EUROPEAN CENTRAL BANK
EUROSYSTEM

Working Paper Series

Carlo Altavilla, Lorenzo Burlon,
Mariassunta Giannetti, Sarah Holton

Is there a zero lower bound? The effects of negative policy rates on banks and firms

Revised June 2020

No 2289 / June 2019

Abstract

Exploiting confidential data from the euro area, we show that sound banks pass on negative rates to their corporate depositors without experiencing a contraction in funding and that the degree of pass-through becomes stronger as policy rates move deeper into negative territory. The negative interest rate policy provides stimulus to the economy through firms' asset rebalancing. Firms with high cash-holdings linked to banks charging negative rates increase their investment and decrease their cash-holdings to avoid the costs associated with negative rates. Overall, our results challenge the common view that conventional monetary policy becomes ineffective at the zero lower bound.

JEL: E52, E43, G21, D22, D25.

Keywords: monetary policy, negative rates, lending channel, corporate channel

Non-technical summary

A tenet of modern macroeconomics is that monetary policy cannot achieve much once interest rates have already reached their zero lower bound (ZLB). Interest rates cannot become negative because market participants would just hoard cash instead. Thus, when short-term interest rates approach zero, central banks cannot stimulate demand by lowering short-term interest rates and the economy enters in a liquidity trap.

This paper challenges this conventional wisdom by showing that banks can charge negative rates on a significant portion of their deposits, especially if they have sound balance sheets. A ZLB may exist for household deposits, which, being relatively small, may be easily withdrawn and held as cash. However, corporations cannot as easily conduct their operations without deposits. This paper shows, using confidential balance sheet data, that relatively sounder banks in the euro area were more likely to charge negative rates on corporate depositors after the European Central Bank (ECB)'s Deposit Facility Rate (DFR) became negative in June 2014.

We conjecture that the transmission from policy to deposit rates below the ZLB is not necessarily impaired, in particular if banks are sound. Low interest rate periods coincide with high demand for safe assets and low investment and consumption. Since economic agents with large cash holdings, such as corporations, cannot easily switch to paper currency, banks can respond to the demand for safe assets by charging negative interest rates on deposits.

We show that sound banks are more inclined to charge negative rates once the ECB policy rates turn negative. In addition, banks do not experience a decrease in deposits even if they charge negative rates. Deposits increase in sound banks, which tend to offer negative interest rates on deposits during this period.

These findings have important implications for the transmission mechanism of monetary policy. The transmission mechanism is not impaired when banks are able to transfer negative rates on deposits. Because overall deposits do not decrease for banks offering negative rates, the cost of funding of these banks decreases. Consequently, banks that pass negative rates on to depositors are able to increase their lending.

We show that in addition to the lending channel, a corporate finance channel of monetary policy also emerges below the ZLB. Firms that have relationships with banks that offer negative rates on deposits are more exposed to negative rates if they hold a lot of cash. These firms appear to lengthen the maturity of the assets to improve their profitability. Thus, they decrease their short-term assets and cash and increase their fixed investment. In summary, our findings suggest that a ZLB arises only if agents lack confidence in the banking system and deposits shrink when the interest rate approaches zero. For sound banks, the transmission mechanism appears to be unaffected even when interest rates turn negative. Not only do sound banks pass the negative rates on the corporate depositors, but the transmission mechanism is enhanced by the fact that firms whose deposits are more exposed to negative rates decrease their liquid asset holdings and start investing more in fixed assets (both tangible and intangible). Thus, in contrast to the conventional wisdom, we find that, when banks are sound, the NIRP can effectively stimulate the real economic activity by influencing the behaviour of both banks and firms.

1. Introduction

Severe downturns normally require ample monetary policy accommodation through substantial cuts in policy interest rates. During the last 40 years, central banks in industrialised countries – such as the Fed, the ECB, and the Bank of Japan – have usually cut rates by around 4% in response to recessions. However, in an environment of low inflation and near zero interest rates, as the one prevailing in advanced economies, constraining policy rates to be in the positive territory would significantly limit the policy space. Accordingly, with policy rates hitting the so-called zero lower bound (ZLB), starting from 2012, central banks in Switzerland, Sweden, Denmark, Japan and the euro area have moved their key policy rates below zero. Yet, there is no agreement in the economic profession on the effectiveness of negative interest rate policies (NIRP).

Theoretically, there is uncertainty about the effectiveness of monetary policies below the ZLB. On the one hand, both in academic and policy circles, some argue that monetary policy becomes ineffective below the ZLB. Banks would not be able to lower interest rates on deposits, which often represent their main source of funding, below zero, because market participants would rather hoard cash. Thus, when short-term interest rates approach zero, central banks would not be able to stimulate lending and demand by lowering short-term interest rates (see, e.g., Keynes, 1936; Krugman, 1998; Eggertsson and Woodford, 2003; Christiano, Eichenbaum, and Rebelo, 2011; Summers, 2015; Correia, Farhi, Nicolini, and

Teles, 2013). Moreover, NIRPs could be contractionary because negative rates reduce banks' profits and lead banks to reduce lending (Brunnemeier and Koby, 2018; Eggertsson, Juelsrud, Summers, and Wold, 2019).[1]

On the other hand, Rogoff (2016 and 2017) argues that the ZLB constraint should not be considered as a law of nature: negative rate policies can work pretty much as "central bank business as usual", at least with some corrective legal, regulatory and tax changes, including especially mechanisms to increase the cost of hoarding cash when central banks move into negative territory.[2]

Ultimately, it is an empirical question whether the zero lower bound constitutes a black hole upending the laws of economics or can unlock self-imposed constraints and make policy response equally effective in negative territory. Limited experience of NIRPs and data availability have so far prevented researchers from systematically answering this question.

This paper contributes to this debate by providing new stylized facts that can inform theories of monetary policy at and below the zero lower bound. We present three main pieces of empirical evidence.

First, we investigate how the pass-through of monetary policy to interest rates on corporate deposits varies when the central bank moves into negative territory.

[1]The Governor of the Bank of England uses similar arguments in a speech criticizing NIRPs. See "Redeeming an unforgiving world", 8th Annual Institute of International Finance G20 conference, Shanghai Friday 26 February 2016.
[2] See also Lilley and Rogoff (2019), Agarwal and Kimball (2015) and Buiter and Panigirtzoglou (2003).

We concentrate on corporate rather than household deposits, because the latter are often subject to regulatory and political constraints that prevent rates from going below zero. More importantly, most household deposits are small and banks can charge fees, which are significantly more opaque, rather than varying interest rates.[3] For these reasons, the question of whether banks can transfer negative rates onto deposits is most relevant for large deposits, such as corporate deposits.

Using the European Central Bank (ECB)'s NIRP and confidential data, we find that on average the pass-through was significantly reduced when policy rates hovered either side of the zero lower bound, but that it increased again after the ECB moved more decisively into negative territory. While on average the pass-through remains lower than in periods of positive rates, there are important cross-sectional differences. Above the zero lower bound, on average all banks pass on 100% of the policy interest rate cut within 12 months. This pattern is basically unchanged for sound banks, such as investment-grade banks, once policy rates move well into negative territory and the NIRP presumably ceased to be considered a short-term policy. The transmission mechanism appears to be impaired for less healthy banks.

As a result of the different pace of pass-through, an increasing number of investment grade banks and more generally sound banks start charging negative rates on corporate deposits after the start of the NIRP. A few banks even lower the

[3] All banks in the euro area were able to increase fees on deposits during our sample period.

interest rate on corporate deposits below the policy rate. Importantly, sound banks do not experience deposit outflows even if they charge negative rates. On average, deposits increase during the NIRP period, as is consistent with high demand for liquidity and safe assets. This is the case even controlling for banks' excess liquidity in order to account for the effects of quantitative easing on bank deposits. Deposits appear to increase to a somewhat larger extent in sound banks, which are more likely to impose negative interest rates on corporate deposits during this period.

Since there has been no broad-based outflow of deposits from banks charging negative rates, which instead appear to have attracted new deposits, the overall cost of funding of sound banks has decreased. Thus, as we show, banks charging negative rates extend relatively more credit. These results suggest that the ECB has not yet reached the reversal rate, at which the negative effect of a lower interest rate on bank profits may lead to a contraction in lending and economic activity (Brunnermeier and Koby, 2016).

Second, we show that bank behaviour has important consequences on investment. Firms that have relationships with banks that impose negative rates on deposits are more exposed to negative rates if they hold lots of cash. These firms increase their fixed investment and decrease their short-term assets and cash. We dub this novel transmission mechanism, whereby negative rates on bank deposits spur investment, the *corporate channel* of monetary policy.

Third, we find that while banks with higher pass-through to deposit rates are able to decrease their funding costs and extend more loans, clients with low current reserves of cash on average do not invest but increase their cash-holdings as insurance to future shocks. This indicates that due to firms' precautionary behaviour, the lending channel of monetary policy loses effectiveness and does not produce real effects below the zero lower bound.

In sum, our findings suggest that although the transmission mechanism of monetary policy might change, it is not impaired if banks are sound. Sound balance sheets appear to confer market power to banks, which consequently are better able than other banks to pass interest rates cuts onto deposit rates. Not only do sound banks pass the negative rates onto corporate depositors and keep lending, but the transmission mechanism is enhanced by the fact that firms with large cash-holdings more exposed to negative rates decrease their liquid asset holdings and invest more. Put differently, in uncertain times, negative deposit rates increase firms' cost of hoarding cash and stimulate investment.

Our findings shed light on why low and negative rates do not appear to adversely affect bank profitability (Altavilla, Boucinha, and Peydro, 2018; Lopez, Rose and Spiegel, 2018). By fostering investment, the NIRP has positive effects on the economy and boosts credit quality thus offsetting the direct negative effect

on intermediation margins.[4] While we cannot exclude that for even lower policy rates corporations may start hoarding cash, our results indicate that the ECB has not yet met an effective lower bound (ELB) and that NIRPs can be effective when the cost of cash hoarding is sufficiently high (Rogoff, 2016, 2017). Our findings are therefore consistent with the implications of theoretical models highlighting that for low levels of the elasticity of currency demand, monetary policy can be effective below the zero lower bound (Ronglie, 2016).

To the best of our knowledge, this is the first paper to question the existence of a ZLB for bank deposits and to highlight the role of firms' cash-holdings in the transmission of monetary policy. Increases in corporate savings have been associated with a dearth of corporate investment and weak macroeconomic performance (Sanchez and Yurdagul, 2013; Summers, 2015). Existing theoretical and empirical literature highlights that in uncertain environments, firms delay investment and hoard cash (e.g., Bernanke, 1983; Bates, Kahle, and Stulz, 2009) and that changes in the cost of holding cash (deposits in our context) may give firms stronger incentives to invest (Azar, Kagy, and Schmalz, 2016). We show that, by increasing the cost of holding cash, negative rates on deposits make delaying investment less desirable and favor the transmission mechanism of monetary policy. These effects may be further strengthened by managers' and

[4] In a recent interview, the President of the European Banking Federation expresses views favorable to the NIRP consistent with this narrative (Financial Times, October 2, 2019).

entrepreneurs' behavioral biases, associated with the fact that negative rates force firms to pay to store cash, thus turning the principles of finance on their head.

