Life Below Zero: Bank Lending Under Negative Policy Rates*

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Abstract

We show that negative policy rates transmit to the real sector via bank lending in a novel way. The European Central Bank's introduction of negative rates in June 2014 induces banks with more deposits to concentrate their lending on riskier borrowers. A one-standard-deviation increase in banks' deposit ratio leads to the financing of firms with 16% higher return-on-assets volatility and to a reduction in lending of 9%. Conversely, a placebo at the time when policy rates fall, but are still non-negative, shows no effect. New risky borrowers appear financially constrained, come from industries known to the bank, and invest more after receiving a loan. Banks do not adjust loan terms, and the risk taking is concentrated in poorly capitalized banks. Besides highlighting the role of banks' funding structure for monetary-policy transmission, our results point to distributional consequences with potential risks to financial stability.

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1 Introduction

This paper examines and quantifies the transmission of negative policy rates to the real economy via the lending behavior of banks. Negative monetary-policy rates are unprecedented and controversial. Central banks around the world struggle to rationalize negative rates using conventional wisdom. To stimulate the economy in its post-crisis state with low growth and low inflation, the European Central Bank (ECB), but also the central banks of Denmark, Switzerland, Sweden and Japan, have set their policy rates below zero. In contrast, the Bank of England and the Federal Reserve have refrained from setting negative rates amid concerns about their effectiveness and adverse implications for financial stability.

We find that negative policy rates transmit to the real economy via bank lending in a novel way. When the ECB reduced the deposit facility (DF) rate from 0 to -0.10% in June 2014, banks with more deposits concentrated their lending on riskier firms in the market for syndicated loans. Specifically, a one-standard-deviation increase in banks' deposit ratio, i.e., 9 percentage points, leads to the financing of firms with at least 16% higher return-on-assets volatility and to a reduction in lending of 9%.

The conventional way to think about monetary-policy transmission via bank lending (above the so-called zero lower bound) cannot explain our finding. There is no role for deposits, and the most affected banks should lend more and take less risk when the policy rate falls, which is the opposite of what we find.

According to the conventional view, the most affected banks are those with the largest maturity mismatch between assets and liabilities. Because those banks have long-term assets and short-term liabilities, and because policy rates transmit to short-term rates first, the transmission of a lower policy rate is stronger on banks' liability than on their asset side. A lower policy rate therefore increases the net worth (or franchise value) of those banks, which is the value difference between assets and liabilities. More net worth, in turn, means more "skin-in-the-game," which relaxes financial constraints, increases lending, and reduces risk

taking. The extent to which a bank's short-term debt consists of deposits does not affect its maturity mismatch.

To explain our findings, we augment the conventional view with a new effect that kicks in when the policy rate becomes negative. Banks are unwilling to pass on negative rates to their depositors. Banks refrain from charging negative deposit rates because they fear withdrawals. As cash offers a zero nominal return, it would dominate deposits if banks charged negative rates on deposits.

When the policy rate becomes negative, a stronger reliance on deposits has an adverse effect on bank net worth. Normally, a lower policy rate reduces a bank's cost of short-term debt and, thus, increases net worth. But with a lower (negative) rate, this no longer holds when the bank's short-term debt is in the form of deposits.

The adverse effect of negative rates on the net worth of banks with more deposits leads to less lending and more risk taking. The mechanism that ties bank net worth to the quantity and quality of lending is as in the conventional view. Less net worth makes it more difficult to obtain funding from outsiders, and undermines incentives for prudent behavior (such as carefully screening new borrowers).

We find that high-deposit banks, as compared to low-deposit banks, lend to significantly riskier firms when the policy rate becomes negative. High-deposit banks lend less than low-deposit banks, and concentrate their lending on privately held, possibly credit-constrained firms.

The transmission of monetary policy via banks' reliance on deposit funding, is unique to negative policy rates. It requires banks' unwillingness to pass on negative rates to depositors. In line with this reasoning, we find no effect of deposits on the quantity and quality of bank lending when the policy rate falls but still is non-negative.

To examine and quantify the transmission of monetary policy via bank lending empirically is challenging for two reasons. First, monetary policy is endogenous. Policy rates not only transmit to the economy, but they also respond to economic conditions. Second, bank lending

is endogenous. It not only depends on banks' loan supply but also on firms' loan demand, both of which respond to changes in interest rates.

To address these identification challenges, we use a difference-in-differences approach, and compare the riskiness of firms financed by high-deposit banks and low-deposit banks around the time when the policy rate becomes negative. The control group of low-deposit banks provides the counterfactual for how the lending of high-deposit banks would have evolved in the absence of negative policy rates.

The counterfactual addresses the identification challenges. It disentangles the effect of monetary policy on bank lending from other forces that shape both monetary policy and bank lending. The following two examples illustrate the essence of the identification strategy.

Suppose the ECB lowers the policy rate because it is concerned about deteriorating economic conditions. At the same time, banks lend less and to riskier borrowers because there are only few and risky lending opportunities around when economic conditions deteriorate. Our result would then be biased upward because the deteriorating economy drives both setting negative policy rates and bank risk taking. Taking the difference between the lending behavior of high-deposit banks and the lending behavior of low-deposit banks adjusts for this bias because both types of banks face the same deteriorating economic conditions.

Next, suppose a lower policy rate increases the net worth of firms. By the same mechanism as for banks, firms would then seek more outside financing and act more prudently. As observed bank lending depends on the interaction of firms' loan demand and banks' loan supply, our result would be biased downward. If firms had not borrowed more and acted more prudently in response to the lower rate, there would be less bank lending and borrowers would be riskier. Again, taking the difference between high-deposit and low-deposit banks removes this bias because both types of banks face the same loan demand.

The threat to our identification strategy is a difference between high-deposit and low-deposit banks that changes when the policy rate becomes negative. Such a time-varying

difference violates the parallel-trends assumption, which is key to the identification of a causal effect in a difference-in-differences setup.

In terms of the examples above, do high-deposit and low-deposit banks face different lending opportunities (or different loan-demand curves) and, importantly, does the difference change when the policy rate becomes negative? Time-invariant differences between high-deposit and low-deposit banks – e.g., high-deposit banks having a different business model or lending to different types of firms – do not matter. They are differenced away when comparing each type of bank before and after the interest-rate change.

Our empirical design takes several steps to mitigate the threat to identification. First, we verify that pre-treatment trends are parallel. Risk taking by high-deposit and low-deposit banks move in parallel before the ECB sets a negative policy rate. Thus, at least prior to treatment, the lending behavior of high-deposit and low-deposit banks does not exhibit any time-varying differences.

Second, a placebo test confirms the validity of low-deposit banks as the control group. Our argument about the impact of a negative policy rate rests on banks' unwillingness to charge negative deposit rates. Therefore, there should be no effect in July 2012, when the ECB lowered its policy rates but the rates still remained non-negative. This what we find. In mid 2012, the difference-in-differences estimate is zero for various measures of bank lending behavior. For policy-rate reductions above zero, there are no time-varying differences affecting the lending of high-deposit and low-deposit banks.

Adding bank-level controls does not affect our estimate, which confirms the validity of low-deposit banks as the control group. Typical bank-level control variables when assessing the transmission of (non-negative) policy rates are bank size, the amount of securities relative to loans, and the amount of equity. None of these typical control variables matter when we examine the transmission of negative policy rates.

Third, the granularity of our data allows us to refine the comparison between high-deposit and low-deposit banks. We add borrowers' country-year and borrowers' industry-year fixed

effects. This eliminates any time-varying differences in lending opportunities between high-deposit and low-deposit banks that may be derived from unobserved time-varying country and industry factors. For example, as the ECB's interest-rate setting is exogenous to any particular member country of the euro area, adding borrowers' country-year fixed effects addresses the concern that monetary policy reacts to a change in the economic conditions of a country.

Fourth, we use the structure of syndicated loans to test our conjecture regarding bank lending and bank risk taking jointly. This enables us to conduct a within-loan analysis by separately including the loan shares of all lenders participating in a syndicated loan in any capacity. In this manner, we hold constant the borrower associated with a given loan and, thus, said borrower's demand. After including loan and bank-firm fixed effects, the treatment effect is identified using borrowers that received loans from multiple banks both before and after June 2014. Thus, we safeguard that high-deposit and low-deposit banks face the same lending opportunities. In this framework, we show that high-deposit banks did not only reduce their total lending, but they also retained smaller loan shares. This effect is, however, confined to safe, rather than risky, borrowers. Thus, the proportion of risky borrowers in the portfolio of all syndicated loans participated in by high-deposit banks increased.

The behavior of high-deposit banks is in line with the bank risk-taking channel. In that 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, high-deposit banks with little equity are significantly more prone to lend to riskier borrowers.

