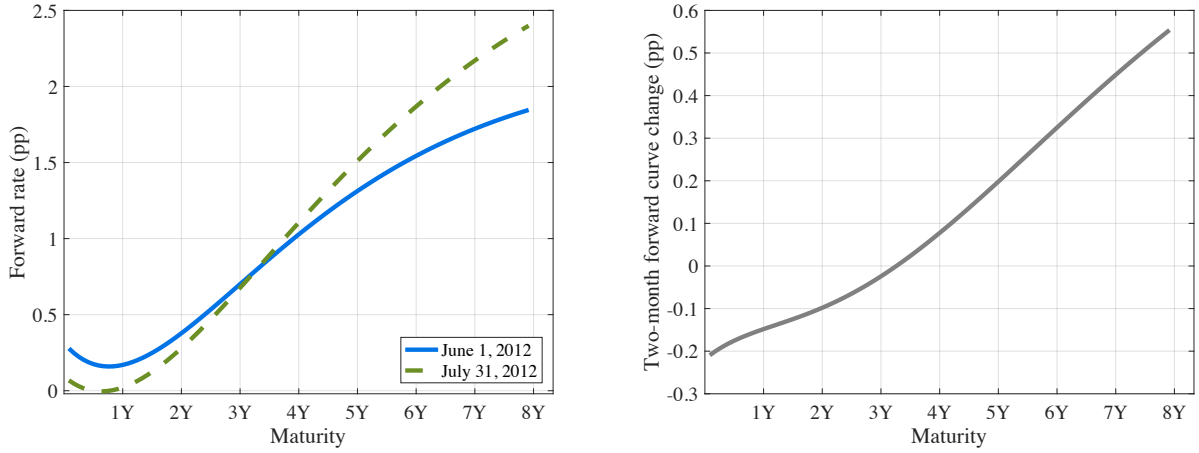
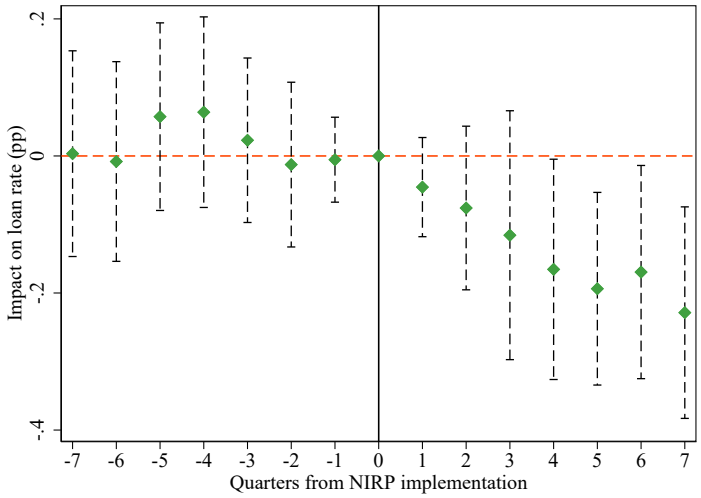


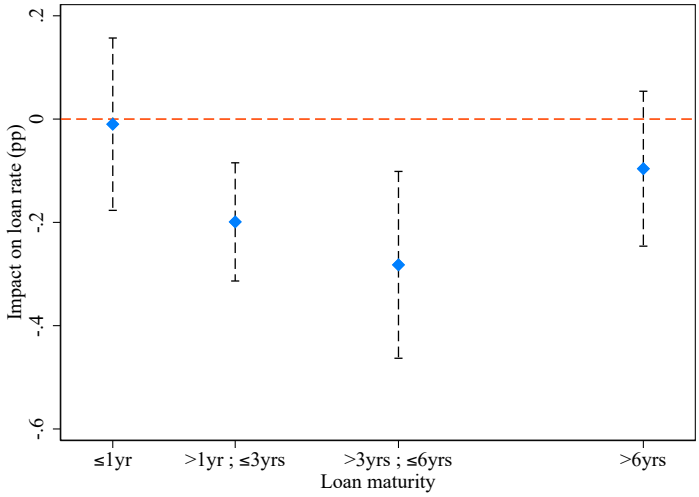
FIGURE 2. Impact of NIRP on bank lending rates

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 panel A and panel B, confidence intervals are obtained by two-way clustering standard errors by bank and firm cluster (i.e., French region $\times$ sector $\times$ size).

