EUROPEAN CENTRAL BANK
EUROSYSTEM

Working Paper Series

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Life below zero: bank lending under negative policy rates

No 2173 / August 2018

Abstract

We show that negative policy rates affect the supply of bank credit in a novel way. Banks are reluctant to pass on negative rates to depositors, which increases the funding cost of high-deposit banks, and reduces their net worth, relative to low-deposit banks. As a consequence, the introduction of negative policy rates by the European Central Bank in mid-2014 leads to more risk taking and less lending by euro-area banks with greater reliance on deposit funding. Our results suggest that negative rates are less accommodative, and could pose a risk to financial stability, if lending is done by high-deposit banks.

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

Keywords: negative interest rates, deposits, zero lower bound, bank balance-sheet channel, bank risk-taking channel

Non-technical Summary

On 5 June 2014, the ECB Governing Council lowered the Main Refinancing Operation rate to 0.15% and the Deposit Facility (DF) rate to -0.10%. Because banks held significant amounts of excess liquidity during this period, short-term market rates closely tracked the DF rate, effectively making the DF rate the main policy rate. With this decision, the ECB ventured into negative territory for the first time in its history.

This paper provides evidence on how negative policy rates impact bank lending behavior and transmit to the real economy. We show that when the ECB reduced the 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. 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 relative reduction in lending of 9%. In other words, when rates become negative, banks that mainly rely on deposit funding take on more risk and lend less than banks relying on other funding sources.

We explain this finding by showing that negative policy rates induce a wedge between deposit and non-deposit funding costs. In normal times, deposit rates tend to be downward flexible; they fall when the policy rate decreases. But when the policy rate becomes negative, banks are reluctant to charge negative rates to depositors. The negative policy rate leads to a lower cost of non-deposit funding, but not to a lower cost of deposit funding. This constitutes a negative shock to the net worth (i.e., the value difference between assets and liabilities) of banks with a lot of deposit funding relative to banks that rely on non-deposit funding.

The adverse effect of negative rates on the net worth of banks with more deposits - relative to low-deposit banks - leads to relatively less lending and more risk taking for these banks. The transmission of negative policy rates is thus different from the standard transmission through banks. When rates are non-negative, a lower policy rate is accommodative because it typically increases bank net worth, independent of the amount of deposit funding. A lower

policy rate reduces both the return on assets and the cost of funding, but the liability-side effect typically dominates because banks engage in maturity transformation, as they have long-term assets and short-term liabilities. In contrast, once rates become negative, a lower policy rate dampens this effect for banks that rely primarily on deposit funding.

Even though high-deposit banks lend less than low-deposit banks, their risk taking appears to overcome rationing. Firms that did not borrow before now receive loans from high-deposit banks. The firms that receive loans appear financially constrained, and do not resemble "zombie" firm. Additionally, the relative reduction in lending for high-deposit banks does not necessarily imply that overall lending decreased. Indeed, the aggregate amount of lending by the euro-area banks in our sample has been steadily growing since mid-2014, albeit at a somewhat slower pace for high-deposit banks. Negative policy rates may therefore stimulate the economy in an unexpected but crucial way.

1 Introduction

How does monetary policy transmit to the real sector once interest rates break through the zero lower bound? Negative monetary-policy rates are unprecedented and controversial. Central banks around the world struggle to rationalize negative rates using conventional wisdom.[1]

This paper examines the transmission of negative policy rates to the real sector via the supply of bank credit. We find that when the European Central Bank (ECB) reduces the deposit facility (DF) rate from 0 to -0.10% in June 2014 and, shortly after, in September 2014, from -0.10 to -0.20%, banks with more deposits concentrate their lending on riskier firms in the market for syndicated loans. A one-standard-deviation increase in banks' deposit ratio leads to the financing of firms with at least 16% higher return-on-assets volatility and to a reduction in lending of 13%.

The typical way to think about monetary-policy transmission via bank lending – as described in, for example, Bernanke (2007) – cannot explain this pattern. First, there is no special role for bank deposits. Second, banks should generally lend more when the policy rate decreases. A lower (positive) policy rate lowers banks' cost of funding, and thereby increases bank net worth. More net worth, in turn, reduces banks' external-finance premium, allowing banks to expand lending. And third, when the policy rate decreases, banks with higher net worth have more "skin-in-the-game" (or, equivalently, a higher franchise value) and should take less risk.

To explain our findings, we augment this standard view with a new effect that kicks in when the policy rate becomes negative. When the policy rate becomes negative, greater reliance on deposits (relative to market-based short-term debt) has an adverse effect on bank

[1] 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. For the concerns of the Bank of England, see Carney (2016). The Federal Reserve's reluctance is described in "Fed's Dislike of Negative Interest Rates Points to Limits of Stimulus Measures" (The Wall Street Journal, August 28, 2016).

net worth. This adverse effect on bank net worth explains why banks with more deposits should lend less and take more risk once the policy rate becomes negative, compared to low-deposit banks.

Deposit funding hurts bank net worth because the lower negative policy rate does not transmit to lower negative deposit rates, while it does transmit to lower negative market rates. Normally, lower positive policy rates transmit to lower rates on both deposits and market-based short-term debt. We show this is no longer the case for deposit rates once the ECB sets negative rates. Hence, banks relying more on deposit funding relative to market-based funding experience a lower reduction in their cost of funding, which adversely affects their net worth.

Negative policy rates do not transmit to lower deposit rates because banks appear reluctant to charge negative rates to their depositors. The distribution of deposit rates of euro-area banks is truncated at zero. Moreover, more deposit rates bunch at zero once the ECB lowers the policy rate to below zero.

The theoretical argument for not charging negative deposit rates is intuitive. As soon as deposits offer a negative nominal return, they become inferior to cash, which offers a zero nominal return, and depositors withdraw. Fearing deposit withdrawals, banks do not lower deposit rates to below zero.[2]

Based on this logic, we examine the transmission of negative policy rates to the supply of bank credit using a difference-in-differences approach. We compare the lending behavior of banks with different deposit ratios before and after the ECB sets negative policy rates in mid-2014. Our identifying assumption therefore is that the lending behavior of low-deposit banks provides the counterfactual for the lending behavior of high-deposit banks in the absence of a negative policy rate.

[2] There may be storage costs of holding physical currency, which could in theory allow banks to charge negative deposit rates. These costs are, however, hard to estimate, and banks appear reluctant to test this boundary by setting negative deposit rates, for which we provide evidence in our analysis.

The following example illustrates the essence of our identification strategy. A common problem of identifying the impact of monetary policy on the supply of bank credit is the endogeneity of monetary policy. The ECB sets negative rates because it may be concerned about deteriorating economic conditions. At the same time, it is plausible that banks lend less and to riskier borrowers because there are only few and risky lending opportunities available when economic conditions deteriorate. In this case, the relationship between negative policy rates and banks' lending behavior is biased because the deteriorating economy drives both.

Comparing instead the lending behavior of high-deposit and low-deposit banks addresses the endogeneity of monetary policy. If both types of banks face the same deterioration in economic conditions, its impact is canceled out when considering only the difference in the lending behavior of high-deposit and low-deposit banks around the introduction of negative policy rates.

A main threat to our identification strategy is that the control group, low-deposit banks, may be inappropriate. This applies when there is a difference between high-deposit and low-deposit banks that changes when the policy rate becomes negative (and matters for their lending behavior). 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 the example above, if economic conditions deteriorate more for high-deposit banks, then comparing their lending behavior to the one of low-deposit banks no longer removes the bias stemming from the endogeneity of monetary policy.

We assess the appropriateness of using low-deposit banks as the control group in a number of robustness checks. For example, we refine the comparison between high-deposit and low-deposit banks by adding a number of control variables. These include bank-level variables typically used when evaluating the transmission of monetary policy. We also include a number of fixed effects to control for certain unobserved heterogeneity in bank lending, e.g., time-varying country and industry factors of borrowers. In our most refined comparison, we examine the lending behavior of high-deposit and low-deposit banks to the same borrower.

Adding firm-year fixed effects eliminates any time-varying difference in lending opportunities or loan demand between high-deposit and low-deposit banks.

Another concern is our use of banks' deposit funding as the variable that determines bank-level exposure to negative policy rates. Clearly, the degree of deposit funding is not assigned randomly to banks. To the extent that banks' different reliance on deposit funding reflects time-invariant differences in bank lending, e.g., because of different business models, these differences drop out when comparing each bank to itself, before and after the policy-rate change.

If banks with different deposit ratios adjusted their reliance on deposits, either in anticipation or as a response to negative policy rates, then this would lead to time-varying differences between the treatment and the control group. In our sample, however, high-deposit and low-deposit banks do not differ in their reliance on deposit funding over time. Both high-deposit and low-deposit banks slightly increase their deposits-to-assets ratios, but not differently so.

To examine the robustness of our results further, we modify the exposure-to-treatment variable using confidential supervisory information on how many deposits are held by households as opposed to non-financial corporations. This information allows us to compare banks with a lot of household deposits to those with few household deposits, irrespective of their overall reliance on deposit funding. Because it is easier for households than for corporates to withdraw their deposits, banks should be more reluctant to charge negative rates on household rather than corporate deposits. In line with this reasoning, we find that our difference-in-differences estimate is not only larger but also more precisely estimated for banks with greater reliance on household deposits.

Comparing banks with different reliance on household versus corporate deposits also limits the scope for other coincidental events driving our findings. Central-bank open-market operations, asset-purchase programs, and other regulatory changes could potentially affect the lending of certain banks more than others. And possibly, this differential effect coincides with banks' deposit ratios and occurs at the same time as negative rates, although we argue

that this is unlikely in our setting. It is, however, much less plausible that these other events affect banks with similar reliance on deposit funding according to the origin of their deposits (i.e., household vs. non-financial-corporation deposits) around the ECB's decision to set negative rates.