We characterize bank risk taking by means of syndicated loans. However, syndicated lending constitutes only a fraction of total bank lending. To gauge the external validity of our results, we provide evidence that high-deposit banks earned lower stock returns only after the policy rate became negative but not when it was reduced to zero in July 2012. This

attests to the idea that high-deposit banks' net worth dropped relative to that of low-deposit banks. This also translates into higher bank-level risk, as we show high-deposit banks to experience higher stock-return volatility and a stronger increase in their CDS spreads when the policy rate becomes negative.

We finish by identifying the real effects and distributional consequences of negative policy rates. 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. 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.

Although this risk taking by high-deposit banks 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. We believe that evaluating this question is at the core of assessing the longer-run implications of negative policy rates for financial stability.

Related literature. Negative interest rates truly are unchartered territory.[1] Previous work has studied the transmission of standard and other, non-standard, monetary policy. This paper characterizes to what extent the transmission of negative policy rates is different, pointing out benefits and potential costs for the real sector.

Our analysis makes the following 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. In this manner, we augment the literature on monetary-policy transmission for negative rates. While the economics of other types of non-standard monetary policy, such as forward guidance and large-scale asset purchases, is well understood and researched, there is little or no evidence about the working of negative policy rates. Few theoretical contributions, e.g., by Rognlie (2016) and Brunnermeier and Koby (2016) on the effective lower bound, serve to inform such discussions.

[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.

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)).

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). Along with our work, these papers share the overarching theme of deriving differential pass-through of monetary-policy rates to identify their transmission through lending activity (e.g., Scharfstein and Sunderam (2016)).

In our case, the introduction of negative policy rates constitutes a shock to the cost of funding for banks with a lot of deposits. Agarwal, Chomsisengphet, Mahoney, and Stroebel (2015) examine the importance of the interaction between borrowers and lenders for how bank lending responds to shocks to their cost of funding. Less creditworthy borrowers are the most willing to borrow more, and yet receive the smallest bank credit. These opposite forces across borrower quality limit the transmission of policies that change banks' cost of funding, such as accommodative monetary policy, via bank lending.

Finally, we sharpen the understanding of the bank risk-taking channel. We exploit banks' reluctance to pass on negative rates to their depositors to disentangle the effect of lower rates on banks' assets and liabilities. This enables us to show how risk is taken, and how the quality of bank lending in the form of risk taking interacts with the quantity of bank lending. Previous empirical research (Jiménez, Ongena, Peydró, and Saurina (2014); Dell'Ariccia, Laeven, and Suarez (2016)) found contradictory evidence about which banks take risk when interest rates fall.

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.[2] As a result, over the last couple of years, the ECB's deposit

[2] 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.

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 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 lending and bank risk taking.

The starting point for the transmission of monetary policy through banks is the existence of an external-finance premium for banks (see Bernanke (2007) for a review of the bank lending channel).[3] 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.

[3] 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)).

High net worth and a low external-finance premium lead to more and safer lending. 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.[4]

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 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

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

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).[5] 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.[6]

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 evolu-

[5] 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.

[6] In fact, when using monthly bank-level household deposit rates to run a panel regression of the change in deposit rates on the change in Eonia, we observe a strong positive correlation between decreases in the Eonia and changes in the deposit rates between January 2012 and June 2014, while this relation completely breaks down after June 2014. Similarly, we also observe a significant decrease in the pass-through of the Eonia to deposit rates for non-financial firms. All these results are available upon request.

tion 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 deposit rates is present for both banks with a lot of deposit funding and those with little deposit funding (Figure 4).[7]

This variation in net worth across banks allows us to identify the impact of negative policy rates on bank lending and bank risk taking. 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.

[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).

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:

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

where y_{ijt} is an outcome variable reflecting firm-level risk, *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 $\textit{Deposit ratio}_j \times After(07/2012)_t$, 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:

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

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, which we list alongside their 2013 deposit ratios in Table 2. In addition, Table 3 zooms in on any potential 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.3a and A.3b 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

[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.

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.3c 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.

In the bottom panel of Table 3, we provide further summary statistics on the syndicated loans in which high- and low-deposit banks participated. Low-deposit banks were lead arrangers of 150 syndicated loans during our sample period, whereas high-deposit banks were lead arrangers of only 71 syndicated loans. The difference is, however, not statistically significant. Furthermore, neither the average loan size nor the average loan share retained by high- and low-deposit banks (in any capacity, i.e., as lead arrangers or participants) are significantly different across high- and low-deposit banks.

Lastly, we characterize lending as serving as a lead arranger on a syndicated loan in this paper. Loan shares retained by lead arrangers are typically not sold off in the secondary market, so we can assume that lead arrangers leave the loan on their books. However, in the subset of so-called leveraged loans, this may not necessarily be the case, even for lead shares. Following the definition of leveraged loans in Bruche, Malherbe, and Meisenzahl (2016),[9] we find that high- and low-deposit banks relatively seldom, but not differentially so, held loan facilities that one could label as leveraged loans. Most importantly, all results in our paper are robust to dropping leveraged loans. For example, in our main regression sample for firm-level ROA volatility (see first row of Table 1, this would affect only 194 out of 1,576 observations.

[9] A facility in DealScan is defined as leveraged if it is secured and has a spread of 125 bps or more.

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 the effect on the volume of bank lending, 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[10] 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 4, 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

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

($9.45 \times 0.017 = 0.16$), 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.

In the fifth column, we extend the sample to the period from January 2011 to December 2015, and include the interaction $\textit{Deposit ratio}_j \times After(07/2012)_t$ 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 $\textit{Deposit ratio}_j \times After(06/2014)_t$. 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 4, 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.[11] 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 $\textit{Deposit ratio}_j \times After(06/2014)_t$ is even stronger in this subsample, and still significantly different (at the 3% level) from the coefficient on $\textit{Deposit ratio}_j \times After(07/2012)_t$. 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 5. In the first column, we exclude government entities and an insurance company with the lowest deposit ratios from the definition of the deposit ratio, our continuous treatment variable. The difference-in-differences estimate is unchanged.[12]

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

[12] Note that we lose five observations for syndicated loans which had only such excluded institutions as lead arrangers.

Next, we ensure that our findings are robust to alternative definitions of our treatment-intensity variable. In the second column of Table 5, 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 4, 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 4.

Our placebo test implies that banks' time-varying characteristics other than their funding structure – e.g., their asset 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 4, and add banks' total assets, their ratio of securities over total assets, and their equity ratio separately across the third, fourth, and fifth column of Table 5. Our difference-in-differences estimate is virtually unchanged. In the last column, we extend the sample to accommodate our placebo test while including all three control variables. The difference-in-differences estimate for banks' deposit ratios remains robust, and is positive and significant only when the policy rate became negative.

We also ensure that our results are not driven by the choice of our risk measure. As a first 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.

One particular concern about our main risk measure – the standard deviation of the return on assets of the borrowing firm – might be that lenders care only about the riskiness

of their debt claim on the firm. If the leverage of the firm is very low, then the riskiness of this debt claim might be relatively small, even when the returns of the firm are very volatile. The results in Table B.4 in the Online Appendix show that our results still hold when taking this concern into account. The risk measure used as dependent variable in this table is the standard deviation of the return on assets of the borrowing firm multiplied by its leverage in $t-1$. This measure allows us to take into account that firms with highly volatile profits and low leverage imply less credit risk for the bank than firms with highly volatile profits and high leverage. Using this alternative measure, we re-run all regression from Table 4. Our main findings remain unchanged: high-deposit banks take on more risk when the policy rate becomes negative.

Table B.5 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 4, 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.6 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 6 and B.7, 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 6, 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 4, indicating that part of the risk taking is indeed operationalized by lending to new borrowers. Table B.7 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 Impact on Bank Lending

Our identification strategy also allows us to analyze not just the quality of bank lending (risk taking) but also the effect on the quantity of bank lending when policy rates become negative. If 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 7 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.[13]

The difference-in-differences estimate is robust to including bank fixed effects in the second column. In the last column of Table 7, 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 bank lending and bank risk taking 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 6 and B.7 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.4 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 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 7), the outflow of safe borrowers from high-deposit banks outweighed the inflow of risky ones.

[13] 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)).

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 8, we use the sample of new borrowers, and we regress the log of loan size on the interaction $Deposit\ ratio_j \times After(06/2014)_t$ and on an increasing number of fixed effects, just as in our baseline setup in Table 6. 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 8 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 $Deposit\ ratio_j \times After(06/2014)_t$ 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.8). This result is very much in line with the increased risk-seeking behavior of high-deposit banks that we already documented in Tables 4 to 6.