A. Timing the impact



B. Decomposing the impact by loan maturity



TABLES

TABLE 1. Summary statistics

This table displays the summary statistics of the samples considered in the analysis. Variable definitions are reported in Table OA1 in the Online Appendix. 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)	121,519	2.466	2.375	1.009	1.000	4.250
Loan volume (in €K)	121,519	317.523	30.500	1,279.784	5.300	1,250.000
Loan maturity (in months)	121,519	50.599	48.000	39.835	3.000	121.000
$\mathbb{1}$(loan maturity $\leq$ 1yr)	121,519	0.281	0.000	0.450	0.000	1.000
$\mathbb{1}$(1yr < loan maturity $\leq$ 3yrs)	121,519	0.156	0.000	0.362	0.000	1.000
$\mathbb{1}$(3yrs < loan maturity $\leq$ 6yrs)	121,519	0.304	0.000	0.460	0.000	1.000
$\mathbb{1}$(6yrs < loan maturity)	121,519	0.259	0.000	0.438	0.000	1.000
Adjustable-rate loan	121,519	0.271	0.000	0.445	0.000	1.000
Collateralized loan	121,519	0.334	0.000	0.472	0.000	1.000
Collateral info is missing	121,519	0.184	0.000	0.387	0.000	1.000
Loan purpose ($\mathbb{1}$(loan is an investment loan))	121,519	0.686	1.000	0.464	0.000	1.000
Firm age (in years)	121,519	16.811	14.750	13.789	0.250	39.250
$\mathbb{1}$(firm is not rated)	121,519	0.736	1.000	0.441	0.000	1.000
$\mathbb{1}$(firm is investment grade)	121,519	0.171	0.000	0.376	0.000	1.000
$\mathbb{1}$(firm is speculative grade)	121,519	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
Capital ratio	77	0.100	0.103	0.034	0.039	0.148
Bank assets (in €Bn)	77	71.911	13.725	234.029	5.305	433.694

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 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	0.0748		-0.0243					
	(0.03)		(-0.01)					
Cash & reserve ratio × after NIRP	-4.4379**		-4.0422**	-5.1386***	-5.3417***	-4.1532***	-3.9072***	-4.5445***
	(-2.15)		(-2.10)	(-3.01)	(-3.15)	(-3.13)	(-2.79)	(-3.38)
Deposit ratio		-0.0872	-0.0906					
		(-0.29)	(-0.33)					
Deposit ratio × after NIRP		-0.2277	-0.1549	-0.0015	-0.0575	0.1564	0.0393	0.0922
		(-1.03)	(-1.19)	(-0.01)	(-0.44)	(1.14)	(0.30)	(0.79)
Bond ratio × after NIRP								0.5779
								(1.26)
TLTRO funding ratio								-3.5738***
								(-3.99)
log Loan volume							-0.0959***	-0.0958***
							(-4.19)	(-4.19)
Adjustable-rate loan							-0.1201	-0.1202
							(-1.64)	(-1.64)
Collateralized loan							0.1169***	0.1168***
							(3.64)	(3.63)
Firm age	-0.0041***	-0.0041***	-0.0041***	-0.0040***	-0.0038***	-0.0023***	-0.0019**	-0.0019**
	(-4.39)	(-4.21)	(-4.36)	(-4.49)	(-4.12)	(-3.12)	(-2.50)	(-2.51)
Firm cluster × Time FE	✓	✓	✓	✓	✓	✓	✓	✓
Bank FE				✓				
Firm cluster × Bank FE					✓	✓	✓	✓
Loan purpose FE	✓	✓	✓	✓	✓			
Loan purpose × Time FE						✓	✓	✓
Firm rating × Time FE						✓	✓	✓
log Loan maturity × Time FE							✓	✓
Observations	121,519	121,519	121,519	121,519	121,519	121,519	121,519	121,519
R^2	0.39	0.39	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 and the dummies measuring 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)	-2.9294**	-1.5915	
	(-2.52)	(-1.28)	
Cash & reserve ratio × after NIRP × 𝟙(1yr < loan maturity ≤ 3yrs)	-3.8274***	-5.0648***	
	(-2.68)	(-3.45)	
Cash & reserve ratio × after NIRP × 𝟙(3yrs < loan maturity ≤ 6yrs)	-6.9810***	-8.3799***	
	(-3.31)	(-4.52)	
Cash & reserve ratio × after NIRP × 𝟙(6yrs < loan maturity)	-4.1609**	-3.6091**	
	(-2.38)	(-2.24)	
𝟙(Cash & reserve ratio > median) × after NIRP × 𝟙(loan maturity ≤ 1yr)			-0.0099
			(-0.12)
𝟙(Cash & reserve ratio > median) × after NIRP × 𝟙(1yr < loan maturity ≤ 3yrs)			-0.1991***
			(-3.47)
𝟙(Cash & reserve ratio > median) × after NIRP × 𝟙(3yrs < loan maturity ≤ 6yrs)			-0.2822***
			(-3.11)
𝟙(Cash & reserve ratio > median) × after NIRP × 𝟙(6yrs < loan maturity)			-0.0961
			(-1.28)
TLTRO funding ratio	-3.3854***		
	(-4.36)		
TLTRO funding ratio × 𝟙(loan maturity ≤ 1yr)		4.8651	7.2421
		(0.76)	(1.22)
TLTRO funding ratio × 𝟙(1yr < loan maturity ≤ 3yrs)		-2.5412	-2.1848
		(-0.87)	(-0.76)
TLTRO funding ratio × 𝟙(3yrs < loan maturity ≤ 6yrs)		-2.9292**	-3.0329***
		(-2.48)	(-2.74)
TLTRO funding ratio × 𝟙(6yrs < loan maturity)		-5.7747***	-5.2085**
		(-3.02)	(-2.60)
Deposit ratio × after NIRP	0.1291		
	(1.16)		
Bond ratio × after NIRP	0.6540*		
	(1.70)		
Additional interaction terms	✓	✓	✓
Deposit ratio interaction terms		✓	✓
Bond ratio interaction terms		✓	✓
Other firm & loan controls	✓	✓	✓
Firm cluster × Time FE	✓	✓	✓
Firm cluster × Bank FE	✓	✓	✓
Loan purpose × Time FE	✓	✓	✓
Firm rating × Time FE	✓	✓	✓
Observations	121,519	121,519	121,519
R^2	0.54	0.54	0.54