Our paper also contributes to a growing literature scrutinizing the transmission mechanism of monetary policy. A large literature shows that banks cut the supply of credit when monetary policy conditions become tighter: the so-called bank lending channel of monetary policy (e.g., Bernanke and Blinder 1988; 1992). Typically, weak banks, being financially constrained, are expected to have stronger reactions both to conventional and unconventional monetary policy interventions (Kashyap and Stein, 2000; Jimenez, Ongena, Peydro, and Saurina, 2012; Altavilla, Canova, and Ciccarelli, 2020). A recent paper of Acharya, Imbierowicz, Steffen and Teichmann (2020) shows that central bank liquidity, offered through the ECB's marginal refinancing operations, lowered deposit rates, but not syndicated loan rates for risky banks. We show that below the ZLB, only healthy banks pass-through changes in policy rates onto corporate depositors. Thus, the transmission mechanism is enhanced for stable banks.

Empirical studies of NIRPs are scant because this was largely untested territory before 2014. Heider, Saidi, and Schepens (2019) argue that banks with a higher proportion of funding from household deposits have lower propensity to issue safe syndicated loans, when rates turn negative. Using aggregate Swedish data, Eggertsson, Juelsrud, Summers, and Wold (2019) document that deposit and

lending rates do not follow policy rates, when the latter turn negative.[5] However, Bottero et al. (2019) find that Italian banks with more liquid assets increased the supply of credit following the start of the NIRP.[6] None of these papers considers banks' propensity to pass negative rates onto corporate deposits and the effects of the latter on the transmission mechanism.

2. Institutional Background

From 2012 to 2016, central banks in Switzerland, Sweden, Denmark, Japan and the euro area reduced their key policy rates below zero for the first time in economic history. These policies allow us to test the ZLB assumption, which is central to macroeconomic theory. In particular, the ECB, which is at the core of our analysis, successively reduced the deposit facility rate (DFR) five times in negative territory: from 0 to -0.10% in June 2014, to -0.20% in September 2014, to -0.30% in December 2015, to -0.40% in March 2016, and to -0.50% in September 2019.

The DFR is the rate on the deposit facility, which banks use to make overnight deposits with the Eurosystem. While the ECB also sets the rate on the marginal lending facility (MLF) and the rate on the main refinancing operations (MRO), the DFR becomes the key policy rate during periods of ample central bank

[5] Evidence from Riksbanken reports, however, suggests that the NIRP has been effective over the long run (Erikson and Vestin, 2019).
[6] Demiralp, Eisenschmidt, and Vlassopoulos (2017) and Basten and Mariathasan (2018) provide similar evidence for the euro area and Switzerland, respectively.

liquidity provision. A bank that has excess liquidity can either deposit it with the ECB or lend it to another bank in the system, and, for this reason, the unsecured overnight interbank interest rate (Eonia) moves towards the DFR.[7] The interest rate at which banks are able to deposit their excess liquidity is therefore the relevant variable in determining banks' costs. The introduction of the ECB's expanded Asset Purchase Programme (APP) at the beginning of 2015 further increased the volume of excess liquidity in the system, thereby reinforcing the key role of the DFR.

The euro area represents an ideal environment to explore whether a troubled banking system lies at the core of the problems generated by low interest rates for the transmission of monetary policy. Such a hypothesis has been advanced to explain the persistence of liquidity traps in the US during the Great Depression, as well as in Japan, following the bubble burst of the late nineties (Bernanke, 1983; Krugman 1998). However, while in the US and Japan most banks were troubled (preventing cross-sectional analysis), the euro area features ample cross-sectional heterogeneity also driven by the different economic conditions of the countries

[7] Excess liquidity is defined as deposits at the deposit facility net of the recourse to the marginal lending facility, plus current account holdings in excess of those contributing to the minimum reserve requirements. In periods of neutral liquidity allotment, i.e., the liquidity management framework of the Eurosystem used before the crisis, Eonia fluctuated around the MRO rate, thereby making this rate the key policy interest rate for the transmission of monetary policy to the money market.

where banks operate following the sovereign crisis in Cyprus, Greece, Ireland, Italy, Portugal, Slovenia, and Spain (hereafter, the "stressed" countries).[8]

Starting in 2009, the stressed countries drifted into a severe crisis as anxiety about their high indebtedness made it increasingly difficult to refinance outstanding debt. This deterioration in the countries' creditworthiness fed back into the financial sector also due to banks' large domestic sovereign exposures (see, e.g., Acharya, Drechsler, and Schnabl, 2014; and Acharya and Steffen, 2015). The drop in the price of domestic sovereign bonds represented a negative valuation shock for banks' balance sheets in stressed countries. As a consequence, banks contracted lending causing large negative effects on domestic borrowers (Altavilla, Pagano, and Simonelli, 2017; Acharya, Eisert, Eufinger, and Hirsch, 2018). The sovereign crisis had opposite effects on German government bonds and the bonds of countries that were perceived as financially sounder, whose prices surged as a result of investors' flight to safety. Therefore, most banks in non-stressed countries were less affected than banks in stressed countries. The resulting large heterogeneity in banks' health at the beginning of the NIRP enables us to explore how these cross-sectional differences affect bank reactions to negative rates.

[8] We define as "stressed" the countries whose 10-year sovereign yield exceeded 6% (or, equivalently, four percentage points above the German yield) for at least one quarter in our sample period.

3. Data

Our empirical analysis relies on several data sources. We obtain information on deposits and lending rates from the Individual Monetary and Financial Institutions Interest Rates (IMIR), a proprietary dataset maintained by the ECB, which contains information on deposits and lending rates charged by banks from August 2007 to November 2019. We obtain additional bank level information from the Individual Balance Sheet Indicators (IBSI), another proprietary database maintained by the ECB, which reports the main asset and liability items of over 300 banks resident in the euro area at monthly frequency. This dataset provides information on the amount of outstanding loans, household and corporate deposits, and other relevant bank balance sheet information. Finally, we complement IMIR and IBSI with information on bank ratings from Bloomberg and CDS spreads from Datastream.

Panel A of Table 1 summarizes the rich set of bank characteristics that we obtain from merging the above datasets. Covering a total of 202 banks, our sample provides comprehensive coverage of banks in the euro area and has more extensive coverage than the stress tests of 2014, which only covered about 100 banks.

We also obtain firm level data from Bureau Van Dijk's Orbis, which provides financial information for listed and unlisted companies worldwide. Importantly, Orbis provides information on the names of the most important banks of a firm in

the following 12 euro area countries: Austria, Estonia, France, Germany, Greece, Latvia, Lithuania, Luxembourg, Malta, the Netherlands, Portugal, and Spain. We exclude euro area countries, such as Italy, for Orbis does not report banks.

As noted by Giannetti and Ongena (2012) and Kalemli-Ozcan, Laeven, and Moreno (2018), Orbis obtains information on firms' main banks from Kompass, which collects data using information provided by chambers of commerce and firm registries, but also conducts phone interviews with firm representatives. Firms are also able to voluntarily register with Kompass. Kompass directories are mostly sold to companies searching for customers and suppliers. Hence the banks reported are most likely to be the ones in which firms have deposits and receive payments. Since they have numerous customers and suppliers, firms are unlikely to switch these banks. More importantly, firms are reluctant to switch bank because they typically obtain credit and a wide range of other services from their banks besides deposits (Santikian, 2014). In fact, banks' ability to take deposits and deal with the customers' payments is considered to be at the origin of banks' information advantage (Fama, 1985). Fears of endangering lending relationships may make firms particularly reluctant to withdraw deposits from sound banks. Thus, even if we do not observe firms' actual deposits and outstanding credit, we expect firms to have both deposits and credit lines with their main banks.

Our final firm level sample consists of an unbalanced panel of 473,213 firms for 12 years from 2007 to 2018, and 121 banks, 708 4-digit NACE2 core industry

classifications, and 27,945 city locations.[9] Panel B of Table 1 summarizes the main variables of the firm-level dataset.

Overall, our sample is highly representative of aggregate and cross-sectional patterns in the euro area. In this respect, it allows us to analyze the real effects of monetary policy, relying on a sample with unprecedented coverage. Other work, which has attempted to do so considering several countries in the euro area (e.g., Acharya, Eisert, Eufinger, and Hirsch, 2019) relies on borrowers in the syndicated loan market, thus considering only few large firms.[10]

While we do not observe how much deposits or credit a firm has with a particular bank, we assume that firms that report institutions that charge negative rates on deposits as main banks are more exposed to the NIRP and that their exposure increases in their cash-holdings.

Not observing actual credit exposure is not a significant limitation in our context. As will be clear later, we find limited evidence that the real effects of the NIRP arise from the lending channel. We instead highlight a channel in the transmission mechanism of monetary policy that goes through firms' cash-holdings. Our firm-level dataset is well suited to explore this mechanism.

[9] The composition and construction of our sample is similar to Kalemli-Ozcan, Laeven, and Moreno (2018).
[10] Syndicated loans extended to firms in the euro area represent less than 10% of the outstanding amount of bank loans. Our sample of banks covers, instead, around 70% of the total bank loan outstanding in the euro area.

4. The Transmission of Monetary Policy Shocks to Deposit Rates

4.1 Developments in interest rate pass-through

In aggregate, deposits are the most important source of financing for European monetary financial institutions (MFIs) and have been growing even during the period of negative interest rates. The importance of deposits for bank funding in Europe makes concerns regarding the impairment of the transmission mechanism of monetary policy at negative rates particularly relevant. Banks being fearful of losing their most important source of funding may be wary of lowering the interest rate on deposits below zero (Eggertsson, Juelsrud, Summers and Wold, 2017). Negative rates could then impair bank profitability leading to a contraction in lending.

To evaluate whether and under what conditions this may be the case we study how the pass-through of monetary policy to deposit rates varies depending on the monetary policy stance. To allow for delayed responses, we estimate impulse response functions for individual banks' corporate deposit rates to changes in the DFR using local projection models (Jorda, 2005). We allow for a delayed response up to 12 months.

Figure 1 presents the impulse response functions. Panel A considers positive rates periods and shows the average dynamics of deposit rates offered by banks on corporate deposits subsequent to the cuts of the DFR up to June 2012 when the level of the DFR was 0.25%. It is evident that starting from eight months after the

change in the DFR nearly 100% of the cut is transmitted to the rates offered on corporate deposits.

As shown in Panel B, this pattern changes dramatically once the policy rate is around the ZLB. When the DFR is between 0.2 and -0.2, that is, up to June 2014, there appears to be very little pass-through to corporate deposit rates. In particular, the pass-through is estimated not to be significantly different from zero up to six months after the initial cut and even afterwards only 20% of the policy interest rate cuts seems to be transferred onto corporate deposits by the average bank. This evidence seems to suggest the existence of a hard ZLB.

Panel C, however, shows that the pass-through to corporate deposit rates increases again as the ECB moves further into negative territory, when the NIRP arguably stops being regarded as a temporary policy. On average, however, even after 12 months only about 50% of the policy rate cut is passed onto corporate deposits, thus on average the pass-through remains significantly lower than when policy rates were firmly into positive territory.

The evidence that banks' reaction is stronger as the ECB moves more into negative territory suggests that the NIRP has yet to meet an ELB. Rather, it appears that the incentives to pass-through negative rates may have been enhanced by the large liquidity injections that started at the beginning of 2015

with the implementation of the APP and by market participants' expectations regarding the persistence of negative rates.[11]

Panel D to F of Figure 1 shows similar patterns for the pass-through of monetary policy to lending rates. If anything, the degree of pass-through is even larger. We consider, however, the evidence on lending rates as merely suggestive because lending rates depend, not only on the cost of bank funding, but also on borrower quality. The increasing rationing of riskier borrowers as the economy deteriorates and rates move further into negative territory could explain the patterns. For this reason, in what follows, we focus on deposit rates. We reconsider the evidence on the lending channel using our firm level dataset, in which we can better control for borrower quality.