To mitigate problems of omitted-variable bias stemming from the possibility that monetary policy simultaneously affects firms' demand for loans, we so far limited our sample to non-Eurozone borrowers. While it is plausible to argue that non-Eurozone borrowers are relatively more shielded from monetary policy in the Eurozone, non-Eurozone borrowers may still be connected to the Eurozone through substantial trade. We can tackle this concern by moving our analysis to the loan-bank level. That is, for each loan we record one observation per (participating or lead) bank. This enables us to include loan fixed effects that keep the borrower constant. In addition, we add bank-firm fixed effects, so that any treatment effect is identified using borrowers that received loans from multiple banks both before and after June 2014.

In the first column of Table 9, we run this specification, and use as dependent variable the share of a syndicated loan retained by a given bank. We find a negative and significant

difference-in-differences estimate, which implies that high-deposit banks did not only reduce the number of loans they granted (Table 7), but even when they did participate in a syndicated loan, they retained a smaller share. In line with the risk-taking channel, this drop in loan shares should pertain to relatively safe borrowers. In order to maintain the ability to run the above-mentioned specification, we use a widely available measure of risk, namely a firm's loan spread before the sample period (as in Table B.2). Doing so, we find in the second and third column of Table 9 that the drop in loan shares retained by high-deposit vs. low-deposit banks (in any capacity, be it as participants or lead arrangers) is indeed confined to safe borrowers with lower previous loan spreads (column 2). As a consequence, the proportion of risky borrowers in the total loan portfolio across syndicated loans granted by high-deposit banks increases.

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, and high-deposit banks also reduced their within-loan exposure to safe, but not to risky, borrowers. The riskiness of the total loan portfolio of high-deposit banks thus increased when policy rates became negative.

3.3 Characterizing the Nature of Risk Taking

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.[14] Similarly, when banks offset the higher risk of borrowers with more collateral, more

[14] 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)).

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 10, 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.9 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 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 11, 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 11, 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.

We also revisit the assumption that a change in the policy rate has an impact on bank net worth. For a subsample of 30 listed banks we can use stock returns as a proxy for the change in their net worth. Figure 6 shows an (unweighted) return index for banks in the highest tercile and banks in the lowest tercile of the distribution of the deposit ratio. The stock returns for banks in both groups evolve very similarly between January 2013 and May 2014, but there is a clear disconnect when rates become negative in June 2014. High-deposit banks perform worse once rates become negative, which is in line with our conjecture of a relative decrease in net worth for these banks.

The results in Table 12 further confirm this finding. As in Table 7, the regressions are run at the bank level. The sample ends in February 2015 so as to make sure that the ECB's public sector purchase program (PSPP) in March 2015 is not driving our results (as markets may have reacted quickly to its announcement). In the first two columns, the dependent variable is a bank's monthly stock return. We find a significantly lower return for banks with a higher deposit ratio, which drops only after the policy rate becomes negative but not when it was reduced to zero in July 2012. In terms of economic significance, a one-standard-deviation increase in banks' deposit ratio corresponds to a decrease of at least 0.7 percentage points.

Similarly, we can validate our results on bank risk taking by using a bank-level, rather than borrower-level, proxy of risk. In the third and fourth column of Table 12, we re-run the regressions from the first two columns, and use as dependent variable the logged unlevered monthly standard deviation of daily bank stock returns. Standard deviations are unlevered by multiplying them with the ratio of bank equity over total assets. In this manner, we yield a proxy for a bank's asset risk, which is seen as an important determinant of default risk in applications of the Merton (1974) model. As in our previous results, we find that high-deposit banks exhibit higher volatility after June 2014 (introduction of negative policy rates) but not after July 2012 (placebo). The last two columns of Table 12 further confirm this finding when using the change in a bank's CDS spread as a proxy for bank risk. High-deposit banks experience a stronger increase in their CDS spreads when rates become negative.

Finally, our setup also allows us to 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 13 illustrates the importance of bank capitalization for the strength of the asset-side channel.

In the first two columns of Table 13, we re-run our baseline specification from Table 4 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 liability 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 13, 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 14, we re-run the specifications from the last two columns of Table 9, using as dependent variable loan shares and including loan as well as bank-firm fixed effects. In this manner, we effectively shut down the demand-side channel. Mirroring our findings for high- and low-spread firms, we find that high-deposit banks reduced their loan exposure to publicly listed *but not to* privately held firms. This suggests that high-deposit banks concentrate their lending on smaller, private firms.

In the third and fourth column, we return to our baseline analysis of firm-level risk (Table 4) 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 lends support to the idea that the increase in bank risk taking leads to an increase in credit availability for firms that are typically seen as more credit constrained.[15]

Furthermore, in the fifth 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 14, 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

[15] The weaker effect for public firms is also 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.

default on previous loans. The last column of Table 14 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 15, 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 15, 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 4 and 8). As such, we expect to see an increase in investment for risky borrowers that contract with high-deposit banks.

The results in Table 15 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*.

Agarwal, S., S. Chomsisengphet, N. Mahoney, and J. Stroebel (2015): "Do Banks Pass Through Credit Expansions to Consumers Who Want to Borrow?," *NBER Working Paper No. 21567*.

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.

Bruche, M., F. Malherbe, and R. Meisenzahl (2016): "Pipeline Risk in Leveraged Loan Syndication," *Cass Business School Working Paper*.

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. S. 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.

Merton, R. C. (1974): "On the Pricing of Corporate Debt: The Risk Structure of Interest Rates," *Journal of Finance*, 29(2), 449–470.

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.

Scharfstein, D. S., and A. Sunderam (2016): "Market Power in Mortgage Lending and the Transmission of Monetary Policy," *Harvard University Working Paper*.

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

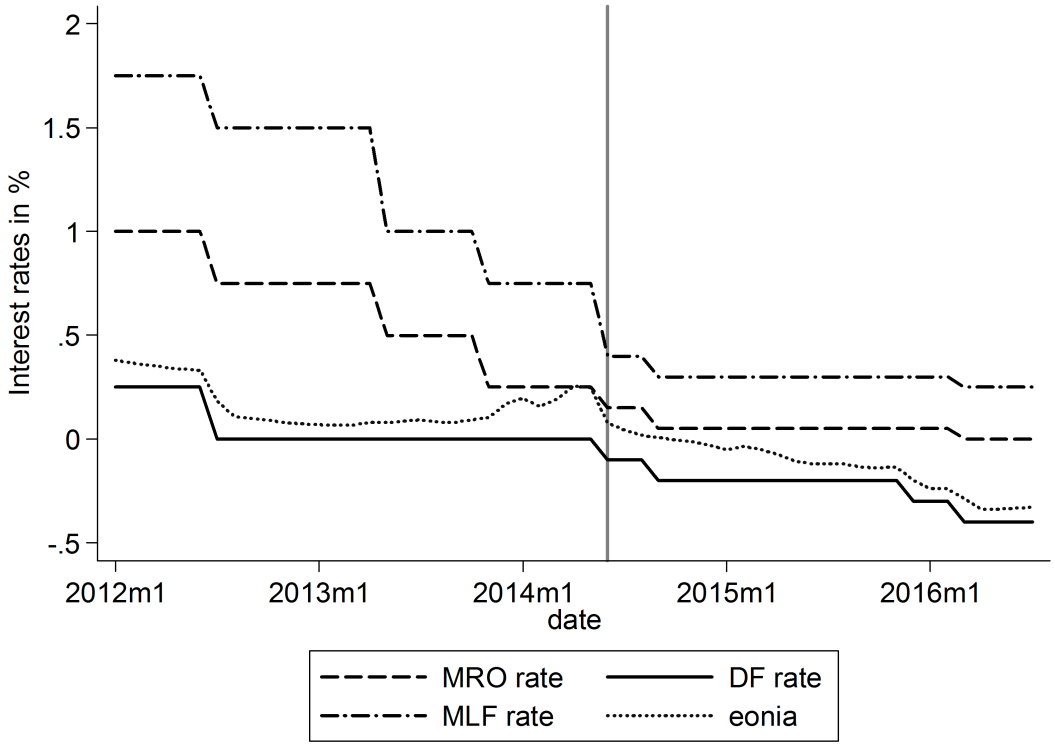


Figure 1: **ECB Key Policy Rates and Interbank Lending Rate.** This figure shows the evolution of the ECB Marginal Lending Facility (MLF) rate, the ECB Main Refinancing Operations Rate (MRO) rate, the ECB Deposit Facility (DF) rate, and the Euro OverNight Index (Eonia) rate between January 2012 and July 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.