Online Appendix

– Not Intended For Publication –

1. Identification Concerns

In this section, we address several identification concerns. We first replicate Equation (1) of the main text by replacing the cash and reserve ratio (CRR) 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 CRR. Column (1) of Table OA4 confirms 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.

Although Figure 2.A already showed the timing of the impact of NIRP depending on a bank's CRR, we present here regression coefficients more formally. For brevity, we consider the interactions of the dummy indicating if a bank's CRR 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 CRR with $after\ NIRP_t$ in Equation (1). The estimation results appear in column (2) of Table OA4. They confirm that no significant differential trend appears before the implementation of NIRP, and a divergence materializes only after that point in time.

A possible concern regarding our results is that banks might have acted strategically in anticipation of NIRP and modified their CRR, DR, and bond ratio back in 2013 to better cope with the implementation of the policy. If this were the case, our estimations would be plagued by endogeneity, and our coefficient estimates biased. We address this concern by first studying the persistence over time of banks' CRR, DR and bond ratio. Specifically, for each ratio, we produce the scatter plot of the levels as of December 31, 2013 against the levels as of December 31, 2011 in Figure OA4. All plots, especially those for DR and the bond ratio, show that most points 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.

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 corresponds to the reduced form of an instrumental variables estimation in which CRR, DR and the bond ratio (measured as of December 31, 2013) are instrumented by their past values. Column (3) of Table OA4 presents regression coefficients. All previous results are confirmed. If anything, the coefficient on CRR, 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 11, 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.[1] The estimation results are presented in column (4) of Table OA4. There does not appear any significant effect related to either CRR or DR 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.

2. Role of Bank Capitalization

In this section, we study the role of bank capitalization in the reaction of banks to NIRP. We first replicate Equation (1) of the main text by adding the capital ratio interacted with $after\,NIRP_t$ as regressor. The results appear in column (1) of Table OA5. The coefficient on this interaction term is not statistically significant at conventional levels, suggesting that the impact of NIRP on lending rates does not hinge on capitalization. Importantly, the key results of Table 2 are unchanged.