Next, one may wonder whether negative policy rates are indeed special. Instead, it may be that we identify a hitherto unknown role of bank deposits for the transmission of monetary policy in general. We examine this possibility first by repeating our difference-in-differences estimation around July 2012, which is the last time the ECB lowered its policy rates prior to going negative. In this placebo setting, we find no evidence for an effect of a lower policy rate on credit supply by banks depending on their reliance on deposit funding.

Second, we expand our sample to include many more policy-rate changes, independent of their size, timing, or whether they are cuts or increases. We then interact banks' deposits-to-assets ratios with the policy rate and an indicator variable for the period of negative rates since June 2014. The double interaction of banks' deposit ratio with the policy rate is virtually zero and insignificant, while the triple interaction with the indicator variable is significant for measures of both the volume of new lending and the ex-ante riskiness of borrowers receiving new loans. This indicates that the transmission of policy rates to the supply of bank credit via bank deposits occurs only when policy rates become negative.

Our preferred explanation for our findings is that less skin-in-the-game exacerbates a bank's internal agency problem, which raises the external-finance premium and gives less incentives to screen and monitor risky borrowers. A potential alternative explanation would be that less net worth induces a "search-for-yield," whereby banks lend to riskier borrowers in order to obtain higher loan rates.

To disentangle the two explanations, we examine the impact of negative policy rates on the loan terms offered by high-deposit and low-deposit banks. Contrary to a search-for-yield, the lending to riskier borrowers is neither offset by higher loan spreads, nor is it offset by more stringent loan terms such as higher collateral, higher loan shares retained by the lead arrangers in a loan syndicate, or more covenants. All of this indicates a relative increase in

high-deposit banks' internal agency problem. Also in line with this reasoning, we find that the risk taking of high-deposit banks is concentrated in banks with little equity, i.e., those that have little skin-in-the-game.

While high-deposit banks lend to riskier firms than do low-deposit banks, these riskier firms do not appear to be "zombie" firms. Firms receiving new loans from high-deposit banks have less leverage and the same profitability as firms receiving new loans from low-deposit banks. Moreover, the riskier lending of high-deposit banks is concentrated in private and, thus, more financially constrained firms. High-deposit banks also engage in riskier lending if they have previously lent to the same industry and have thereby accumulated some expertise in assessing borrowers. Altogether, the evidence suggests more risk taking but no obviously reckless lending behavior.

Finally, we assess the external validity of our findings. While syndicated loans account for a sizable portion of total bank lending, they do not necessarily capture overall bank lending behavior. Using market data, we show that high-deposit banks exhibit higher stock-return volatility and a stronger increase in their CDS spreads when the policy rate becomes negative, attesting to their risk taking. Using annual balance-sheet data, we also show that while overall bank lending increases after the setting of negative policy rates, the lending of high-deposit banks increases less than the lending of low-deposit banks.

2 Related Literature

Our analysis makes the following contributions. First, negative policy rates truly are uncharted territory, both theoretically and empirically.[3] To the best of our knowledge, ours is the first paper to examine empirically how negative policy rates transmit to the real economy.[4]

[3] 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.

[4] Recently, Demiralp, Eisenschmidt, and Vlassopoulos (2017) and Basten and Mariathasan (2018) study banks' reaction to negative policy rates in the euro area and in Switzerland, respectively. Arseneau (2017) examines a stress-testing survey in which U.S. banks are asked about the impact of hypothetical negative rates on their balance sheets. None of these studies use granular data on lenders and their borrowers (e.g., to control for loan demand).

Brunnermeier and Koby (2018) propose a theory of the "reversal rate" below which accommodative monetary policy becomes contractionary. Their theory, however, does not explicitly consider negative policy rates. Rognlie (2016) and Eggertsson, Juelsrud, and Wold (2017) present New Keynesian macroeconomic models to evaluate the impact of negative policy rates. In Rognlie (2016), there is no banking sector and negative rates are costly because they subsidize holding currency, which offers a zero nominal return. In Eggertsson, Juelsrud, and Wold (2017), banks finance themselves only with deposits, the rate of which cannot become negative. The lack of pass-through of a negative policy rate to lower, i.e., negative, deposit rates leads to a lack of pass-through to lower lending rates. Therefore, negative policy rates are not expansionary.

Second, to explain our findings, we augment the bank lending and bank risk-taking channels with the zero lower bound on deposit rates. We therefore contribute to an emerging literature on the role of deposit financing for bank behavior. Drechsler, Savov, and Schnabl (2017b) examine the ability of U.S. bank branches to raise deposit rates and attract deposits when the policy rate increases. An increase in the policy rate transmits more to market rates than to deposit rates. Deposits become less attractive as a store of value and hence, banks lose deposit funding. This loss of stable funding causes banks to reduce lending. Drechsler, Savov, and Schnabl (2017a) show that banks' maturity transformation does not expose banks to interest-rate risk. Market power allows banks to keep deposit rates stable, which is then matched with stable income from long-term assets.

Third, by considering policy-rate reductions into negative territory, we extend the literature on the bank lending channel, i.e., how policy-rate changes impact the supply of bank credit. This literature explores the role of bank size, holdings of liquid assets, and bank equity (Kashyap and Stein (2000); Kishan and Opiela (2000); Jiménez, Ongena, Peydró, and Saurina (2012)). Recently, Gomez, Landier, Sraer, and Thesmar (2016) examine the role of the interest-rate sensitivity of assets and liabilities, while Agarwal, Chomsisengphet, Mahoney, and Stroebel (2018) show how asymmetric information between banks and their borrowers modifies the response of bank lending to funding-cost shocks.

Fourth, we extend the understanding of the bank risk-taking channel (Jiménez, Ongena, Peydró, and Saurina (2014); Ioannidou, Ongena, and Peydró (2015); Dell'Ariccia, Laeven, and Suarez (2017); Paligorova and Santos (2017)) and link it to the literature on the bank lending channel. The bank behavior we characterize – lending less and to riskier firms in response to a negative shock to bank net worth – is in line with theoretical models in which lower bank net worth increases agency problems when screening and monitoring risky, opaque borrowers (e.g., Keeley (1990); Holmström and Tirole (1997); Hellmann, Murdock, and Stiglitz (2000); Dell'Ariccia, Laeven, and Marquez (2014)).[5]

Fifth, we contribute to the recent literature assessing the impact of non-standard monetary-policy measures, where existing work mainly focuses on the impact of asset-purchase programs and extraordinary liquidity provision. Chakraborty, Goldstein, and MacKinlay (2017), Darmouni and Rodnyansky (2017), Di Maggio, Kermani, and Palmer (2016), as well as Kandrac and Schlusche (2016) investigate the impact of quantitative easing in the United States. Crosignani and Carpinelli (2016) examine the ECB's three-year long-term refinancing operations, which provided liquidity to euro-area banks. Lastly, Ferrando, Popov, and Udell (2017) and Acharya, Eisert, Eufinger, and Hirsch (2017) analyze the ECB's outright monetary transactions program to buy (potentially unlimited) amounts of euro-area sovereign bonds.

3 Empirical Strategy and Data

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

[5] Angeloni, Faia, and Lo Duca (2015) offer a different take on the relationship between monetary policy and bank risk taking, and test it using aggregate time-series data when policy rates are positive. Lower policy rates induce banks to take (long-term) risk on their liability side by substituting cheaper but run-prone deposits for equity.

3.1 Institutional Background and Hypothesis Development

On June 5, 2014, the European Central Bank (ECB) Governing Council lowered the deposit facility (DF) rate to -0.10%. Shortly after, on September 4, 2014, the DF rate was lowered again to -0.20%. With these actions, the ECB ventured into negative territory for policy rates for the first time in its history.[6] The main goal of setting negative rates was to provide monetary-policy accommodation (Praet (2014)). The setting of negative rates in mid-2014 was seen as a bold and controversial move. Especially the cut in September came as a surprise. Since then, the ECB has lowered the DF rate two more times, on December 9, 2015, to -0.30%, and on March 6, 2016, to -0.40%.

Within Europe, euro-area 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 determines 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, at -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). We exploit these additional instances of negative policy rates as a robustness check.

Our explanation of how policy-rate changes transmit to the real economy via changes in the supply of bank credit is based on the standard external-finance premium for banks (see Bernanke and Gertler (1995) and Gertler and Kiyotaki (2010)). Raising external funds is costly for banks because of agency conflicts between outside investors and inside decision

[6] The DF rate is not the only policy rate of the ECB, but since the introduction of the "fixed-rate-full-allotment" regime in October 2008 after the Lehman bankruptcy, the DF rate is the relevant policy rate. For a review of how the ECB implements monetary policy before and after the financial crisis, see Garcia-de-Andoain, Heider, Hoerova, and Manganelli (2016).

makers (e.g., Holmström and Tirole (1997)). The size of the external-finance premium limits the amount of intermediation that banks can perform. The external-finance premium depends on the balance sheet of banks. In particular, a smaller difference between a bank's assets and liabilities, i.e., less net worth, increases the external-finance premium. When bank net worth is small, insiders have little "skin-in-the-game," agency conflicts are severe, and banks can perform little intermediation. Moreover, insiders with little "skin-in-the-game" have little incentives to carefully screen and monitor risky loans in order to preserve future rents from intermediation (Keeley (1990); Hellmann, Murdock, and Stiglitz (2000); Dell'Ariccia, Laeven, and Marquez (2014))).