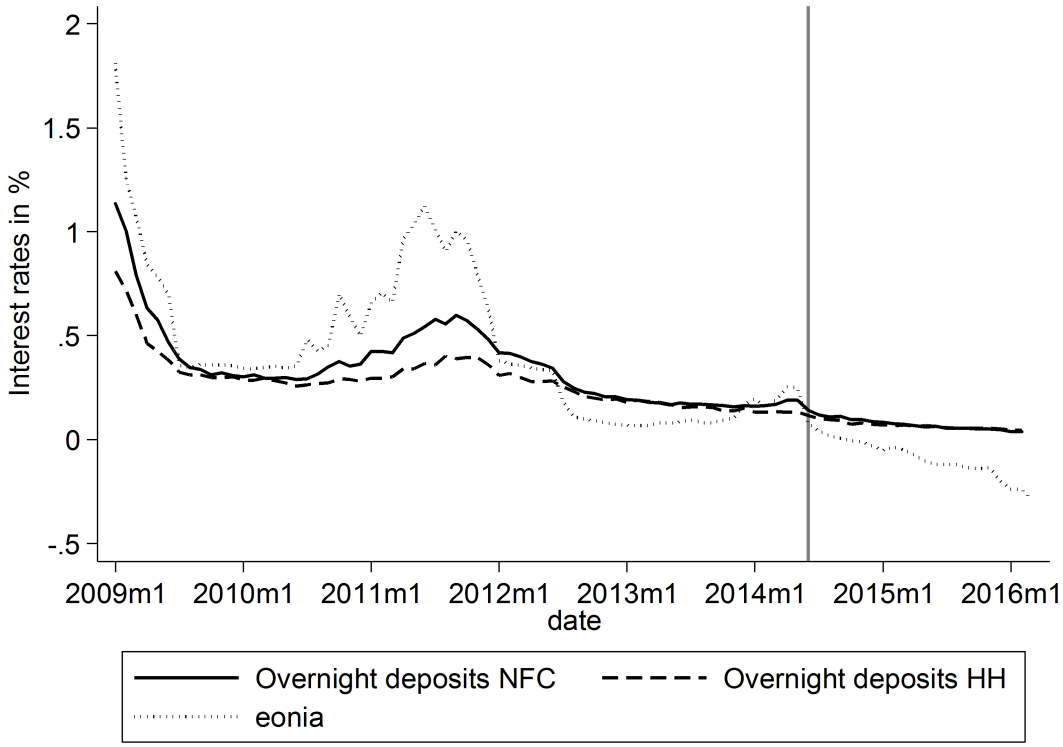


Figure 2: **Deposit Rates on Overnight Deposits (Households and Non-financial Corporations).** This figure shows the evolution of overnight deposit rates at Eurozone banks between January 2009 and March 2016, in comparison to the Euro OverNight Index Average (Eonia) of overnight unsecured lending transactions 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.

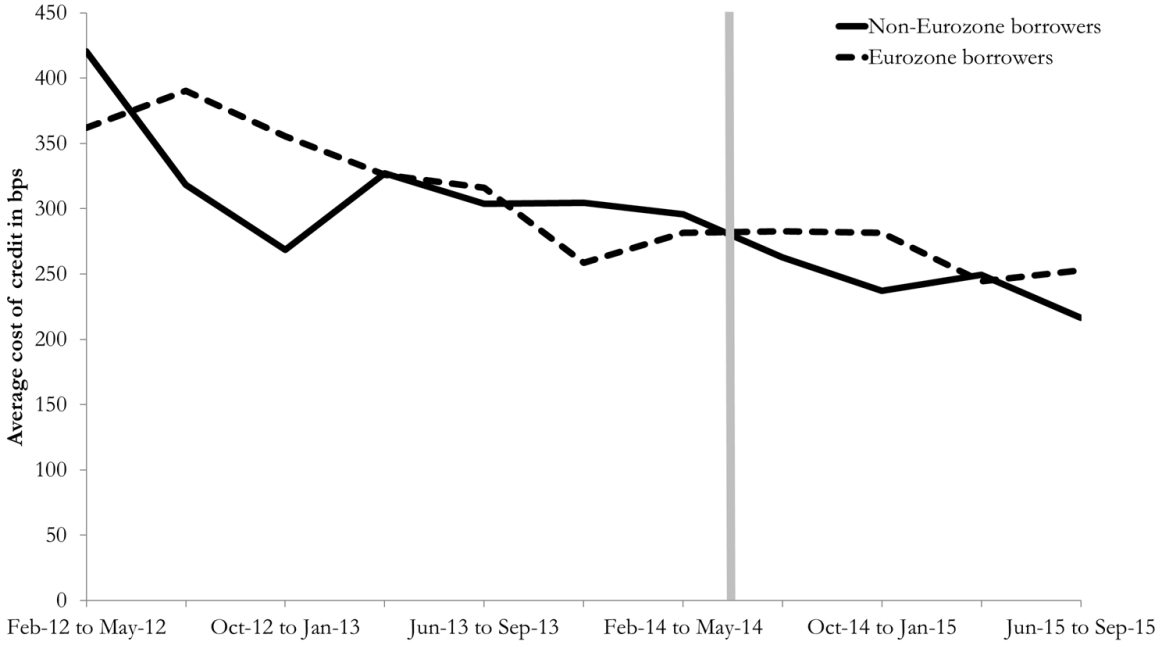


Figure 3: **Evolution of Cost of Debt associated with Loans granted by Eurozone Banks.** This figure plots the four-month (forward-looking) average of the total cost of credit charged by Eurozone lead arrangers, separately for Eurozone and non-Eurozone borrowers.

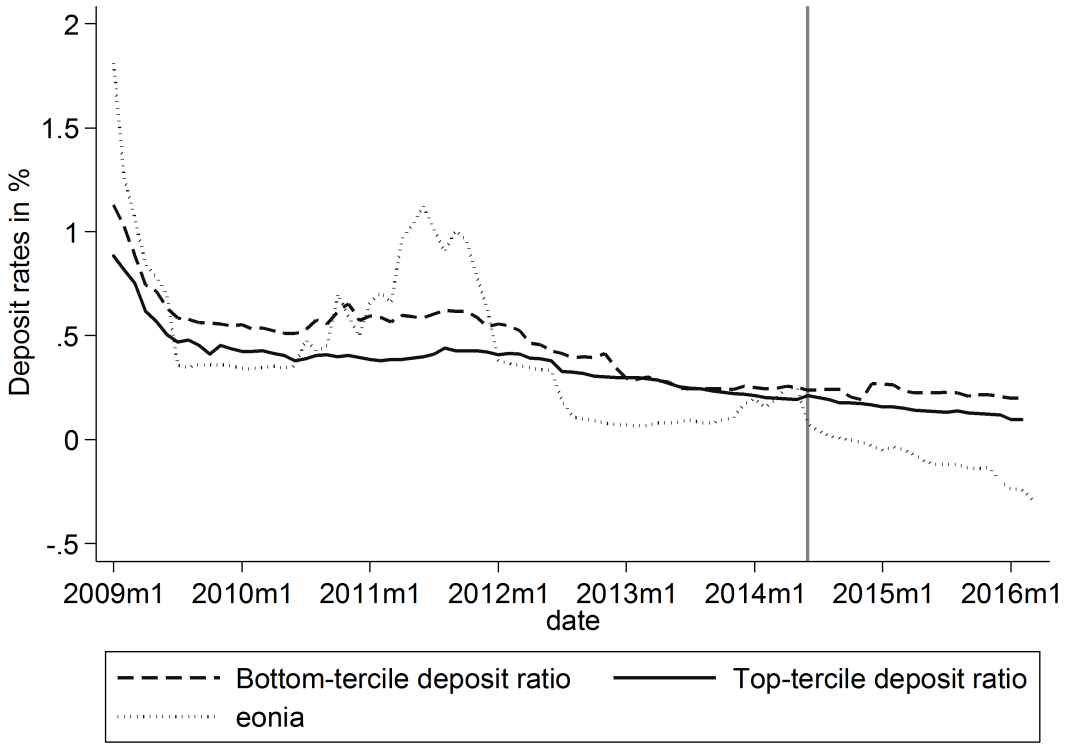


Figure 4: **Deposit Rates on Overnight Deposits (Households) – High-deposit vs. Low-deposit Banks.** This figure shows the evolution of overnight deposit rates for households in the Eurozone between January 2009 and March 2016. The rates are shown for banks in the top tercile of the distribution of the 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.

