Life Below Zero: Bank Lending Under Negative Policy Rates*

Florian Heider† — ECB & CEPR

Farzad Saidi‡ — Stockholm School of Economics & CEPR

Glenn Schepens§ — ECB

October 23, 2016

Abstract

This paper studies the transmission of negative monetary-policy rates via the lending behavior of banks. Unlike for positive rates, the transmission of negative rates depends on banks' funding structure. High-deposit banks take on more risk and lend less than low-deposit banks. The risk taking is concentrated in poorly-capitalized banks. Part of the risk taking comes in the form of new syndicated loans to risky firms without such loans previously. Safe borrowers switch from high-deposit to low-deposit banks. The new risky borrowers appear financially constrained, and use the new funding to invest. For identification, we employ a difference-in-differences approach. Banks with different reliance on deposit funding experience a different pass-through of negative policy rates. To isolate borrowers from interest-rate changes, we use lenders located in a different currency zone. A placebo at the time when policy rates fall – but are still positive – shows no effect. The results point to distributional consequences of negative policy rates with potential risks to financial stability.

JEL classification: E44, E52, E58, G20, G21

Keywords: monetary policy, zero lower bound, negative interest rates, bank risk taking

*We thank Tobias Berg, Patrick Bolton, Matteo Crosignani, Luc Laeven, Teodora Paligorova, Daniel Paravisini, Anthony Saunders, Antoinette Schoar, Sascha Steffen and Per Strömberg, as well as seminar audiences at University of Cambridge, Sveriges Riksbank, Federal Reserve Board, University of Maryland, Georgetown University, Erasmus University Rotterdam, the 2016 London Business School Summer Finance Symposium, the 2016 CEPR European Summer Symposium in Financial Markets, and the 4th Annual HEC Paris Workshop for their comments and suggestions. We also thank Valentin Klotzbücher and Francesca Barbiero for excellent research assistance. The views expressed do not necessarily reflect those of the European Central Bank or the Eurosystem.

†European Central Bank, Financial Research Division, Sonnemannstr. 22, 60314 Frankfurt am Main, Germany. E-mail: florian.heider@ecb.int

‡Stockholm School of Economics, Swedish House of Finance, Drottninggatan 98, SE-111 60 Stockholm, Sweden. E-mail: farzad.saidi@hhs.se

§European Central Bank, Financial Research Division, Sonnemannstr. 22, 60314 Frankfurt am Main, Germany. E-mail: glenn.schepens@ecb.int

1 Introduction

At the so-called zero lower bound, lowering monetary-policy rates is usually thought to lose traction. Firms, banks, and households prefer to hold cash, which offers a zero nominal rate, rather than short-term debt (e.g., deposits) once its nominal rate becomes negative.

The post-crisis ultra-low rates clash with the need to use standard interest-rate policy to stimulate the economy in its post-crisis state with low growth and low inflation in most of the industrialized world. To maintain traction at the zero lower bound, central banks around the world engaged in non-standard monetary policy measures, such as forward guidance and large-scale asset purchases.

Ignoring the zero lower bound, some central banks set policy rates below zero. The European Central Bank (ECB), but also the central banks of Denmark, Switzerland, and Sweden, have recently implemented negative policy rates.[1] Yet, central banks are deeply divided about negative rates as a policy tool. The Bank of England refrained from setting negative rates, while the Federal Reserve has not ruled them out for the future.

Moreover, there are concerns about the limited effectiveness of negative rates and the risk they pose to financial stability. This is because negative rates may undermine bank profitability and lead to, possibly excessive, risk taking. In search of higher returns on their assets, banks turn away from traditional lending, and start to invest more in financial assets.

Negative interest rates truly are unchartered territory. While the economics of forward guidance and large-scale asset purchases is well understood and researched, there is little theory or evidence about the working of negative policy rates.[2] The novel nature of negative rates raises several questions. How does standard monetary policy function in such non-standard territory? Is the transmission different for negative than for positive policy rates?

[1] Before the introduction of negative policy rates in Europe, Saunders (2000) laid out potential implications for bank behavior by considering the case of Japan in the late 1990s.

[2] Recent exceptions are work on the theory of the effective lower bound by Rognlie (2016) and Brunnermeier and Koby (2016).

What are the benefits and costs? Do negative rates stimulate the economy? What are the risks of setting negative rates?

In this paper, we answer some of these questions by examining the granting of new loans before and after the ECB introduced a negative policy rate in June 2014. We show that when accommodative monetary policy pushes rates below zero, their transmission is shaped by the funding structure of banks. Banks are reluctant to pass on negative rates to depositors, which generates variation in the pass-through of negative rates to banks' cost of funding depending on their reliance on deposit funding. In contrast, this mechanism is of no importance for the transmission of positive monetary-policy rates.

Using a difference-in-differences setup, we compare the riskiness of firms financed by high-deposit banks and low-deposit banks around the time when the policy rate became negative. We find that following the reduction of the ECB's deposit facility (DF) rate from 0 to -0.10% in June 2014, high-deposit banks financed significantly riskier firms than low-deposit banks. In particular, a ten-percentage-point increase in the lender's deposit ratio is associated with an increase of roughly 20% in the standard deviation of the return on assets of borrowers.

We also characterize the distributional consequences of negative policy rates. The risk taking of high-deposit banks consists of lending to new risky borrowers and dropping existing safe ones, some of which switch to low-deposit banks. High-deposit banks grant new loans to risky firms that did not borrow previously, and that previously borrowed from low-deposit firms. However, overall lending by high-deposit banks decreases. Therefore, we observe an even stronger flow of safe borrowers from high-deposit to low-deposit banks. The risk taking induced by negative rates appears to overcome rationing. The characteristics of the new risky borrowers indicate that they are financially constrained. They are private firms with little leverage and, importantly, use the new funds to invest.

The identification of a causal effect of monetary policy on bank lending behavior relies on how well low-deposit banks provide the counterfactual for high-deposit banks: what would have been the lending behavior of high-deposit banks had the policy rate not become negative? A placebo version of our difference-in-differences setup in mid 2012, when the

ECB lowered its policy rates but the rates still remained non-negative, confirms the validity of low-deposit banks as a control group. We find no difference between the risk taking of low-deposit and high-deposit banks when interest rates fall at that time.

Another important concern when examining the transmission of monetary policy through bank lending is the interplay of loan supply and loan demand. We wish to identify how banks' loan supply responds to changes in monetary policy, and must therefore hold firms' loan demand constant. Monetary policy, however, affects both banks' loan supply and firms' loan demand. To disentangle loan supply from loan demand, we also analyze a subsample of borrower firms in Europe but outside the Eurozone. As these firms are located in a different currency area than the banks they borrow from, we effectively hold loan demand constant when the ECB lowers its DF rate below zero.

The behavior of high-deposit banks is in line with the risk-taking channel. Lower interest rates reduce the net worth of some banks (in our case, high-deposit banks), and lead to less monitoring and screening of borrowers. Accordingly, we find that high-deposit banks do not offset the higher risk of borrowers by charging higher loan spreads or asking for more stringent loan terms such as higher collateral, higher loan shares retained by lead arrangers, or more covenants. Moreover, only high-deposit banks with little equity lend to riskier borrowers.

Our analysis makes three contributions. First, we show how banks' funding structure governs the transmission of negative rates to the real economy. Standard interest-rate policy operates differently below the zero bound because banks do not pass on negative rates to their depositors.

To the best of our knowledge, ours is the first paper to examine negative rates using granular data on characteristics of lenders and their borrowers. The existing literature on the impact of monetary policy on banks' lending behavior focuses exclusively on environments with positive policy rates (Bernanke and Gertler (1995); Stein and Kashyap (2000); Jiménez, Ongena, Peydró, and Saurina (2012); Ioannidou, Ongena, and Peydró (2015); Dell'Ariccia, Laeven, and Suarez (2016); Kacperczyk and Di Maggio (2016); Paligorova and Santos (2016)) or, more recently, on non-standard monetary policy in the form of large-scale asset purchases

by central banks (Chakraborty, Goldstein, and MacKinlay (2016); Kandrac and Schlusche (2016)). Furthermore, the general transmission of monetary policy to credit supply through banks' funding structure is also discussed by Crosignani and Carpinelli (2016) and Drechsler, Savov, and Schnabl (2016).

Second, we sharpen the understanding of the bank risk-taking channel. We show how risk is taken and how the risk-taking channel interacts with the bank lending channel. Previous empirical research found contradictory evidence about which banks take risk when interest rates fall.

Third, we identify distributional consequences of monetary policy with possible threats to financial stability. Negative rates change the matching of borrowers and lenders in the economy. High-deposit banks lend to new risky borrowers, while safe borrowers switch to low-deposit banks. Although risk taking appears beneficial, because it overcomes rationing, it is not clear that high-deposit banks are, or should be, the natural risk takers in the banking sector.

The remainder of the paper is organized as follows. In Section 2, we discuss our identification strategy, and describe the data. Our results are in Section 3, and Section 4 concludes.

2 Empirical Strategy and Data

In this section, we start by providing background information on the introduction of negative policy rates, on the basis of which we develop our hypotheses. We then lay out our identification strategy for estimating the effect of negative policy rates on bank lending. Finally, we describe the empirical implementation and the data.

2.1 Institutional Background

On June 5, 2014, the European Central Bank (ECB) Governing Council lowered the marginal lending facility (MLF) rate to 0.40%, the main refinancing operations (MRO) rate to 0.15%,

and the deposit facility (DF) rate to -0.10% (see Figure 1). Shortly after, on September 4, 2014, the rates were lowered again: the MLF rate to 0.30%, the MRO rate to 0.05%, and the DF rate to -0.20%. With these actions, the ECB ventured into negative territory for some policy rates for the first time in its history. Ever since, the DF rate has continued to drop, to -0.40% on March 10, 2016.

The main goal of lowering the rates was to provide monetary-policy accommodation (in accordance with the ECB's forward guidance). In order to preserve the difference between the cost of borrowing from the ECB (at the MRO rate) and the benefit of depositing with the ECB (at the deposit facility rate), thereby incentivizing banks to lend in the interbank market, the deposit facility rate became negative. The evolution of the Euro overnight interbank rate (Eonia) in Figure 1 illustrates that the negative DF rate led to negative interbank rates, despite the fact that the MRO rate remained positive. The reason for this is that when banks hold significant amounts of excess liquidity, short-term market rates closely track the deposit facility rate.[3] As a result, over the last couple of years, the ECB's deposit facility rate has become its most important policy rate in an environment of ample excess liquidity.

Within Europe, Eurozone banks are not the only ones exposed to negative policy rates. The Swedish Riksbank reduced the repo rate, its main policy rate, from 0% to -0.10% on February 18, 2015. The repo rate is the rate of interest at which Swedish banks can borrow or deposit funds at the Riksbank. The Swedish experience is preceded by the Danish central bank, Nationalbanken, lowering the deposit rate to -0.20% on July 5, 2012. While the Danish deposit rate was raised to 0.05% on April 24, 2014, it was brought back to negative territory, -0.05%, on September 5, 2014. Furthermore, the Swiss National Bank went negative on December 18, 2014, by imposing a negative interest rate of -0.25% on sight deposits exceeding a given exemption threshold (see Bech and Malkhozov (2016) for further

[3] In the current economic and institutional environment, banks hold reserves, even though they effectively are taxed, for three reasons. First, they hold reserves because it insures them against liquidity shocks in between the ECB's weekly open-market operations. Second, they hold reserves because they are a valuable means of payment, especially when banks have concerns about counterparty risk. And as a consequence, third, banks may end up holding reserves as a by-product of their transactions with other banks.

details on the implementation of negative policy rates in Europe and the transmission to other interest rates).

2.2 Hypothesis Development

We next discuss the relationship between lower monetary-policy rates and bank lending behavior. We argue that when rates become negative, this allows a clean empirical identification of the impact of monetary policy on bank behavior through the bank risk-taking channel and the bank lending channel.

The starting point for the transmission of monetary policy through banks is the existence of an external-finance premium for banks.[4] Raising funding from outside investors is costly for banks because outsiders know less about the quality of bank assets (adverse selection, see Stein (1998)) and the quality of management's decision making (moral hazard, see Holmström and Tirole (1997)).

The external-finance premium is related to a bank's net worth, i.e., the difference between assets and liabilities. When a bank's net worth is high, the external-finance premium is low because adverse-selection and moral-hazard problems are less severe.

High net worth and a low external-finance premium lead to more lending (bank lending channel) and safer lending (bank risk-taking channel). This is because high net worth guarantees repayment to outsiders even when they are imperfectly informed about asset quality. High net worth also safeguards sound decision making because management has "skin-in-the-game" – it wants to preserve existing rents that accrue from high net worth.[5]

The effect of monetary policy on bank net worth, and thus on bank lending and bank risk taking, is in principle ambiguous because monetary policy affects both the return on assets

[4] That is, the Modigliani-Miller irrelevance of capital structure does not hold for banks (see Bernanke (2007) for a review of the bank lending channel). Originally, the bank lending channel refers to the withdrawal or injection of reserves through a central bank's purchase or sale of securities (Bernanke and Blinder (1988) and also Bernanke and Gertler (1995)).

[5] Equivalently, high net worth makes it worthwhile to engage in costly screening and monitoring of loans, so that lending becomes safer.

and the cost of capital (Dell'Ariccia, Laeven, and Marquez (2014); Dell'Ariccia, Laeven, and Suarez (2016)). When lower policy rates are passed on to loan rates, they reduce the value of bank assets and reduce net worth ceteris paribus. Conversely, when lower policy rates reduce the cost of funding, they reduce the value of bank liabilities and *increase* net worth ceteris paribus. Hence, it is not clear from a theoretical viewpoint whether lower policy rates lead to more and riskier bank lending.

For the bank risk-taking channel, the theoretical ambiguity about the impact of lower policy rates on bank net worth translates into ambiguous empirical findings. Jiménez, Ongena, Peydró, and Saurina (2014) find that low-capitalized banks lend to riskier firms, while Dell'Ariccia, Laeven, and Suarez (2016) find that high-capitalized banks lend to riskier firms.

In terms of the bank lending channel, higher policy rates lead to a reduction of loan making for low-capitalized banks and banks with few liquid assets (Kishan and Opiela (2000), Stein and Kashyap (2000), and Jiménez, Ongena, Peydró, and Saurina (2012)). When banks have little capital, the increase in the cost of funding dominates the increase in loan rates. Moreover, when banks have few liquid assets, they cannot offset the increase in the cost of funding by selling assets.

When the policy rate becomes negative, a bank's reluctance to lower the cost of deposit funding offers a unique opportunity to arrive at unambiguous and joint predictions about bank lending and bank risk taking. Normally – i.e., when rates are positive – deposit rates closely track policy rates. But when policy rates become negative, banks are reluctant to charge negative rates to depositors (e.g., because the latter could take their deposits to another bank that does not charge negative deposit rates).

Banks that rely heavily on deposit funding should lend less and make riskier loans when policy rates become negative. The reluctance to charge negative rates to depositors mitigates the pass-through of lower policy rates to the cost of funding for banks with a lot of deposits (relative to other sources of outside financing). When the impact of policy-rate changes via the cost of funding is mitigated, the impact via loan rates is stronger.