Normally – i.e., when rates are positive – a lower policy rate increases the supply of bank credit because it reduces banks' external-finance premium. A lower policy rate transmits to lower rates on short-term liabilities. This reduces banks' cost of funding because they finance their long-term assets with short-term liabilities. A lower cost of funding increases bank net worth and, thus, leads to more "skin-in-the-game" for insiders who extend more credit and screen as well as monitor borrowers more carefully. This is a joint description of the bank balance-sheet channel of monetary-policy transmission (Boivin, Kiley, and Mishkin (2010)), which focuses on the volume of bank lending, and the bank risk-taking channel (Adrian and Shin (2010); Borio and Zhu (2012)), which focuses on the riskiness of bank lending.

Lowering the policy rate to below zero is special because it affects the cost of deposit funding and the cost of market-based short-term debt funding differently. The standard description of how monetary policy affects the supply of bank credit does not assign a special role to deposit funding. A lower policy rate is typically seen to transmit both to lower rates on market-based short-term debt and to lower deposit rates.[7]

While lowering the policy rate to below zero transmits to lower, negative market rates on short-term debt, it does not transmit to lower, negative deposit rates. Figure 1 shows

[7] For the transmission of central-bank policy rates to short-term market rates see, for example, Kuttner (2001). The transmission to deposit rates is less strong than for market rates on average, but the average decomposes into a strong transmission when the policy rate decreases (which is what we are interested in) and a weak transmission when the policy rate increases (Hannan and Berger (1991); Driscoll and Judson (2013)). Recently, Drechsler, Savov, and Schnabl (2017b) and Drechsler, Savov, and Schnabl (2017a) explore the role of market power for banks' willingness to change deposit rates.

the ECB's deposit facility (DF) rate together with a market rate of unsecured short-term debt (3-month Euribor) and the median rate of overnight deposits of euro-area banks. The vertical line indicates June 2014, which is when the ECB lowered the DF rate to below zero. The gray area indicates our baseline sample period from January 2013 to December 2015.

Prior to January 2013, increases and decreases in the DF rate transmit to increases and decreases in the 3-month Euribor and the median euro-area deposit rate. In our "pre-treatment period" from January 2013 to May 2014, the ECB keeps the DF rate stable and consequently, the 3-month Euribor and the median deposit rate are stable as well. After the lowering of the DF rate to below zero in June 2014, the paths of the 3-month Euribor and the median deposit rate diverge. While the 3-month Euribor decreases in line with the lower policy rate, the median deposit rate remains fairly stable.[8]

The differential transmission of negative policy rates to market rates of short-term debt and to deposit rates yields a break in the correlation between changes in the cost of deposit and non-deposit funding for banks around policy-rate changes. Figure 2 shows the median correlation between changes in the 3-month Euribor and changes in individual deposit rates for euro-area banks over a 12-month period after each policy-rate cut between 2011 and 2014. The correlation ranges from 0.14 to 0.18 when the ECB sets lower but still positive DF rates in November 2011, December 2011, and July 2012. The correlation drops to 0.01 for the cut to below zero in June 2014 (and remains extremely low at 0.035 after the reinforcement of negative policy rates in September 2014).

The negative policy rate does not transmit to lower deposit rates because banks appear reluctant to charge negative rates to their depositors. Figure 3 shows the distribution of individual banks' rates on household and non-financial-corporation deposits before and after June 2014. While there is a shift of the distribution to the left, indicating banks' attempt to lower their cost of deposit funding, the shift is limited by the truncation of the distribution at zero. Not a single bank charges negative deposit rates to households in December 2014

[8] The stability is also present in the rates on longer-term deposits with an agreed maturity below one year (available upon request). At the same time, loan rates have been falling since the end of 2011 (in our transaction-level data for syndicated loans originated by euro-area banks to both euro-area and non-euro-area borrowers, as well as for long-term loans in general (available upon request)).

(top panel). A few banks charge negative deposit rates to non-financial corporations (NFCs, bottom panel), which is a feature that we will exploit in our empirical analysis.

The main argument for why banks are reluctant to charge negative deposit rates is based on the zero nominal return on cash. If a bank charged a negative rate to its depositors, they would withdraw their deposits and hold cash as an alternative store of value and means of payment. This argument should apply more to household deposits than to corporate deposits. Households should find it easier to withdraw their deposits and hold cash than corporations, because they have fewer and much smaller deposit accounts. The evidence in Figure 3 that some banks are able to charge negative deposit rates to non-financial corporations is consistent with this logic. The absence of a hard zero lower bound on the market rate of short-term debt is also in line with this logic. Those who lend to a bank in money markets and trade short-term debt are other banks and financial institutions. Holding cash instead is not an option for them as it would incur large transaction and storage costs.[9]

The differential transmission of negative policy rates to market rates of short-term debt and to deposit rates exposes banks differently to negative policy rates depending on their liability structure. Relative to banks with little deposit funding, banks with a lot of deposit funding experience a lower reduction of their cost of funding and, thus, a negative shock to their net worth (holding everything else constant – an assumption that motivates our empirical strategy and its robustness throughout the analysis).

Banks with a lot of deposit funding indeed experience a negative shock to their net worth relative to banks with little deposit funding when the ECB sets a negative policy rate in June 2014. Figure 4 shows an (unweighted) stock price index for listed euro-area banks in the highest and the lowest tercile of the deposits-to-assets-ratio distribution. The stock prices of high-deposit and low-deposit banks move in tandem between January 2013 and May 2014, prior to the introduction of negative policy rates. But there is a disconnect since June 2014:

[9] This may no longer be true if a central bank were to set deeply negative rates.

high-deposit banks perform worse since the policy rate becomes negative. Within a couple of months they lose around 10% of stock market value.[10]

Given that high-deposit banks experience a lower reduction of their cost of funding when the policy rate becomes negative and, thus, experience a negative shock to their net worth, we expect this reduction of insiders' "skin-in-the-game" to lead to more risk taking and less lending (all relative to low-deposit banks).

In sum, our argument about the impact of negative policy rates on the supply of bank credit yields the following testable hypothesis:

Hypothesis: *Negative policy rates lead to greater risk taking and less lending by banks with more deposit funding.*

3.2 Identification Strategy

To test our hypothesis, we use a difference-in-differences strategy, which we implement by comparing the lending behavior of euro-area banks with different deposit ratios around the ECB's introduction of negative policy rates in June 2014.

Our baseline specification is:

$$y_{ijt} = \beta Deposit\ ratio_j \times After(06/2014)_t + \gamma X_{ijt} + \delta_t + \eta_j + \epsilon_{ijt}, \quad (1)$$

where y_{ijt} is an outcome variable reflecting, for instance, a firm/loan characteristic such as firm risk or loan terms associated with firm i's loan provided by bank j at time t. To directly infer percent changes, we often use the dependent variable in logs. $Deposit\ ratio_j$ is the deposits-to-assets ratio (in percent) of bank j in 2013. $After(06/2014)_t$ is a dummy variable for the period from June 2014 onwards, X_{ijt} denotes firm-level and bank-level control variables, and δ_t and η_j denote time and bank fixed effects, respectively.

[10] Ampudia and Van den Heuvel (2017) provide complementary evidence using an event-study methodology. In normal times, a decrease in the policy rate increases banks' stock prices irrespective of their deposits-to-assets ratio. When the policy rate becomes negative, a decrease in the policy rate decreases banks' stock prices, and more so for high-deposit banks.

To minimize the influence of confounding factors, we use a relatively short window around the June-2014 event, from January 2013 to December 2015, in our baseline. We examine the robustness of our results by varying the estimation window, e.g., by shortening the "post-treatment" period. We cluster standard errors at the bank level.

The key identifying assumption is that conditional on bank and time fixed effects, as well as potential control variables X_{ijt}, low-deposit banks provide the counterfactual for the lending behavior of high-deposit banks in the absence of a negative policy rate. In that case, the estimate of β in regression (1) gives the causal impact of the negative policy rate on the supply of bank credit via banks' cost of funding.

The main threat to the identifying assumption are time-varying differences across high-deposit and low-deposit banks. Such time-varying differences put the lending behavior of high-deposit and low-deposit banks on different trends, which cannot be differenced out.

We assess the robustness of our difference-in-differences strategy in several ways. First, we examine whether the deposits-to-assets ratio changes differently across high-deposit and low-deposit banks, either in response to or in anticipation of the negative policy rate. If it did, low-deposit banks could turn into high-deposit banks, and would therefore no longer provide the counterfactual for the lending behavior of high-deposit banks.

Next, we vary the set of control variables X_{ijt}, which essentially refines the comparison of our treatment group (high-deposit banks) and our control group (low-deposit banks). For instance, we include borrowers' country-time and borrowers' industry-time fixed effects. This controls for unobserved time-varying heterogeneity across banks caused by borrowers operating in different countries or industries. We also include those bank characteristics that, according to the previous literature, matter for the transmission of (non-negative) policy rates to the supply of bank credit.

In our most refined specification, we exploit the structure of syndicated loans, and explain the loan shares retained by high-deposit and low-deposit banks. This enables us to include firm-time fixed effects, so that we compare the lending of high-deposit and low-deposit

banks to the same firm. This addresses the concern that high-deposit and low-deposit banks potentially face different changes in the demand for bank credit over time.