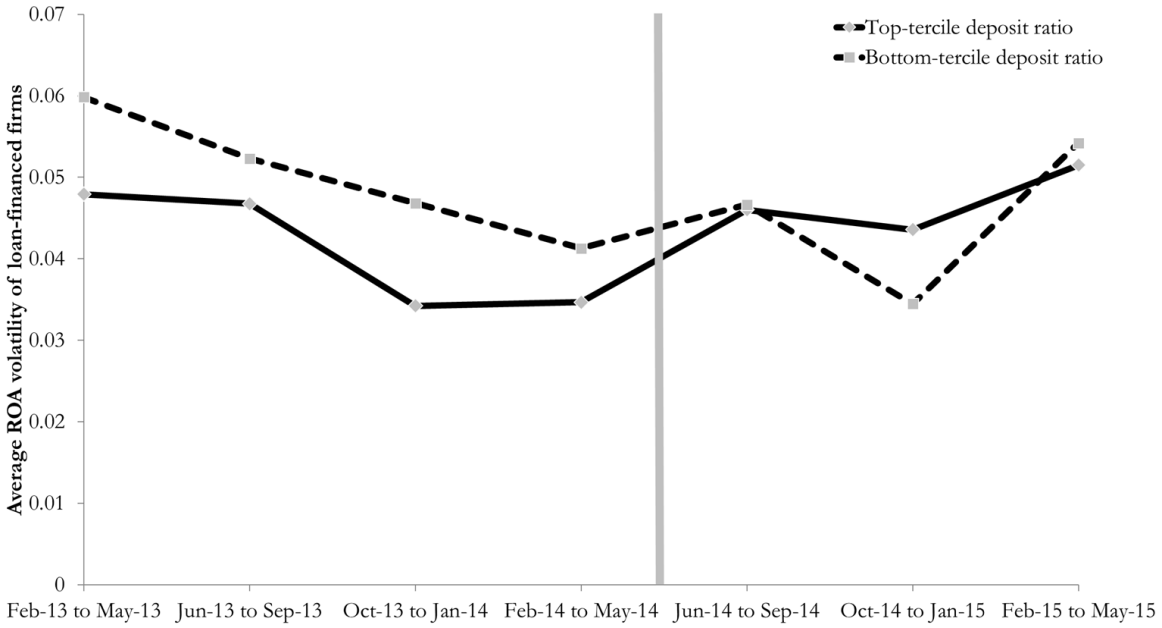


Figure 5: **ROA Volatility of Firms associated with Loans granted by Eurozone Banks with High vs. Low Deposit Ratios.** This figure plots the four-month (forward-looking) average of ROA volatility of all private and publicly listed firms that received loans from Eurozone lead arrangers that were in the 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 $t-1$.

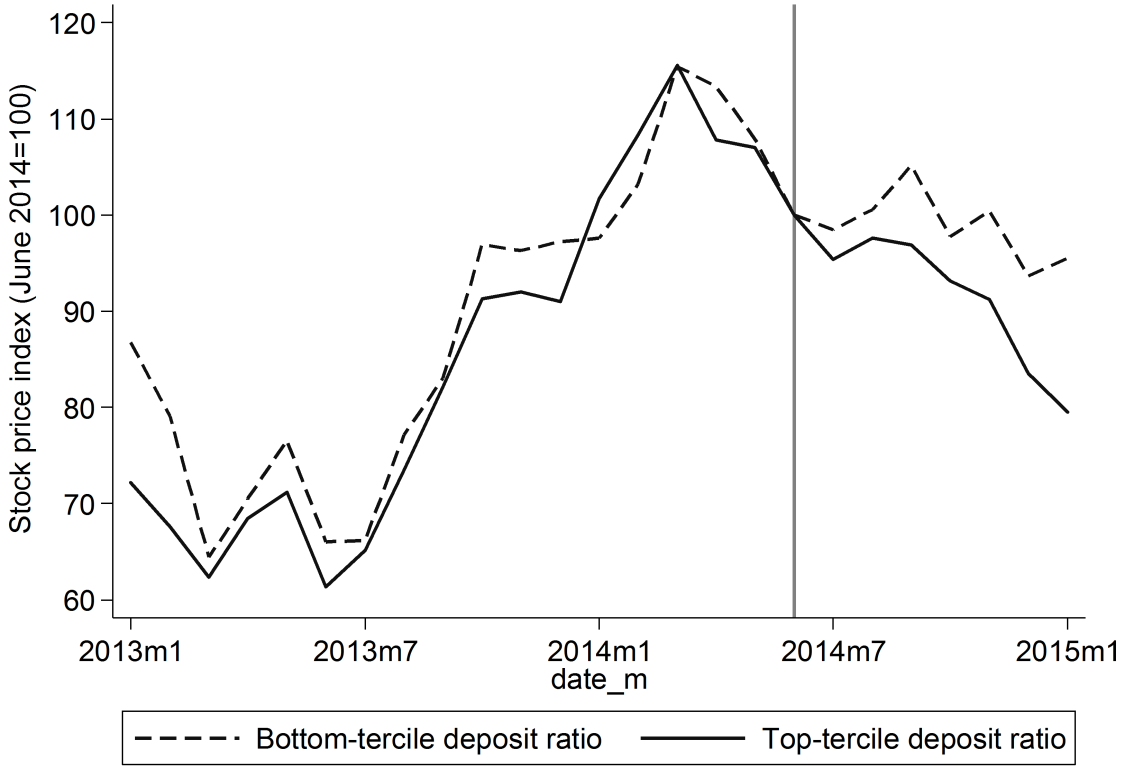


Figure 6: **Stock Price Index of Listed Banks.** This figure shows the evolution of a monthly stock price index (June 2014$\bar{1}$00) for the listed banks in our sample between January 2013 and February 2015. We calculate a price index for each bank, and plot the median index for banks in the top tercile of the distribution of the deposit ratio in December 2013 (solid line) and for banks in the bottom tercile (dashed line). Stock-market data are taken from Thomson Reuters Datastream.

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
ROA in %	4.351	9.144	-98.060	80.010	1,576
Leverage in %	35.902	20.147	0.000	99.985	1,569
No. of employees in thousands	21.687	56.339	0.000	610.989	1,456
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 lead arrangers $\in [0, 100]$	23.287	18.602	0	100	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. $ROA_{i,t-1}$ is firm i's return on assets (ROA, using P&L before tax) in year $t-1$. $Leverage_{i,t-1}$ is firm i's leverage in year $t-1$. *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: **List of Eurozone Lead Arrangers**

Name (group level)	Country	Deposit ratio in 2013 (in %)
BAWAG P.S.K.	AT	60.47
Erste Group Bank	AT	61.19
Raiffeisen Bank	AT	50.85
Raiffeisen Zentralbank Österreich	AT	51.36
Belfius Banque	BE	33.72
Dexia	BE	3.85
KBC Group	BE	55.19
Allianz Group	DE	1.57
Bayerische Landesbank	DE	33.73
Commerzbank	DE	50.30
DZ Bank	DE	25.81
Deutsche Bank	DE	25.67
HRE Holding	DE	12.21
HSH Nordbank	DE	37.27
IKB Deutsche Industriebank	DE	39.40
KfW	DE	2.43
Landesbank Baden-Württemberg	DE	29.88
Landesbank Hessen-Thüringen	DE	24.63
NORD/LB	DE	29.85
Portigon (formerly WestLB)	DE	22.43
Westdeutsche Genossenschafts-Zentralbank	DE	24.10
ABANCA Corporacion	ES	55.64
BBVA	ES	51.57
BFA Sociedad Tenedora Acciones	ES	40.33
Banca March	ES	54.22
Banco Cooperativo Espanol	ES	15.21
Banco Mare Nostrum	ES	71.14
Banco Popular Espanol	ES	60.84
Banco Santander	ES	54.48
Banco de Sabadell	ES	60.76
Bankinter	ES	54.06
Caja Rural de Navarra	ES	60.25
EBN Banco de Negocios	ES	29.45
Fundacion Bancaria La Caixa	ES	50.16
Grupo Cooperativo	ES	69.09
Ibercaja Banco	ES	63.41
Instituto de Credito Oficial	ES	1.78
Liberbank	ES	78.39
OP Financial Group	FI	49.66
BNP Paribas	FR	30.57
Crédit Agricole Group	FR	37.95
Crédit Mutuel Group	FR	44.93
Groupe BPCE	FR	40.72
Société Générale	FR	27.52
Alpha Bank	GR	57.65
National Bank of Greece	GR	56.68
Allied Irish Banks	IE	55.78
Bank of Ireland	IE	55.90
Banca Monte dei Paschi	IT	45.86
Banca Popolare di Milano	IT	53.55
Banca Popolare di Vicenza	IT	50.83
Banca Popolare dell'Emilia	IT	54.61
Banco Popolare	IT	38.05
Cassa Depositi e Prestiti	IT	70.45
Intesa Sanpaolo	IT	36.71
Mediobanca	IT	23.53
UBI Banca	IT	40.82
UniCredit	IT	48.61
European Investment Bank	LU	0.49
ABN AMRO Group	NL	55.80
Bank Nederlandse Gemeenten	NL	7.65
ING Bank	NL	64.53
NIBC Bank	NL	38.70
Rabobank Group	NL	49.21
SNS Bank	NL	58.90
Banco BPI	PT	59.86
Banco Comercial Português	PT	59.70
Banco Esperito Santo	PT	45.69
Banif	PT	46.34
Caixa Geral	PT	59.78