Our argument relies on banks' reluctance to charge negative rates on deposits. Figure 2 shows that this is indeed the case. Before June 2014, when policy rates are still positive, the rates on overnight deposits for households (HH) and non-financial corporations (NFC) move in line with the overnight unsecured interbank rate (Eonia), which in turn follows the rate of the ECB's deposit facility (as shown in Figure 1).[6] This changes as of June 2014 when the deposit facility rate is set to negative. While the Eonia falls in line with the now negative policy rate, deposit rates level off at zero. As a result, an increasing gap develops between the cost of deposit funding and the cost of unsecured overnight funding in the market.

Our argument also relies on the pass-through of policy rates to loan rates. And indeed, the total cost of credit for syndicated loans originated by Eurozone banks to Eurozone and non-Eurozone borrowers (this will be our sample for loans for which we can observe information about borrowers and loan terms) falls continuously in line with falling policy rates, and, importantly, continues to do so after June 2014 (Figure 3). The vast majority of syndicated loans in our sample are in fact floating-rate loans.

The pass-through of policy rates to loan rates is not limited to our sample of syndicated loans. Loan rates on long-term (above five years) loans in the Eurozone follow the evolution of Eonia, which itself closely tracks the deposit facility rate (Figure A.1 in the Online Appendix).

To sum up, lower policy rates lead to lower loan rates even when the policy rate becomes negative. In contrast, lower policy rates do not lead to lower deposit rates when the policy rate becomes negative. Hence, we obtain variation in the cost of funding and consequently net worth across banks with different reliance on deposit funding.

The reliance on deposit funding is not related to the reluctance of charging negative deposit rates. The leveling off at zero of deposits rates is present for both banks with a lot of deposit funding and those with little deposit funding (Figure 4).[7]

[6] For the average Eurozone bank, overnight deposits make up 55 to 60 percent of total customer (households and non-financial corporations) deposits during our sample period.

[7] Figure 4 shows overnight deposits for households. The leveling off at zero is also present in the rates on overnight deposits for non-financial corporations (Figure A.2 in the Online Appendix) as well as in the rates on longer-term deposits with an agreed maturity below one year (available upon request).

This variation in net worth across banks allows us to identify the impact of negative policy rates on bank behavior via the bank lending and the bank risk-taking channels. We summarize our argument in the following testable hypothesis:

Hypothesis: *Owing to banks' reluctance to charge negative deposit rates, negative policy rates lead to greater risk taking and less lending for banks with more deposit funding.*

We now present our identification strategy to test this hypothesis.

2.3 Identification Strategy

The setting at hand lends itself to a difference-in-differences strategy, which we implement by comparing the lending behavior of Eurozone banks with different deposit ratios around the ECB's introduction of negative policy rates in June 2014. We characterize bank risk taking by means of the ex-ante firm-level volatility of borrower firms, thereby capturing the amount of risk realized in the real economy. In this manner, we capture the observable riskiness of firms that were granted loans by differentially treated banks.

To test the impact of negative policy rates on the level of risk of loan-financed firms, we estimate the following difference-in-differences specification at the level of loans granted to firm i by Eurozone lead arrangers j at date t:

$$y_{ijt} \quad = \quad \beta_1 \textit{Deposit ratio}_j \times After(06/2014)_t + \beta_2 X_{it} + \delta_t + \eta_j + \epsilon_{ijt}, \tag{1}$$

where y_{ijt} is an outcome variable reflecting firm-level risk, $\textit{Deposit ratio}_j$ is the average ratio (in %) of deposits over total assets across all Eurozone lead arrangers j in 2013, $After(06/2014)_t$ is a dummy variable for the period from June 2014 onwards, X_{it} denotes firm-level control variables, namely industry(-year) and country(-year) fixed effects, and δ_t and η_j denote month-year and bank fixed effects, respectively, where bank fixed effects are included for all Eurozone lead arrangers. Standard errors are clustered at the bank level, using a vector of all banks j that acted as lead arrangers to firm i for a given loan.

We hypothesize the difference-in-differences estimate, β_1, to be positive, indicating that banks with higher deposit ratios financed riskier firms following the introduction of negative policy rates. For identification, we use a relatively short window around the June-2014 event, from January 2013 to December 2015. This ensures that our difference-in-differences estimate, at the time-varying bank level jt, is not contaminated by any other major bank-level shocks.

To control for between-year time trends and time-invariant unobserved bank heterogeneity, we always control for month-year and bank fixed effects. Bank fixed effects are included for all Eurozone lead arrangers of a given loan, which underlie the calculation of the average *Deposit ratio*$_j$ in 2013. Thus, we effectively estimate the average risk associated with loans granted by banks with different deposit ratios before and after June 2014.

In this setting, a potential concern regarding the identification of a causal chain from negative policy rates to bank risk taking may be centered on bank-firm matching. Given the relatively short time window around the June-2014 event, most firms are observed to have received only one loan, which eradicates the possibility of including (bank-)firm fixed effects. This is, however, crucial insofar as central banks lower interest rates when the economy is doing badly, which is also when lending tends to be riskier because of riskier borrowers. This makes it difficult to distinguish between our supply-side explanation, i.e., banks picking riskier borrowers, and an alternative demand-side explanation, i.e., risky borrowers demanding relatively more credit from high-deposit banks in times of negative policy rates.

We take two steps to control for this possibility. First, we include industry-year and country-year fixed effects to capture any time-varying unobserved heterogeneity of borrowers that could be explained by their industry or country dynamics. Second, we limit our sample to *non-Eurozone borrowers* with syndicated loans granted by Eurozone lenders to filter out any effect of an environment with negative policy rates on the composition of borrowers.

Furthermore, we provide evidence that low-deposit banks deliver the counterfactual for high-deposit banks if policy rates had not become negative. For this purpose, we use the reduction of the DF rate to what was believed to be the zero lower bound in July 2012

(see also Acharya, Eisert, Eufinger, and Hirsch (2016)) as a placebo treatment, and show that high-deposit and low-deposit banks were not differentially affected in their risk taking. To test this, we extend our sample to the period from January 2011 to December 2015, and include the interaction $Deposit\ ratio_j \times After(07/2012)_t$, where $After(07/2012)_t$ is a dummy variable for the period from July 2012 onwards, in (1). This lends support to the idea that the bank risk-taking channel is identified only when the pass-through of loan rates and deposit rates is asymmetric, which is the case when short-term rates become negative, rather than when they decrease but remain positive. Crucially, if firm-level demand was driving our findings, we should find similar effects after both rate decreases in July 2012 and June 2014.

Lastly, we show our results to be robust to the inclusion of Danish, Swedish, and Swiss lenders by exploiting the staggered timing of negative policy rates across these countries and the Eurozone. To this end, we modify (1) as follows:

$$y_{ijt} \quad = \quad \beta_1 Deposit\ ratio_j \times After_{jt} + \beta_2 X_{it} + \delta_t + \eta_j + \epsilon_{ijt}, \tag{2}$$

where $Deposit\ ratio_j$ is now the average ratio (in %) of deposits over total assets across all Eurozone, Danish, Swedish, or Swiss lead arrangers j in 2013, $After_{jt}$ is a dummy variable for the period from June 2014 onwards for all loans with any Eurozone (but no Danish, Swedish, or Swiss) lead arrangers, or from January 2013 to April 2014 and again from September 2014, February 2015, or January 2015 for all loans with Danish, Swedish, or Swiss (but no Eurozone) lead arrangers, respectively. η_j denotes bank fixed effects, which are included for all Eurozone, Danish, Swedish, and Swiss lead arrangers.

2.4 Empirical Implementation and Data Description

To measure bank risk taking, we use the riskiness of borrowers associated with syndicated loans. For our loans sample, we use DealScan data, which we match with Bureau van Dijk's Amadeus data on European firms. We consider the lead arrangers when identifying the

types of banks that granted the loan. We determine their ratio of deposits over total assets as our treatment-intensity measure by hand-matching the respective lead arrangers with balance-sheet and P&L data at the bank-group level from SNL.

In our baseline sample, we use syndicated loans with *any* Eurozone lead arrangers from January 2013 to December 2015. When we include Danish, Swedish, and Swiss lenders, we limit the sample to loans with *any mutually exclusive* Eurozone, Danish, Swedish, or Swiss lead arrangers, as Sweden and Switzerland introduced negative policy rates, and Denmark re-introduced them, only after the Eurozone did.

For each loan granted to firm i by lead arranger(s) j at date t, we define the associated level of ex-ante observable firm risk as follows. Our main outcome variable for both private and publicly listed firms is $\sigma(ROA_i)^{5y}$, the five-year standard deviation of firm i's return on assets (ROA, using P&L before tax) from year $t-5$ to $t-1$. In addition, for public firms only, which make for almost half of our sample, we also use $\sigma(return_i)^{36m}$, which is the standard deviation of firm i's stock returns in the 36 months before t.

In the top panel of Table 1, we present summary statistics for all key variables in our analysis. An interesting feature about European syndicated loans is their relatively long maturity, five years on average. Note, furthermore, that all loans in our sample are floating-rate loans. Importantly, while roughly half of the loans in our sample have a unique lead arranger, the average number of lead arrangers is 3.6. This set of lead arrangers serves as the basis for *Deposit ratio*$_j$, which is the average ratio (in %) of deposits over total assets across all applicable lead arrangers j in 2013.[8] Accordingly, in regression specification (1), we include bank fixed effects η_j for *all* such lead arrangers of a given loan. Hence, a convex combination of these bank fixed effects captures the level effect of *Deposit ratio*$_j$, leaving the coefficient on *Deposit ratio*$_j \times After(06/2014)_t$ as our difference-in-differences estimate.

The bottom panel of Table 1 presents separate bank-level summary statistics for all Eurozone banks in our baseline sample. In addition, Table 2 zooms in on any potential

[8] This explains the lower maximum value for the deposit ratio in the upper panel of Table 1 compared to the bank-level summary statistics reported in the bottom panel.

differences in bank characteristics between high-deposit and low-deposit banks, i.e., our treatment and control groups. High-deposit (low-deposit) banks are defined as banks in the highest (lowest) tercile of the deposit-ratio distribution. The average deposit ratio in the high-deposit group is almost three times as high as in the low-deposit group (61.13% vs. 21.58%). High-deposit banks are also smaller, have higher equity ratios (6.19 % vs 4.98%), higher loans-to-assets ratios (68.44% vs 39.92%), and higher net interest margins (1.53% vs. 0.78%). In our empirical setup, however, permanent differences between both groups are taken into account by including bank fixed effects. As such, only the variation over time of these variables could have an impact on our results.

This is particularly important for the deposit ratio, as this is our selection variable, and the equity ratio, as it is typically seen as an important determinant of bank risk taking. Reassuringly, Figures A.3 and A.4 in the Online Appendix illustrate that both the deposit ratio and the equity ratio exhibit roughly parallel trends for high-deposit and low-deposit banks throughout the entire sample period. If anything, deposit ratios may have increased somewhat more for high-deposit banks, which speaks to the existence of a zero lower bound on deposit rates, because one would have expected depositors to withdraw their funds otherwise.

Another concern may be that while both types of banks are unable to pass on negative rates to customer depositors, high-deposit banks may have moved towards charging them higher fees. Figure A.5 in the Online Appendix indicates that this is not the case, as the fee income of banks in both groups moved in parallel before 2014. Starting 2014, if anything, low-deposit banks started charging relatively higher fees. This potentially further strengthens the treatment of high-deposit banks by the introduction of negative policy rates.

3 Results

We present our results in three main steps. First, we document the effect of negative policy rates on bank risk taking, as characterized by the ex-ante volatility of firms financed by Eurozone banks. We then discuss our findings in the context of the bank lending channel,

and carve out the distributional consequences of negative monetary-policy rates. Finally, we discuss potential underlying mechanism and real effects among loan-financed firms in the economy.

3.1 Effect of Negative Policy Rates on Bank Risk Taking

We start our empirical analysis by visualizing the main finding on bank risk taking in Figure 5, namely that high-deposit Eurozone banks financed riskier firms following the introduction of negative policy rates in June 2014. We plot the four-month average[9] of ROA volatility of all firms that received loans from Eurozone lead arrangers that were in the top vs. bottom tercile of the distribution of *Deposit ratio*$_j$. That is, we yield three data points per year.

In the period leading up to the introduction of negative policy rates, risk taking of both treated high-deposit and control low-deposit banks is decreasing, and high-deposit banks financed less risky firms than low-deposit banks. This gap closes when policy rates become negative (the June-2014 data point uses data from June to September 2014), and the previous trend is eventually reversed, implying significantly greater risk taking by high-deposit banks after June 2014.

In Table 3, we confirm that this is indeed the case by estimating equation (1). In the first column, we find a positive and significant treatment effect, meaning that high-deposit banks take on more risk when rates become negative. As *Deposit ratio*$_j$ is expressed in % and the dependent variable is in logs, one can infer the percent change in ROA volatility by multiplying the difference-in-differences estimate with $0 - 100$. According to Table 1, *Deposit ratio*$_j$ exhibits a standard deviation of approximately 9.45%. Thus, a one-standard-deviation increase in *Deposit ratio*$_j$ translates into a 16-percent increase in ROA volatility ($9.45 \times 0.017 = 0.16$), which is substantial. Our difference-in-differences estimate further increases from 0.017 to 0.020 after including industry-year and country-year fixed effects in the fourth column.

[9] This is to ensure that we yield enough observations for the calculation of the mean.

In the fifth column, we extend the sample to the period from January 2011 to December 2015, and include the interaction *Deposit ratio*$_j \times After(07/2012)_t$ to test the (placebo) impact of reducing policy rates to zero in July 2012. Not only is the respective estimate close to zero and insignificant, but it is also significantly different (at the 1% level) from the coefficient on *Deposit ratio*$_j \times After(06/2014)_t$. Besides reaffirming the parallel-trends assumption, this lends support to the idea that differential risk taking by high-deposit vs. low-deposit banks is specific to rate decreases when the policy rate is negative, rather than positive.

In the last column of Table 3, we reduce the sample from the fifth column to European borrowers outside of the Eurozone so as to filter out any impact of the overall economic situation in the Eurozone that might simultaneously affect interest-rate decisions and firm characteristics.[10] In this subsample, firms should not be affected by economic policies in the Eurozone, other than through trade and other connections to Eurozone firms. The difference-in-differences estimate on *Deposit ratio*$_j \times After(06/2014)_t$ is even stronger in this subsample, and still significantly different (at the 3% level) from the coefficient on *Deposit ratio*$_j \times After(07/2012)_t$. This confirms that our main result is not driven by changes in the overall economic environment that could govern both the reduction in the policy rate and the riskiness of loan-financed firms.

We provide a battery of robustness checks in Table 4. In particular, our placebo test implies that banks' time-varying characteristics other than their funding structure are unlikely to explain the differential effect of negative policy rates on risk taking by high-deposit vs. low-deposit banks. To provide further support for this, we re-run the regressions from the fourth column of Table 3, and add banks' total assets, their ratio of securities over total assets, and their equity ratio separately and together across the first four columns of Table 4. Our difference-in-differences estimate is virtually unchanged. In the fifth column, we add a separate difference-in-differences term for banks' equity ratio (in 2013), and find no signif-

[10] The majority of these firms (70%) are UK firms, followed by Swedish (9.4%), Swiss (7.4%), and Norwegian (7.4%) firms.

icant effect, whereas the difference-in-differences estimate for banks' deposit ratios remains robust.