We also modify our measure of banks' exposure to the setting of negative policy rates in order to limit the possibility that some confound affects the lending of high-deposit and low-deposit banks differently. Instead of the ratio of overall deposits to total assets, we consider household (HH) and non-financial-corporation (NFC) deposits over total assets, and estimate the following regression specification:

$$\begin{aligned} y_{ijt} &= \beta_1 HH\ deposit\ ratio_j \times After(06/2014)_t \\ &\quad + \beta_2 NFC\ deposit\ ratio_j \times After(06/2014)_t + \gamma X_{ijt} + \delta_t + \eta_j + \epsilon_{ijt}. \end{aligned} \tag{2}$$

According to the evidence shown in Figure 3, the zero lower bound is harder for household-deposit rates than for corporate-deposit rates. We therefore expect the effect of the policy-rate cut to negative to be concentrated in banks with relatively more household deposits. Regression (2) compares banks with a lot of household deposits to those with few household deposits (and, thus, a lot of corporate deposits) irrespective of the overall deposits-to-assets ratio.

Another concern is that there is nothing special about negative policy rates. Even though we lay out a mechanism through which they are special – because of the zero lower bound on deposit rates – we could be picking up a hitherto unknown role of deposits for the transmission of policy-rate cuts in general. To examine this possibility, we estimate the following regression:

$$\begin{aligned} y_{ijt} &= \beta_1 Deposit\ ratio_j \times After(06/2014)_t \\ &\quad + \beta_2 Deposit\ ratio_j \times After(07/2012)_t + \gamma X_{ijt} + \delta_t + \eta_j + \epsilon_{ijt}, \end{aligned} \tag{3}$$

where $After(07/2012)_t$ is a dummy variable for the period from July 2012 onwards.

In July 2012, the ECB cut the DF rate from 0.25% to zero.[11] If negative rates are special, then we expect the estimate of β_2 to be insignificant and the estimate of β_1 to be similar to the estimate of β from the baseline. If, however, there was nothing special about negative policy rates, then the estimate of β_2 (as well as of β_1) should be picking up a general role of deposits for the effect of policy-rate cuts on the supply of bank credit.

This is also a useful placebo test in the following sense. Suppose it is not the difference in the deposits-to-assets ratio across banks that drives lending behavior but the difference in some other bank characteristic. If that other characteristic exposes banks differently to policy-rate cuts in general, then one should observe a significant estimate of β_2.

To extend our test of whether negative policy rates are special, we estimate the following generalization of (3):

$$\begin{aligned} y_{ijt} \;=\; & \beta_1 \textit{Deposit ratio}_{j,t-1} \times \textit{DF rate}_t \times After(06/2014)_t \\ & + \beta_2 \textit{Deposit ratio}_{j,t-1} \times \textit{DF rate}_t + \beta_3 \textit{Deposit ratio}_{j,t-1} \times After(06/2014)_t \\ & + \beta_4 \textit{Deposit ratio}_{j,t-1} + \delta_t + \eta_j + \epsilon_{ijt}, \end{aligned} \tag{4}$$

where $\textit{Deposit ratio}_{j,t-1}$ is the deposits-to-assets ratio (in percent) of bank j in year $t-1$, and $\textit{DF rate}_t$ is the ECB's deposit facility rate at the monthly level.

Regression (4) allows us to examine changes in the policy rate more generally, independent of their size, timing, or whether they are cuts or increases.[12] The coefficient of interest in equation (4) is on the triple interaction of banks' deposit ratio, the ECB's DF rate, and the dummy for the period of negative policy rates since June 2014. The estimate of β_1 shows whether the transmission of negative policy rates via deposits is different from the transmission of positive policy rates, which is captured by β_2. Moreover, an insignificant

[11] We choose the DF rate cut in July 2012 because it is the last cut prior to going negative. The rate reductions in early 2009 and late 2011 are somewhat unusual because they occurred at the height of the financial crisis and the sovereign debt crisis. We include them when we estimate equation (4) below. To estimate (3), we extend our sample to the period from January 2011 to December 2015.

[12] To estimate (4), we extend our sample to the time period from January 2009 to December 2015, during which the ECB's $\textit{DF rate}_t$ varies from +1% to -0.30%.

estimate of β_2 indicates that the deposits-to-assets ratio does not affect the transmission of policy rates to the supply of bank credit in normal times.

Finally, we exploit geographic variation. We limit our sample to non-euro-area borrowers in order to (at least partially) filter out any effect of negative policy rates on the demand for bank credit. We also show that only the average deposit ratio of euro-area lead arrangers, but not that of non-euro-area ones, matters. In the Online Appendix, we also report the results of a staggered difference-in-differences estimation that includes the instances of negative rates in Denmark, Sweden, and Switzerland.

3.3 Data Description and Empirical Implementation

To link borrowers and lenders, and obtain loan-level information, we use data on the issuance of syndicated loans from DealScan. We match the DealScan data with Bureau van Dijk's Amadeus data on European firms and with SNL Financial's data on European banks.

In the syndicated-loan market, different banks form a syndicate, which then lends to firms. In the syndicate, there are lead arrangers, which organize the loan making (including monitoring and screening responsibilities) and typically hold on to their loan share throughout its life, and other syndicate members, which often sell their shares in the secondary market (for more information about the institutional details of the syndicated-loan market, see, for example, Ivashina (2009) and Berg, Saunders, and Steffen (2016)).[13]

The set of euro-area lead arrangers serves as the basis for the deposits-to-assets-ratio measure in our regressions. Hence, $\textit{Deposit ratio}_j$ is the average ratio (in percent) of deposits over total assets across all euro-area lead arrangers j in the syndicate of the loan to firm i made at time t.[14]

[13] In the subset of so-called leveraged loans, even the lead arrangers may sell their shares. All results in our paper are robust to dropping leveraged loans, where we follow the definition of leveraged loans in Bruche, Malherbe, and Meisenzahl (2017).

[14] Accordingly, the bank fixed effect η_j is actually a set of bank fixed effects containing one fixed effect for each lead arranger in the syndicate that lends to firm i at time t.

In the top panel of Table 1, we present summary statistics for our baseline sample of syndicated loans with any euro-area lead arrangers from January 2013 to December 2015. An interesting feature of European syndicated loans is their relatively long maturity, five years on average, and that all loans in our sample are floating-rate loans. Roughly half of the loans in our sample actually have a unique lead arranger, and the average number of lead arrangers is 3.6. The bottom panel of Table 1 presents separate bank-level summary statistics for all euro-area banks in our baseline sample (for a list of banks and their 2013 deposit ratios, see Table B.1).[15]

Table 2 examines 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%). However, as argued above, permanent differences between high-deposit and low-deposit banks do not matter in our empirical setup.

Time-varying differences across banks with different deposit ratios during our sample period could matter. Although we conduct a number of formal robustness tests to address this concern (e.g., checking for parallel trends, estimating equations (2) and (3)), it is useful to examine raw bank characteristics of high-deposit and low-deposit banks over time. Banks' equity and securities ratios, both potentially important determinants of how banks adjust their lending behavior to changes in the policy rate (e.g., Kashyap and Stein (2000)), move roughly in parallel since 2011, well before the start of our sample period in 2013 (Figures A.1a and A.1b).

Reassuringly, a bank's deposits-to-assets ratio, our treatment-intensity variable, is fairly stable across high-deposit and low-deposit banks over time (Figure A.1c). There is a slight

[15] The loan-level deposit ratio in the upper panel of Table 1 is different from the bank-level deposit ratio in the bottom panel because the former is calculated as an average across lead arrangers in the same syndicate.

overall trend of higher deposit ratios, and this trend appears slightly larger for the banks in the top tercile of the deposit-ratio distribution. However, the increase in the deposit ratio of that group of banks occurs in 2013, i.e., prior to our measurement of the deposit ratio at the end of 2013. Since then, there are no time-varying differences in the deposit ratio across high-deposit and low-deposit banks. We also fail to find any time-varying differences in deposit ratios across high-deposit and low-deposit banks more formally when we estimate specification (1) at the bank level with deposit growth as the dependent variable over the period from 2011 to 2015.[16]

The absence of such time-varying differences in the deposit ratio is intuitive. Given the uncertainty around the controversial and surprising move by the ECB to lower the DF rate to -0.20% in 2014, banks presumably do not make costly adjustments to the structure of their liabilities well before the actual decision on the policy rate. And while the argument in Drechsler, Savov, and Schnabl (2017b) suggests that banks could in principle see an inflow of deposits after 2014, the argument does not suggest a different inflow across high-deposit and low-deposit banks.

Another concern may be that instead of charging negative deposit rates, high-deposit banks charge higher fees than low-deposit banks, thereby "undoing" the (relative) negative shock to their net worth. Figure A.1d indicates that this is not the case. The fee income of high-deposit and low-deposit banks move in parallel before 2014. Since 2014, if anything, it is the low-deposit banks that start charging higher fees.

In the bottom panel of Table 2, we provide further summary statistics on the syndicated loans in which high-deposit and low-deposit banks participate. On average, low-deposit banks are lead arrangers of 151 syndicated loans during our sample period, whereas high-deposit banks are lead arrangers of 71 syndicated loans (this difference is not statistically significant). Both types of banks are equally likely to serve as lead arrangers for the loans included in our sample. Furthermore, neither the average loan size nor the average loan

[16] These untabulated results are available upon request.

share retained by high- and low-deposit banks (in any capacity, i.e., as lead arrangers or participants) are significantly different.

4 Results

We present our results in four 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 euro-area banks, and on the volume of bank lending. We then examine the robustness of our results. Thereafter, we further characterize the changes in the supply of bank credit in order to assess the underlying mechanism. Finally, we evaluate the external validity of our results.

4.1 Effect of Negative Policy Rates on Bank Risk Taking and Bank Lending

In the first four columns of Table 3, we present the results from estimating equation (1) when the dependent variable y_{ijt} is a measure of banks' ex-ante risk taking. Our baseline measure of ex-ante risk taking is $\sigma(ROA_i)^{5y}$, the five-year standard deviation of loan-financed firm i's return on assets (ROA, using profit & loss before tax) from year $t-5$ to $t-1$.