Table 3: **Further Bank-level Summary Statistics**

	Tercile	N	Mean	Std. dev	t-stat
Deposit ratio in %	Bottom	23	21.58	12.60	13.82
	Top	23	61.13	6.04	
Equity ratio in %	Bottom	23	4.98	2.26	1.94
	Top	23	6.19	2.04	
ln(Total assets)	Bottom	23	12.22	1.61	2.00
	Top	23	11.46	0.94	
Loans-to-assets ratio in %	Bottom	23	39.92	17.97	6.75
	Top	23	68.44	8.56	
Return on assets in %	Bottom	23	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	
Number of loans (lead arranger)	Bottom	23	150.48	230.75	1.47
	Top	23	71.30	117.10	
Average loan size in 2016 €bn	Bottom	23	1.19	0.68	0.97
	Top	23	1.02	0.53	
Average loan share $\in [0, 100]$	Bottom	23	17.87	21.63	0.48
	Top	23	15.01	17.04	
Proportion of leveraged loans $\in [0, 1]$	Bottom	23	0.16	0.21	0.54
	Top	23	0.13	0.10	

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 tests in the top panel is the year 2013. The sample period underlying the summary statistics in the bottom panel corresponds to the main regression sample of all completed syndicated loans of both private and publicly listed firms granted by any Eurozone (participating or lead) bank from January 2013 to December 2015.

Table 4: **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 5: **ROA Volatility of Firms Financed by Banks Following Negative Policy Rates – Robustness**

			$\ln(\sigma(ROA_i)^{5y})$			
Sample			2013 – 2015			2011 – 2015
Robustness	No low deposits	Alt. dep. ratio				
Deposit ratio × After(06/2014)	0.020***	0.019***	0.021***	0.023***	0.019***	0.020***
	(0.006)	(0.005)	(0.005)	(0.006)	(0.006)	(0.006)
Deposit ratio × After(07/2012)						-0.008*
						(0.005)
$\ln(\text{Assets})_{t-1}$			0.082			0.078
			(0.059)			(0.054)
Securities ratio_{t-1}				0.009**		0.000
				(0.004)		(0.005)
Equity ratio_{t-1}					0.036	0.056
					(0.054)	(0.039)
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	1,571	1,576	1,576	1,576	1,576	2,490

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 five columns and from January 2011 to December 2015 in the last column. 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 $t-1$. In the first column, *Deposit ratio*$_j$ is the average ratio (in %) of deposits over total assets across all Eurozone lead arrangers j in 2013, with the exception of government entities – Bank Nederlandse Gemeenten (with a deposit ratio of 7.65% in 2013), European Investment Bank (0.49%), Instituto de Credito Oficial (1.78%), and KfW (2.43%) – and the insurance company Allianz Group (1.57%). In the second column, *Deposit ratio*$_j$ is the average ratio (in %) of deposits over total liabilities across all Eurozone lead arrangers j in 2013. In the remaining columns, *Deposit ratio*$_j$ is the average ratio (in %) of deposits over total assets 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. $After(07/2012)_t$ 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 6: **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 7: **Impact of Negative Policy Rates on Total Bank Lending**

	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. Robust standard errors (clustered at the bank level) are in parentheses.

Table 8: **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 9: **Impact of Negative Policy Rates on Loan Shares: Within-loan Estimation**

	Loan share $\in [0, 100]$		
Sample	All	Bottom-tercile loan spread	Top-tercile loan spread
Deposit ratio × After(06/2014)	-0.045*	-0.045**	0.077**
	(0.023)	(0.017)	(0.037)
Loan FE	Y	Y	Y
Bank-firm FE	Y	Y	Y
Bank-country-year FE	Y	Y	Y
N	1,854	545	434

Notes: The sample consists of all completed syndicated loans of both private and publicly listed firms i at date t granted by any Eurozone (participating or lead) bank j from January 2013 to December 2015. Observations are at the loan-bank level, i.e., each loan comprises multiple observations, but only one observation per (participating or lead) bank. All singletons are dropped from the total number of observations N. In the second and third column, the sample consists of borrower firms in the bottom and top tercile, respectively, of the distribution 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, but no earlier than January 2003 (as in Table B.2). The dependent variable is the loan share (in %) retained by (participating or lead) bank j. $\textit{Deposit ratio}_j$ 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. Bank-country-year fixed effects are based on the bank group's country of origin in the Eurozone. Public-service, energy, and financial-services borrower firms are dropped. Robust standard errors (clustered at the bank level) are in parentheses.

Table 10: **Impact of Negative Policy Rates on Loan Spreads**

	ln(All-in-drawn spread)					
Sample	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. $\textit{Deposit ratio}_j$ 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. $After(07/2012)_t$ 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 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 12: **Bank-level Stock Returns, Stock-return Volatility, and CDS Returns**

	Stock $return_j^{1m}$		$\ln(\sigma(return_j)^{1m})$		*CDS* $return_j^{1m}$	
Deposit ratio × After(06/2014)	-0.076***	-0.067***	0.012*	0.013**	0.141**	0.126**
	(0.0208)	(0.017)	(0.0065)	(0.0054)	(0.062)	(0.058)
Deposit ratio × After(07/2012)		0.026		-0.006		-0.043
		(0.041)		(0.016)		(0.047)
Bank FE	Y	Y	Y	Y	Y	Y
Month-year FE	Y	Y	Y	Y	Y	Y
N	775	1,471	775	1,471	898	1,689

Notes: all data points used in this table are at a bank's month-year level. In the first four columns, we use stock market data on 30 listed banks, from January 2013 to February 2015 in the first and third column, and from January 2011 to February 2015 in the second and fourth column. The dependent variable in the first two columns is the monthly stock return (in %) at the bank level and the logged unlevered monthly standard deviation of bank stock returns in the third and the fourth column. For each bank, the monthly standard deviation is calculated using daily stock returns. Standard deviations are unlevered by multiplying them with the ratio of bank equity over total assets. In the last two columns, we use monthly CDS-spread returns (in %) for 36 banks. The sample period runs from January 2013 to February 2015 in the fifth column, and from January 2011 to February 2015 in the last column. *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. Robust standard errors (clustered at the bank level) are in parentheses.

Table 13: **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 14: **Impact of Negative Policy Rates on Banks' Loan Portfolio**

	Loan share $\in [0,100]$		$\ln(\sigma(ROA_i)^{5y})$	$\ln(\sigma(ROA_i)^{5y})$	$\ln(\sigma(ROA_i)^{5y})$	$ROA_{i,t-1}$	$Leverage_{i,t-1}$
Sample	Private firms	Public firms	Private firms	Public firms	Private and public firms		
Deposit ratio × After(06/2014)	-0.022	-0.062*	0.027***	0.011	0.012*	-0.036	-0.238**
	(0.031)	(0.036)	(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)		
Loan FE	Y	Y	N	N	N	N	N
Bank-firm FE	Y	Y	N	N	N	N	N
Bank-country-year FE	Y	Y	N	N	N	N	N
Bank FE	N	N	Y	Y	Y	Y	Y
Month-year FE	N	N	Y	Y	Y	Y	Y
Country-year FE	N	N	Y	Y	Y	Y	Y
Industry-year FE	N	N	Y	Y	Y	Y	Y
N	945	876	904	672	1,576	1,576	1,569

Notes: The sample consists of all completed syndicated loans of only private (in the first and third column), only publicly listed (in the second and fourth column), and both private and publicly listed firms i (in the remaining columns) at date t granted by any Eurozone (participating or lead) bank j (in the first two columns) and any Eurozone lead arranger(s) j (in the remaining columns) from January 2013 to December 2015. In the first two columns, observations are at the loan-bank level, i.e., each loan comprises multiple observations, but only one observation per (participating or lead) bank; all singletons are dropped from the total number of observations N. In the remaining columns, observations are at the aggregate loan (package) level. In the first two columns, the dependent variable is the loan share (in %) retained by (participating or lead) bank j. The dependent variable in the third to fifth column 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 sixth 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 last column is firm i's leverage in year $t-1$, measured in % ($\in [0,100]$). In the first two columns, $Deposit\ ratio_j$ is bank j's ratio (in %) of deposits over total assets in 2013. In the remaining columns, $Deposit\ ratio_j$ 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. In the first two columns, bank-country-year fixed effects are based on the bank group's country of origin in the Eurozone. In the remaining columns, 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 15: **Real Effects of Negative Policy Rates: Investment**