To shed light on the determinants of pass-through to deposit rates, we explore cross-sectional differences between banks. We consider that, in periods of high demand of safe assets, sound balance sheets may confer market power on banks with respect to their ability to set corporate deposit rates. Market power should imply higher pass-through to corporate deposits when policy rates decrease into negative territory because accepting deposits implies higher costs for banks if they need to deposit liquidity with the central bank at the negative DFR. This contrasts with what occurs when policy rates are positive, when a lower pass-

[11] Anecdotal evidence from Denmark and Switzerland suggests that the gradual tendency to lower interest rates on deposits below zero, as it becomes clear that negative policy rates are likely to persist for long periods of time, is not limited to the euro area. See, for instance, "Denmark's Jyske Bank imposes negative interest rates" in the Financial Times on August 20, 2019.

through is considered a manifestation of market power in the deposit market (Drechsler, Savov, and Schnabl, 2017).

Figure 2, Panels A to C consider investment grade banks, approximately 54% of the observations in our sample, as safe and all remaining banks as risky. When policy rates are above the ZLB and the demand for safe assets is presumably lower, the degree of pass-through is indistinguishable for investment grade and other banks and is significantly reduced for both groups of banks in the vicinity of the ZLB, when arguably the NIRP was viewed as temporary. When the ECB moves more decisively into negative territory, however, the extent of pass-through of investment grade banks increases considerably and appears just slightly lower than the extent of pass-through in positive territory.

Overall, these findings suggest that safe banks may have particularly strong market power when a weak economy requires NIRPs. A reason for safe banks' market power is that corporate treasurers are advised to deposit liquidity in banks whose deposits have high ratings.[12] In addition, strong relationships with safe banks may be good insurance for firms in case their financing needs were to increase in the future.

We also consider whether bank behaviour may be driven by concerns about the ability to substitute corporate deposits with other sources of funding. Figure 2,

[12] See "Deposit Ratings: Why Treasurers Need to Use Them", retrieved from the Association of Financial Professionals https://www.afponline.org/ideas-inspiration/topics/articles/Details/deposit-ratings-why-treasurers-need-to-use-them/ on October 16, 2019.

Panels D to F find no evidence that this is the case. If anything, banks with a proportion of liabilities funded by corporate deposits above the median always have higher degree of pass-through. Thus, the conversion of deposits to cash emphasized in many influential macroeconomic theories does not appear to be able to explain differences in bank behaviour.

4.2 Which banks decrease their deposit rates below zero?

The previous subsection shows that when the ECB moved deeper into negative territory, substantial differences in pass-through between banks emerged. Since our data show that all banks offered practically the same level of interest rates on corporate deposits during the earlier periods, we wonder to what extent differences in behaviour lead some banks but no others to break the zero lower bound. This analysis also allows us to investigate whether bank health is the most salient feature explaining differences in bank behaviour in a multivariate analysis.

Figure 3 reports the mean interest rate on the deposits of non-financial corporations within different percentiles. We distinguish between interest rate adjustments on the stock of all deposits (Panel A) and interest rates on new deposits with agreed maturity up to 1 year (Panel B). Not only do a few banks appear to charge negative rates on deposits following the ECB's decision to lower the DFR below zero, but a few also charge interest rates that are below the DFR on new deposits from non-financial corporations, as shown in Panel B.

The conventional wisdom that interest rates on deposits do not fall below zero appears to still hold for the median bank in the euro area. Nevertheless, the interest rates turn negative on an economically significant fraction of deposits of banks in the euro area, as shown in Panel A of Figure 4, which presents the distribution of corporate deposit rates across banks in the euro area, weighted by deposit volume as of January 2019. As shown in Panel B of Figure 4, at the end of 2014, a few months after the ECB had lowered the DFR below zero, less than 10 percent of the deposits of non-financial corporations in the euro area were charged negative rates, while by the end of 2019 the share had increased to a quarter.[13]

Irrespective of the aggregate proportion of deposits affected, to understand under what conditions the NIRP can be effective, it is important to ask how differences in banks' abilities to lower the interest rates on corporate deposits below zero are related to their propensities to pass-through changes in policy rates. In particular, if bank health confers market power, we would expect that the banks charging negative rates on corporate deposits are healthier than average even after controlling for other banks' characteristics.

In Table 2, we consider how bank characteristics in our monthly panel are associated with the probability that a bank starts charging negative rates after June

[13] Around 80% of the deposits of non-financial corporations in the euro area are overnight deposits. The segment of deposits with agreed maturity has been progressively shrinking as monetary policy interventions flattened the yield curve. Lower interest rates at longer maturities eliminated the advantage of holding deposits with agreed maturity and consequently firms opted for overnight deposits. All the effects we highlight can therefore be ascribed to overnight deposits.

2014. Since we are interested in cross-sectional differences, we cluster errors at the bank level. We also cluster standard errors at the time level to account for the fact that banks respond to the same monetary policy shocks. For the same reason, we include time fixed effects in all specifications.

Column 1 shows that on average banks in non-stressed countries are more likely to charge negative rates on corporate deposits. The effect is not only statistically significant, but also economically large. The probability is expressed in percentage points. Overall, during our sample period, which starts in 2007, well before the NIRP, 2.5% of the observations correspond to banks that charge negative rates. Being in a stressed country thus decreases the probability of charging negative rates by over 100% relative to the sample mean.

Consistent with our earlier results, this effect appears crucially related to bank health, which we proxy in columns 2, 3 and 4, respectively, using a dummy capturing banks without an investment grade rating, CDS spreads, and the proportion of non-performing loans (NPL). Only banks that are more solid, as captured by an investment grade rating, a lower default risk (CDS spread), or a lower proportion of NPL impose negative interest rates on corporate deposits.

The effects are both statistically and economically significant. The probability that a bank charges negative rates on corporate deposits drops by over 150% for banks without an investment rating. Similarly, a one-standard-deviation increase in CDS spreads decreases the probability that a lender starts charging negative

rates during the sample period by almost 40%. A one-standard-deviation increase in the share of NPL (amounting to an increase of 10 percentage points) implies a decrease in the probability of starting to charge negative rates of 0.5 percentage points, which is an over 60% decrease relative to the average of the sample.

The economic relevance of bank health is even more evident in Figure 5, in which we explore how the probability of our proxies for bank health is associated with negative interest rates on deposits dynamically, by estimating repeated cross-sections. It is evident that the effects become larger over time. Thus, this figure confirms that the effects of the NIRP are gradual and that the ECB has yet to meet an ELB.

In the rest of Table 2, we control for time-varying bank characteristics and in addition include country fixed effects in columns 7 and 8. Our conclusion that bank health is an important determinant for the pass-through of monetary policy on depositors when rates turn negative is also robust to the inclusion of bank fixed effects.

In columns 5 to 8, we also control for the proportion of corporate deposits over bank assets, which appears unrelated to banks' probability of charging negative rates on corporate deposits. We also control for the banks' excess liquidity. Consistent with the fact that the profits of banks with high excess liquidity are more negatively affected when the DFR drops, these banks are more likely to impose negative rates. In our sample, healthier banks tend to have higher excess

liquidity and may therefore be better able to impose negative rates on deposits. The effect of our proxies for bank health is however unchanged when we control for excess liquidity, indicating that, holding constant incentives to charge negative rates to safeguard profits, healthy banks are able to do so to a larger extent.

Such an intuition is confirmed in column 8, which illustrates in a more direct way the importance of bank health. The positive effect of a bank's investment grade on the probability of charging negative rates increases with the bank's excess liquidity. In principle, all banks with high excess liquidity would want to charge negative rates on deposits. The positive coefficient on the interaction term between the investment grade bank dummy and excess liquidity indicates that healthy banks are better able to transfer negative rates onto deposits, as is consistent with our earlier interpretation of the empirical evidence.

Overall, Table 2 suggests that healthy banks that have high pass-through of monetary policy shocks to deposit rates are more likely to charge negative rates on deposits. It is thus relevant to ask how the NIRP is transmitted to the real economy.

4.3 Negative rates and outstanding corporate deposits

The evidence so far indicates that sound banks succeed in passing negative rates onto their corporate depositors. Does this lead to outflows of corporate deposits?

Table 3 shows that, if anything, deposit growth is higher after banks start imposing negative rates on deposits. Consistent with the conjecture that bank health is important, we find that high-NPL banks experience lower deposit growth in the months following the implementation of the NIRP.

Importantly, in column 3 and 4, this result holds when we control for the change in excess liquidity experienced by the bank over the same period. This is important because over this period the ECB also implemented direct asset purchases that contributed to increase liquidity and deposits. While these effects should have affected all banks, some banks may have been more affected. Even taking account this effect, however, we observe that banks do not experience large deposit outflows when they start charging negative rates.

We also ask whether the deposits of banks that eventually charge negative rates always had different growth rates. For this reason, we consider the change in deposits in the period leading to the NIRP, between 2012 and 2014. Since during this period no bank charged negative rates on corporate deposits, instead of the *Bank Charges Negative Rates* dummy, our variable of interest is a dummy that takes value equal to one for banks that have high pass-through and will eventually charge negative rates. In column 5, we find no evidence that these high pass-through banks had different deposit growth before the NIRP.

5. The Real Effects of Negative Rates

5.1 Main results

Bank behaviour may affect firms through their assets and liabilities. Banks that manage to transfer negative rates onto their depositors may be more inclined to extend credit. Negative rates can however also affect firms' asset composition, because they increase the cost of holding cash. Friedman (1969) suggests considering cash as any other factor of production: When it costs more there will be greater incentives to substitute for other production resources. When interest rates on deposits are sufficiently low, the net benefit of hoarding cash and procrastinating investment becomes lower than the expected payoff from investment (Bernanke, 1983b). We label this mechanism of transmission as the *corporate channel of monetary policy*. It is an empirical question whether firms prefer to incur the transaction costs of holding paper currency, which we would observe in their balance sheet as cash, or if they rather prefer to invest.

Our large panel of firms allows us to control for shocks faced by different firms similarly to Acharya, Eisert, Eufinger, and Hirsch (2018), who in turn apply a modified Khwaja and Mian (2008) methodology. We conjecture that shocks affect firms based on industry and location.[14] Overall, our sample includes firms in 715 four-digit industries and 27,598 cities. We saturate our specifications including interactions of industry and time fixed effects, interactions of city and

[14] Degryse et al (2019) suggest that this methodology works at least as well as widely used methodologies identifying supply only from firms with multiple banks relationships.

time fixed effects and even interactions of city, industry and time fixed effects. Our identifying assumption is that any shocks affect firms in the same cluster similarly.

Table 4 explores whether firms associated with banks with high pass-through rates, which we identify as those that will eventually charge negative rates on corporate deposits, are able to use more financial loans and whether this has positive real effects. Column 1 tests whether following the NIRP (as captured by the dummy variable *Post*) firms that report a relationship with at least one high pass-through bank, which we identify as a bank that will eventually charge negative rates on deposits, have higher access to financial loans. We include firm fixed effects to absorb persistent differences in leverage and interactions of industry, country, and time effects to control for country-specific industry level shocks affecting firms' creditworthiness, demand for credit and the like. We also include a dummy that takes a value of one starting from the year in which a bank starts to charge negative rates.

The estimates in columns 1 and 2 indicate a small positive effect of the NIRP on access to financial debt for clients of banks with high pass-through. The result is robust as we increasingly saturate the equation by including interactions of city and time effects in column 2. These findings suggest that demand shocks related to industry or geographical growth opportunities are unlikely to drive our findings

and that the increase in the use of financial debt by firms is likely to be supply-driven.