Next, we ensure that our findings are robust to alternative definitions of both our treatment-intensity variable and our variable choice for firm-level risk. In the last column of Table 4, we show that our difference-in-differences estimate is also robust to using the ratio of deposits over total liabilities, rather than assets. In Table B.1 of the Online Appendix, we re-run all regressions from Table 3, but replace our treatment-intensity variable *Deposit ratio*$_j$ by the average deposit ratio across all Eurozone lead arrangers from 2011 to 2013, rather than in 2013. The results are unaltered compared to those in Table 3.

As an alternative measure of ex-ante risk, we use firms' former loan spreads on syndicated loans that they received before the sample period. The results in Table B.2 suggest that high-deposit, rather than low-deposit, banks indeed financed riskier firms after June 2014, as these firms were associated with riskier and, thus, more expensive loans beforehand. For the subsample of public firms (Table B.3), we can also confirm that our results are robust to using borrower firms' stock-return volatility, based on monthly returns, as dependent variable. Note that statistical significance survives, but suffers somewhat, due to the drop in sample size in the already short sample period.

Table B.4 in the Online Appendix illustrates that our main results also hold when including Danish, Swedish, and Swiss banks to yield a staggered timing of negative policy rates across these countries and the Eurozone. In said table, we re-run the regressions from the first four columns of Table 3, and define $After_{jt}$ as an indicator for the period characterized by negative policy rates that is specific to the Eurozone, Denmark, Sweden, and Switzerland. We again find that high-deposit banks engage in more risk taking when interest rates become negative.

We also re-run our baseline specification for a sample period that ends in February 2015 to ensure that our results are not driven by the ECB's public sector purchase program (PSPP) that started on March 9, 2015. From this date onwards, the ECB expanded its existing asset-purchase programs, and started purchasing around 60 billion euro of public

and private securities a month. If the potential impact of these purchases on bank risk taking depends on the deposit ratio of a bank, then this could bias the estimation of our treatment effect. Table B.5 in the Online Appendix shows that is not the case, as our results survive when shortening our estimation window so as to exclude the PSPP months.

Overall, these results illustrate that in line with our conjecture, high-deposit banks take on more risk when policy rates become negative. More risk taking, however, is not necessarily an undesirable outcome, as it may also lead to the relaxation of financial constraints of firms. To shed light on this, in Tables 5 and B.6, we scrutinize to what extent our main results are driven by new borrowers, i.e., firms that did not, and possibly were not able to, borrow in the syndicated-loans market before the policy rate became negative, and borrowers that switched banks with different reliance on deposit funding.

More precisely, in Table 5, the $After_t$ period consists only of borrowers that did not have an outstanding syndicated loan between January 2013 and June 2014. The results are very similar to our full-sample results in Table 3, indicating that part of the risk taking is indeed operationalized by lending to new borrowers. Table B.6 shows the results for firms that already had access to the syndicated-loans market and, thus, potentially switched between high-deposit and low-deposit banks in the post-period. The positive albeit somewhat weaker treatment effect in this table reflects that we cannot rule out that some of the riskier firms switched to high-deposit banks, and some of the safer firms to low-deposit banks.

3.2 Bank Lending Channel

Our identification strategy also allows us to examine the working of the bank lending channel when policy rates become negative. When deposit rates remain fixed at the zero lower bound, this weakens the liability-side channel for high-deposit banks, so that the net worth of high-deposit banks decreases relatively more. We therefore expect the total volume of lending by high-deposit banks, relative to low-deposit banks, to decrease.

Table 6 confirms this for banks' total volume of lending aggregated to the month-year level. In the first column, we regress the log of the total volume of lending at the bank-month-year level on the interaction $Deposit\ ratio_j \times After(06/2014)_t$ and $Deposit\ ratio_j$, which is replaced by bank fixed effects in the second column, for the period from 2013 to 2015. The negative coefficient on the interaction term implies that a one-standard-deviation increase in the deposit ratio leads to a sizable decrease in lending of 9.45% ($= 0.01 \times 9.45$).

When considering loan volumes, it is important to bear in mind that we focus on syndicated loans in this analysis, and not on the total volume of loans on a bank's balance sheet. In our sample, outstanding syndicated loans on average make up at least 9% of a bank's total loan portfolio.[11]

The difference-in-differences estimate is robust to including bank fixed effects in the second column. In the last column of Table 6, we extend our sample to the period from 2011 to 2015, which allows us to add an interaction effect for the July-2012 placebo. Our June-2014 treatment effect is robust. While the coefficient on the placebo treatment is insignificant, the difference between the two coefficients is significant at the 8% level. This indicates that the liabilities structure of a bank is crucial for understanding both the bank risk-taking and the bank lending channel when policy rates become negative, while this is less important during times of decreasing, but still positive, policy rates.

Having found that high-deposit banks in our sample lent relatively less in the syndicated-loans market, we can interpret our findings in Tables 5 and B.6 as suggesting that high-deposit banks added new risky borrowers that replaced safer ones. In addition, some of this movement can be explained by firms switching banks. We document this graphically in Figure A.6 in the Online Appendix, where we plot the ROA volatility of firms that switched banks between the pre- and the post-period around June 2014 against the difference in

[11] We compute the share of outstanding syndicated loans compared to total loans by comparing syndicated loans in DealScan with the yearly SNL balance-sheet data. We take into account the maturity structure of the syndicated loans to derive the total amount of outstanding syndicated loans each year. Our measure is rather conservative, as we exclude all syndicated loans that are credit lines or institutional term loans. Credit lines are typically off-balance-sheet exposures until they are drawn down, and institutional term-loan tranches are often securitized or sold off (Ivashina and Sun (2011)).

the average 2013 deposit ratio of Eurozone lenders from which firms received loans in the post-period vs. pre-period.

The positive correlation reflects the idea that some of the safe borrowers switched from high-deposit to low-deposit banks, and some of the risky borrowers switched from low-deposit to high-deposit banks. Finally, as total lending volume relatively decreased for high-deposit banks (as seen in Table 6), the outflow of safe borrowers from high-deposit banks outweighed the inflow of risky ones.

Next, we investigate what is driving the relative reduction in lending by high-deposit banks. Is the average size of a loan reduced, or are high-deposit banks extending fewer loans? In the first four columns of Table 7, we use the sample of new borrowers, and we regress the log of loan size on the interaction $\textit{Deposit ratio}_j \times After(06/2014)_t$ and on an increasing number of fixed effects, just as in our baseline setup in Table 5. The results show that there is no significant change in the size of the loans granted by high-deposit banks compared to the loans granted by low-deposit banks. This implies that the reduction in total loan volume must be driven by a reduction in the number of loans.

The last column of Table 7 reveals another interesting finding: while there is no difference in average loan size, high-deposit banks do grant larger loans to risky borrowers. This is evident from the positive and significant interaction term between $\textit{Deposit ratio}_j \times After(06/2014)_t$ and our preferred firm-risk variable $\sigma(ROA_i)^{5y}$. Conversely, this effect is absent from the sample of potential switchers that had loans outstanding in both the pre- and the post-period around June 2014 (see Table B.7). This result is very much in line with the increased risk-seeking behavior of high-deposit banks that we already documented in Tables 3 to 5.

In combination, our findings suggest that following the introduction of negative policy rates, loans associated with greater firm-level volatility have become more attractive for high-deposit banks. At the same time, the total volume of lending by these treated banks has decreased. The riskiness of the total loan portfolio of high-deposit banks thus increased when policy rates became negative.

3.3 Underlying Mechanism

Are banks compensating the increase in risk taking that we documented in the previous section by charging higher loan rates or tightening loan terms? If the increased riskiness is compensated by higher loan rates or tightened loan terms, then our previous findings would not reflect risk taking in its strict sense. If banks are compensated for higher risk with higher loan rates, then bank behavior reflects a "search for yield" (Rajan (2005)) rather than risk taking.[12] Similarly, when banks offset the higher risk of borrowers with more collateral, more covenants, or shorter maturities, then one cannot view such behavior as an increase in risk taking either.

To show that this is not the case, we re-estimate regression specification (1) for various loan-level (contractual) outcomes. In the first four columns of Table 8, we find no significant difference in the average loan spread charged by high-deposit and low-deposit banks once policy rates become negative. This finding is somewhat in line with Ioannidou, Ongena, and Peydró (2015) and Paligorova and Santos (2016), who find that banks charge riskier borrowers lower spreads in times of low but positive interest rates. In the fifth column, there is no difference between the two difference-in-differences estimates around the two rate decreases in June 2014 and July 2012. In the last column, where we limit the sample to non-Eurozone borrowers, the effect does not survive either.

Additionally, Table B.8 in the Online Appendix shows that most of these insights hold up to incorporating relevant loan fees, for which we use the total cost of borrowing defined in Berg, Saunders, and Steffen (2016).

This is particularly interesting in light of our finding in Table B.2 that high-deposit banks financed riskier firms, as measured by their *former* loan spreads (before the start of the sample period). In sum, our evidence suggests that high-deposit banks have become

[12] An increase of loan rates also would be inconsistent with the pass-through of lower policy rates to lower loan rates, which is required for the identification of the bank risk-taking channel (for more on this as well as the distinction between search-for-yield and risk taking, see Dell'Ariccia, Laeven, and Marquez (2014); Dell'Ariccia, Laeven, and Suarez (2016)).

willing to finance riskier firms without adjusting their loan spreads to reflect the higher risk of borrowers.

Other loan terms at origination are not adjusted either: in Table 9, we fail to find any treatment effects on whether loans are secured, the use of financial covenants, or loan maturity. Importantly, in the second column of Table 9, we do not find any treatment effect on the (average) loan share retained by the lead arranger(s). The lead share carries particular importance in syndicated lending, as it reflects lead arrangers' incentives to monitor borrower behavior (see Ivashina (2009), Ivashina and Scharfstein (2010)). Therefore, higher ex-ante risk taking, together with no corresponding increase in monitoring incentives, may additionally lead to higher *ex-post* riskiness of the respective bank loans.

Our setup allows us to also investigate the role of ex-ante bank capitalization for risk taking. As explained before, a change in interest rates can affect bank risk taking through both assets and liabilities. Throughout the paper, we have illustrated the importance of the asset-side channel by shutting down the liability-side channel. On top of that, Table 10 illustrates the importance of bank capitalization for the strength of the asset-side channel.

In the first two columns of Table 10, we re-run our baseline specification from Table 3 on two subsamples: the first column contains all banks in the bottom tercile of the distribution of the ratio of equity over total assets, while the second column contains all banks in the top tercile of said distribution. Our difference-in-differences estimate is positive and significant at the 1% level only for the group of poorly-capitalized banks. In other words, after we shut down the net-worth effect on the liabilities side, we show that bank capitalization still matters for the strength of the asset-side channel.

This continues to hold true in the last two columns of Table 10, where we extend the sample to include our placebo treatment: poorly-capitalized banks financed significantly riskier firms after the introduction of negative policy rates than they did after the deposit facility rate was reduced to zero in July 2012 (the difference between the two interaction terms is significant at the 2% level). In this manner, we confirm the findings of Jiménez,

Ongena, Peydró, and Saurina (2014) to hold true even after muting the pass-through to lower cost of funding in low-rate environments.

3.4 Real Effects

In Section 3.2, we have shown that high-deposit banks concentrate their lending on risky borrowers when rates become negative. In particular, some of these high-risk borrowers did not borrow in the syndicated-loans market before the policy rate became negative, indicating that they may have been credit constrained. In this section, we further document the characteristics of these firms that are more likely to receive credit, and investigate the impact on firm-level investment to argue that high-deposit banks relaxed financial constraints of risky borrowers.

In the first two columns of Table 11, we re-run our baseline analysis separately for privately held and publicly listed firms in our sample. The results indicate that the increase in bank risk taking is stronger for the sample of private firms. This again suggests that the increase in bank risk taking leads to an increase in credit availability for firms that are typically seen as more credit constrained. Additionally, note that the weaker effect for public firms is in line with our (weaker) findings for stock-return volatility using the same sample of firms (see Table B.3), conditional on the availability of stock-return data.

Furthermore, in the third column, we add as explanatory variable an indicator variable for whether banks were previously more exposed to the borrower firm's industry. The positive and significant coefficient on the triple interaction implies that the treatment effect is $0.019/0.012 = 1.58$ times stronger for firms operating out of industries that the lead arrangers had experience with. This suggests that the risk taking by high-deposit banks is partly characterized by loans to sectors that are correlated with other sources of the same bank's revenues.

In the last two columns of Table 11, the dependent variable is, respectively, the return on assets and the leverage of the firm receiving a loan, both measured in the year before

receiving the loan. The results in the fourth column show that firms that received loans from high-deposit banks after policy rates became negative are no less profitable. This suggests that our earlier findings are unlikely to be driven by so-called "zombie loans," i.e., loans that banks grant only to keep firms afloat and to ensure that these borrowers would not default on previous loans. The last column of Table 11 illustrates that high-deposit banks do lend more to low-leverage firms, again suggesting an improvement in access to credit for financially constrained borrowers.

Finally, we investigate whether the relaxation of financial constraints for risky borrowers translates into higher firm-level investment. In Table 12, the dependent variable is the difference in the logged value of a firm's investment, as measured by the change in tangible fixed assets, after a loan is granted. This implies that we, for example, evaluate the impact of a loan granted in July 2014 on firm-level investment between the end of 2014 and the end of 2015 (assuming that the firm files its balance sheets at the end of the year). In the first and third column of Table 12, the sample consists of borrowers in the bottom tercile of the distribution of ROA volatility, while the second and fourth column contain the results for firms in the top tercile of said distribution.

Our previous results showed that high-deposit banks lend more to riskier firms (see, e.g., Tables 3 and 7). As such, we expect to see an increase in investment for risky borrowers that contract with high-deposit banks.

The results in Table 12 confirm this. For low-risk firms, it does not seem to matter whether they borrow from high- or low-deposit banks. Risky firms, on the other hand, invest significantly more when they borrow from high-deposit banks. Note that while the positive difference-in-differences estimate for risky borrowers in the last column is insignificant – possibly due to the large drop in sample size – it is still positive and borderline significantly different from the placebo treatment (at the 14% level), whereas the reverse holds true in the sample of low-risk borrowers in the third column.

4 Conclusion

When central banks charge negative policy rates to stimulate a post-crisis economy, they enter unchartered territory. We document the distributional effects of such standard monetary policy below the zero bound. In particular, we identify negative policy rates to lead to greater risk taking by high-deposit banks, as compared to low-deposit banks, in the market for syndicated loans. This risk taking is accompanied by reduced lending by high-deposit banks that concentrate their lending on privately held, possibly credit-constrained, but *riskier* borrower firms. Safer borrowers, in turn, switch to low-deposit banks. In this manner, we document how negative policy rates transmit to the real economy through bank lending.

Lowering policy rates into negative territory provides a suitable natural experiment to study the impact of central-bank decisions on bank behavior. Normally, it is difficult to disentangle the effect of lower policy rates on the asset side of banks' balance sheets from the effect on the liability side. We exploit banks' reluctance to pass on negative rates to their depositors. This effectively shuts down the effect on the liability side for banks that rely more on deposit funding.