	$\Delta_{t+1,t}\ln(Investment_i)$			
Sample	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

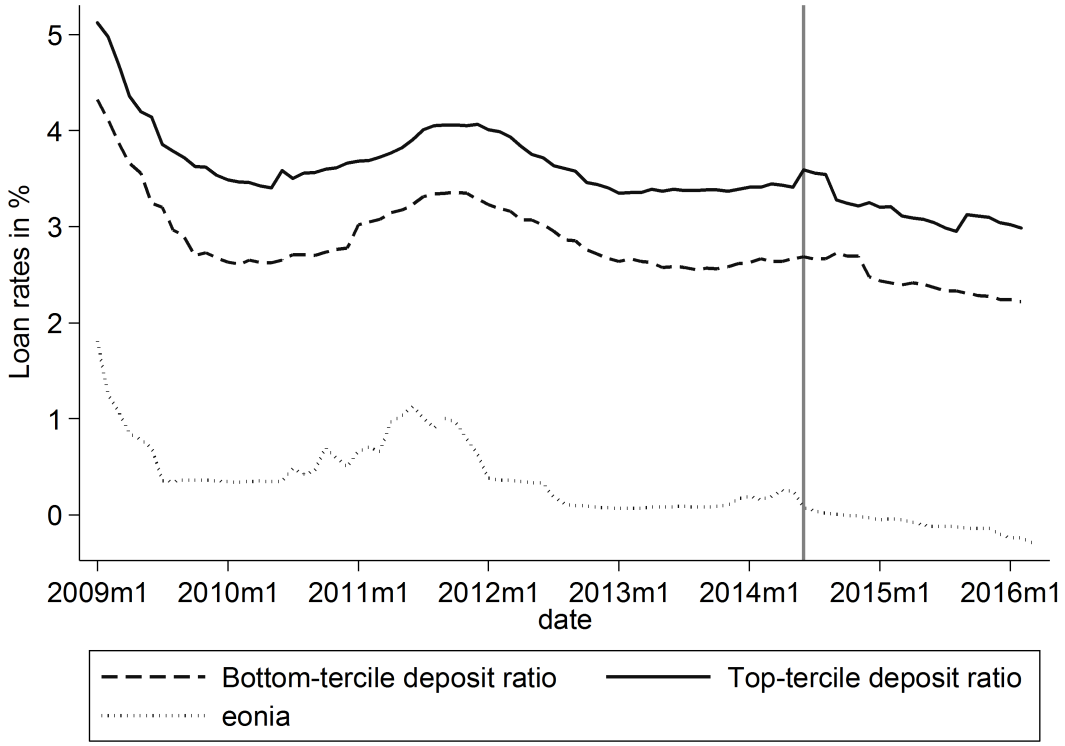


Figure A.1: **Loan Rates on Long-term (>5y) Loans (NFCs) – High-deposit vs. Low-deposit Banks.** This figure shows the evolution of loan rates on outstanding long-term (above five years) loans for non-financial corporations (NFCs) in the Eurozone between January 2009 and March 2016. The rates are shown 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.

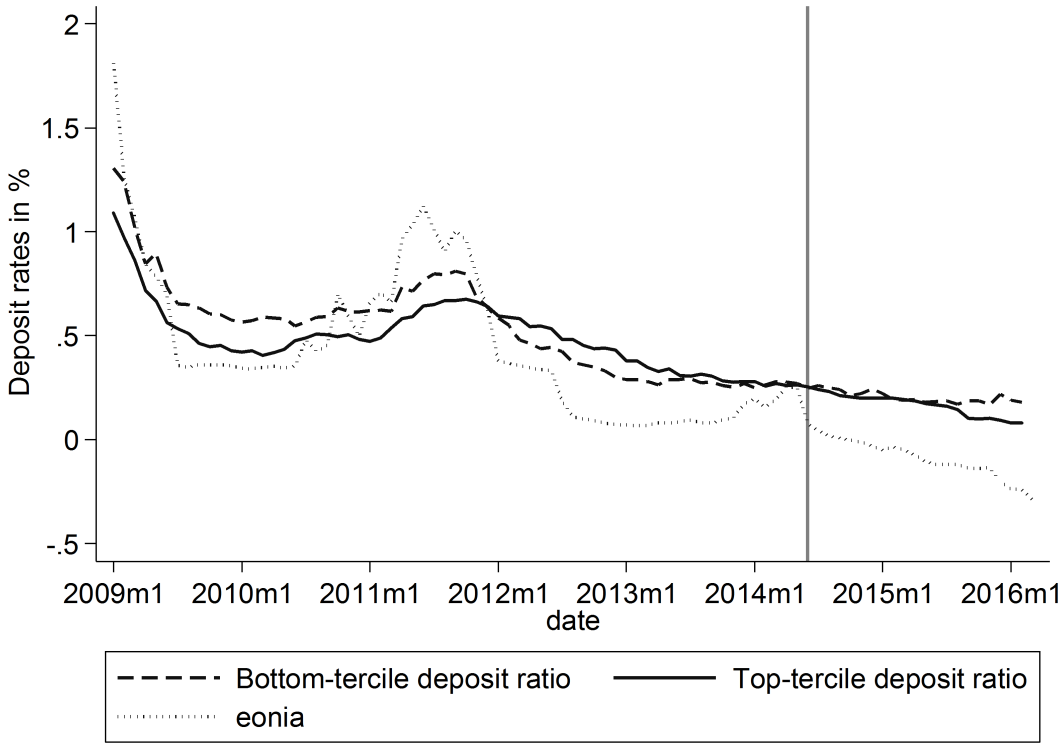
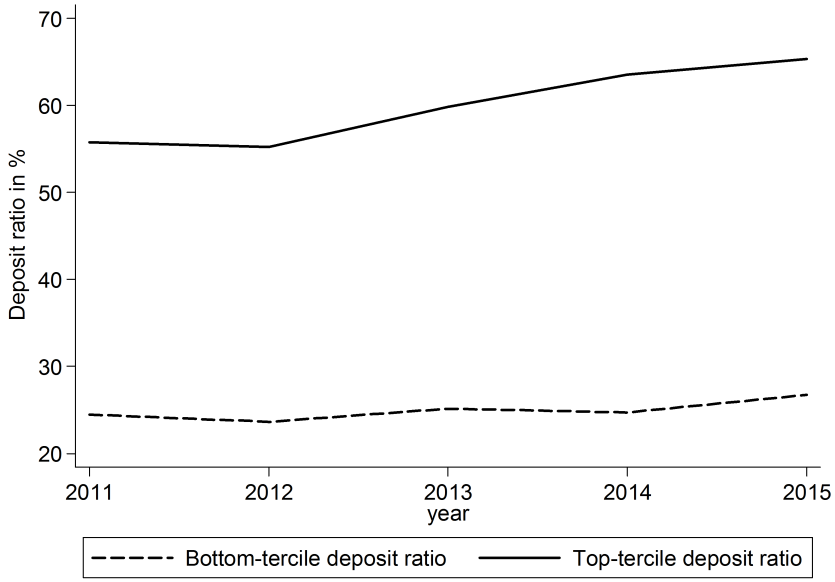
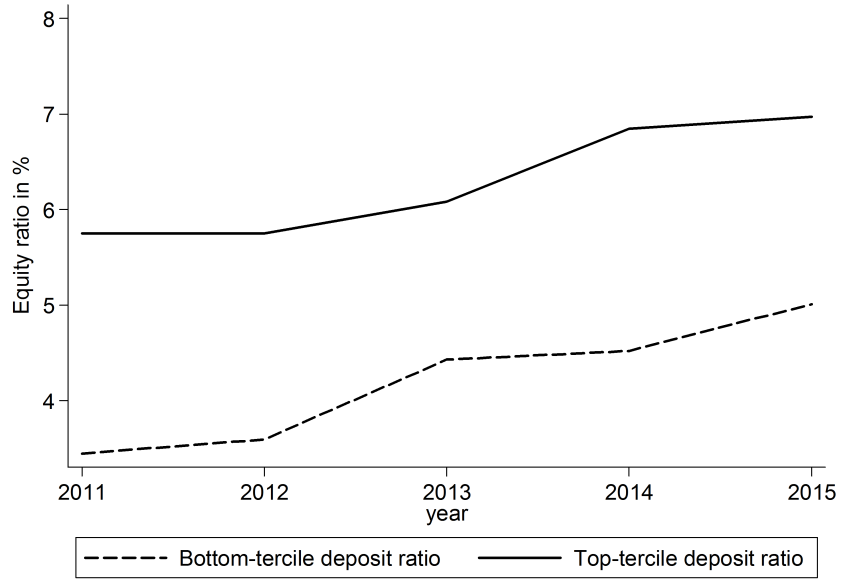