In columns 3, however, we fail to identify an analogous positive effect on investment, measured as the annual growth rate of fixed assets. Firms however appear to invest more when their bank starts charging negative rates, a behaviour that we do not find to be associated with better access to financial debt. This finding would suggest that while high pass-through banks extend more credit, there are no real effects associated with the lending channel. Nevertheless, the NIRP may have real effects. Because firms typically also have deposits at their main banks, we can explore whether there are any differential effects related to the fact that the clients of banks imposing negative rates on deposits are taxed on their cash-holdings.

We conjecture that firms with ex-ante high cash-holdings should experience a larger drop in the net benefit of hoarding cash when one of their banks starts charging negative rates on deposits. To capture this, we define a variable, *Exposure,* measured as the proportion of assets held as cash-holdings (current assets) of firms associated with banks that charge negative interest rates on deposits. These firms are taxed for their cash-holdings and may want to rebalance their assets and decrease their cash-holdings to avoid the negative rates. By construction, *Exposure* is zero for firms without a bank that is currently charging negative rates on deposits.

When we include *Exposure* in our empirical models in columns 4 to 6 of Table 4, we find that firms with higher cash-holdings that are charged negative rates on their deposits subsequently increase their investment. Columns 5 and 6 show that firms with ex ante high cash-holdings that are associated with negative deposit rate banks decrease their cash-holdings and increase their investment. Quite to the contrary, firms, which are associated with negative rates banks and have ex ante low cash-holdings, tend to increase their cash-holdings. Importantly, this result is obtained controlling for the direct effect of the cash-holdings. Thus, the coefficient on *Exposure* only captures the differential reactions of firms that have high cash-holdings and are associated with banks that charge negative rates on deposits.

Since the real effects appear to be driven by the increase in the cost of holding cash, rather than by the increase in access to financial loans, in what follows, we concentrate on the direct effects of negative rates on deposits, that is, the corporate channel of monetary policy, abstracting from the lending channel. To abstract from the lending channel, we include in all specifications interactions of bank and time fixed effects. We thus fully absorb banks' increased ability to provide credit and control non-parametrically for the fact that healthier banks may serve firms with stronger growth opportunities (Schwert, 2018). We explore how the clients of a given lender react to the NIRP depending on their cash-holdings and the lender's propensity to charge negative rates on deposits.

Since we control for the direct effect of cash-holdings, our estimates only capture cross-sectional differences in reactions between firms with different levels of cash-holdings associated with the same bank. This allows us to exclude alternative explanations that would attribute differences in investment behaviour to either bank characteristics or firms' cash-holdings. Alternative explanations, which do not rely on differences in the cost of holding cash of firms with different banks, would not be able to account for the differential reactions of firms.

Columns 1 to 3 in Panel A of Table 5 provide further evidence on our conjecture that firms with more cash-holdings, which are subject to negative rates on their deposits, rebalance towards fixed assets by investing more. We continue to find that firms that turn out to have higher exposure to the NIRP increase their investment after we control for interactions of bank and time fixed effects. The effect is not only statistically, but also economically significant. A one-standard-deviation increase in cash-holdings increases investment for the average firm associated with a negative rate bank by about 70%.

Column 2 allows for the possibility that these firms are in industries that have higher investment opportunities. We thus include interactions of bank, time, and industry fixed effects. We continue to find that firms with high cash-holdings and banks that impose negative rates on deposits invest more and the effect is, if anything, larger. In the same spirit, column 3 allows for the possibility that some firms are in industries and cities experiencing more investment opportunities.

Including interactions of bank, time, industry, and city fixed effects further increases the positive effect on the investment of firms with high cash-holdings and banks imposing negative rates on deposits.

So far, we have considered firms to be exposed to negative rates if the firm reports at least one bank charging negative rates on deposits. Since the sample includes firms reporting more than one bank, in column 4, we focus on the subsample of firms reporting only one bank. Our results are qualitatively unchanged.

Panel B explores whether there are differences in the reaction between small and large firms. Large firms need more working capital and may therefore have a harder time converting their deposits to cash. On the other hand, small firms rely more on close relationships with their banks to maintain access to credit. For the same reason, they may be at least as reluctant as large firms to withdraw their deposits, because doing so could result in worse relationships with their banks. In column 1 and 2, we consider, respectively, small and large firms (defined as firms with total assets above and below the median). Small firms with high cash-holdings appear to have an even stronger reaction than large firms, suggesting that considerations related to the stability of bank-firm relationships are important.

5.2 Mechanisms

This subsection explores whether changes in firms' financial policies are consistent with the corporate channel of monetary policy. In particular, if greater investment is indeed due to firms rebalancing their assets away from cash, we should observe that firms' cash-holdings decrease.

Table 6 performs tests similar to Panel A of Table 5 considering the proportion of cash-holdings. Consistent with the corporate channel of monetary policy, the increase in investment is accompanied by a decrease in firms' cash-holdings.

Further supporting our interpretation that the real effects of the NIRP arise from ex-ante high cash-holdings firms' asset rebalancing, Table 7 shows that the increase in investment is driven by an increase in tangible and intangible assets, but that overall firms' total assets are unaffected.

One may wonder whether the changes in investment we observe are optimal. To answer this question, Table 8 considers how different measures of profitability vary for firms with ex-ante high cash-holdings that are clients of banks imposing negative interest rates, that is, for the firms that we have shown to invest more. The different indicators of profitability show that firms with high cash-holdings experience a small drop in profitability in the year in which their bank starts to charge negative rates and they increase investment. Profitability increases in the following years according to all our proxies.

These findings suggest that before the adoption of the NIRP, precautionary behaviour in the face of an uncertain economic environment led firms to hoard liquidity and apply a too high discount rate on investment opportunities (Bernanke, 1983b). Negative interest rates on deposits increase the cost of holding liquid assets and tilt the decision in favour of investing. This leads to increases in profitability, previously constrained by the decision of holding back investment.

Finally, Table 9 explores whether the corporate channel of monetary policy is specific to negative interest rate environments or is relevant following any interest rate cut. In particular, we test how high cash-holdings and an association with banks that have low rates on deposits affected investment after the policy rate cuts in the period 2009-2011 and during the low, but positive, DFR period from 2012 to 2013. We compare the effects with those on firms associated with banks that impose negative rates on deposits. To have a group of firms affected by low rates comparable to those affected by negative rates, we define as more exposed ex-ante high cash-holdings firms associated with banks offering deposits rates below the fifth percentile in each of the two previous time periods.

It appears that high exposure firms increase their investment and reduce their cash-holdings to a larger extent only when their banks start charging negative rates on deposits.[15] These estimates are consistent with the idea that negative rates on deposits make precautionary saving too expensive for firms and stimulate

[15] These results mirror the findings of Bottero et al (2019), who show that banks with high excess liquidity increase lending in times of negative rates, but not in low rates periods.

investment. It is unsurprising that we do not find similar effects when interest rates are above zero because in real option models (e.g., Bernanke 1983b), firms find it optimal to invest only when a net benefit of investment threshold is reached. Interest rates on deposits must be sufficiently low for firms to meet the threshold. Firms' incentives to invest may be further strengthened by managers' and entrepreneurs' behavioral biases associated with the fact that negative rates force firms to pay to store cash, thus turning the principles of finance on their head.

In summary, the NIRP has real effects that do not seem to be driven by better access to financial loans. Instead, firms with high cash-holdings associated with negative rates banks invest more thus stimulating the real economy.

6. Conclusions

This paper explores the transmission mechanism of monetary policy below the ZLB, a topic that is under-researched from an empirical point of view, because central banks in Switzerland, Sweden, Denmark, Japan, and the euro area have only recently moved their policy rates into the negative territory. However, breaking the so-called ZLB is likely to become more relevant in the future, given the secular trend of lower (natural) interest rates in advanced economies.

We show that sound banks are able to pass negative rates onto their corporate depositors without experiencing a contraction in funding. While banks charging

negative rates provide more credit than other banks, the real effects of the NIRP on firm investment are primarily associated with firms rebalancing their assets. Firms with high cash-holdings at banks imposing negative rates appear to increase their investment in tangible and intangible assets and to decrease their liquid assets to avoid the costs associated with negative rates.

Overall, our results suggest that the transmission mechanism of monetary policy is not impaired below the ZLB, even though it works differently. In normal times, monetary policy interventions are transmitted mostly by weak banks, whose financial constraints are relaxed to a larger extent, when policy interest rates drop. However, below the ZLB, healthy banks are better able to transfer negative rates onto their depositors than other banks.

The positive effects of the NIRP on the economy are thus stronger if banks are healthy and can charge negative rates on deposits. Mechanisms aiming to preserve banks' profitability and intermediation capacity in periods of negative rates may therefore be particularly desirable. With this goal, central banks in some jurisdictions (e.g., Japan, Switzerland, and, more recently, the ECB) have introduced various forms of tiering systems exempting part of the bank holdings of (excess) reserves from negative rates. To the extent that these mitigating measures improve bank health they will also increase the number of banks that may be able to transfer negative rates onto corporate deposits thus indirectly stimulating investment.

References

Acharya, V. V., I. Drechsler, and P. Schnabl. (2014). A Pyrrhic victory? Bank bailouts and sovereign credit risk. *Journal of Finance* 69, 2689–739.

Acharya, V. V., and S. Steffen. (2015). The greatest carry trade ever? Understanding eurozone bank risks. *Journal of Financial Economics* 115, 215–36.

Acharya, V. V., T. Eisert, C. Eufinger, and C. Hirsch. (2018). Real Effects of the Sovereign Debt Crisis in Europe: Evidence from Syndicated Loans. *Review of Financial Studies* 31, 2855–2896.

Acharya, V. V., T. Eisert, C. Eufinger, and C. Hirsch. (2019). Whatever It Takes: The Real Effects of Unconventional Monetary Policy. *Review of Financial Studies*, forthcoming.

Acharya, V. V., B. Imbierowicz, S. Steffen, and D. Teichmann. (2017). Does the Lack of Financial Stability Impair the Transmission of Monetary Policy? *Journal of Financial Economics,* forthcoming.

Agarwal, R., and M. Kimball. (2015). Breaking through the Zero Lower Bound. International Monetary Fund Working Paper 15/224.

Altavilla, C., F. Canova, and M. Ciccarelli (2020). Mending the broken link: heterogeneous bank lending and monetary policy pass-through, *Journal of Monetary Economics,* forthcoming.

Altavilla, C., M. Boucinha, J.-L. Peydro. (2018). Monetary policy and bank profitability in a low interest rate environment. *Economic Policy*, October, 533-583.

Altavilla, C., M. Pagano, S. Simonelli. (2017). Bank Exposures and Sovereign Stress Transmission, *Review of Finance*, 21, 2103–2139.

Azar, J. A., J. F. Kagy, M. C. Schmalz. (2016). Can Changes in the Cost of Carry Explain the Dynamics of Corporate "Cash" Holdings? *Review of Financial Studies*, 29, 2194–2240.

Basten, C., M. Mariathasan. (2017). How Banks Respond to Negative Interest Rates: Evidence from the Swiss Exemption Threshold CESifo Working Paper Series No. 6901.

Bates, T. W., K. M. Kahle, R. M. Stulz. (2009). Why Do US Firms Hold So Much More Cash than They Used To? *Journal of Finance*, 64, 1985–2021.

Bernanke, B. S. (1983). Nonmonetary Effects of the Financial Crisis in the Propagation of the Great Depression. *American Economic Review* 73, 257—276.

Bernanke, B. S. (1983b), Irreversibility, Uncertainty, and Cyclical Investment, *Quarterly Journal of Economics,* 98, 85–106.