We use transaction-level data on syndicated loans to examine bank lending behavior. While the market for syndicated loans represents only a fraction of overall bank lending, it offers two key advantages in our setting. First, it allows us to match banks with firms. We can therefore study the characteristics of firms that receive new loans – most notably an ex-ante measure of risk – from banks with differential exposure to lower policy rates (through their different reliance on deposit funding). Second, the market for syndicated loans is global. This enables us to study borrowers that are isolated from a change in the policy rate, because they are located in a different currency zone. This effectively shuts down the demand channel, which is based on the premise that monetary policy and the economic environment are endogenous.

While negative policy rates are intended to deliver additional monetary stimulus, they operate through banks as suppliers of financing to the real economy. We show that negative

rates change the matching of borrowers and lenders, facilitating investment by riskier firms. Crucially, the transmission of negative rates to the real sector depends on banks' funding structure, which we have shown to matter only in times of rate decreases when rates are negative, rather than positive. Our evidence may serve to motivate the incorporation of negative rates in macroeconomic models.

Furthermore, our findings attest to the possibility that the effective lower bound on monetary policy, at which accommodative policy becomes contractionary (Brunnermeier and Koby (2016)), may be negative. Future research on the longer-run consequences of negative policy rates is needed to shed light on the implications for financial stability. In this context, our results leave open whether high-deposit banks, which tend to be more profitable and better capitalized, are matched efficiently with high-risk borrowers. This calls into question the role of deposit funding for the stability of banks, and whether negative policy rates are effective in the longer run.

References

Acharya, V. V., T. Eisert, C. Eufinger, and C. W. Hirsch (2016): "Whatever it takes: The Real Effects of Unconventional Monetary Policy," *NYU Stern Working Paper*.

Bech, M. L., and A. Malkhozov (2016): "How Have Central Banks Implemented Negative Policy Rates?," *BIS Quarterly Review No. 1*.

Berg, T., A. Saunders, and S. Steffen (2016): "The Total Costs of Corporate Borrowing in the Loan Market: Don't Ignore the Fees," *Journal of Finance*, 71(3), 1357–1392.

Bernanke, B. S. (2007): "The Financial Accelerator and the Credit Channel," The Credit Channel of Monetary Policy in the Twenty-first Century Conference, Federal Reserve Bank of Atlanta, Atlanta, Georgia.

Bernanke, B. S., and A. S. Blinder (1988): "Money, Credit and Aggregate Demand," *American Economic Review*, 82, 901–921.

Bernanke, B. S., and M. Gertler (1995): "Inside the Black Box: The Credit Channel of Monetary Policy Transmission," *Journal of Economic Perspectives*, 9(4), 27–48.

Brunnermeier, M. K., and Y. Koby (2016): "The Reversal Interest Rate: An Effective Lower Bound on Monetary Policy," *Princeton University Working Paper*.

Chakraborty, I., I. Goldstein, and A. MacKinlay (2016): "Monetary Stimulus and Bank Lending," *University of Pennsylvania Working Paper*.

Crosignani, M., and L. Carpinelli (2016): "The Effect of Central Bank Liquidity Injections on Bank Credit Supply," *Federal Reserve Board Working Paper*.

Dell'Ariccia, G., L. Laeven, and R. Marquez (2014): "Real Interest Rates, Leverage, and Bank Risk-Taking," *Journal of Economic Theory*, 149, 65–99.

Dell'Ariccia, G., L. Laeven, and G. Suarez (2016): "Bank Leverage and Monetary Policy's Risk-Taking Channel: Evidence from the United States," *Journal of Finance*, forthcoming.

Drechsler, I., A. Savov, and P. Schnabl (2016): "The Deposits Channel of Monetary Policy," *NBER Working Paper No. 22152*.

Holmström, B., and J. Tirole (1997): "Financial Intermediation, Loanable Funds, and the Real Sector," *Quarterly Journal of Economics*, 106(1), 663–691.

Ioannidou, V., S. Ongena, and J.-L. Peydró (2015): "Monetary Policy, Risk-Taking, and Pricing: Evidence from a Quasi-Natural Experiment," *Review of Finance*, 19(1), 95–144.

Ivashina, V. (2009): "Asymmetric Information Effects on Loan Spreads," *Journal of Financial Economics*, 92(2), 300–319.

Ivashina, V., and D. Scharfstein (2010): "Loan Syndication and Credit Cycles," *American Economic Review: Papers and Proceedings*, 100(2), 1–8.

Ivashina, V., and Z. Sun (2011): "Institutional Demand Pressure and the Cost of Corporate Loans," *Journal of Financial Economics*, 99(3), 500–522.

Jiménez, G., S. Ongena, J.-L. Peydró, and J. Saurina (2012): "Credit Supply and Monetary Policy: Identifying the Bank Balance-Sheet Channel with Loan Applications," *American Economic Review*, 102(5), 2301–2326.

——— (2014): "Hazardous Times for Monetary Policy: What Do Twenty-Three Million Bank Loans Say About the Effects of Monetary Policy on Credit Risk-Taking?," *Econometrica*, 82(2), 463–505.

Kacperczyk, M. T., and M. Di Maggio (2016): "The Unintended Consequences of the Zero Lower Bound Policy," *Journal of Financial Economics*, forthcoming.

Kandrac, J., and B. Schlusche (2016): "Quantitative Easing and Bank Risk Taking: Evidence from Lending," *Federal Reserve Board Working Paper*.

Kishan, R. P., and T. P. Opiela (2000): "Bank Size, Bank Capital, and the Bank Lending Channel," *Journal of Money, Credit and Banking*, 32(1), 121–141.

Paligorova, T., and J. A. C. Santos (2016): "Monetary Policy and Bank Risk-Taking: Evidence from the Corporate Loan Market," *Federal Reserve Bank of New York Working Paper*.

Rajan, R. G. (2005): "Has financial development made the world riskier?," in *Proceedings, Federal Reserve Bank of Kansas City*, pp. 313–369.

Rognlie, M. (2016): "What Lower Bound? Monetary Policy with Negative Interest Rates," *Northwestern University Working Paper*.

Saunders, A. (2000): "Low Inflation: The Behavior of Financial Markets and Institutions," *Journal of Money, Credit and Banking*, 32(4), 1058–1087.

Stein, J. C. (1998): "An adverse-selection model of bank asset and liability management with implications for the transmission of monetary policy," *RAND Journal of Economics*, 29, 466–486.

Stein, J. C., and A. K. Kashyap (2000): "What Do a Million Observations on Banks Say about the Transmission of Monetary Policy?," *American Economic Review*, 90(3), 407–428.

5 Figures

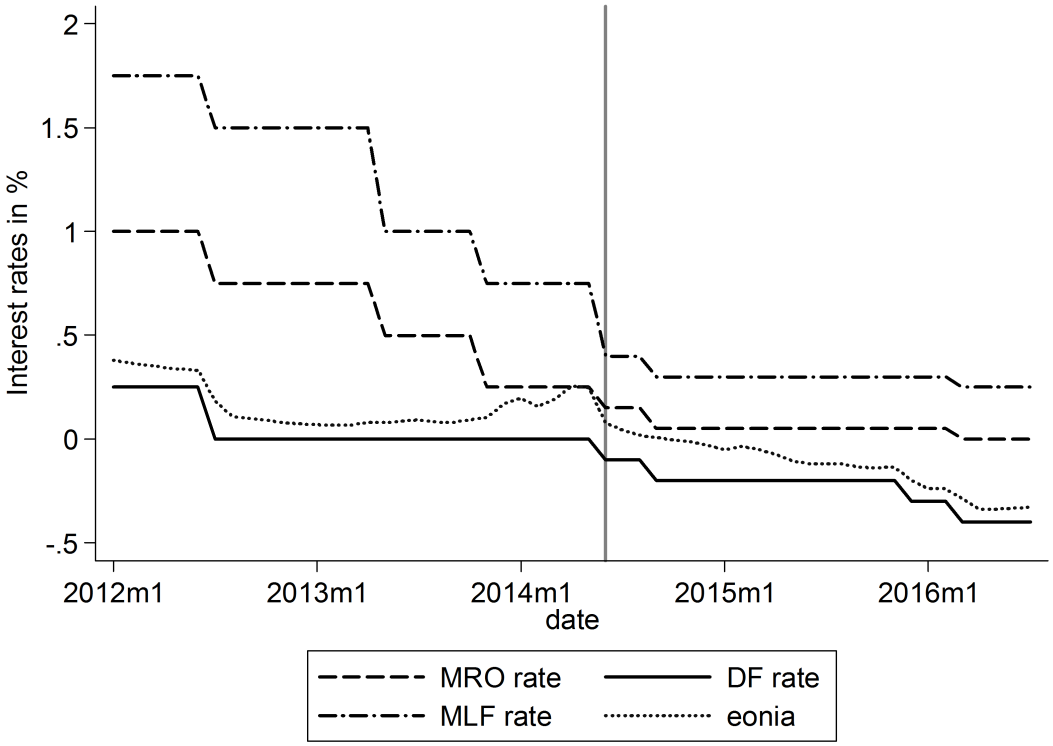

Figure 1: **ECB Key Policy Rates and Interbank Lending Rate.** This figure shows the evolution of the ECB Marginal Lending Facility (MLF) rate, the ECB Main Refinancing Operations Rate (MRO) rate, the ECB Deposit Facility (DF) rate, and the Euro OverNight Index (Eonia) rate between January 2012 and July 2016. The vertical line indicates June 2014, the first month that the DF rate was set below zero. All data series are taken from the ECB Statistical Data Warehouse.

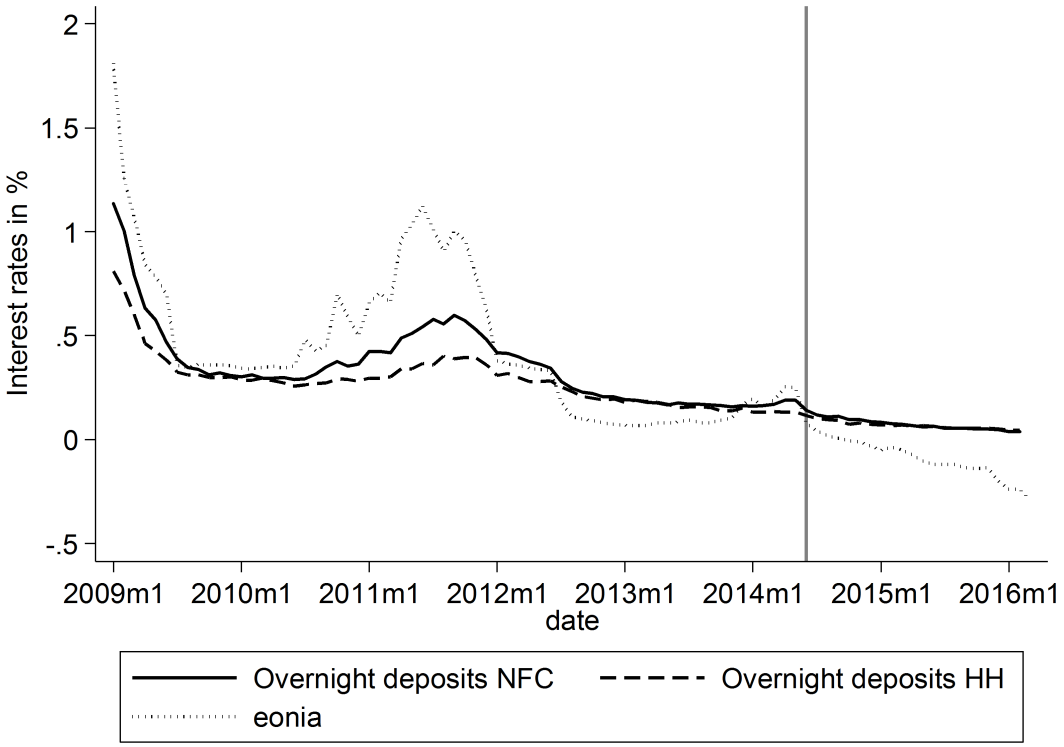

Figure 2: **Deposit Rates on Overnight Deposits (Households and Non-financial Corporations).** This figure shows the evolution of overnight deposit rates at Eurozone banks between January 2009 and March 2016, in comparison to the Euro OverNight Index Average (Eonia) of overnight unsecured lending transactions in the interbank market. The data are taken from the ECB IMIR interest rate statistics database, which provides monthly data on deposit rates for the median Eurozone bank at the monetary financial institution (MFI) level.

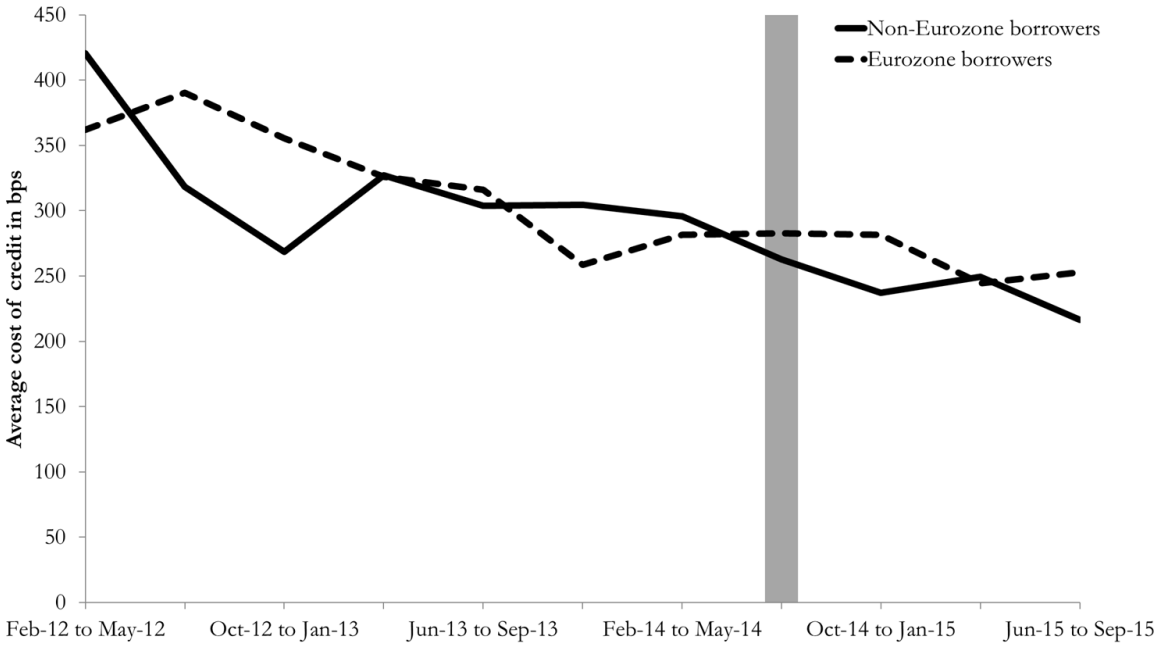

Figure 3: **Evolution of Cost of Debt associated with Loans granted by Eurozone Banks.** This figure plots the four-month (forward-looking) average of the total cost of credit charged by Eurozone lead arrangers, separately for Eurozone and non-Eurozone borrowers.