The first column shows the basic difference-in-differences specification with bank and month-year fixed effects only. We find a positive and significant treatment effect. Banks with more deposits finance riskier firms when rates become negative. In terms of economic significance, a one-standard-deviation increase in $Deposit\ ratio_j$ ($= 9.45$ percentage points) translates into a 16% increase in ROA volatility ($9.45 \times 0.017 = 0.161$).

Figure 5 gives a graphical, non-parametric representation of our baseline result. In the period leading up to the introduction of negative policy rates, risk taking by both high-deposit banks and low-deposit banks move in parallel.[17] It decreases, with high-deposit

[17] We plot the four-month average of ROA volatility to ensure that we have enough observations for the calculation of the mean.

banks lending to 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 columns 2 to 4 of Table 3, we progressively add fixed effects to control for borrower characteristics. By removing unobserved time-varying country and industry factors of borrowers, we increase the difference-in-differences estimate from 0.017 to 0.020.

In column 5, we show the results from estimating equation (3), which tests whether the transmission of the negative rate cut via deposits is special. We apply the same difference-in-differences approach also to the rate cut in July 2012, when the ECB lowers the DF rate from 0.25% to zero. The estimate of β_2, the coefficient on the interaction *Deposit ratio*$_j \times After(07/2012)_t$, is insignificant, while the estimate of β_1, the coefficient on the interaction *Deposit ratio*$_j \times After(06/2014)_t$, is unchanged. Different deposit ratios expose banks differently to lower, negative rates but not to lower, non-negative rates.

In column 6 of Table 3, we reduce the sample to European borrowers outside the euro area.[18] The loan demand of these non-euro-area firms should be less affected by economic conditions and policies in the euro area. The coefficient on our treatment *Deposit ratio*$_j \times After(06/2014)_t$ is stronger, while the coefficient on *Deposit ratio*$_j \times After(07/2012)_t$ remains insignificant. This suggests that our main result is unlikely to be driven by monetary policy reacting to the economic condition of firms or by monetary policy affecting loan demand.

In column 7, we perform a falsification test using non-euro-area lenders to non-euro-area borrowers.[19] As non-euro-area lenders are not directly affected by euro-area monetary policy, we expect to find no effect of setting negative policy rates on the risk taking of those banks.

[18] The majority of these firms (70%) are UK firms.

[19] Non-euro-area borrowers are likely to contract with non-euro-area lead arrangers, even if the latter join forces with euro-area lead arrangers in the syndication process. This enables us to re-run the specification from column 6 by adding non-euro-area lead arrangers. The respective sample in column 7 has overlap with the syndicated loans in column 6, but additionally comprises loans with only non-euro-area lead arrangers. We re-define *Deposit ratio*$_j$ as the average deposit ratio of all non-euro-area lead arrangers in these syndicates.

In line with this reasoning, the coefficient on the treatment $Deposit\ ratio_j \times After(06/2014)_t$ is insignificant.

Our logic about the impact of negative policy rates on the net worth of banks yields not only implications about bank risk taking but also about the volume of lending. Table 4 confirms that the volume of new lending of high-deposit banks relative to low-deposit banks decreases after the introduction of negative policy rates.

In the first column of Table 4, we move the estimation of equation (1) to the bank-month-year level, using the log of the total volume of newly issued syndicated loans as the dependent variable. In the second column, we replace the bank fixed effects with the actual deposit ratio for robustness. In the third column, we estimate equation (3). The estimate of the coefficient on $Deposit\ ratio_j \times After(06/2014)_t$ is negative and significant (at the 5% level in columns 2 and 3, and at the 10% level in column 1) across all specifications. Taking the estimate from the third column, a one-standard-deviation increase in a bank's deposit ratio (= 14.76 percentage points in this particular sample) leads to an economically relevant reduction in lending of 13% ($14.76 \times 0.009 = 0.133$).[20] In contrast, the estimate of the coefficient on the placebo treatment $Deposit\ ratio_j \times After(07/2012)_t$ is insignificant.

We also conduct a falsification test, and re-run the regression from column 3 for all non-euro-area lead arrangers. As can be seen in the last column, we find no effect, as should be the case for non-euro-area banks that are not directly affected by the ECB's policy rates.

Table 5 shows the results of estimating equation (4). In columns 1 and 2, we consider bank risk taking at the transaction level as in Table 3. In columns 3 and 4, we move to the bank-month-year level, and consider the volume of bank lending as in Table 4.

The coefficient on $Deposit\ ratio_{j,t-1} \times DF\ rate_t$ is never significant and close to zero. Banks with different extent of deposit funding do not respond differently to policy-rate changes when the policy rate is not negative. This is different when the policy rate becomes negative, as indicated by the significant coefficient on $Deposit\ ratio_{j,t-1} \times DF\ rate_t \times After(06/2014)_t$.

[20] The effect is also visible in the raw data when plotting lending by high- and low-deposit banks over time in Figure A.2.

Only lower rates that are negative lead to more risk taking (columns 1 and 2) and less lending (columns 3 and 4).

4.2 Robustness

In this section, we provide several robustness checks for our results on both bank risk taking and the volume of bank lending. We start with risk taking in Table 6. In the first column, we exclude those banks with the lowest deposit ratios from the definition of *Deposit ratio*$_j$. These are government entities and one insurance company, which may behave differently than banks. The difference-in-differences estimate is unchanged.[21]

Next, we ensure that our findings are robust to alternative definitions of our treatment-intensity variable. In the second column of Table 6, our difference-in-differences estimate is robust to using the ratio of deposits over total liabilities (rather than assets). This indicates that our results do reflect the different funding structure of banks, and are not driven by variation in bank size. In Table B.2 of the Online Appendix, we re-run the first five (main) specifications from Table 3, but replace our treatment-intensity variable *Deposit ratio*$_j$ with the average deposit ratio across all euro-area lead arrangers from 2011 to 2013 (rather than in 2013). Again, our results do not change when using this well pre-determined measure of a bank's deposit ratio.

One possible concern is that the introduction of negative policy rates in June 2014 coincides with other events that might affect the risk taking of banks. As long as other coincidental events affect high-deposit and low-deposit banks in the same way, these other concurrent policy measures are differenced out. However, if they affect high-deposit and low-deposit banks differently, then our results could be biased.

For example, the ECB started its public sector purchase program (PSPP) on March 9, 2015. From this date onwards, the ECB expanded its existing, rather limited, asset-purchase programs (of covered bonds and asset-backed securities) to include public-sector

[21] Five syndicated loans have only the excluded institutions as lead arrangers, and are subsequently dropped from the sample.

bonds (for a total monthly amount of initially €60bn). Although it is not clear why the PSPP would impact risk taking differently according to the deposit ratio of banks, we address this potential confound by shortening our sample period and setting its end to February 2015. Table B.3 in the Online Appendix shows that our results are robust to excluding months with large-scale asset purchases by the ECB.[22]

Other possible candidates for confounding, coincidental events are the introduction of the Basel III liquidity coverage ratio (LCR) and the ECB's first series of targeted longer-term refinancing operations (TLTROs). The LCR requires banks to hold a buffer of liquid assets against net short-term outflows under stress, which could plausibly affect high-deposit and low-deposit banks differently (although it would hurt low-deposit banks more as non-deposit funding requires a higher buffer). The timing of the LCR, however, does not fully coincide with the negative policy rate because it was introduced on January 1, 2015, with a four-year roll-out period.

The first series of TLTROs, in which the ECB lends long term and at a discount to banks that provide credit to firms, was announced in June 2014 and subsequently executed in two separate stages in September and December 2014. As with the PSPP, it is not clear ex ante why the TLTRO take-up would differ according to the deposit ratio of banks. Additionally, the take-up was below expectations and mainly used to substitute liquidity from other ECB operations.[23] As a result, it seems implausible that TLTROs are driving our findings.

To rule out such confounds more formally, we estimate equation (2), using confidential data from the Single Supervisory Mechanism (SSM). In columns 3 and 4 of Table 6, we compare banks with different exposure to negative rates according to whether their deposits are held by households or by non-financial corporations. Because of the harder zero lower bound on household deposits, we expect a stronger effect for banks with more household

[22] This robustness check also excludes the ECB's cut of the DF rate to -0.30%, which occurs in the last month of our baseline sample period in December 2015.

[23] Only €212.4bn was allotted during the September-2014 and December-2014 TLTROs, which amounts to roughly half of the available funding. About one-third of this amount was used to substitute existing liquidity from other ECB operations, leading to a net take-up of €143bn in these two months. Additionally, the December-2011 and February-2012 three-year LTROs both matured in January and February 2015, potentially leading to even larger substitution effects.

deposits than for banks with more corporate deposits. In contrast, neither the PSPP, the LCR, nor the TLTROs should affect household and corporate deposits differently.[24] More generally, any coincidental confound would now have to affect banks differently according to the type of deposits, and no longer according to their level.

In column 3 of Table 6, we limit the sample to syndicated loans with any one of the 43 euro-area lead arrangers for which we have the supervisory data to decompose lead-arranger deposits, while in column 4 we consider only syndicates in which all lead arrangers come from this group of 43 banks. As hypothesized, the difference-in-differences estimate is much more precisely estimated, and also larger in size, for banks that rely more on household deposits.

In columns 5 and 6 of Table 6, we control for banks' size, their equity ratio, and their securities ratio. The previous literature identifies these balance-sheet characteristics as important for the transmission of monetary policy. In this manner, we compare high-deposit and low-deposit banks, holding constant these other balance-sheet characteristics. Column 5 shows the results from estimating our baseline equation (1), while column 6 shows the results from estimating equation (3). Adding these control variables leaves the difference-in-differences estimate virtually unchanged.