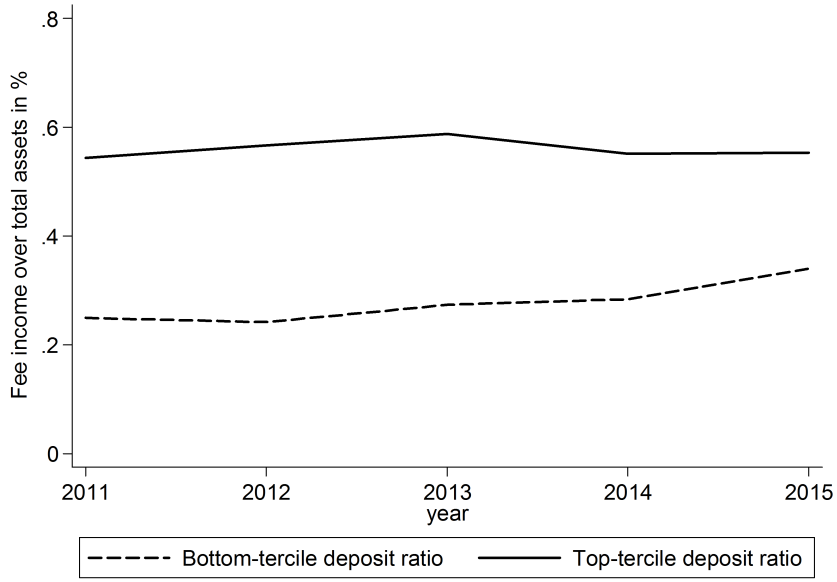
Figure A.2: **Deposit Rates on Overnight Deposits (NFCs) – High-deposit vs. Low-deposit Banks.** This figure shows the evolution of overnight deposit rates for non-financial corporations (NFCs) in the Eurozone between January 2009 and March 2016. The rates are shown for banks in the top tercile of the 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.



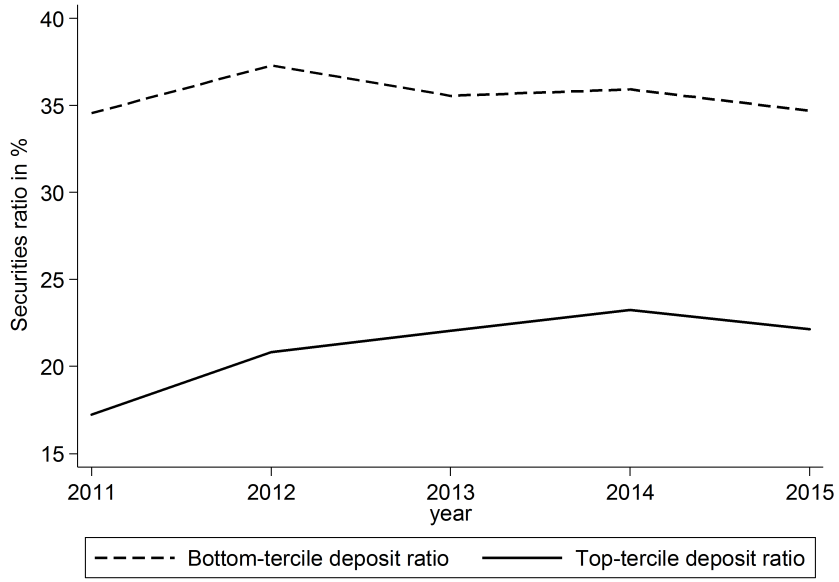
(a) Deposit ratio



(b) Equity ratio



(c) Fee income



(d) Securities ratio

Figure A.3: **Evolution of Bank Balance-sheet Characteristics.** This figure shows the evolution of the average deposit ratio (total deposits over total assets), equity ratio (total equity over total assets), fee income ratio (total fee income over total assets), and securities ratio (total securities over total assets) for Eurozone banks in the top (straight line) and the bottom tercile (dashed line) of the deposit-ratio distribution (based on 2013 data). Averages are calculated using yearly bank-level information for all banks included in the baseline sample.

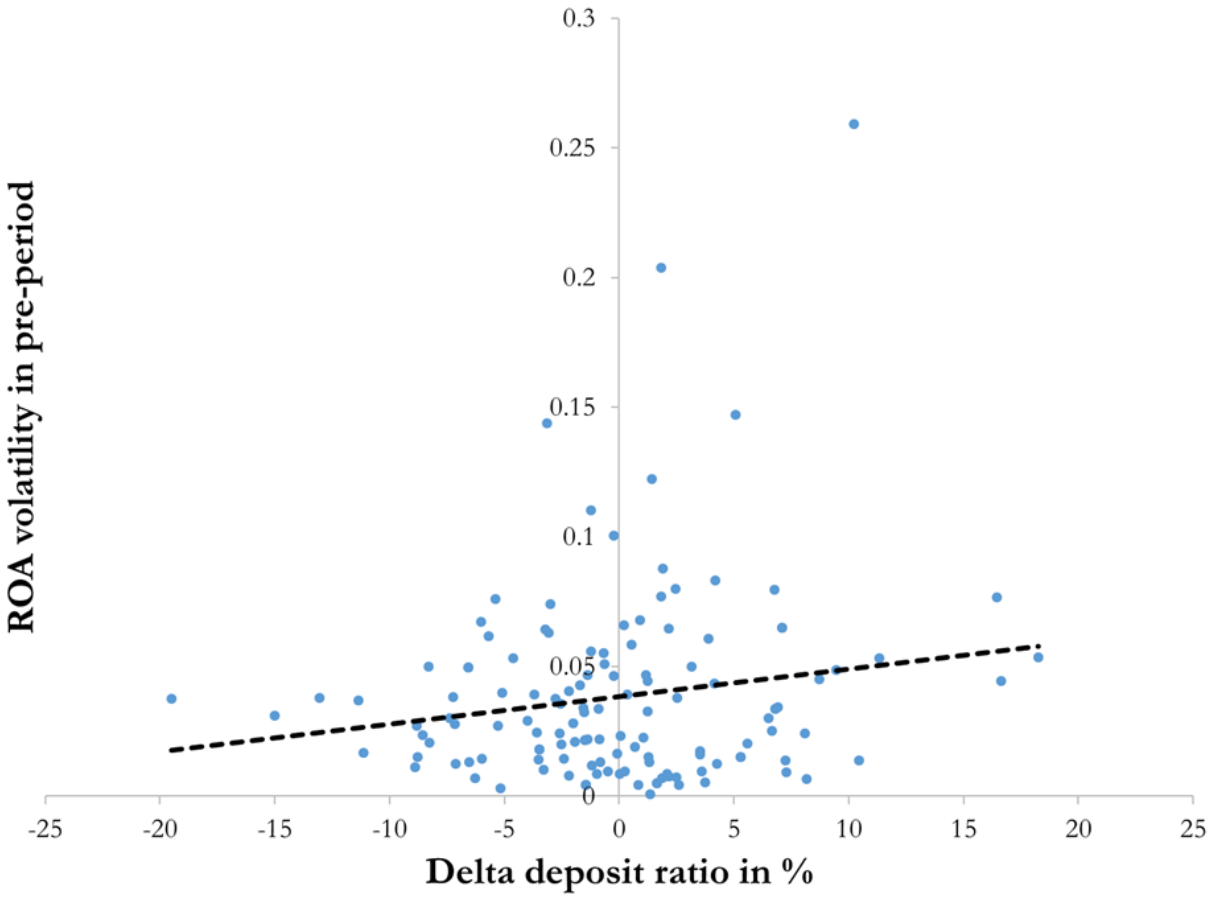


Figure A.4: **ROA Volatility of Firms Switching Banks.** The sample consists of private and publicly listed firms that received at least one loan in both the period from January 2013 leading up to June 2014 (pre-period) and in the period thereafter until December 2015 (post-period). This figure plots 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 – Incorporation of Leverage**

	$\ln(\sigma(ROA_i)^{5y} \times Leverage_{i,t-1})$					
Sample	2013 – 2015				2011 – 2015	2011 – 2015, non-Euro
Deposit ratio × After(06/2014)	0.007**	0.007**	0.008**	0.008**	0.009**	0.007
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.008)
Deposit ratio × After(07/2012)					-0.004	-0.005
					(0.003)	(0.007)
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	1,569	1,569	1,569	1,569	2,478	537

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 five-year standard deviation of firm i's return on assets (ROA, using P&L before tax) from year $t-5$ to $t-1$ multiplied by firm i's leverage in year $t-1$. *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.5: **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.6: **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.7: **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.8: **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.9: **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.