Bernanke, B. S., and A. S. Blinder. (1988). Credit, Money, and Aggregate Demand. *American Economic Review* 78, 435–439.

Bernanke, B. S., and A. S. Blinder. (1992). The federal funds rate and the channels of monetary transmission. *American Economic Review* 82, 901–921.

Bottero, M., C. Minoiu, J.-L. Peydro, A. Polo, A. Presbitero, and E. Sette. (2019). Negative Monetary Policy Rates and Portfolio Rebalancing: Evidence from Credit Register Data, International Monetary Fund WP/19/44.

Brunnermeier, M. K. and Y. Koby. (2016). The reversal interest rate: An effective lower bound on monetary policy. Working Paper. Princeton University.

Buiter, W. H. and N. Panigirtzoglou. (2003). Overcoming the Zero Bound on Nominal Interest Rates with Negative Interest on Currency: Gesell's Solution. *Economic Journal* 113, 723–746.

Correia, I., E. Farhi, J.-P. Nicolini and P. Teles. (2013). Unconventional Fiscal Policy at the Zero Bound, *American Economic Review*, 103, 1172–1211.

Christiano, L., M. Eichenbaum and S. Rebelo. (2011). When Is the Government Spending Multiplier Large?, *Journal of Political Economy* 119, 78–121

Degryse, H., O. De Jonghe, S. Jakovljević, K. Mulier, and G. Schepens. (2019). Identifying credit supply shocks with bank-firm data. Methods and applications. *Journal of Financial Intermediation*, forthcoming.

Demiralp, S., J. Eisenschmidt, and T. Vlassopoulos (2017). Negative interest rates, excess liquidity and bank business models: Banks' reaction to unconventional monetary policy in the euro area, Koç University-TUSIAD Economic Research Forum Working Papers 1708.

Drechsler, I., A. Savov, and P. Schnabl. (2017). The Deposits Channel of Monetary Policy, *Quarterly Journal of Economics*, 132,1819–1876.

Eggertsson, G. B., and M. Woodford. (2003). The Zero Bound on Interest Rates and Optimal Monetary Policy, *Brookings Papers on Economic Activity*, 139–211.

Eggertsson, G. B., R. E. Juelsrud, L. H. Summers and E. G. Wold. (2019). Negative Nominal Interest Rates and the Bank Lending Channel, NBER Working Paper No. 25416.

Erikson, H., and D. Vestin. (2019). Pass-through at mildly negative policy rates: The Swedish case. VoxEU.org.

Fama, E., (1985). What's different about banks? *Journal of Monetary Economics* 15, 29–36.

Financial Times. (2019). Denmark's Jyske Bank imposes negative interest rates. August 20, 2019.

Financial Times. (2019). UniCredit chief urges rethink on negative rates complaints. October 2, 2019.

Friedman, M. (1969). The optimum quantity of money: And other essays. Chicago, IL: Aldine.

Giannetti, M., and S. Ongena. (2012). "Lending by Example": Direct and Indirect Effects of Foreign Banks in Emerging Markets, *Journal of International Economics*, 86, 167–180.

Heider, F., F. Saidi, and G. Schepens. (2019). Life Below Zero: Bank Lending Under Negative Policy Rates, *Review of Financial Studies*, 32, 3728–3761.

Holton, S., and C. Rodriguez d'Acri. (2018). Interest rate pass-through since the euro area crisis, *Journal of Banking & Finance* 96, 277–291.

Jimenez, G., S. Ongena, J.-L. Peydro, and J. Saurina. (2012). Credit Supply and Monetary Policy: Identifying the Bank Balance-Sheet Channel with Loan Applications. *American Economic Review* 102, 2301–26.

Jordà, Ò. (2005). Estimation and Inference of Impulse Responses by Local Projections. *American Economic Review* 95, 161–182.

Kalemli-Ozcan, S., L. Laeven, and D. Moreno. (2018). Debt Overhang, Rollover Risk, and Corporate Investment: Evidence from the European Crisis. NBER Working Paper No. 24555.

Kashyap, A. K., and J. Stein. (2000). What Do a Million Observations on Banks Say about the Transmission of Monetary Policy? *American Economic Review* 90, 407–428.

Keynes, J. M. (1936). The General Theory of Employment, Interest, and Money (Macmillan).

Khwaja, A. I., and A. Mian. (2008). Tracing the Impact of Bank Liquidity Shocks: Evidence from an Emerging Market. *American Economic Review* 98 (4): 1413–1442.

Krugman, P. R. (1998). It's Baaack: Japan's Slump and the Return of the Liquidity Trap, *Brookings Papers on Economic Activity*, 29, 137–206.

Lilley, A. and K. Rogoff. (2019). The Case for Implementing Effective Negative Interest Rate Policy. Strategies for Monetary Policy, (Stanford: Hoover Institution Press).

Lopez, J. A., A. K. Rose, and M. Spiegel. (2018). Why Have Negative Nominal Interest Rates Had Such a Small Effect on Bank Performance? Cross Country Evidence. NBER Working Paper No. 25004.

Rogoff, K. (2016). The Curse of Cash. Princeton University Press.

Rogoff, K. (2017). Dealing with Monetary Paralysis at the Zero Bound. *Journal of Economic Perspectives* 31, 47–66.

Ronglie, M. (2016). What Lower Bound? Monetary Policy with Negative Interest Rates. Working Paper, Northwerstern University.

Santikian, L. (2014). The Ties That Bind: Bank Relationships and Small Business Lending. *Journal of Financial Intermediation* 23, 177–213.

Schwert, M., 2018, Bank Capital and Lending Relationships, *Journal of Finance* 73, 787–830.

Sanchez, J., and E. Yurdagul. (2013), Why are Corporations Holding so Much Cash? *Federal Reserve Bank of St. Louis' The Regional Economist*, 21, 5–8.

Summers, L. H. (2015), Demand Side Secular Stagnation. *American Economic Review* 105, 60–

Figure 1: Pass-through to Deposit and Lending Rates

The figure reports the coefficients β_h resulting from the regression $\Delta R_{i,t+h} = \alpha_{i,h} + \beta_h \Delta DFR_t + \epsilon_{i,t+h}$, for $h = 1, \ldots, 12$. $\Delta R_{i,t+h}$ is the change in the interest rates on deposits or loans of bank i between t and $t+h$, the variable ΔDFR represents the change in the interest rate on liquidity deposited at the central bank. The coefficient β_h gives the cumulated response of banks' interest rates on deposits (Panels A to C) and loans (Panels D to F) up to time $t+h$ to a change in deposit facility rate at time t. We control for bank fixed effects $\alpha_{i,h}$. The blue solid line reports the coefficients β_h while the red dashed lines report the 95% confidence intervals for each horizon h with robust standard errors. Panels A and D report the results when the DFR is between 1% and 0.2%, Panels B and E when the DFR is between 0.2% and -0.2%, and Panels C and F when the DFR is below 0.2%.

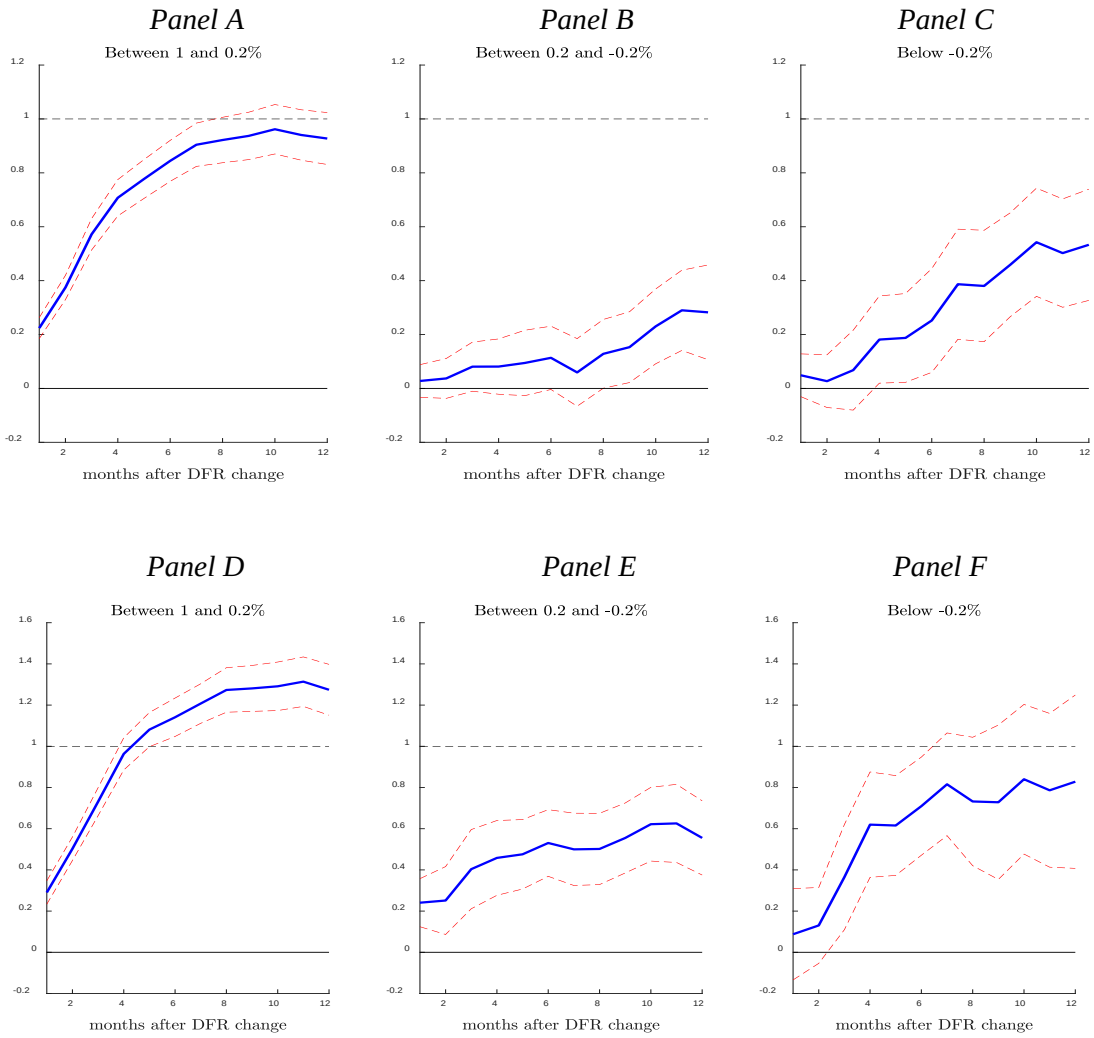


Figure 2: Pass-through to Deposit Rates by Bank Risk and Deposit Funding

The figure reports the coefficients β_h resulting from the regression $\Delta D_{i,t+h} = \alpha_{i,h} + \beta_h \Delta DFR_t + \epsilon_{i,t+h}$, for $h = 1, \ldots, 12$. $\Delta D_{i,t+h}$ is the change in deposit rates (ΔD) of bank i between t and $t+h$, the variable ΔDFR represents the change in the interest rate on liquidity deposited at the central bank. The coefficient β_h gives the cumulated response of banks' deposit rates up to time $t+h$ to a change in deposit facility rate at time t. We control for bank fixed effects $\alpha_{i,h}$. In Panels A to C, the blue solid line reports the coefficients β_h for banks that have an investment grade rating, the red dashed line reports the coefficients β_h for the other banks. In Panels D to F, the blue solid line reports the coefficients β_h for banks that have a low (below median) deposit ratio and the red dashed line reports the coefficients β_h for banks that have a high (above median) deposit ratio. Panels A and D report the results when the DFR is between 1% and 0.2%, Panels B and E when the DFR is between 0.2% and -0.2%, and Panels C and F when the DFR is below -0.2%.