In column 7, we furthermore interact banks' size, equity ratio, and securities ratio (in 2013) with $After(06/2014)_t$. Only the coefficient on the interaction effect with $Deposit\ ratio_j$ is significant. Thus, higher risk taking cannot be explained by different responses of banks with different size, equity, or securities ratios to negative policy rates.

We also ensure that our results are not driven by how we measure the ex-ante risk of borrowers. As an alternative to ROA volatility, we use a firm's interest rate (all-in-drawn spread) on previous syndicated loans, i.e., those prior to our sample period (Table B.4 in the Online Appendix). For the subsample of public firms, we use firms' stock-return volatility, derived from monthly stock returns (Table B.5 in the Online Appendix). In addition, lenders may care more about the risk of their debt claim rather than the risk of the overall firm. To

[24] For example, the LCR regulation does not attribute different run-off charges to retail and wholesale deposits (BIS (2013)).

examine this possibility, we multiply the standard deviation of the return on assets of the borrowing firm with its leverage in year $t-1$ (Table B.6 of the Online Appendix). None of these alternative risk measures change our main finding.

Finally, we modify our sample to add the introduction of negative rates in Denmark, Sweden, and Switzerland.[25] The extra, staggered number of treatments makes it less likely that, despite our numerous robustness tests, there may still be some omitted factor in June 2014 that drives the risk taking of high-deposit banks. Again, high-deposit banks finance riskier firms when policy rates become negative (Table B.7 in the Online Appendix).

Next, we discuss the robustness of our results on the volume of bank lending in Table 7. In doing so, we re-run as many of the tests from Table 6 as possible, while accounting for the reduced number of observations when aggregating loans at the bank-time level.

Our finding that high-deposit banks lend less than low-deposit banks after negative policy rates is robust to excluding financial institutions with very low deposit ratios (column 1), and to replacing the deposits-to-assets ratio with the deposits-to-liabilities ratio (column 2).

In column 3, we estimate equation (2). Our difference-in-differences estimate is more than six times larger (in absolute terms) for banks relying on household deposits, on which they are more reluctant to charge negative rates, albeit significant only at the 19% level.

In column 4, we add the controls for bank balance-sheet characteristics, and in column 5 we also add the placebo treatment in July 2012 (equation (3)). Doing so leaves our difference-in-differences estimate unaltered, while the coefficient on the placebo treatment remains insignificant.

In Table 8, we move our analysis to the loan-bank level to include firm-time fixed effects. By comparing the lending behavior of high-deposit and low-deposit banks to the same borrower, we address the concern that changes in firms' demand for credit over time may bias our results on bank lending and bank risk taking.

[25] When we include Danish, Swedish, and Swiss lenders, we limit the sample to loans with any mutually exclusive euro-area, Danish, Swedish, or Swiss lead arrangers, as Sweden and Switzerland introduced negative policy rates, and Denmark re-introduced them, only after the euro area did.

For each syndicated loan, we now have multiple observations that record each (participating or lead) bank's loan share. The dependent variable now is the share of a syndicated loan retained by a bank. We also add bank-firm fixed effects to compare the lending of the same banks to the same firm before and after June 2014, as well as banks' country-time fixed effects to control for time-varying differences across banks driven by factors at the level of their home countries.[26]

In the first column of Table 8, we estimate this within-borrower specification of our baseline equation (1), and find a negative and significant difference-in-differences estimate. High-deposit banks not only reduce the total volume of syndicated loans they grant once the policy rate becomes negative (Table 4), but they also reduce their share in syndicated loans to the same firm. In column 2, we re-estimate equation (3). As before, the difference-in-differences estimate is unchanged, and the coefficient on the placebo is insignificant.

In columns 3 to 6 of Table 8, we use the within-borrower specification to test the robustness of our results on bank risk taking. To do this, we sort borrowers into the bottom and top halves according to their ROA volatility (our baseline measure of ex-ante risk) in columns 3 and 4. Within safe borrowers, high-deposit banks reduce their loan shares (column 3), while within risky borrowers, they increase their loan shares (column 4). In columns 5 and 6, we instead use firms' loan spreads on previous syndicated loans (prior to our sample period) to measure ex-ante risk.[27] Again, we find that high-deposit banks reduce their loan share within safe borrowers with low previous loan spreads (column 5). Within borrowers with higher previous loan spreads, their loan share does not change significantly (column 6).

Overall, these results using loan shares confirm our previous finding on bank lending and bank risk taking: the average riskiness in the loan portfolio of high-deposit banks increases when the policy rate becomes negative.

[26] Note that the banks lending to the same firm are not necessarily part of the same syndicate, nor are they all lead arrangers now.

[27] This is the same measure of risk as in Table B.4 of the Online Appendix. Using this measure allows us to increase the sample size considerably, which is practical in this setting because DealScan has only imperfect coverage of the loan shares in a syndicate.

4.3 Characterizing the Nature of Bank Lending

We now characterize the nature of bank lending by examining loan terms, the role of bank capitalization, and the characteristics of firms financed by high-deposit vs. low-deposit banks after the introduction of negative policy rates.

High-deposit banks lend less and to riskier borrowers once the policy rate becomes negative. We explain this risk taking with lower net worth giving less "skin-in-the-game" and, thus, giving less incentives to screen and monitor risky borrowers. An alternative explanation is that high-deposit banks engage in a "search-for-yield" (see Rajan (2005)).[28]

We propose to distinguish between risk taking and search-for-yield by examining loan rates in Table 9. If the lending behavior of high-deposit banks leads to higher loan rates, then this would indeed suggest a search-for-yield. If instead high-deposit banks do not charge higher loan rates, then this is in line with risk taking.

The five columns of Table 9 replicate the specifications in the first five columns of Table 3, now with the all-in-drawn spread as the dependent variable y_{ijt}. There is no significant difference in the average spread of loans from high-deposit and low-deposit banks when the policy rate becomes negative, even though high-deposit banks lend to riskier borrowers (Table 3). This also holds when including relevant loan fees as in Berg, Saunders, and Steffen (2016) (see Table B.8 in the Online Appendix).

In Table B.9 of the Online Appendix, we investigate the impact of negative policy rates on other loan terms. The loans of high-deposit banks do not have more collateral, a larger lead share (a measure of monitoring incentives, see Ivashina (2009)), more financial covenants, or a shorter loan maturity relative to the loans of low-deposit banks once the policy rate becomes negative. The failure to adjust these other loan terms at origination is in line with a

[28] Dell'Ariccia, Laeven, and Marquez (2014) and Dell'Ariccia, Laeven, and Suarez (2017) argue that risk taking is more likely when a financial institution has long-term assets and short-term liabilities, like a bank. In contrast, they argue that a search-for-yield is more likely when it has short-term assets and long-term/fixed liabilities, like an insurance company or a money market fund. For evidence of search-for-yield by money market funds, see Kacperczyk and Di Maggio (2017).

larger incentive problem for high-deposit banks. They do not adjust loan terms to counteract a potentially higher probability of loan default of riskier borrowers.

In Table 10, we examine the size of loans granted by high-deposit vs. low-deposit banks after the introduction of negative policy rates. On average, high-deposit banks do not grant larger loans than low-deposit banks (columns 1 to 4). But they do grant larger loans to riskier borrowers, as shown by the positive and significant coefficient on the interaction term of the treatment, $Deposit\ ratio_j \times After(06/2014)_t$, and our baseline measure of firm risk, $\sigma(ROA_i)^{5y}$, in column 5. This result, which mirrors our previous results on loan shares (Table 8), supports our argument that negative rates should affect both the risk and the volume of bank lending.

Next, we examine the role of bank capitalization for risk taking. With less capital, a bank's agency problem is worse, and it has less incentives to refrain from risk taking once its net worth is hit by a negative shock.

In the first two columns of Table 11, we re-run our baseline specification from column 4 in Table 3 on two subsamples: banks in the bottom and the top tercile of the distribution according to their equity-to-assets ratio. The difference-in-differences estimate is positive and significant only for the group of poorly-capitalized banks in column 1. This is also the case when we add the placebo treatment in the last two columns.

In Table 12, we examine the impact of negative rates on banks' loan portfolio in more detail by investigating other borrower characteristics. In the first two columns, we partition the sample into privately held and publicly listed firms, and re-run our baseline analysis from Table 3. The risk taking of high-deposit banks is significant only for private firms. Private firms are typically seen as more credit constrained and, thus, more exposed to variation in the supply of bank credit than public firms that have access to other sources of financing.

In the next three columns of Table 12, we provide evidence that the risk taking of high-deposit banks does not lead to "zombie" lending, i.e., lending to firms with low profitability or those that are already heavily indebted.

The dependent variable in column 3 is the borrower's return on assets, measured in the year before receiving the loan. The difference-in-differences estimate is insignificant. The firms receiving loans from high-deposit banks have the same profitability as firms receiving loans from low-deposit banks after June 2014. In column 4, the dependent variable is the leverage (debt-to-assets ratio) of borrowers. The difference-in-differences estimate is negative and significant. High-deposit banks lend more to low-leverage firms than do low-deposit banks once the policy rate becomes negative.

The risk taking of high-deposit banks is stronger if they know more about the borrower, which also sheds a more positive light on their risk taking. In column 5 of Table 12, we interact the treatment $Deposit\ ratio_j \times After(06/2014)_t$ with an indicator variable $Exposure_{ij}$ that is one if lead arrangers have significant prior lending activity in the borrower's SIC2 industry. The positive and significant coefficient on the triple interaction shows that the treatment effect is 1.58 ($= 0.019/0.012$) times stronger for banks with prior exposure to the borrower's industry.