[1] 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.

We then investigate how the portfolio substitution caused by NIRP alters with bank capitalization. A priori, low-capital banks should be more inclined to substitute cash and reserves with corporate loans following NIRP. The reason is that a reduction in profitability, and potentially a loss, would be particularly impactful on them given their lower capacity of absorbing shocks. Therefore, according to the portfolio substitution mechanism, NIRP should trigger a search for yield especially amongst low-capital banks.

We test this hypothesis by splitting our sample in two subsamples depending on whether a lending bank's capitalization is below or above the sample median capitalization. Then, we run Equation (1) on each of the two subsamples. By following this strategy, we allow the coefficient on the interaction of cash and reserve ratio with $after\,NIRP_t$ as well as all other coefficients to differ depending on the level of bank capitalization. We find that the portfolio substitution mechanism is at play exactly amongst low-capital banks, while it is silent amongst high-capital banks. This confirms our hypothesis and corroborates the portfolio substitution mechanism. Interestingly, we also find that central bank liquidity mainly reduces lending rates of high-capital banks. This suggests that low-capital banks are less willing to offer lower lending rates once they receive central bank liquidity, possibly in an effort to sustain their profitability and their capital position.

ADDITIONAL FIGURES

FIGURE OA1. OIS forward curves and the interest rate cut of September 2014

This figure plots the OIS forward curves before and after the 10 basis points cut (from -0.10% to -0.20%) 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.

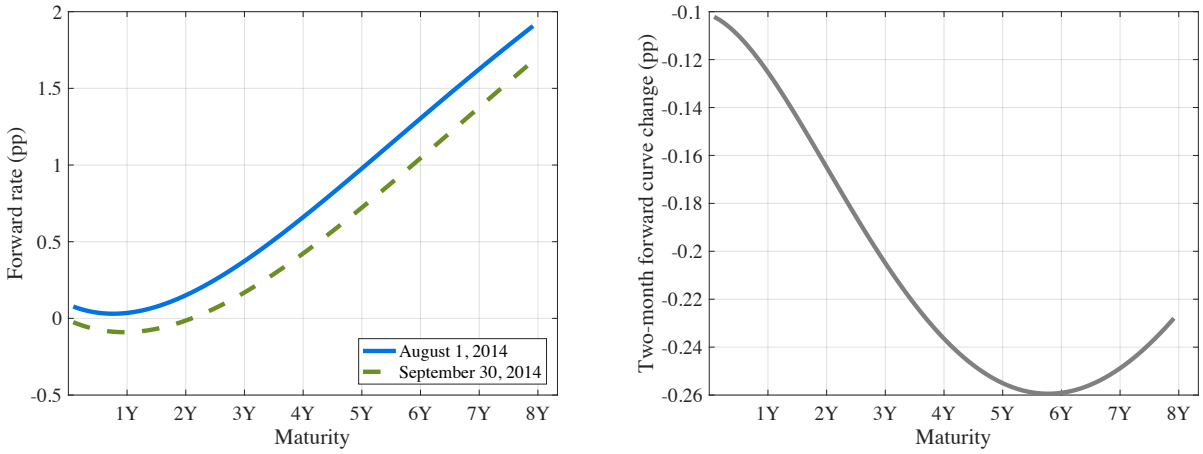


FIGURE OA2. Euro-area excess reserves and selected banking systems' shares

This figure plots the dynamics of the total volume of excess reserves in the euro area (grey area) and of the shares held by the banking systems of the four largest economies. The vertical line indicates the announcement of NIRP.