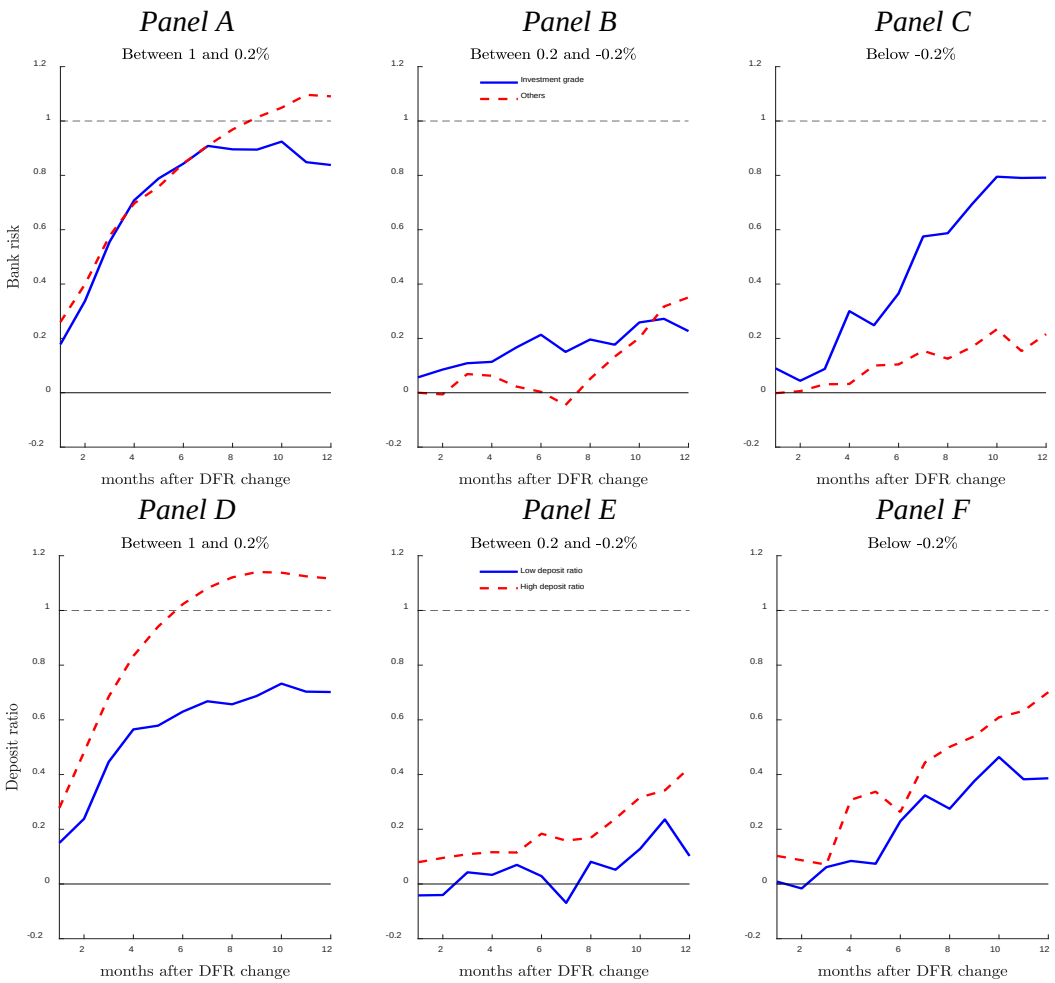
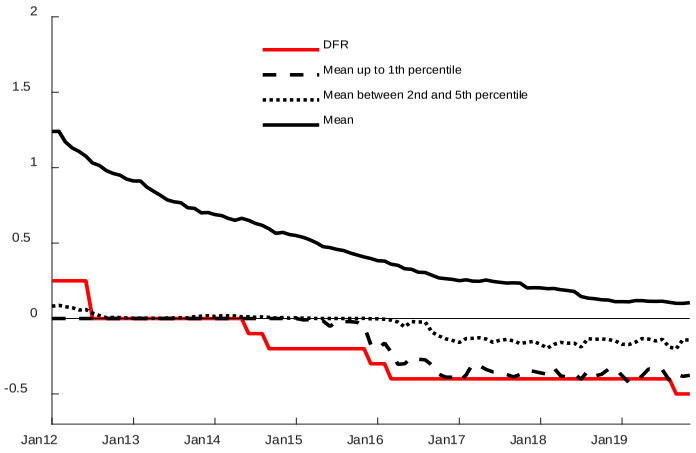


Figure 3: Evolution of Deposit Rates

The figure shows the evolution of the ECB's deposit facility rate (DFR) and the interest rates offered by banks on non-financial corporations' deposits. We plot the mean interest rate on the deposits of non-financial corporations distinguishing between different percentiles. Panel A reports the deposit rates on the outstanding amounts averaged across all deposit segments. Panel B reports the deposit rates on new deposits of non-financial corporations with agreed maturity up to 1 year.

Panel A: Stock of Deposits



Panel B: New Deposits with Agreed Maturity up to 1 year

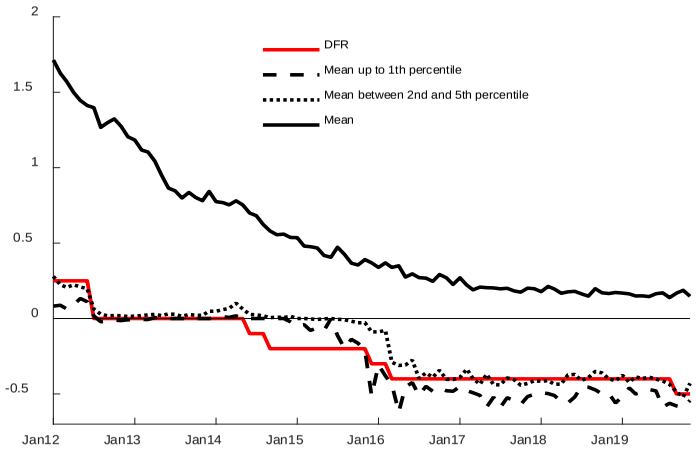
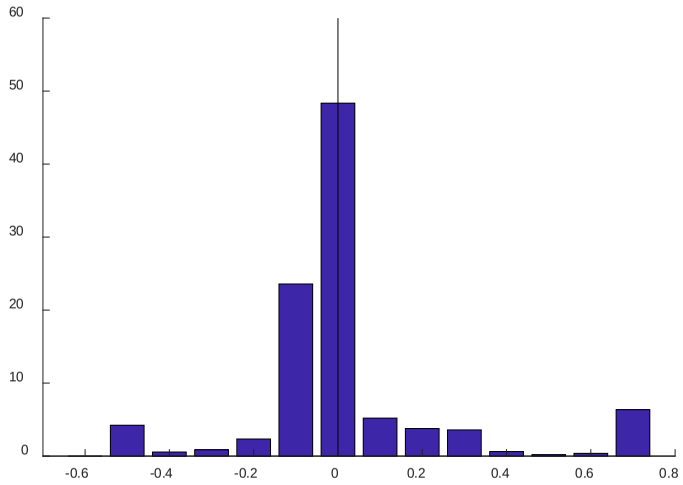


Figure 4: Deposits with Negative Rates

Panel A shows the distribution of deposit rates to NFCs across individual MFIs in November 2019, the x-axis reports the deposit rates in percentages per annum, the y-axis indicates the frequencies in percentages, weighted by deposit volumes. Panel B shows the proportion of corporate deposits on which banks charge negative rates over time, with the detail for overnight deposits and deposits with agreed maturity up to 2 years.

Panel A



Panel B

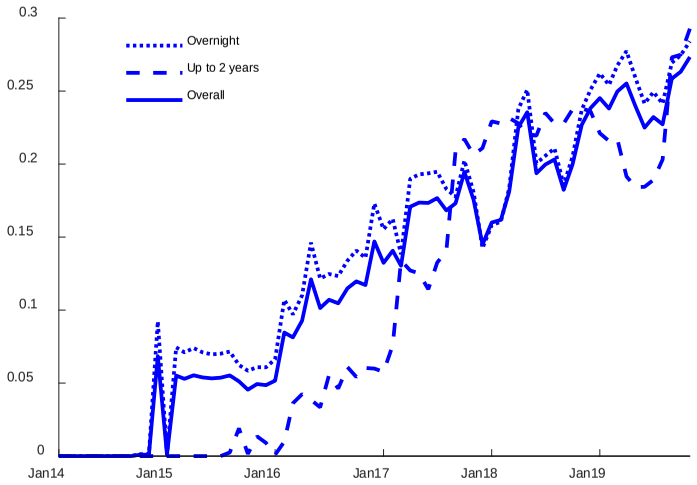


Figure 5: Estimated Cross-sectional Differences in the Probability of Negative Rates

The figure illustrates the dynamic effects of our proxies for bank health on the probability that a bank charges negative rates on non-financial corporations' deposits. We plot the estimated coefficient on the non-investment grade dummy (Panel A), the NPL ratio (Panel B) and the CDS spread (Panel C) of cross-sectional regressions in which the dependent variable is a categorical variable that takes value equal to 100 if a bank charges negative rates on deposits at a given point in time. We also plot the confidence intervals. The blue vertical lines indicate the five episodes of DFR cuts below zero.

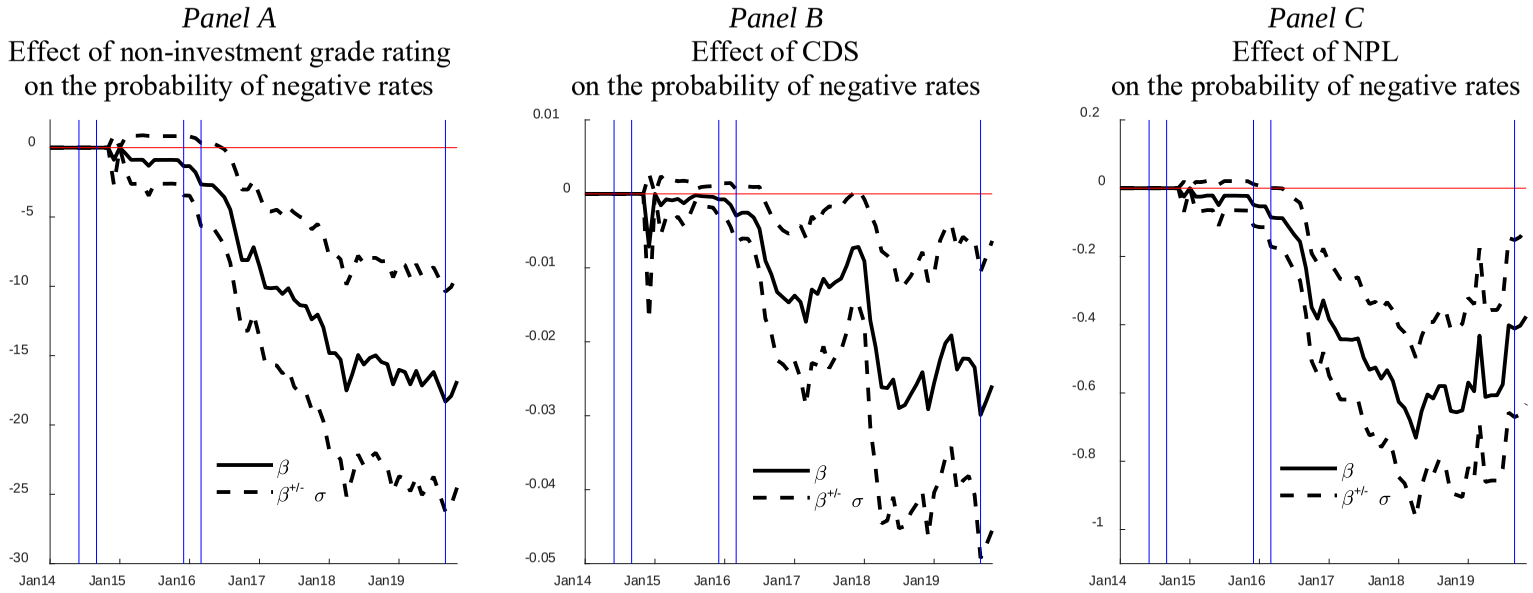


Table 1: Variable Definitions and Summary Statistics

Panel A. Bank-level dataset

The unit of observation is the bank-month. Our sample consists of a panel of 195 banks from August 2007 to November 2019 (148 months).