4.4 External Validity

So far, we have characterized banks' lending behavior under negative policy rates using syndicated loans, which allows us to link borrowers and lenders as well as to analyze individual loan terms. However, syndicated lending represents only a fraction of banks' total lending. In our sample, outstanding syndicated loans on average make up at least 9% of a bank's total loan portfolio.[29]

We examine the external validity of our results on bank risk taking using the market's view of overall bank behavior. In columns 1 and 2 of Table 13, we estimate our baseline specification (1) as well as specification (3) using the log of the (unlevered) monthly standard

[29] We compute the share of outstanding syndicated loans to total loans by comparing syndicated loans in DealScan to loans in annual SNL balance-sheet data. We take into account the maturity structure of syndicated loans to derive the total amount of outstanding syndicated loans each year. Our estimate 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)).

deviation of daily bank stock returns as the dependent variable. In columns 3 and 4, we repeat this exercise with banks' credit-default swap (CDS) returns. Both market-based risk measures confirm that high-deposit banks become riskier (relative to low-deposit banks) after lower, negative policy rates in June 2014 but not after lower, positive rates in July 2012.

To examine the external validity with respect to the volume of lending, we are forced to fall back on annual SNL balance-sheet data, which is not plentiful enough for a regression analysis. In Figure 6, we inspect these data on total bank lending, and build an annual lending index (December 2013 = 100) for the top, middle, and bottom terciles of banks in the deposit-ratio distribution (in 2013).

High-deposit banks generally lend less than other banks, and this lending gap increases further in 2014, when the policy rate is reduced to negative. This confirms our negative difference-in-differences estimate for the volume of lending in the syndicated-loan market. While total lending increases in 2014 and 2015 for all groups, the recovery is markedly slower for high-deposit banks (solid line). Negative rates are less accommodative for high-deposit banks.

5 Conclusion

When central banks charge negative policy rates, they enter unchartered territory. We identify negative policy rates to lead to less lending and more risk taking by high-deposit banks, as compared to low-deposit banks, in the market for syndicated loans. We explain how the conventional view of monetary-policy transmission through bank net worth and the associated external-financial premium, when augmented with banks' reluctance to charge negative rates on deposits, can explain the transmission of negative policy rates.

Our results suggest potential costs of negative policy rates in terms of limited stimulus and financial instability. Normally, one views high-deposit banks as traditional intermediaries providing most of the lending and being most stable. Negative policy rates have the potential to change the role of these banks for the supply of credit to the real economy.

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6 Figures

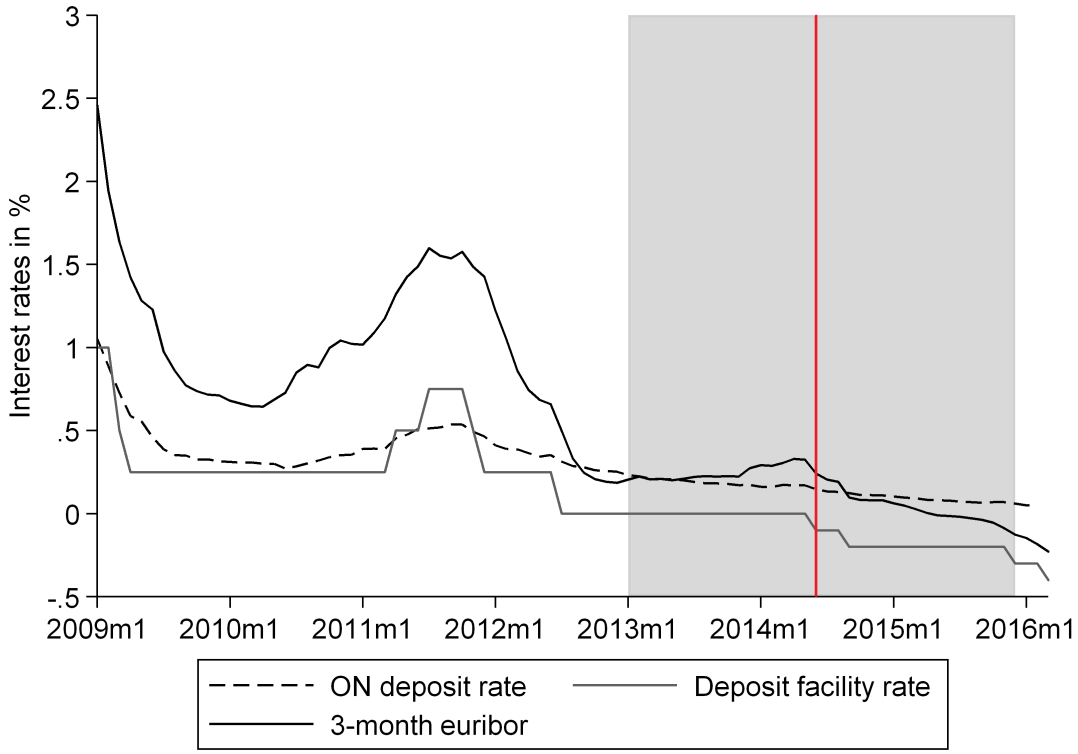


Figure 1: **The Deposit Facility Rate, the 3-month Euribor, and the Overnight Deposit Rate.** This figure shows the evolution of the median overnight deposit rate at euro-area banks between January 2009 and March 2016, in comparison to the 3-month Euro Interbank Offered Rate (Euribor) and the deposit facility (DF) rate. The Euribor and the DF rate are taken from the ECB Statistical Data Warehouse. Deposit rates are taken from the ECB IMIR database, which provides monthly interest-rate data for euro-area banks at the monetary financial institution (MFI) level. The monthly overnight deposit rate is calculated in two steps. We first calculate the average overnight deposit rate at the MFI level using the overnight rate on household deposits and the overnight rate on non-financial-corporation deposits. We then take the median rate over all MFIs for each month. The gray area indicates the sample period for our main analysis (January 2013 to December 2015). The red line is drawn at June 2014.

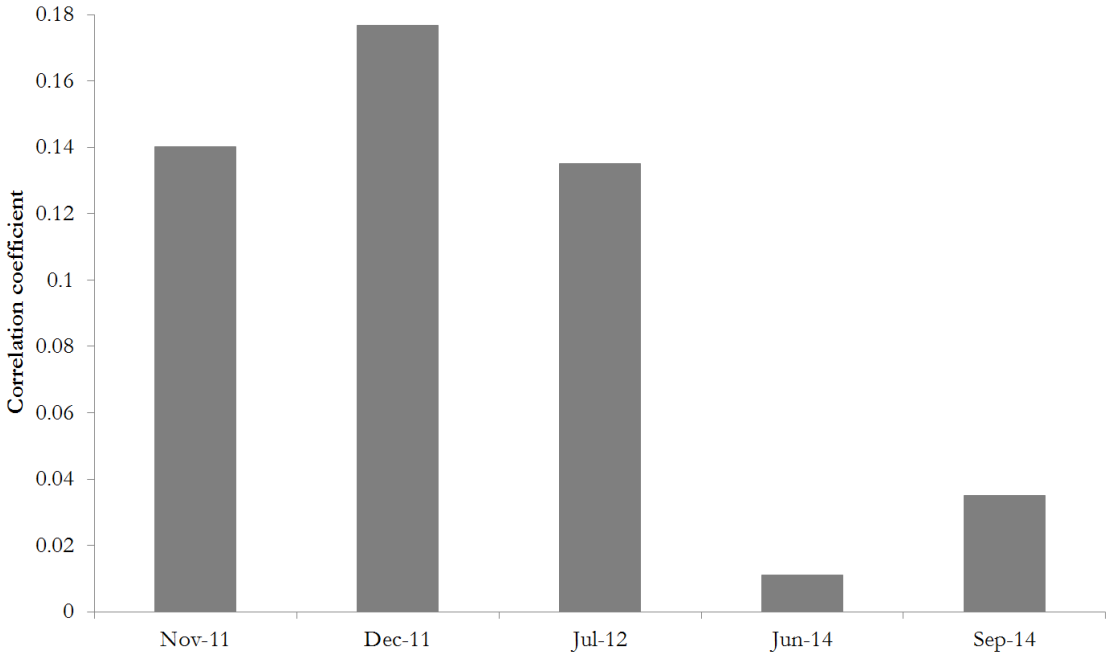
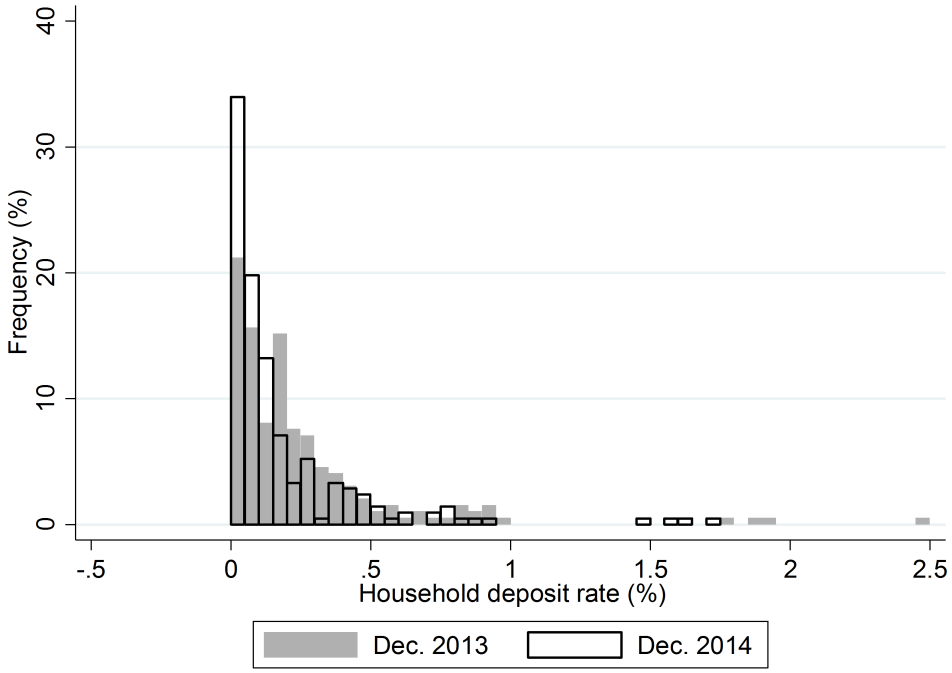
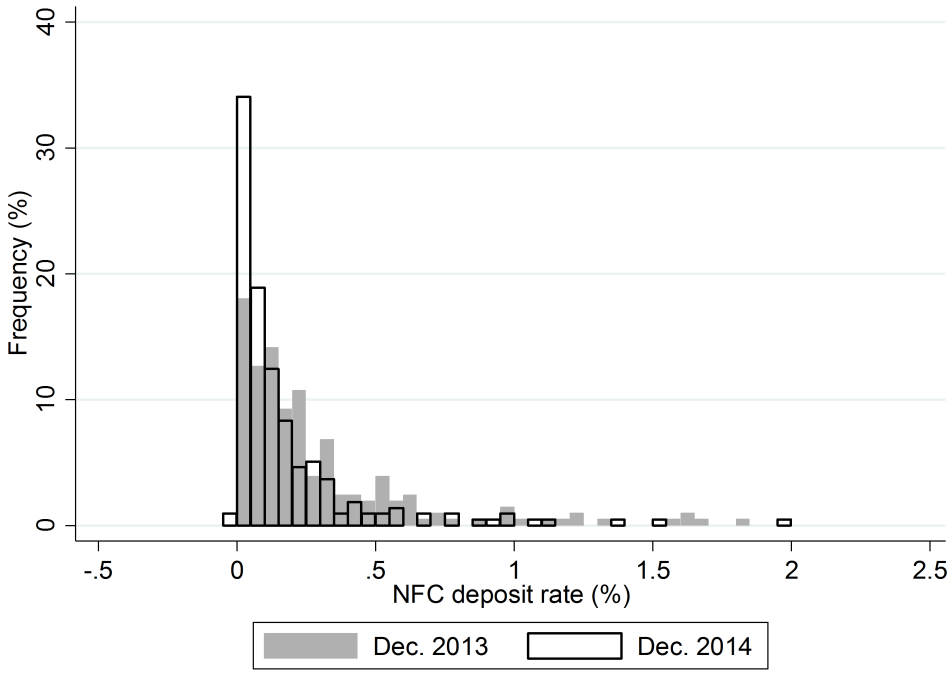