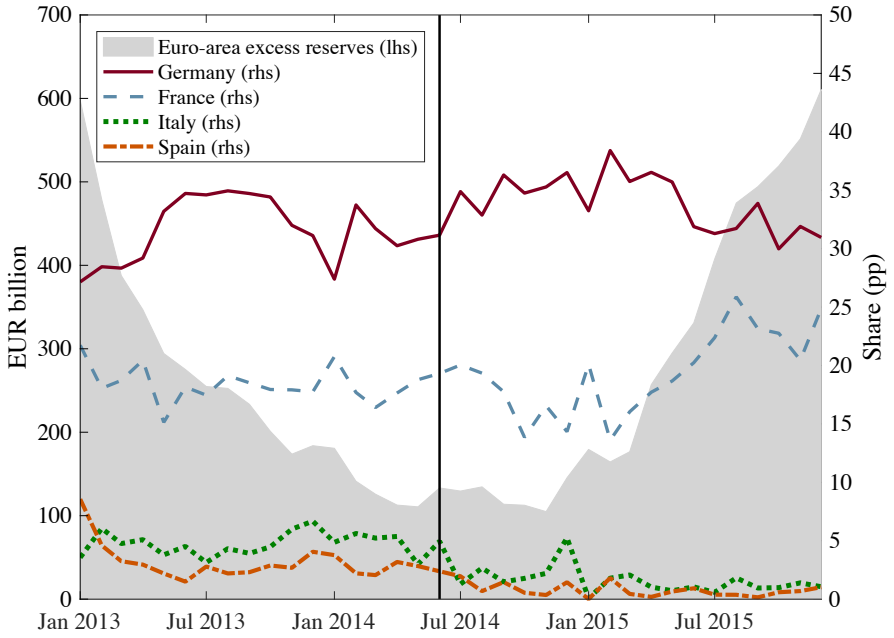
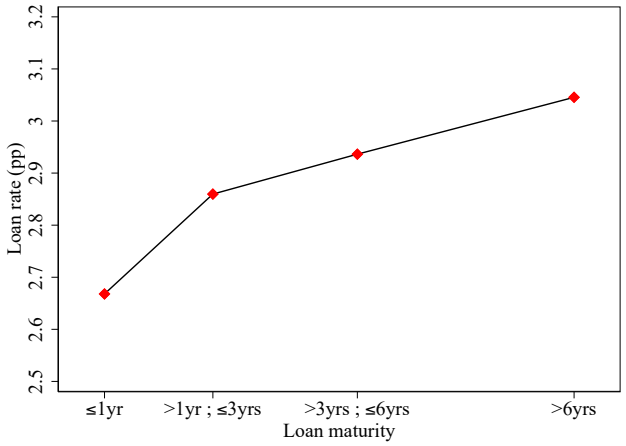


FIGURE OA3. Relation between loan rate and either loan maturity or firm credit rating

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.

A. Loan maturity



B. Firm credit rating

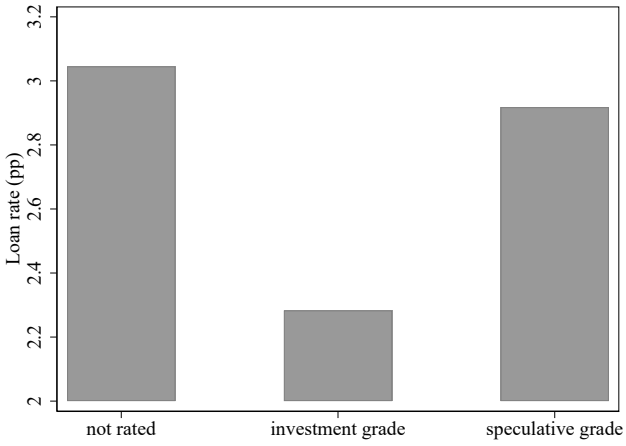
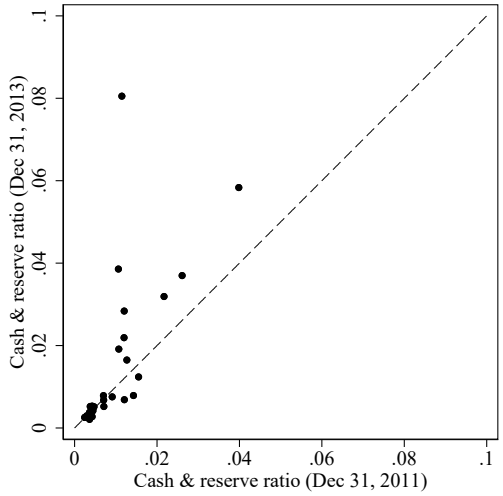


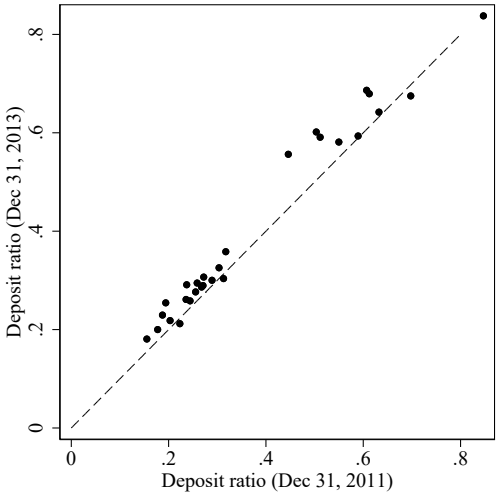
FIGURE OA4. Persistence of banks' financial ratios

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.