Variable name	Units	Definition	Obs.	Mean	St.Dev.	Min	p25	p50	p75	Max
Deposit rate	%	Average deposit rate on outstanding amounts of overnight deposits from NFCs or deposits with agreed maturity from NFCs.	23838	0.9	1.1	-0.8	0.1	0.5	1.3	11.3
Probability that deposit rate<0	%	Dummy variable equal to 100 if the average deposit rate has been less than zero at least once until a given month.	23838	2.5	15.5	0.0	0.0	0.0	0.0	100.0
Non-investment grade	Cat.	Dummy variable equal to 1 if the average rating is not investment grade, 0 otherwise. One month lag.	23838	0.1	0.3	0.0	0.0	0.0	0.0	1.0
CDS spread	b.p.	Price of a given bank's credit default swap. One month lag.	14511	201.2	301.8	1.7	70.1	110.7	189.1	5272.5
NPL ratio	%	Ratio of gross impaired loans over loans at amortized costs. Quarterly frequency, extended over the reference quarter. One month lag.	23838	7.6	10.1	0.0	2.2	4.2	8.5	53.8
Stressed country	Cat.	Dummy variable equal to 1 if a given bank is located in a stressed country (IT, ES, IE, PT, GR, CY, SI).	23838	0.5	0.5	0.0	0.0	0.0	1.0	1.0
Assets	Log	Log of total assets minus remaining assets (check BSI statistics for details), in €Mln. One month lag.	23838	10.4	1.5	2.2	9.6	10.5	11.4	13.9
ROA	%	Return on assets. One month lag.	23838	0.2	1.2	-6.7	0.1	0.3	0.7	2.5
Foreign branch/subs.	Cat.	Dummy variable equal to 1 if a given bank is a branch or a subsidiary of a group whose head institution is located in a different country than the bank's.	23838	0.2	0.4	0.0	0.0	0.0	0.0	1.0
Deposit ratio	%	Ratio of total deposits to NFC over main liabilities. One month lag.	23838	8.3	7.3	0.0	3.4	7.1	11.3	100.0
Excess liquidity	%	Ratio of excess liquidity (current account + deposit facility - minimum reserve requirements) over main assets. One month lag.	23838	2.7	7.3	-0.1	0.0	0.1	2.1	68.8
Loan volume	€Mln	Outstanding amounts of loans to NFC at all agreed maturities, excluding overdrafts.	23838	14211	21123	0.0	1929	6711	15507	143580
Lending rate	%	Average lending rate on outstanding amounts of loans to NFC at all agreed maturities, excluding overdrafts.	23025	3.3	1.4	0.6	2.3	3.1	4.1	7.0
Deposit volume	€Mln	Outstanding amounts of overnight deposits from NFCs or deposits with agreed maturity from NFCs.	23838	59010	10917	1.0	544	1830	5247	88630
Growth in deposits since May 2014	%	Growth rate in deposit volume since May 2014.	23838	13.8	55.4	-99.9	-18.6	0.8	32.9	166.7
Change in exc. liq. since May 2014	%	Change in ratio of excess liquidity over main assets volume since May 2014.	23838	1.9	6.1	-12.1	0.0	0.0	1.5	58.0

Panel B. Firm-level dataset

The observation is a given firm in a given year. Our sample consists of an unbalanced panel of 473,213 firms for 12 years from 2007 to 2018, and covers 12 countries, 121 banks, 708 4-digit NACE2 core industry classifications, and 27,945 city locations.

Variable name	Units	Definition	Obs.	Mean	St.Dev.	Min	p25	p50	p75	Max
High Pass-Through Bank	Cat.	Dummy variable equal to 1 if the main bank ever charges a negative average deposit rate to NFCs, 0 otherwise.	3371915	0.1	0.3	0.0	0.0	0.0	0.0	1.0
Bank charges negative rate	Cat.	Dummy variable equal to 1 when the main bank charges a negative average deposit rate to NFCs, 0 otherwise.	3371915	0.0	0.1	0.0	0.0	0.0	0.0	1.0
% of negative rates banks	Cat.	Percentage of negative rates banks over the total number of partner banks of a given firm. 9 possible values from 0 to 1.	3371915	0.1	0.3	0.0	0.0	0.0	0.0	1.0
Low rates bank in 2009-2011	Cat.	Dummy variable equal to 1 if the main bank ever charges, between January 2009 and December 2011, an average deposit rate to NFCs equal or below the 5th percentile of the distribution within country-month, 0 otherwise.	3371915	0.3	0.5	0.0	0.0	0.0	1.0	1.0
Low rates bank in 2012-2013	Cat.	Dummy variable equal to 1 if the main bank ever charges, between January 2012 and May 2014, an average deposit rate to NFCs equal or below the 5th percentile of the distribution within country-month, 0 otherwise.	3371915	0.2	0.4	0.0	0.0	0.0	0.0	1.0
Post	Cat.	Dummy variable equal to 1 if the year is 2014 or later, 0 otherwise.	3371915	0.4	0.5	0.0	0.0	0.0	1.0	1.0
Debt/Assets	%	Ratio of total liabilities over total assets	3371819	60.9	27.6	2.8	39.6	63.8	84.0	100.0
Investment	%	Annual growth rate in fixed assets.	3371915	19.0	115.9	-94.3	-13.9	-2.9	8.9	876.2
Cash-Holdings	%	Ratio of current assets over total assets.	3371816	67.5	26.8	3.4	49.1	74.2	90.7	100.0
Growth in tangible fixed assets	%	Annual growth rate in tangible fixed assets.	3287483	20.7	138.5	-99.3	-18.5	-4.8	6.7	1054.7
Growth in intangible fixed assets	%	Annual growth rate in intangible fixed assets.	1579259	86.9	675.0	-100.0	-50.2	-12.5	0.0	5868.1
Total assets	%	100*Log of total assets.	3371791	1388.5	172.6	0.0	1276.4	1379.4	1489.9	2436.6
Current liabilities	%	Ratio of current liabilities over total liabilities.	3370137	72.9	30.0	0.0	53.3	84.4	100.0	100.0
Interest paid	%	Ratio of interest paid over total liabilities.	2686488	2.3	2.3	0.0	0.6	1.6	3.3	12.9
ROA	%	Ratio of net income over total assets.	3205489	2.1	13.0	-51.9	-0.7	1.8	6.8	43.5
Profit margin	%	Ratio of net income over sales.	3153660	0.9	14.9	-65.2	-0.5	1.6	5.6	47.1
EBITDA margin	%	Ratio of earnings before interests, tax, depreciation and amortization over sales.	3026801	6.0	15.8	-57.7	1.4	5.1	11.1	61.9
EBIT margin	%	Ratio of earnings before interests and taxes over sales.	3166612	2.1	14.7	-63.2	0.1	2.7	6.9	48.3
Cashflow /Op. Rev.	%	Ratio of cashflow over operating revenue.	3013443	4.0	14.3	-57.8	0.8	3.6	8.5	52.3

Table 2: Which Banks Impose Negative Rates on Deposits?

This table provides estimates of linear probability models in which the dependent variable takes value equal to 100 if a bank charges negative rates on non-financial corporations' deposits in month *t* and to zero if the bank offers positive rates. We consider a range of bank characteristics. Standard errors are double-clustered at the bank and time levels. All models include fixed effects as indicated on the table, but the coefficients are not reported. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

Dependent Variable: Probability that deposit rate<0	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Stressed country	-2.988***				-0.739			
	(1.020)				(1.038)			
Non-investment grade		-4.046***			-2.771***	-3.288***	-3.764***	-1.842**
		(1.054)			(0.947)	(1.043)	(1.120)	(0.874)
CDS spread			-0.003***					
			(0.001)					
NPL ratio				-0.117***	-0.021			
				(0.037)	(0.046)			
Excess liquidity					0.545***	0.515***	0.532***	0.577***
					(0.142)	(0.133)	(0.114)	(0.121)
Non-investment grade*Exc. Liq.								-0.854***
								(0.174)
Assets					1.094**	1.144**	4.186**	4.040**
					(0.466)	(0.523)	(1.611)	(1.639)
ROA					-0.204	0.009	-0.131	-0.084
					(0.204)	(0.188)	(0.161)	(0.158)
Foreign branch/subs.					-0.347	-1.829		
					(1.001)	(1.173)		
Deposit ratio					-0.076	-0.045	-0.210	-0.199
					(0.075)	(0.073)	(0.127)	(0.126)
Time FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country FE	-	-	-	-	-	Yes	-	-
Bank FE	-	-	-	-	-	-	Yes	Yes
Observations	23,838	23,838	14,511	23,838	23,838	23,838	23,838	23,838
R-squared	0.077	0.074	0.092	0.073	0.142	0.167	0.337	0.341

Table 3: Deposit Growth and Bank Health

We relate changes in banks' deposits over the intervals indicated on top of each column to a dummy capturing whether a bank charges negative rates on deposits and bank NPL in May 2014, right before the start of the NIRP and other bank characteristics. Standard errors are corrected for heteroskedasticity. All models include fixed effects as indicated on the table, but the coefficients are not reported. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively. In column 5, the placebo is the change between May-14 and Jun-12.