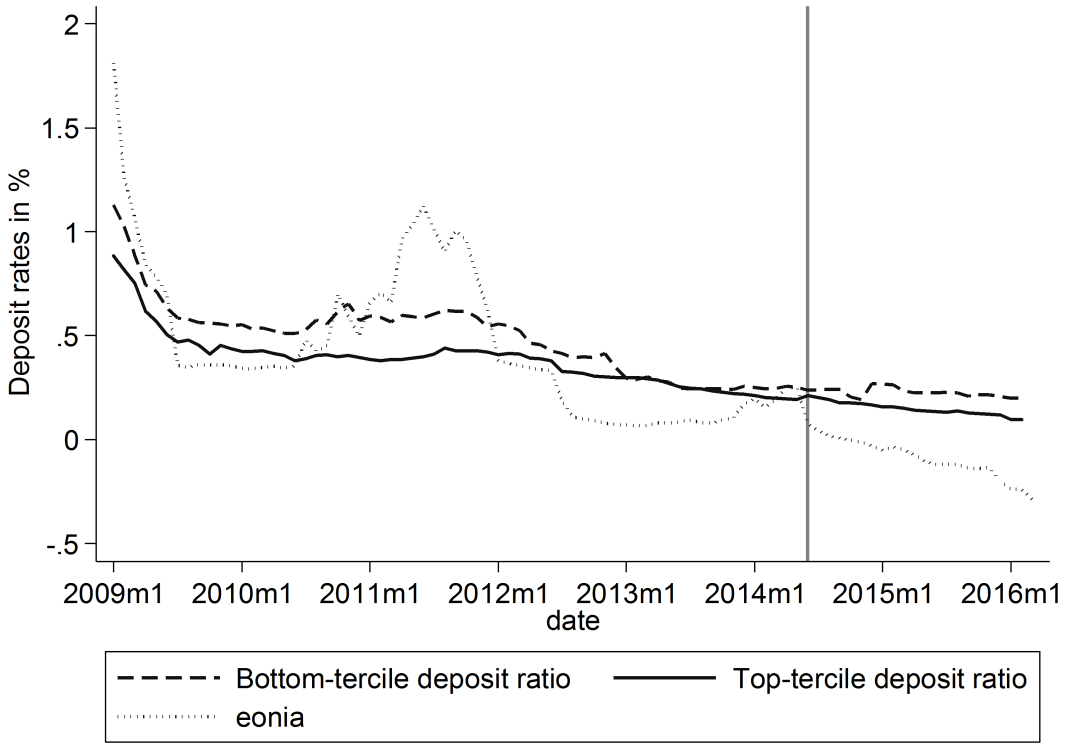

Figure 4: **Deposit Rates on Overnight Deposits (Households) – High-deposit vs. Low-deposit Banks.** This figure shows the evolution of overnight deposit rates for households in the Eurozone between January 2009 and March 2016. The rates are shown for banks in the top tercile of the distribution of the deposit ratio in December 2013 (dashed line) and for banks in the bottom tercile (full line). The dotted line represents the Euro OverNight Index Average (Eonia) of overnight unsecured lending transactions in the interbank market. The data are taken from the ECB IBSI and IMIR database, which provides monthly bank balance-sheet and interest-rate data for Eurozone banks at the monetary financial institution (MFI) level.

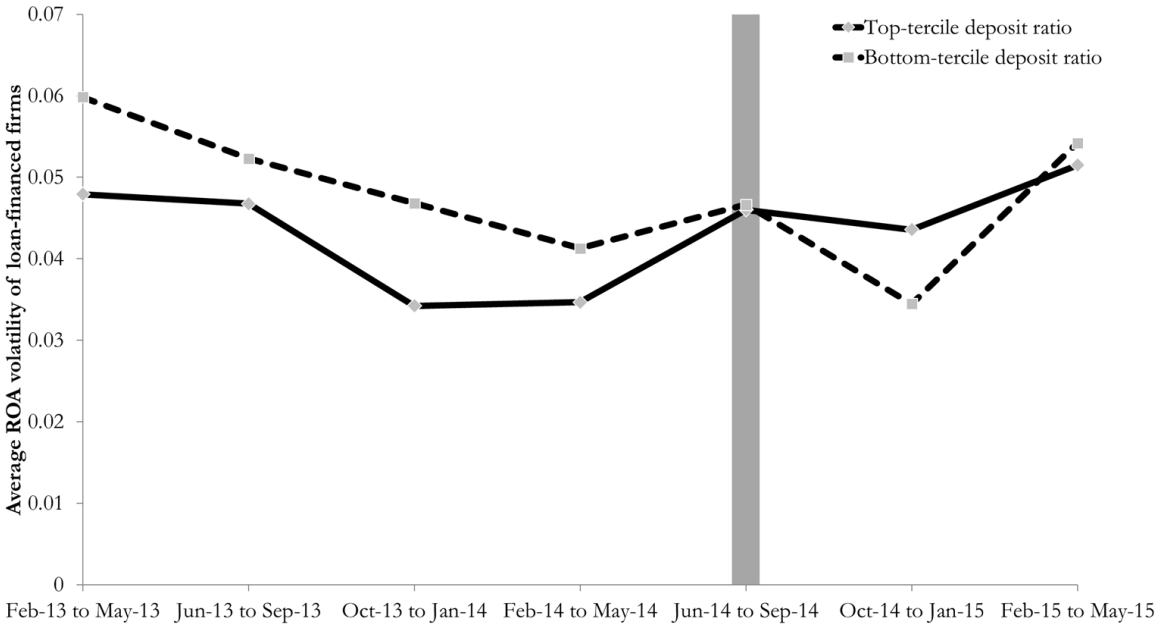

Figure 5: **ROA Volatility of Firms associated with Loans granted by Eurozone Banks with High vs. Low Deposit Ratios.** This figure plots the four-month (forward-looking) average of ROA volatility of all private and publicly listed firms that received loans from Eurozone lead arrangers that were in the top vs. bottom tercile of the distribution of the average ratio of deposits over total assets in 2013. For a given loan at date t, the associated ROA volatility is measured as the five-year standard deviation of the borrower firm's return on assets (ROA, using P&L before tax) from year $t-5$ to $t-1$.

6 Tables

Table 1: **Summary Statistics**

Loans sample	Mean	Std. dev.	Min	Max	N
$\sigma(ROA_i)^{5y}$	0.041	0.046	0.001	0.488	1,576
$\sigma(return_i)^{36m}$	0.085	0.036	0.030	0.329	665
Deposit ratio in %	40.793	9.452	0.486	64.527	2,450
Equity ratio in %	5.369	1.088	3.398	13.608	2,450
Eurozone firm $\in \{0, 1\}$	0.781	0.414	0	1	2,450
All-in-drawn spread in bps	264.329	157.035	10	850	791
Loan size in 2016 €bn	0.741	1.932	0.001	68.482	2,426
Secured $\in [0, 1]$	0.690	0.460	0	1	986
Avg. loan share of lead arrangers $\in [0, 1]$	0.233	0.186	0	1	591
Financial covenants $\in \{0, 1\}$	0.034	0.181	0	1	2,450
Maturity of loan in months	58.782	27.331	1	345	2,386
No. of lead arrangers	3.644	2.862	1	20	2,450
Bank-level sample	Mean	Std. dev.	Min	Max	N
Deposit ratio in %	43.053	18.688	0.486	78.392	70
Equity ratio in %	6.158	2.878	1.463	22.643	70
ln(Total assets)	11.872	1.361	7.064	14.409	70
Loans-to-assets ratio in %	57.207	17.602	2.025	87.402	66
Return on assets in %	0.064	0.834	-3.288	4.067	70
Net interest margin in %	1.252	0.672	-0.042	3.423	68

Notes: In the top panel, the baseline sample consists of all completed syndicated loans (package level) of both private and publicly listed firms i at date t granted by any Eurozone lead arranger(s) j from January 2013 to December 2015. $\sigma(ROA_i)^{5y}$ is the five-year standard deviation of firm i's return on assets (ROA, using P&L before tax) from year $t-5$ to $t-1$. $\sigma(return_i)^{36m}$ is the standard deviation of firm i's stock returns in the 36 months before t. *Deposit ratio*$_j$ is the average ratio (in %) of deposits over total assets across all Eurozone lead arrangers j in 2013. *Eurozone firm*$_i$ is an indicator for whether firm i is headquartered in the Eurozone. The all-in-drawn spread is the sum of the spread over LIBOR and any annual fees paid to the lender syndicate. The bottom panel presents the bank-level summary statistics for all Eurozone banks included in the baseline sample. All bank-level variables are calculated using yearly balance-sheet and P&L data for the year 2013.

Table 2: **Further Bank-level Summary Statistics**

	Tercile	N	Mean	Std. dev	t-stat
Deposit ratio in %	Bottom	24	21.58	12.60	13.82
	Top	23	61.13	6.04	
Equity ratio in %	Bottom	24	4.98	2.26	1.94
	Top	23	6.19	2.04	
ln(Total assets)	Bottom	24	12.22	1.61	2.00
	Top	23	11.46	0.94	
Loans-to-assets ratio in %	Bottom	22	39.92	17.97	6.75
	Top	23	68.44	8.56	
Return on assets in %	Bottom	24	0.04	0.44	0.54
	Top	23	0.17	1.05	
Net interest margin in %	Bottom	23	0.78	0.44	4.98
	Top	23	1.53	0.57	

Notes: This table compares yearly bank balance-sheet characteristics between banks with high and low deposit ratios. High-deposit (low-deposit) banks are defined as banks that are in the top (bottom) tercile of the distribution of the deposit ratio in 2013. The deposit ratio is defined as total retail deposits over total assets. The last column shows the absolute value of the t-statistic for a t-test that tests whether the difference in mean between both groups is equal to zero. The sample period for the test is the year 2013.

Table 3: **ROA Volatility of Firms Financed by Banks Following Negative Policy Rates**

	$\ln(\sigma(ROA_i)^{5y})$					
Sample	$2013-2015$				$2011-2015$	$2011-2015$, non-Euro
Deposit ratio × After(06/2014)	0.017***	0.016***	0.018***	0.020***	0.020***	0.033**
	(0.005)	(0.005)	(0.005)	(0.005)	(0.006)	(0.014)
Deposit ratio × After(07/2012)					-0.007	-0.012
					(0.004)	(0.010)
Bank FE	Y	Y	Y	Y	Y	Y
Month-year FE	Y	Y	Y	Y	Y	Y
Country FE	N	Y	N	N	N	N
Industry FE	N	Y	Y	N	N	N
Country-year FE	N	N	Y	Y	Y	Y
Industry-year FE	N	N	N	Y	Y	Y
N	1,576	1,576	1,576	1,576	2,490	542

Notes: The sample consists of all completed syndicated loans (package level) of both private and publicly listed firms i at date t granted by any Eurozone lead arranger(s) j, from January 2013 to December 2015 in the first four columns and from January 2011 to December 2015 in the last two columns. In the last column, we furthermore limit the sample to non-Eurozone borrowers. The dependent variable is the logged five-year standard deviation of firm i's return on assets (ROA, using P&L before tax) from year $t-5$ to $t-1$. *Deposit ratio*$_j$ is the average ratio (in %) of deposits over total assets across all Eurozone lead arrangers j in 2013. $After(06/2014)_t$ is a dummy variable for the period from June 2014 onwards. $After(07/2012)_t$ is a dummy variable for the period from July 2012 onwards. Bank fixed effects are included for all Eurozone lead arrangers. Industry(-year) fixed effects are based on two-digit SIC codes. Country(-year) fixed effects are based on the firm's country of origin. Public-service, energy, and financial-services firms are dropped. Robust standard errors (clustered at the bank level) are in parentheses.

Table 4: **ROA Volatility of Firms Financed by Banks Following Negative Policy Rates – Robustness**

	$\ln(\sigma(ROA_i)^{5y})$					
Robustness						Alt. definition deposit ratio
Deposit ratio × After(06/2014)	0.020***	0.023***	0.019***	0.022***	0.019***	0.019***
	(0.005)	(0.006)	(0.006)	(0.006)	(0.006)	(0.005)
$\ln(\text{Assets})_{t-1}$	0.081			0.029		
	(0.059)			(0.063)		
Securities ratio_{t-1}		0.009**		0.014**		
		(0.004)		(0.006)		
Equity ratio_{t-1}			0.035	0.105**		
			(0.054)	(0.049)		
Equity ratio × After(06/2014)					0.025	
					(0.051)	
Bank FE	Y	Y	Y	Y	Y	Y
Month-year FE	Y	Y	Y	Y	Y	Y
Country-year FE	Y	Y	Y	Y	Y	Y
Industry-year FE	Y	Y	Y	Y	Y	Y
N	1,576	1,576	1,576	1,576	1,576	1,576

Notes: The sample consists of all completed syndicated loans (package level) of both private and publicly listed firms i at date t granted by any Eurozone lead arranger(s) j, from January 2013 to December 2015. The dependent variable is the logged five-year standard deviation of firm i's return on assets (ROA, using P&L before tax) from year $t-5$ to $t-1$. *Deposit ratio*$_j$ is the average ratio (in %) of deposits over total assets across all Eurozone lead arrangers j in 2013 in the first five columns. In the last column, *Deposit ratio*$_j$ is the average ratio (in %) of deposits over total liabilities across all Eurozone lead arrangers j in 2013. *Assets*$_{j,t-1}$ is the logged average value of total assets across all Eurozone lead arrangers j in year $t-1$. *Securities ratio*$_{j,t-1}$ is the average ratio (in %) of securities over total assets across all Eurozone lead arrangers j in year $t-1$. *Equity ratio*$_{j,t-1}$ is the average ratio (in %) of equity over total assets across all Eurozone lead arrangers j in year $t-1$. *Equity ratio*$_j$ is the average ratio (in %) of equity over total assets across all Eurozone lead arrangers j in 2013. $After(06/2014)_t$ is a dummy variable for the period from June 2014 onwards. Bank fixed effects are included for all Eurozone lead arrangers. Industry-year fixed effects are based on two-digit SIC codes. Country-year fixed effects are based on the firm's country of origin. Public-service, energy, and financial-services firms are dropped. Robust standard errors (clustered at the bank level) are in parentheses.

Table 5: **ROA Volatility of Firms Financed by Banks Following Negative Policy Rates: New Borrowers**

	$\ln(\sigma(ROA_i)^{5y})$			
Deposit ratio × After(06/2014)	0.017***	0.016***	0.017***	0.018***
	(0.005)	(0.005)	(0.006)	(0.006)
Bank FE	Y	Y	Y	Y
Month-year FE	Y	Y	Y	Y
Country FE	N	Y	N	N
Industry FE	N	Y	Y	N
Country-year FE	N	N	Y	Y
Industry-year FE	N	N	N	Y
N	1,468	1,468	1,468	1,468

Notes: The sample consists of all completed syndicated loans (package level) of both private and publicly listed firms i at date t granted by any Eurozone lead arranger(s) j, from January 2013 to December 2015, where borrowers that received a loan (from a Eurozone lender) in the period from June 2014 onwards had no outstanding loan (from any bank) in the period leading up to June 2014. The dependent variable is the logged five-year standard deviation of firm i's return on assets (ROA, using P&L before tax) from year $t-5$ to $t-1$. *Deposit ratio*$_j$ is the average ratio (in %) of deposits over total assets across all Eurozone lead arrangers j in 2013. $After(06/2014)_t$ is a dummy variable for the period from June 2014 onwards. Bank fixed effects are included for all Eurozone lead arrangers. Industry(-year) fixed effects are based on two-digit SIC codes. Country(-year) fixed effects are based on the firm's country of origin. Public-service, energy, and financial-services firms are dropped. Robust standard errors (clustered at the bank level) are in parentheses.