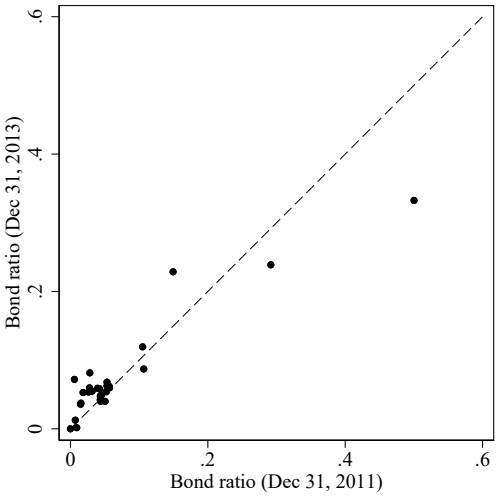
A. Cash & reserve ratio



B. Deposit ratio



C. Bond ratio



ADDITIONAL TABLES

TABLE OA1. 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)
Collateralized loan	Dummy 0/1 indicating whether the loan is secured by real estate or other guarantees (item *type de sûreté* takes the value "1", "2" or "3")	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 value "500" or "510" and not "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* takes the value "0")	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)
Capital ratio	Total equity (item *F1.30240*) divided by total assets (item *F1.10400*)	BdF (FINREP)
Bank assets	Bank total assets (item *F1.10400*)	BdF (FINREP)

TABLE OA2. 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
	(*continued*)

Crcam Centre Loire	Crédit Agricole
Crcam Centre-Est	Crédit Agricole
Crcam Charente-Maritime Deux-Sevres	Crédit Agricole
Crcam Charente-Perigord	Crédit Agricole
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
	(*continued*)

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 OA3. 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 and the dummies identifying firm credit risk and derived from the firm credit rating. A firm cluster is defined as French region × sector × size. Standard errors are two-way clustered by bank and 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)	-4.7682***	-4.9998***	
	(-2.86)	(-2.93)	
Cash & reserve ratio × after NIRP × 𝟙(firm is investment grade)	-4.8789***	-3.9094***	
	(-4.51)	(-3.54)	
Cash & reserve ratio × after NIRP × 𝟙(firm is speculative grade)	-3.3434*	-4.7559**	
	(-1.91)	(-2.22)	
𝟙(Cash & reserve ratio > median) × after NIRP × 𝟙(firm is not rated)			-0.1730***
			(-2.91)
𝟙(Cash & reserve ratio > median) × after NIRP × 𝟙(firm is investment grade)			-0.1405***
			(-3.19)
𝟙(Cash & reserve ratio > median) × after NIRP × 𝟙(firm is speculative grade)			-0.1708**
			(-2.08)
TLTRO funding ratio	-3.6091***		
	(-4.09)		
TLTRO funding ratio × 𝟙(firm is not rated)		-3.3292***	-3.2117***
		(-3.45)	(-3.14)
TLTRO funding ratio × 𝟙(firm is investment grade)		-4.2619	-4.1124
		(-1.17)	(-1.22)
TLTRO funding ratio × 𝟙(firm is speculative grade)		-12.8096*	-12.8209*
		(-1.77)	(-1.76)
Deposit ratio × after NIRP	0.1055		
	(0.85)		
Bond ratio × after NIRP	0.6260		
	(1.46)		
Additional interaction terms	✓	✓	✓
Deposit ratio interaction terms		✓	✓
Bond ratio interaction terms		✓	✓
Other firm & loan controls	✓	✓	✓
Firm cluster × Time FE	✓	✓	✓
Firm cluster × Bank FE	✓	✓	✓
Loan purpose × Time FE	✓	✓	✓
log Loan maturity × Time FE	✓	✓	✓
Observations	121,519	121,519	121,519
R^2	0.52	0.52	0.52