Dependent Variable:	(1)	(2)	(3)	(4)	(5)
Growth in deposits since May 2014	until Jun-15	until Nov-19	until Nov-19	until Nov-19	Placebo
Bank charges negative rates*100	0.496***	0.297*	0.285*	0.179	
	(0.125)	(0.150)	(0.149)	(0.146)	
High Pass-Through Bank *100					-0.036
					(0.124)
NPL ratio in May 2014	-1.438**	-1.409*	-1.411*	-1.505*	0.712
	(0.563)	(0.732)	(0.748)	(0.760)	(0.572)
Assets in May 2014	1.340	-4.574	-4.696	-12.278	9.102
	(2.789)	(4.304)	(4.531)	(8.785)	(8.195)
ROA in May 2014	-4.192*	0.193	0.177	0.864	-1.969
	(2.286)	(4.048)	(3.954)	(4.383)	(3.475)
Foreign branch/subs.	-12.710	-20.601*	-22.476*	-28.178**	-5.449
	(8.268)	(12.382)	(12.665)	(13.151)	(10.169)
Deposit ratio in May 2014			0.462	-0.486	-1.442**
			(1.041)	(1.158)	(0.719)
Change in exc. liq. since May 2014			0.616	0.808	2.110*
			(1.293)	(1.356)	(1.197)
Deposit rate in May 2014				-16.257	-4.475
				(15.772)	(13.447)
Lending rate in May 2014				0.364	-2.843
				(8.067)	(8.001)
Deposit volume in May 2014				0.001	-0.001*
				(0.001)	(0.001)
Loan volume in May 2014				-0.000	-0.000
				(0.001)	(0.000)
Country FE	Yes	Yes	Yes	Yes	Yes
Observations	134	134	134	134	134
R-squared	0.264	0.336	0.340	0.362	0.299

Table 4: The Bank Lending Channel

The unit of observation is the firm-year and we relate firm level outcomes indicated on top of each column to firms' exposure to the NIRP. The dummy *Post* takes value equal to one after the ECB lowered the DFR below zero in 2014. *Exposure* is a firm's cash-holdings multiplied by a dummy that takes value equal to one if a firm's bank starts charging negative rates on corporate deposits. Standard errors are clustered at bank level. All models include fixed effects as indicated on the table, but the coefficients are not reported. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

	(1)	(2)	(3)	(4)	(5)	(6)
Dependent Variable:	Debt/Assets	Debt/Assets	Investment	Debt/Assets	Investment	Cash-holdings
High pass-through bank*Post	0.503***	0.302***	0.974	0.511***	0.859	-0.126*
	(0.151)	(0.112)	(0.652)	(0.150)	(0.718)	(0.067)
Bank charges negative rate	-0.194	-0.137	2.621*	-0.234	-40.501***	6.655***
	(0.155)	(0.138)	(1.429)	(0.473)	(2.885)	(0.508)
Exposure				0.000	0.597***	-0.092***
				(0.006)	(0.043)	(0.007)
Cash-holdings (lag)				-0.073***	2.980***	0.554***
				(0.003)	(0.053)	(0.007)
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Country-Sector-Time FE	Yes	Yes	Yes	Yes	Yes	Yes
City-Time FE	-	Yes	-	-	-	-
Observations	3,184,969	3,093,374	3,185,074	3,184,969	3,185,074	3,184,966
R-squared	0.842	0.848	0.171	0.843	0.235	0.909

Table 5: Exposure to Negative Rates and Firms' Investment

Panel A. Average Effects.
The unit of observation is the firm-year and we relate firm level investment to firms' exposure to the NIRP. In columns 1 to 3, *Exposure* is a firm's cash-holdings multiplied by a dummy that takes value equal to one if a firm's bank has started charging negative rates on corporate deposits. In column 4, we consider firms reporting only one bank. Standard errors are clustered at the bank level. All models include fixed effects as indicated on the table, but the coefficients are not reported. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

Dependent Variable: Investment	(1)	(2)	(3)	(4)
Exposure	0.556***	0.848***	1.085***	0.830***
	(0.048)	(0.067)	(0.171)	(0.077)
Cash-holdings (lag)	2.989***	2.985***	3.114***	3.121***
	(0.056)	(0.054)	(0.045)	(0.059)
Firm FE	Yes	Yes	Yes	Yes
Bank-Time FE	Yes	-	-	-
Bank-Sector-Time FE	-	Yes	-	Yes
Bank-Sector-City-Time FE	-	-	Yes	-
Observations	3,371,915	3,183,808	1,283,582	1,789,390
R-squared	0.230	0.262	0.427	0.287

Panel B. Small vs. Large Firms
The unit of observation is the firm-year and we relate firm level investment to firms' exposure to the NIRP. In column 1 (2), small (large) firms are defined as firms with total assets below (above) the median. *Exposure* is a firm's cash-holdings multiplied by a dummy that takes value equal to one if a firm's bank has started charging negative rates on corporate deposits. All models include fixed effects as indicated on the table, but the coefficients are not reported. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

Dependent Variable: Investment	(1) Small firms	(2) Large firms
Exposure	1.262***	0.281***
	(0.100)	(0.059)
Cash-holdings (lag)	3.130***	3.085***
	(0.058)	(0.065)
Firm FE	Yes	Yes
Bank-Time FE	Yes	Yes
Observations	1,667,030	1,668,502
R-squared	0.233	0.277

Table 6: Exposure to Negative Rates and Firms' Cash-Holdings

The unit of observation is the firm-year and we relate firm level cash-holdings to a firms' exposure to the NIRP. The dummy *Post* takes value equal to one after the ECB lowered the DFR below zero in 2014. In columns 1 to 3, *Exposure* is a firm's cash-holdings multiplied by a dummy that takes value equal to one if a firm's bank has started charging negative rates on corporate deposits. In column 4, we consider firms reporting only one bank. Standard errors are clustered at the bank level. All models include fixed effects as indicated on the table, but the coefficients are not reported. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

Dependent Variable: Cash-holdings	(1)	(2)	(3)	(4)
Exposure	-0.089***	-0.126***	-0.164***	-0.132***
	(0.007)	(0.010)	(0.015)	(0.009)
Cash-holdings (lag)	0.552***	0.554***	0.537***	0.534***
	(0.007)	(0.007)	(0.009)	(0.009)
Firm FE	Yes	Yes	Yes	Yes
Bank-Time FE	Yes	-	-	-
Bank-Sector-Time FE	-	Yes	-	Yes
Bank-Sector-City-Time FE	-	-	Yes	-
Observations	3,371,804	3,183,699	1,283,522	1,789,291
R-squared	0.906	0.912	0.931	0.911

Table 7: Exposure to Negative Rates and Firms' Investment into Tangible and Intangible Assets

The unit of observation is the firm-year and we relate firm level outcomes indicated on top of each column to firms' exposure to the NIRP. *Exposure* is a firm's cash-holdings multiplied by a dummy that takes value equal to one if a firm's bank has started charging negative rates on corporate deposits. Standard errors are clustered at the bank level. All models include fixed effects as indicated on the table, but the coefficients are not reported. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

	(1)	(2)	(3)
Dependent Variable:	Growth in tangible fixed assets	Growth in intangible fixed assets	Total assets
Exposure	0.485***	1.610***	0.012
	(0.053)	(0.611)	(0.019)
Cash-holdings (lag)	2.327***	3.087***	0.045
	(0.103)	(0.141)	(0.030)
Firm FE	Yes	Yes	Yes
Bank-Time FE	Yes	Yes	Yes
Observations	3,283,251	1,547,720	3,371,777
R-squared	0.191	0.201	0.964

Table 8: Exposure to the NIRP and Firm Performance

The unit of observation is the-firm year and we relate different measures of firm profitability indicated on each row to a firm's exposure to the NIRP. *Exposure* is a firm's cash-holdings multiplied by a dummy that takes value equal to one if a firm's bank has started charging negative rates on corporate deposits. All models include fixed effects as indicated on the table, but the coefficients are not reported. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

Dependent Variable		Period	Exposure	Cash-holdings (lag)	Firm FE	Bank-Time FE	Obs.	R-sq.
(1)	ROA	Level at T	-0.019*	0.028***	Yes	Yes	3,203,279	0.461
			(0.010)	(0.002)				
		Change from T to T+2	0.039**	-0.008***	Yes	Yes	2,317,344	0.145
			(0.018)	(0.001)				
(2)	Profit margin	Level at T	-0.029***	0.027***	Yes	Yes	3,149,182	0.474
			(0.006)	(0.002)				
		Change from T to T+2	0.074**	-0.043***	Yes	Yes	2,260,811	0.152
			(0.034)	(0.002)				
(3)	EBITDA margin	Level at T	-0.013**	-0.045***	Yes	Yes	3,023,004	0.553
			(0.006)	(0.003)				
		Change from T to T+2	0.051***	0.002	Yes	Yes	2,169,243	0.148
			(0.006)	(0.003)				
(4)	EBIT margin	Level at T	-0.014**	0.015***	Yes	Yes	3,163,240	0.475
			(0.006)	(0.002)				
		Change from T to T+2	0.035**	-0.029***	Yes	Yes	2,274,459	0.149
			(0.015)	(0.002)				
(5)	Cashflow /Op. Rev.	Level at T	-0.025***	-0.037***	Yes	Yes	3,008,554	0.518
			(0.009)	(0.003)				
		Change from T to T+2	0.132***	-0.004	Yes	Yes	2,156,853	0.147
			(0.040)	(0.002)				

Table 9: Effects of Rate Cuts Above and Below the ZLB

The unit of observation is the firm-year and we relate firm level outcomes indicated on top of each column to a firm's exposure to the NIRP. The variables *Exposure*Low(2009-2011)* and *Exposure *Low(2012-2013)* are a firm's cash-holdings multiplied by a dummy that takes value equal to one if a firm's bank offered deposits rates below the fifth percentile in the periods from 2009 to 2011 and from 2012 to 2013, respectively. *Exposure* is a firm's cash-holdings multiplied by a dummy that takes value equal to one if a firm's bank is actually charging negative rates on corporate deposits. All models include fixed effects as indicated on the table, but the coefficients are not reported. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

	(1)	(2)
Dependent Variable:	Investment	Cash-holdings
Exposure Low(2009-2011) * Post(2009-2011)	0.014	-0.000
	(0.021)	(0.002)
Exposure Low(2012-2013) * Post(2012-2013)	-0.021	0.000
	(0.095)	(0.006)
Exposure	0.556***	-0.089***
	(0.048)	(0.007)
Cash-holdings (lag)	2.988***	0.552***
	(0.057)	(0.007)
Firm FE	Yes	Yes
Bank-Time FE	Yes	Yes
Observations	3,371,915	3,371,804
R-squared	0.230	0.906

Acknowledgements

First version: January 2019. We thank Gabriel Chodorow-Reich, José Dorich, José-Luis Peydró-Alcade, Andrea Polo, Kenneth Rogoff, Glenn Schepens, Ganesh Viswanath, Annette Vissing-Jorgensen, and seminar participants at the NBER Summer Institute Corporate Finance Meeting, the ECB Conference on Monetary Policy: bridging science and practice, the Bank of Finland and CEPR Joint Conference on Monetary Economics and Reality, the Barcelona Graduate School of Economics Summer Forum Workshop on Financial Shocks, Channels, and Macro Outcomes, the CSEF-IGIER Symposium on Economics and Institutions, the Workshop on Institution, Individual Behavior and Economic Outcomes, the University of Minnesota, the University of Amsterdam, the Universitat Autònoma de Barcelona, the Bank of France, the Bank of France Research Workshop of the Monetary Policy Committee Task Force on Banking Analysis for Monetary Policy, the Bank of Norway, the Joint CEMLA-ECB-FRBNY-BCRP Conference on Financial Intermediation, Credit and Monetary Policy in Lima, and the Irish Economic Association Annual Conference for comments. Giannetti gratefully acknowledges financial support from the Jan Wallander and Tom Hedelius Foundation and the Riksbankens Jubileumsfond. The opinions in this paper are those of the authors and do not necessarily reflect the views of the European Central Bank or the Eurosystem.

Carlo Altavilla
European Central Bank, Frankfurt am Main, Germany; email: carlo.altavilla@ecb.europa.eu

Lorenzo Burlon
European Central Bank, Frankfurt am Main, Germany; email: lorenzo.burlon@ecb.europa.eu

Mariassunta Giannetti
Stockholm School of Economics, Stockholm, Sweden; CEPR and ECGI; email: mariassunta.giannetti@hhs.se

Sarah Holton
Central Bank of Ireland, Dublin, Ireland; email: sarah.holton@centralbank.ie

Postal address 60640 Frankfurt am Main, Germany
Telephone +49 69 1344 0
Website www.ecb.europa.eu

PDF ISBN 978-92-899-3551-7 ISSN 1725-2806 doi:10.2866/23378 QB-AR-19-070-EN-N