Table 6: **Impact of Negative Policy Rates on Bank Lending Channel**

	ln(Total loan volume)		
Sample	$2013-2015$	$2013-2015$	$2011-2015$
Deposit ratio × After(06/2014)	-0.010**	-0.009*	-0.009**
	(0.004)	(0.005)	(0.004)
Deposit ratio × After(07/2012)			0.008
			(0.006)
Deposit ratio	-0.003		
	(0.009)		
Bank FE	N	Y	Y
Month-year FE	Y	Y	Y
N	759	759	1,371

Notes: The level of observation is a bank's month-year, based on all completed syndicated loans granted by lead arranger j at date t, from January 2013 to December 2015 in the first two columns and from January 2011 to December 2015 in the last column. In general, the sample of banks is limited to those that consistently – at least for 30 months during the respective sample period – act as lead arrangers in syndicated loans. The dependent variable is the logged total loan volume granted by bank j in its function as lead arranger in syndicated loans, calculated on the basis of the respective loan shares. *Deposit ratio*$_j$ is bank j's ratio (in %) of deposits over total assets in 2013. $After(06/2014)_t$ is a dummy variable for the period from June 2014 onwards. $After(07/2012)_t$ is a dummy variable for the period from July 2012 onwards. Bank fixed effects are included for all Eurozone lead arrangers. Robust standard errors (clustered at the bank level) are in parentheses.

Table 7: **Impact of Negative Policy Rates on Loan Size: New Borrowers**

	ln(Loan size)				
Deposit ratio × After(06/2014)	-0.000	-0.005	-0.006	-0.006	-0.011
	(0.006)	(0.006)	(0.005)	(0.006)	(0.007)
Deposit ratio × After(06/2014) × $\sigma(ROA_i)^{5y}$					0.284**
					(0.126)
Deposit ratio × $\sigma(ROA_i)^{5y}$					-0.252***
					(0.091)
$\sigma(ROA_i)^{5y}$ × After(06/2014)					-8.584
					(5.413)
$\sigma(ROA_i)^{5y}$					6.886*
					(3.739)
Bank FE	Y	Y	Y	Y	Y
Month-year FE	Y	Y	Y	Y	Y
Country FE	N	Y	N	N	N
Industry FE	N	Y	Y	N	N
Country-year FE	N	N	Y	Y	Y
Industry-year FE	N	N	N	Y	Y
N	1,468	1,468	1,468	1,468	1,468

Notes: The sample consists of all completed syndicated loans (package level) of both private and publicly listed firms i at date t granted by any Eurozone lead arranger(s) j from January 2013 to December 2015, where borrowers that received a loan (from a Eurozone lender) in the period from June 2014 onwards had no outstanding loan (from any bank) in the period leading up to June 2014. The dependent variable is the log of the loan size. *Deposit ratio*$_j$ is the average ratio (in %) of deposits over total assets across all Eurozone lead arrangers j in 2013. $After(06/2014)_t$ is a dummy variable for the period from June 2014 onwards. $\sigma(ROA_i)^{5y}$ is the five-year standard deviation of firm i's return on assets (ROA, using P&L before tax) from year $t-5$ to $t-1$. Bank fixed effects are included for all Eurozone lead arrangers. Industry(-year) fixed effects are based on two-digit SIC codes. Country(-year) fixed effects are based on the firm's country of origin. Public-service, energy, and financial-services firms are dropped. Robust standard errors (clustered at the bank level) are in parentheses.

Table 8: **Impact of Negative Policy Rates on Loan Spreads**

Sample	ln(All-in-drawn spread)					
	2013 − 2015				2011 − 2015	2011 − 2015, non-Euro
Deposit ratio × After(06/2014)	-0.009	-0.006	-0.003	-0.002	-0.001	0.015
	(0.006)	(0.005)	(0.006)	(0.007)	(0.006)	(0.012)
Deposit ratio × After(07/2012)					-0.002	0.002
					(0.004)	(0.015)
Bank FE	Y	Y	Y	Y	Y	Y
Month-year FE	Y	Y	Y	Y	Y	Y
Country FE	N	Y	N	N	N	N
Industry FE	N	Y	Y	N	N	N
Country-year FE	N	N	Y	Y	Y	Y
Industry-year FE	N	N	N	Y	Y	Y
N	791	791	791	791	1,332	367

Notes: The sample consists of all completed syndicated loans (package level) of both private and publicly listed firms i at date t granted by any Eurozone lead arranger(s) j, from January 2013 to December 2015 in the first four columns and from January 2011 to December 2015 in the last two columns. In the last column, we furthermore limit the sample to non-Eurozone borrowers. The dependent variable is the log of the all-in-drawn spread (in bps), which is the sum of the spread over LIBOR and any annual fees paid to the lender syndicate. $Deposit\ ratio_j$ is the average ratio (in %) of deposits over total assets across all Eurozone lead arrangers j in 2013. $After(06/2014)_t$ is a dummy variable for the period from June 2014 onwards. $After(07/2012)_t$ is a dummy variable for the period from July 2012 onwards. Bank fixed effects are included for all Eurozone lead arrangers. Industry(-year) fixed effects are based on two-digit SIC codes. Country(-year) fixed effects are based on the firm's country of origin. Public-service, energy, and financial-services firms are dropped. Robust standard errors (clustered at the bank level) are in parentheses.

Table 9: **Impact of Negative Policy Rates on Other Loan Terms**

	Secured	Lead share	Covenants	ln(Maturity)
Deposit ratio × After(06/2014)	-0.000	0.003	0.001	-0.001
	(0.003)	(0.002)	(0.001)	(0.002)
Bank FE	Y	Y	Y	Y
Month-year FE	Y	Y	Y	Y
Country-year FE	Y	Y	Y	Y
Industry-year FE	Y	Y	Y	Y
N	986	591	2,450	2,386

Notes: The sample consists of all completed syndicated loans (package level) of both private and publicly listed firms i at date t granted by any Eurozone lead arranger(s) j from January 2013 to December 2015. The dependent variable in the first column is the proportion, between 0 and 1, of facilities within the package that are secured, in the second column the average loan share, between 0 and 1, retained by all Eurozone lead arrangers, in the third column an indicator for whether the loan has at least one financial covenant, and in the last column the logged maturity. *Deposit ratio*$_j$ is the average ratio (in %) of deposits over total assets across all Eurozone lead arrangers j in 2013. $After(06/2014)_t$ is a dummy variable for the period from June 2014 onwards. Bank fixed effects are included for all Eurozone lead arrangers. Industry(-year) fixed effects are based on two-digit SIC codes. Country(-year) fixed effects are based on the firm's country of origin. Public-service, energy, and financial-services firms are dropped. Robust standard errors (clustered at the bank level) are in parentheses.

Table 10: **Negative Policy Rates and Firms' ROA Volatility: Interaction of Treatment with Bank Capitalization**

	$\ln(\sigma(ROA_i)^{5y})$			
Sample	$2013-2015$		$2011-2015$	
	Bottom tercile	Top tercile	Bottom tercile	Top tercile
Deposit ratio × After(06/2014)	0.033***	-0.010	0.031***	-0.010
	(0.010)	(0.014)	(0.010)	(0.015)
Deposit ratio × After(07/2012)			-0.007	-0.006
			(0.008)	(0.016)
Bank FE	Y	Y	Y	Y
Month-year FE	Y	Y	Y	Y
Country-year FE	Y	Y	Y	Y
Industry-year FE	Y	Y	Y	Y
N	527	534	819	832

Notes: The sample consists of all completed syndicated loans (package level) of both private and publicly listed firms i at date t granted by any Eurozone lead arranger(s) j, from January 2013 to December 2015 in the first two columns and from January 2011 to December 2015 in the last two columns. In the first and third (second and fourth) column, the sample consists of Eurozone banks in the bottom (top) tercile of the distribution of the average ratio of equity over total assets in 2013. The dependent variable is the logged five-year standard deviation of firm i's return on assets (ROA, using P&L before tax) from year $t-5$ to $t-1$. *Deposit ratio*$_j$ is the average ratio (in %) of deposits over total assets across all Eurozone lead arrangers j in 2013. $After(06/2014)_t$ is a dummy variable for the period from June 2014 onwards. $After(07/2012)_t$ is a dummy variable for the period from July 2012 onwards. Bank fixed effects are included for all Eurozone lead arrangers. Industry-year fixed effects are based on two-digit SIC codes. Country-year fixed effects are based on the firm's country of origin. Public-service, energy, and financial-services firms are dropped. Robust standard errors (clustered at the bank level) are in parentheses.

Table 11: **Impact of Negative Policy Rates on Banks' Loan Portfolio**

Sample	$\ln(\sigma(ROA_i)^{5y})$ Private firms	$\ln(\sigma(ROA_i)^{5y})$ Public firms	$\ln(\sigma(ROA_i)^{5y})$ Private and public firms	$ROA_{i,t-1}$ Private and public firms	$Leverage_{i,t-1}$ Private and public firms
Deposit ratio × After(06/2014)	0.027***	0.011	0.012*	-0.036	-0.238**
	(0.009)	(0.007)	(0.007)	(0.083)	(0.110)
Deposit ratio × Exposure × After(06/2014)			0.019*		
			(0.011)		
Deposit ratio × Exposure			-0.006		
			(0.006)		
Exposure × After(06/2014)			-0.923**		
			(0.451)		
Exposure			0.328		
			(0.274)		
Bank FE	Y	Y	Y	Y	Y
Month-year FE	Y	Y	Y	Y	Y
Country-year FE	Y	Y	Y	Y	Y
Industry-year FE	Y	Y	Y	Y	Y
N	904	672	1,576	1576	1,569

Notes: The sample consists of all completed syndicated loans (package level) of only private (in the first column), only publicly listed (in the second column), and both private and publicly listed firms i (in the remaining columns) at date t granted by any Eurozone lead arranger(s) j, from January 2013 to December 2015. The dependent variable in the first three columns is the logged five-year standard deviation of firm i's return on assets (ROA, using P&L before tax) from year $t-5$ to $t-1$. The dependent variable in the fourth column is firm i's return on assets (ROA, using P&L before tax) in year $t-1$, measured in % ($\in [0, 100]$). The dependent variable in the fifth column is firm i's leverage in year $t-1$, measured in % ($\in [0, 100]$). *Deposit ratio*$_j$ is the average ratio (in %) of deposits over total assets across all Eurozone lead arrangers j in 2013. *Exposure*$_{ij}$ is an indicator for whether the proportion of loans granted to firms in the same SIC2 industry as firm i by all Eurozone lead arrangers j in 2013 is above the sample median. $After(06/2014)_t$ is a dummy variable for the period from June 2014 onwards. Bank fixed effects are included for all Eurozone lead arrangers. Industry-year fixed effects are based on two-digit SIC codes. Country-year fixed effects are based on the firm's country of origin. Public-service, energy, and financial-services firms are dropped. Robust standard errors (clustered at the bank level) are in parentheses.

Table 12: **Real Effects of Negative Policy Rates: Investment**

Sample	$\Delta_{t+1,t}\ln(Investment_i)$			
	$2013-2014$		$2011-2014$	
	Bottom tercile	Top tercile	Bottom tercile	Top tercile
Deposit ratio × After(06/2014)	-0.057	0.514**	-0.050	0.171
	(0.118)	(0.243)	(0.081)	(0.139)
Deposit ratio × After(07/2012)			0.053	-0.061
			(0.060)	(0.076)
Bank FE	Y	Y	Y	Y
Month-year FE	Y	Y	Y	Y
Country-year FE	Y	Y	Y	Y
Industry-year FE	Y	Y	Y	Y
N	146	149	305	308

Notes: The sample consists of all completed syndicated loans (package level) of both private and publicly listed firms i at date t granted by any Eurozone lead arranger(s) j, from January 2013 to December 2014 in the first two columns and from January 2011 to December 2014 in the last two columns. In the first and third (second and fourth) column, the sample consists of borrower firms in the bottom (top) tercile of the distribution of the five-year standard deviation of firms' return on assets (ROA, using P&L before tax) from year $t-5$ to $t-1$. The dependent variable is the difference (between year $t+1$ and t) in the logged value of firm i's investment, where investment is measured as the difference in tangible fixed assets between year t and $t-1$. *Deposit ratio*$_j$ is the average ratio (in %) of deposits over total assets across all Eurozone lead arrangers j in 2013. $After(06/2014)_t$ is a dummy variable for the period from June 2014 onwards. $After(07/2012)_t$ is a dummy variable for the period from July 2012 onwards. Bank fixed effects are included for all Eurozone lead arrangers. Industry-year fixed effects are based on two-digit SIC codes. Country-year fixed effects are based on the firm's country of origin. Public-service, energy, and financial-services firms are dropped. Robust standard errors (clustered at the bank level) are in parentheses.

Supplementary Appendix (Not for Publication)

A Supplementary Figures

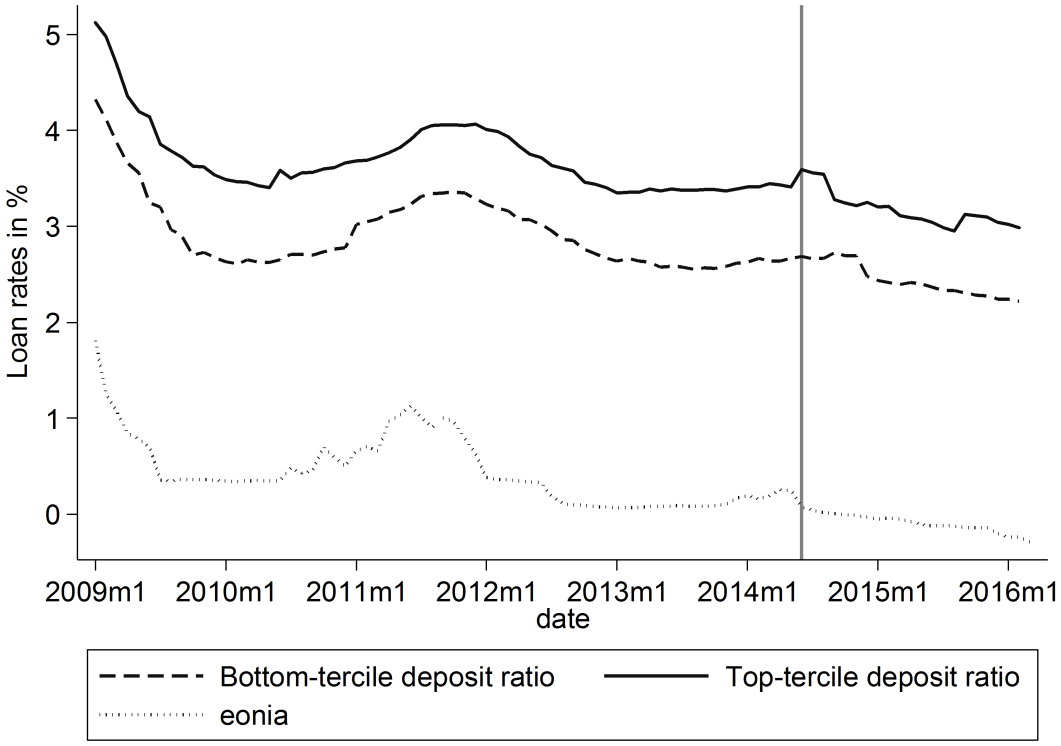

Figure A.1: **Loan Rates on Long-term (>5y) Loans (NFCs) – High-deposit vs. Low-deposit Banks.** This figure shows the evolution of loan rates on outstanding long-term (above five years) loans for non-financial corporations (NFCs) in the Eurozone between January 2009 and March 2016. The rates are shown for banks in the top tercile of the distribution of the deposit ratio in December 2013 (dashed line) and for banks in the bottom tercile (full line). The dotted line represents the Euro OverNight Index Average (Eonia) of overnight unsecured lending transactions in the interbank market. The data are taken from the ECB IBSI and IMIR database, which provides monthly bank balance-sheet and interest-rate data for Eurozone banks at the monetary financial institution (MFI) level.