TABLE OA4. 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 and reserve ratio by a dummy 0/1 indicating whether the bank's cash and 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 and 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 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	-0.1654***			
	(-3.23)			
$\mathbb{1}$(Cash & reserve ratio > median) × NIRP (< t - 1yr)		0.0211		
		(0.34)		
$\mathbb{1}$(Cash & reserve ratio > median) × NIRP (t - 1yr ; t)		0.0228		
		(0.56)		
$\mathbb{1}$(Cash & reserve ratio > median) × NIRP (t ; t + 1yr)		-0.1059*		
		(-1.82)		
$\mathbb{1}$(Cash & reserve ratio > median) × NIRP (> t + 1yr)		-0.1907***		
		(-2.96)		
Cash & reserve ratio (Dec 31, 2011) × after NIRP			-8.2162***	
			(-4.05)	
Cash & reserve ratio (Dec 31, 2011) × after deposit facility rate = 0				2.4548
				(1.09)
Deposit ratio × after NIRP	0.2543	0.2594*		
	(1.66)	(1.68)		
Deposit ratio (Dec 31, 2011) × after NIRP			0.0982	
			(0.82)	
Deposit ratio (Dec 31, 2011) × after deposit facility rate = 0				-0.0263
				(-0.21)
Bond ratio × after NIRP	-0.1353	-0.1483		
	(-0.28)	(-0.31)		
Bond ratio (Dec 31, 2011) × after NIRP			0.3792	
			(0.89)	
Bond ratio (Dec 31, 2011) × after deposit facility rate = 0				-1.4831**
				(-2.20)
TLTRO funding ratio	-3.4543***	-4.5824***	-3.5349***	
	(-3.71)	(-5.39)	(-3.65)	
Other firm & loan controls	✓	✓	✓	✓
Firm cluster × Time FE	✓	✓	✓	✓
Firm cluster × Bank FE	✓	✓	✓	✓
Loan purpose × Time FE	✓	✓	✓	✓
Firm rating × Time FE	✓	✓	✓	✓
log Loan maturity × Time FE	✓	✓	✓	✓
Observations	121,519	121,519	121,268	92,083
R^2	0.53	0.53	0.53	0.54

TABLE OA5. Role of bank capitalization

In this table, we study the role of bank capitalization in the reaction of banks to NIRP. In all columns, the dependent variable is the loan rate (in pp). In column (1), we run Equation (1) and add capital ratio × after NIRP as regressor. In columns (2) and (3), we run Equation (1) on two subsamples distinguishing between banks whose capitalization is below the sample median and banks whose capitalization is above it. A firm cluster is defined as French region × sector × size. Standard errors are two-way clustered by bank and firm cluster. *t*-statistics are in parentheses. Statistical significance at the 1%, 5%, and 10% level is indicated by ***, **, and *, respectively.

	All sample	Bank capitalization	
		below median	above median
	(1)	(2)	(3)
Cash & reserve ratio × after NIRP	-3.3207**	-3.8315***	7.4866
	(-2.50)	(-3.46)	(1.39)
Deposit ratio × after NIRP	0.1988	0.1355	-0.3354
	(1.37)	(0.96)	(-1.36)
Bond ratio × after NIRP	0.5606	0.2152	0.5785
	(1.45)	(0.38)	(0.63)
TLTRO funding ratio	-3.6340***	5.4702	-3.6939***
	(-4.22)	(0.87)	(-9.36)
Capital ratio × after NIRP	1.2991		
	(1.57)		
log Loan volume	-0.0959***	-0.1010**	-0.0943***
	(-4.19)	(-2.42)	(-8.89)
Adjustable-rate loan	-0.1193	-0.0525	-0.1544
	(-1.63)	(-0.49)	(-1.64)
Collateralized loan	0.1168***	0.1072***	0.1390***
	(3.63)	(3.19)	(2.94)
Firm age	-0.0019**	-0.0034***	-0.0000
	(-2.50)	(-3.23)	(-0.08)
Firm cluster × Time FE	✓	✓	✓
Firm cluster × Bank FE	✓	✓	✓
Loan purpose × Time FE	✓	✓	✓
Firm rating × Time FE	✓	✓	✓
log Loan maturity × Time FE	✓	✓	✓
Observations	121,519	57,558	61,998
R^2	0.53	0.60	0.48