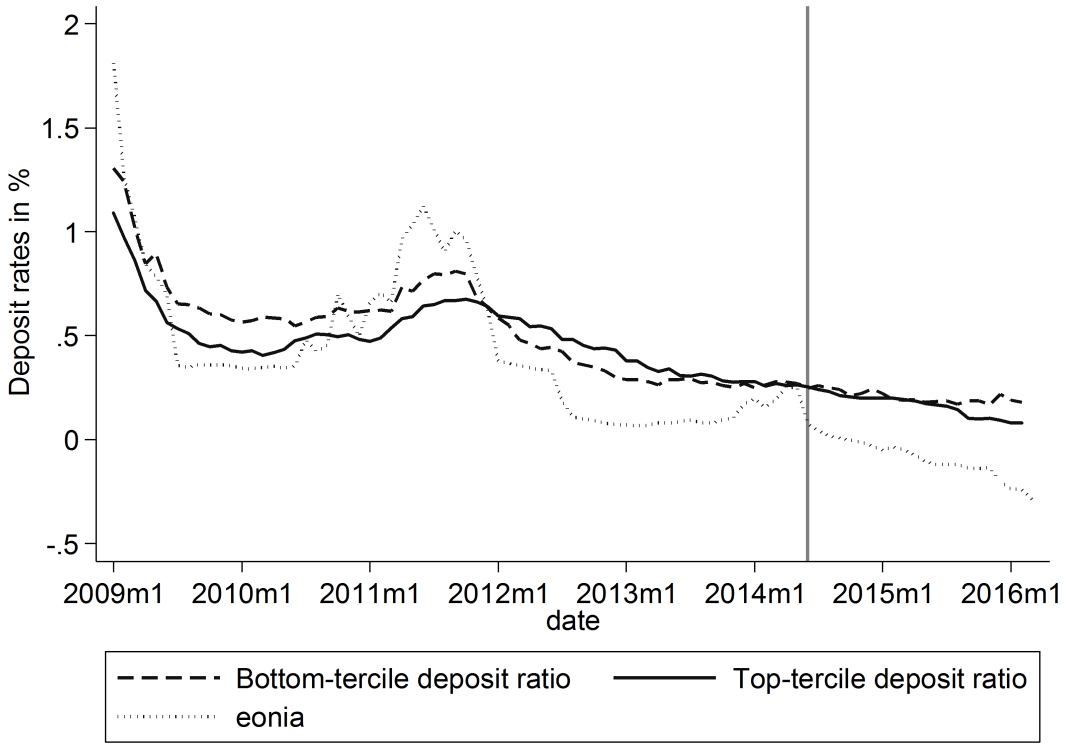

Figure A.2: **Deposit Rates on Overnight Deposits (NFCs) – High-deposit vs. Low-deposit Banks.** This figure shows the evolution of overnight deposit rates for non-financial corporations (NFCs) in the Eurozone between January 2009 and March 2016. The rates are shown for banks in the top tercile of the distribution of the deposit ratio in December 2013 (dashed line) and for banks in the bottom tercile (full line). The dotted line represents the Euro OverNight Index Average (Eonia) of overnight unsecured lending transactions in the interbank market. The data are taken from the ECB IBSI and IMIR database, which provides monthly bank balance-sheet and interest-rate data for Eurozone banks at the monetary financial institution (MFI) level.

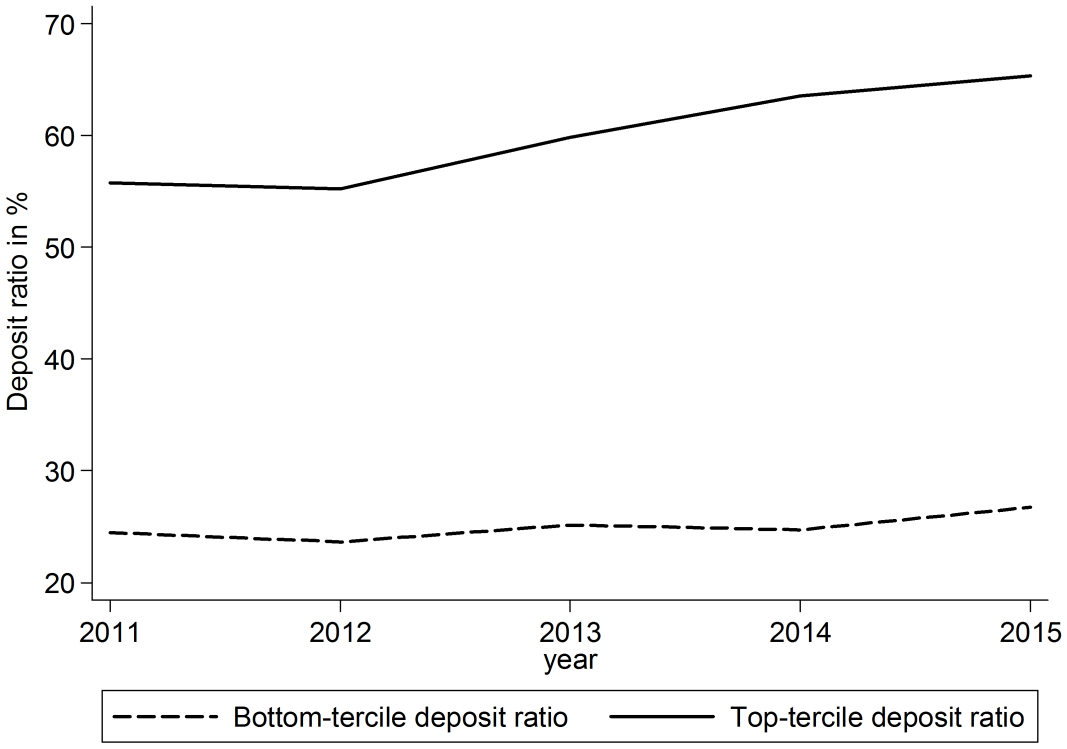

Figure A.3: **Deposit Ratio over Time.** This figure shows the evolution of the median deposit ratio for Eurozone banks in the top and the bottom tercile of the deposit-ratio distribution (based on 2013 data). Medians are calculated using yearly bank-level information for all banks included in the baseline sample.

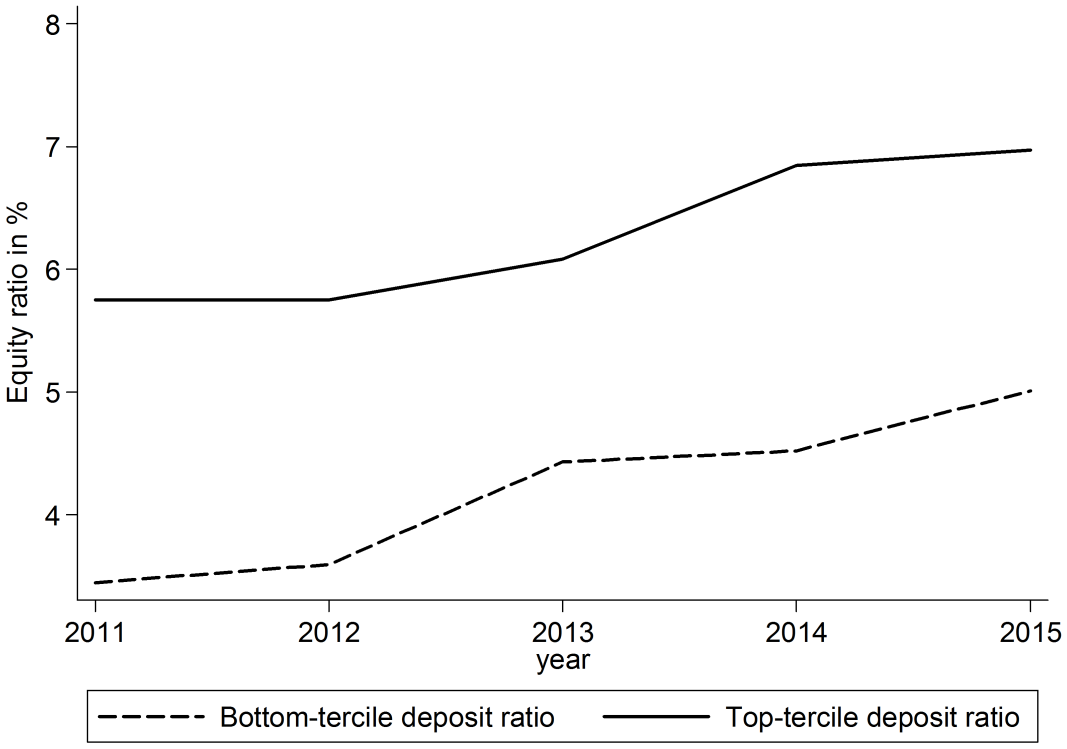

Figure A.4: **Equity Ratio over Time.** This figure shows the evolution of the median equity ratio for Eurozone banks in the top and the bottom tercile of the deposit-ratio distribution (based on 2013 data). Medians are calculated using yearly bank-level information for all banks included in the baseline sample.

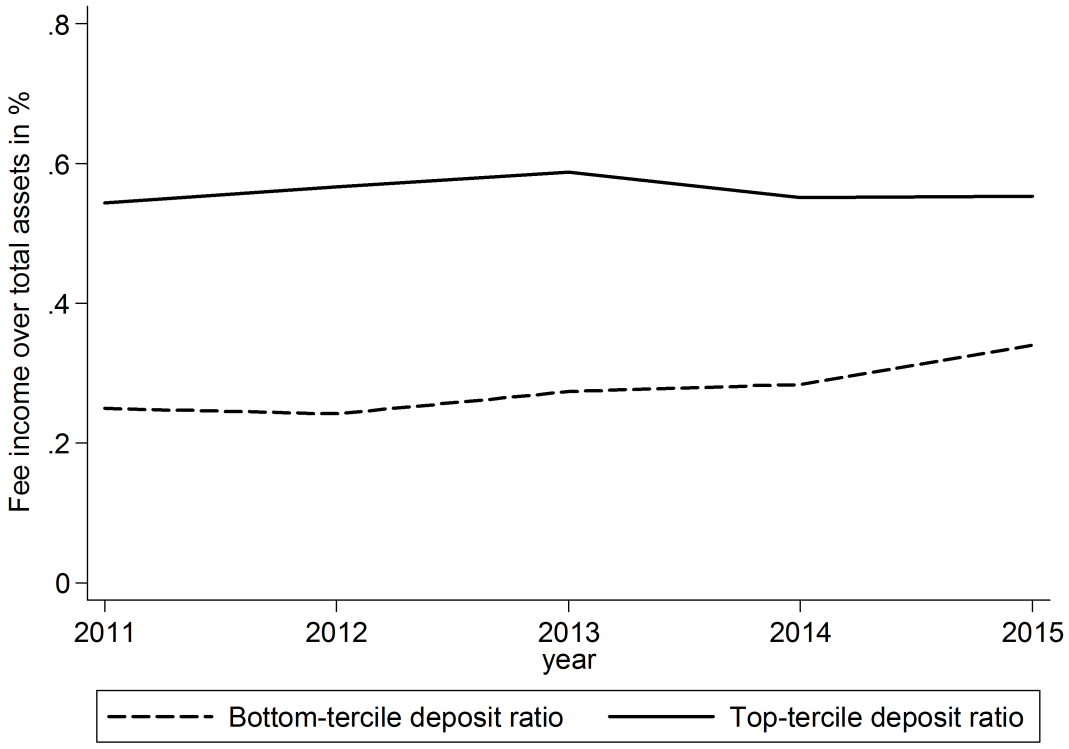

Figure A.5: **Fee Income Ratio over Time.** This figure shows the evolution of the median fee income ratio (total fee income over total assets) for Eurozone banks in the top and the bottom tercile of the deposit-ratio distribution (based on 2013 data). Medians are calculated using yearly bank-level information for all banks included in the baseline sample.

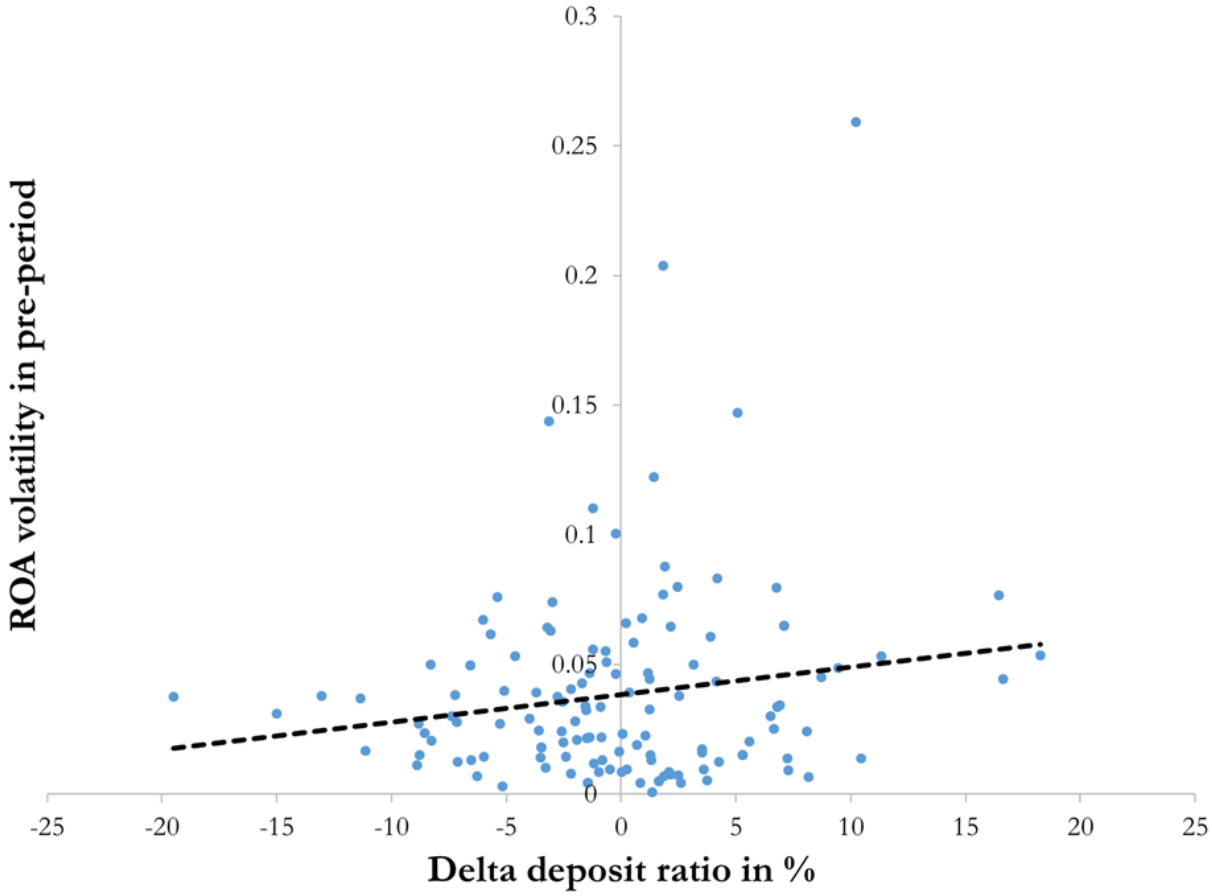

Figure A.6: **ROA Volatility of Firms Switching Banks.** The sample consists of private and publicly listed firms that received at least one loan in both the period from January 2013 leading up to June 2014 (pre-period) and in the period thereafter until December 2015 (post-period). This figure plots firms' ex-ante riskiness, as measured by their ROA volatility in the pre-period, against the difference in the average 2013 deposit ratio of Eurozone lenders from which firms received loans in the post-period vs. pre-period. The figure furthermore includes only firms that had a non-zero change in said average deposit ratio between the pre-period and the post-period, i.e., firms switching banks.

B Supplementary Tables

Table B.1: **ROA Volatility of Firms Financed by Banks Following Negative Policy Rates – Robustness to Definition of Deposit Ratio**

	$\ln(\sigma(ROA_i)^{5y})$					
Sample	$2013-2015$				$2011-2015$	$2011-2015$, non-Euro
Deposit ratio × After(06/2014)	0.018***	0.017***	0.019***	0.022***	0.021***	0.039**
	(0.005)	(0.005)	(0.006)	(0.006)	(0.007)	(0.017)
Deposit ratio × After(07/2012)					-0.006	-0.016
					(0.005)	(0.011)
Bank FE	Y	Y	Y	Y	Y	Y
Month-year FE	Y	Y	Y	Y	Y	Y
Country FE	N	Y	N	N	N	N
Industry FE	N	Y	Y	N	N	N
Country-year FE	N	N	Y	Y	Y	Y
Industry-year FE	N	N	N	Y	Y	Y
N	1,576	1,576	1,576	1,576	2,490	542

Notes: The sample consists of all completed syndicated loans (package level) of both private and publicly listed firms i at date t granted by any Eurozone lead arranger(s) j, from January 2013 to December 2015 in the first four columns and from January 2011 to December 2015 in the last two columns. In the last column, we furthermore limit the sample to non-Eurozone borrowers. The dependent variable is the logged five-year standard deviation of firm i's return on assets (ROA, using P&L before tax) from year $t-5$ to $t-1$. *Deposit ratio*$_j$ is the average ratio (in %) of deposits over total assets across all Eurozone lead arrangers j from 2011 to 2013. $After(06/2014)_t$ is a dummy variable for the period from June 2014 onwards. $After(07/2012)_t$ is a dummy variable for the period from July 2012 onwards. Bank fixed effects are included for all Eurozone lead arrangers. Industry(-year) fixed effects are based on two-digit SIC codes. Country(-year) fixed effects are based on the firm's country of origin. Public-service, energy, and financial-services firms are dropped. Robust standard errors (clustered at the bank level) are in parentheses.

Table B.2: **Former Loan Spreads of Firms Financed by Banks Following Negative Policy Rates**

	ln(All-in-drawn spread before sample period)					
Sample	2013 − 2015				2011 − 2015	2011 − 2015, non-Euro
Deposit ratio × After(06/2014)	0.012**	0.011**	0.012**	0.010*	0.007	0.041*
	(0.006)	(0.005)	(0.006)	(0.006)	(0.008)	(0.023)
Deposit ratio × After(07/2012)					-0.003	-0.020
					(0.007)	(0.017)
Bank FE	Y	Y	Y	Y	Y	Y
Month-year FE	Y	Y	Y	Y	Y	Y
Country FE	N	Y	N	N	N	N
Industry FE	N	Y	Y	N	N	N
Country-year FE	N	N	Y	Y	Y	Y
Industry-year FE	N	N	N	Y	Y	Y
N	1,218	1,218	1,218	1,218	1,746	445

Notes: The sample consists of all completed syndicated loans (package level) of both private and publicly listed firms i at date t granted by any Eurozone lead arranger(s) j, from January 2013 to December 2015 in the first four columns and from January 2011 to December 2015 in the last two columns. In the last column, we furthermore limit the sample to non-Eurozone borrowers. The dependent variable is the log of the all-in-drawn spread (in bps), which is the sum of the spread over LIBOR and any annual fees paid to the lender syndicate, associated with the most recent syndicated loan of firm i before 2013 in the first four columns, and before 2011 in the last two columns, but no earlier than January 2003. *Deposit ratio*$_j$ is the average ratio (in %) of deposits over total assets across all Eurozone lead arrangers j in 2013. $After(06/2014)_t$ is a dummy variable for the period from June 2014 onwards. $After(07/2012)_t$ is a dummy variable for the period from July 2012 onwards. Bank fixed effects are included for all Eurozone lead arrangers. Industry(-year) fixed effects are based on two-digit SIC codes. Country(-year) fixed effects are based on the firm's country of origin. Public-service, energy, and financial-services firms are dropped. Robust standard errors (clustered at the bank level) are in parentheses.

Table B.3: **Stock-return Volatility of Firms Financed by Banks Following Negative Policy Rates**

	$\ln(\sigma(return_i)^{36m})$					
Sample	$2013-2015$				$2011-2015$	$2011-2015$, non-Euro
Deposit ratio × After(06/2014)	0.006**	0.006**	0.008***	0.009***	0.006*	-0.001
	(0.003)	(0.003)	(0.003)	(0.003)	(0.004)	(0.011)
Deposit ratio × After(07/2012)					0.002	0.011
					(0.003)	(0.011)
Bank FE	Y	Y	Y	Y	Y	Y
Month-year FE	Y	Y	Y	Y	Y	Y
Country FE	N	Y	N	N	N	N
Industry FE	N	Y	Y	N	N	N
Country-year FE	N	N	Y	Y	Y	Y
Industry-year FE	N	N	N	Y	Y	Y
N	665	665	665	665	1,061	309

Notes: The sample consists of all completed syndicated loans (package level) of publicly listed firms i at date t granted by any Eurozone lead arranger(s) j, from January 2013 to December 2015 in the first four columns and from January 2011 to December 2015 in the last two columns. In the last column, we furthermore limit the sample to non-Eurozone borrowers. The dependent variable is the logged standard deviation of firm i's stock returns in the 36 months before t. *Deposit ratio*$_j$ is the average ratio (in %) of deposits over total assets across all Eurozone lead arrangers j in 2013. $After(06/2014)_t$ is a dummy variable for the period from June 2014 onwards. $After(07/2012)_t$ is a dummy variable for the period from July 2012 onwards. Bank fixed effects are included for all Eurozone lead arrangers. Industry(-year) fixed effects are based on two-digit SIC codes. Country(-year) fixed effects are based on the firm's country of origin. Public-service, energy, and financial-services firms are dropped. Robust standard errors (clustered at the bank level) are in parentheses.

Table B.4: **ROA Volatility of Firms Financed by Banks Following Negative Policy Rates – Inclusion of Danish, Swedish, and Swiss Banks**

	$\ln(\sigma(ROA_i)^{5y})$			
Deposit ratio × After	0.011***	0.010**	0.011**	0.012***
	(0.004)	(0.004)	(0.005)	(0.005)
Bank FE	Y	Y	Y	Y
Month-year FE	Y	Y	Y	Y
Country FE	N	Y	N	N
Industry FE	N	Y	Y	N
Country-year FE	N	N	Y	Y
Industry-year FE	N	N	N	Y
N	1,342	1,342	1,342	1,342

Notes: The sample consists of all completed syndicated loans (package level) of both private and publicly listed firms i at date t granted by granted by any mutually exclusive Eurozone, Danish, Swedish, or Swiss lead arranger(s) j from January 2013 to December 2015. The dependent variable is the logged five-year standard deviation of firm i's return on assets (ROA, using P&L before tax) from year $t-5$ to $t-1$. *Deposit ratio*$_j$ is the average ratio (in %) of deposits over total assets across all Eurozone, Danish, Swedish, or Swiss lead arrangers j in 2013. *After*$_{jt}$ is a dummy variable for the period from June 2014 onwards for all loans with any Eurozone (but no Danish, Swedish, or Swiss) lead arrangers, or from January 2013 to April 2014 and again from September 2014, February 2015, or January 2015 for all loans with Danish, Swedish, or Swiss (but no Eurozone) lead arrangers, respectively. Bank fixed effects are included for all Eurozone, Danish, Swedish, and Swiss lead arrangers. Industry(-year) fixed effects are based on two-digit SIC codes. Country(-year) fixed effects are based on the firm's country of origin. Public-service, energy, and financial-services firms are dropped. Robust standard errors (clustered at the bank level) are in parentheses.

Table B.5: **ROA Volatility of Firms Financed by Banks Following Negative Policy Rates – End Sample in February 2015**

	$\ln(\sigma(ROA_i)^{5y})$			
Deposit ratio × After(06/2014)	0.014**	0.012*	0.013$^{(*)}$	0.016*
	(0.007)	(0.007)	(0.008)	(0.008)
Bank FE	Y	Y	Y	Y
Month-year FE	Y	Y	Y	Y
Country FE	N	Y	N	N
Industry FE	N	Y	Y	N
Country-year FE	N	N	Y	Y
Industry-year FE	N	N	N	Y
N	864	864	864	864

Notes: The sample consists of all completed syndicated loans (package level) of both private and publicly listed firms i at date t granted by any Eurozone lead arranger(s) j, from August 2013 to February 2015. The dependent variable is the logged five-year standard deviation of firm i's return on assets (ROA, using P&L before tax) from year $t-5$ to $t-1$. *Deposit ratio*$_j$ is the average ratio (in %) of deposits over total assets across all Eurozone lead arrangers j in 2013. $After(06/2014)_t$ is a dummy variable for the period from June 2014 onwards. Bank fixed effects are included for all Eurozone lead arrangers. Industry(-year) fixed effects are based on two-digit SIC codes. Country(-year) fixed effects are based on the firm's country of origin. Public-service, energy, and financial-services firms are dropped. Robust standard errors (clustered at the bank level) are in parentheses.

Table B.6: **ROA Volatility of Firms Financed by Banks Following Negative Policy Rates: Potential Switchers**

	$\ln(\sigma(ROA_i)^{5y})$			
Deposit ratio × After(06/2014)	0.015**	0.013*	0.012	0.020**
	(0.007)	(0.007)	(0.008)	(0.009)
Bank FE	Y	Y	Y	Y
Month-year FE	Y	Y	Y	Y
Country FE	N	Y	N	N
Industry FE	N	Y	Y	N
Country-year FE	N	N	Y	Y
Industry-year FE	N	N	N	Y
N	1,061	1,061	1,061	1,061

Notes: The sample consists of all completed syndicated loans (package level) of both private and publicly listed firms i at date t granted by any Eurozone lead arranger(s) j, from January 2013 to December 2015, where borrowers had loans outstanding in both the period leading up to June 2014 and in the period thereafter. The dependent variable is the logged five-year standard deviation of firm i's return on assets (ROA, using P&L before tax) from year $t-5$ to $t-1$. *Deposit ratio*$_j$ is the average ratio (in %) of deposits over total assets across all Eurozone lead arrangers j in 2013. $After(06/2014)_t$ is a dummy variable for the period from June 2014 onwards. Bank fixed effects are included for all Eurozone lead arrangers. Industry(-year) fixed effects are based on two-digit SIC codes. Country(-year) fixed effects are based on the firm's country of origin. Public-service, energy, and financial-services firms are dropped. Robust standard errors (clustered at the bank level) are in parentheses.

Table B.7: **Impact of Negative Policy Rates on Loan Size: Potential Switchers**

	ln(Loan size)				
Deposit ratio × After(06/2014)	-0.006	-0.002	-0.001	-0.000	0.004
	(0.008)	(0.007)	(0.008)	(0.009)	(0.011)
Deposit ratio × After(06/2014) × $\sigma(ROA_i)^{5y}$					0.021
					(0.177)
Deposit ratio × $\sigma(ROA_i)^{5y}$					-0.207**
					(0.083)
$\sigma(ROA_i)^{5y}$ × After(06/2014)					1.608
					(7.855)
$\sigma(ROA_i)^{5y}$					5.214
					(3.446)
Bank FE	Y	Y	Y	Y	Y
Month-year FE	Y	Y	Y	Y	Y
Country FE	N	Y	N	N	N
Industry FE	N	Y	Y	N	N
Country-year FE	N	N	Y	Y	Y
Industry-year FE	N	N	N	Y	Y
N	1,061	1,061	1,061	1,061	1,061

Notes: The sample consists of all completed syndicated loans (package level) of both private and publicly listed firms i at date t granted by any Eurozone lead arranger(s) j from January 2013 to December 2015, where borrowers had loans outstanding in both the period leading up to June 2014 and in the period thereafter. *Deposit ratio*$_j$ is the average ratio (in %) of deposits over total assets across all Eurozone lead arrangers j in 2013. $After(06/2014)_t$ is a dummy variable for the period from June 2014 onwards. $\sigma(ROA_i)^{5y}$ is the five-year standard deviation of firm i's return on assets (ROA, using P&L before tax) from year $t-5$ to $t-1$. Bank fixed effects are included for all Eurozone lead arrangers. Industry(-year) fixed effects are based on two-digit SIC codes. Country(-year) fixed effects are based on the firm's country of origin. Public-service, energy, and financial-services firms are dropped. Robust standard errors (clustered at the bank level) are in parentheses.

Table B.8: **Impact of Negative Policy Rates on Total Cost of Borrowing**

	ln(Total cost of borrowing)					
Sample	2013 − 2015				2011 − 2015	2011 − 2015, non-Euro
Deposit ratio × After(06/2014)	-0.016	0.005	-0.004	-0.006	-0.036	0.013***
	(0.012)	(0.012)	(0.022)	(0.071)	(0.067)	(0.000)
Deposit ratio × After(07/2012)					0.030	0.021***
					(0.047)	(0.000)
Bank FE	Y	Y	Y	Y	Y	Y
Month-year FE	Y	Y	Y	Y	Y	Y
Country FE	N	Y	N	N	N	N
Industry FE	N	Y	Y	N	N	N
Country-year FE	N	N	Y	Y	Y	Y
Industry-year FE	N	N	N	Y	Y	Y
N	174	174	174	174	292	92

Notes: The sample consists of all completed syndicated loans (package level) of both private and publicly listed firms i at date t granted by any Eurozone lead arranger(s) j, from January 2013 to December 2015 in the first four columns and from January 2011 to December 2015 in the last two columns. In the last column, we furthermore limit the sample to non-Eurozone borrowers. The dependent variable is the log of the total cost of borrowing (in bps), as defined in Berg, Saunders, and Steffen (2016). $Deposit\ ratio_j$ is the average ratio (in %) of deposits over total assets across all Eurozone lead arrangers j in 2013. $After(06/2014)_t$ is a dummy variable for the period from June 2014 onwards. $After(07/2012)_t$ is a dummy variable for the period from July 2012 onwards. Bank fixed effects are included for all Eurozone lead arrangers. Industry(-year) fixed effects are based on two-digit SIC codes. Country(-year) fixed effects are based on the firm's country of origin. Public-service, energy, and financial-services firms are dropped. Robust standard errors (clustered at the bank level) are in parentheses.