Figure 2: **Correlation between Deposit-rate Changes and Euribor Changes.** This figure shows the median correlation between changes in the 3-month Euribor and changes in individual deposit rates for euro-area banks over twelve months after each policy-rate cut between 2011 and 2014. Deposit rates are taken from the ECB IMIR database, which provides monthly interest-rate data for euro-area banks at the monetary financial institution (MFI) level. The 3-month Euribor rate is taken from the ECB Statistical Data Warehouse.



(a) Household deposit rates



(b) NFC deposit rates

Figure 3: **Distribution of Deposit Rates (Households and Non-financial Corporations).** This figure shows the distribution of overnight deposit rates for households (in the top panel) and non-financial corporations (in the bottom panel) in December 2013 (gray bars) and December 2014 (white bars). The data are taken from the ECB IMIR database, which provides monthly interest-rate data for euro-area banks at the monetary financial institution (MFI) level.

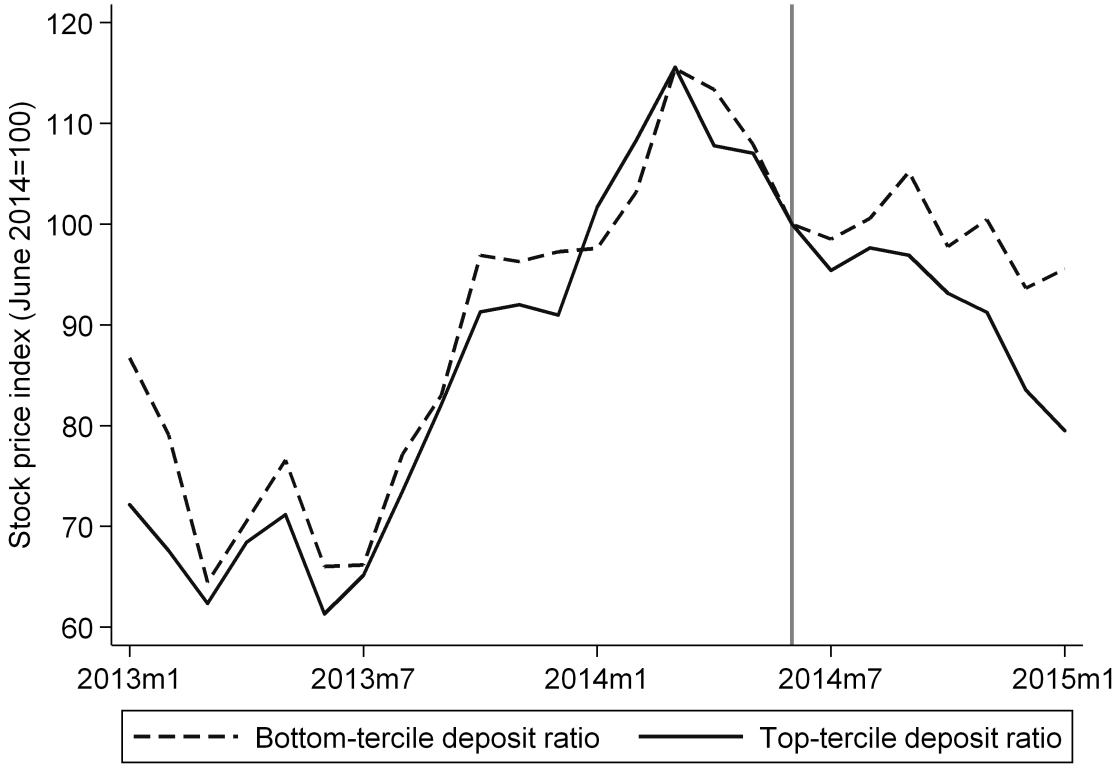


Figure 4: **Stock Price Index of Listed Banks with High vs. Low Deposit Ratios.** This figure shows the evolution of a monthly stock price index (June 2014 = 100) for listed euro-area banks in our sample between January 2013 and February 2015. We calculate a price index for each bank, and plot the median index for banks in the top (solid line) and bottom tercile (dashed line) of the deposit-ratio distribution in 2013. Stock-market data are taken from Thomson Reuters Datastream.

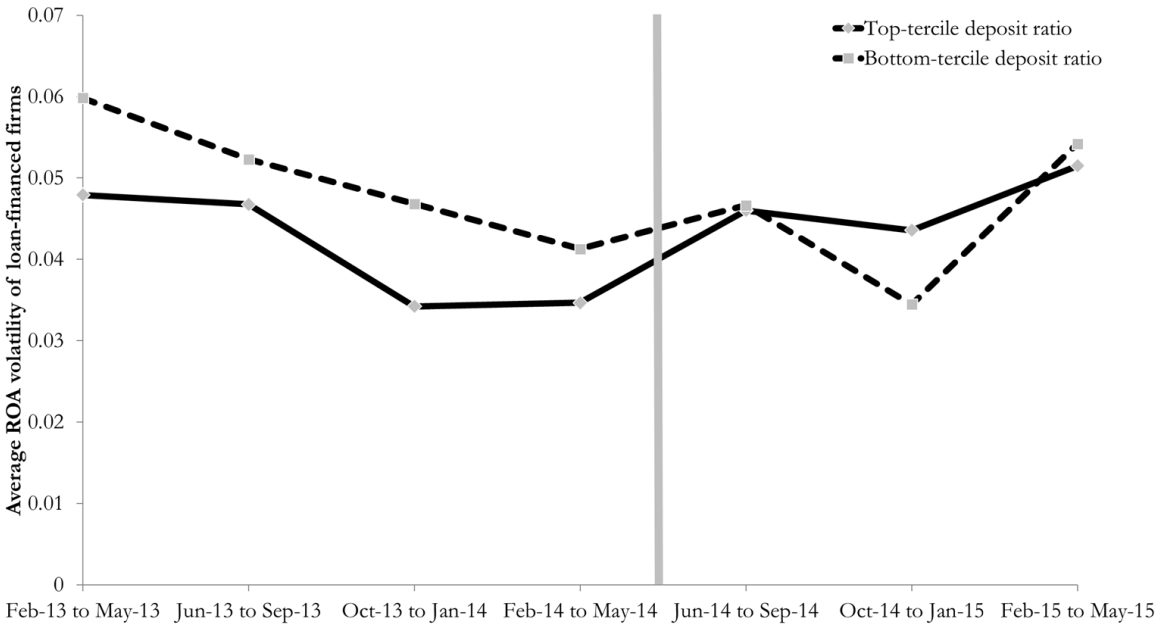


Figure 5: **ROA Volatility of Firms Associated with Loans Granted by Banks with High vs. Low Deposit Ratios.** This figure plots the four-month (forward-looking) average of ROA volatility of both private and publicly listed firms that received loans from euro-area lead arrangers in the top (solid line) and bottom tercile (dashed line) 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 $t-1$. The sample is aligned with that from Table 3.

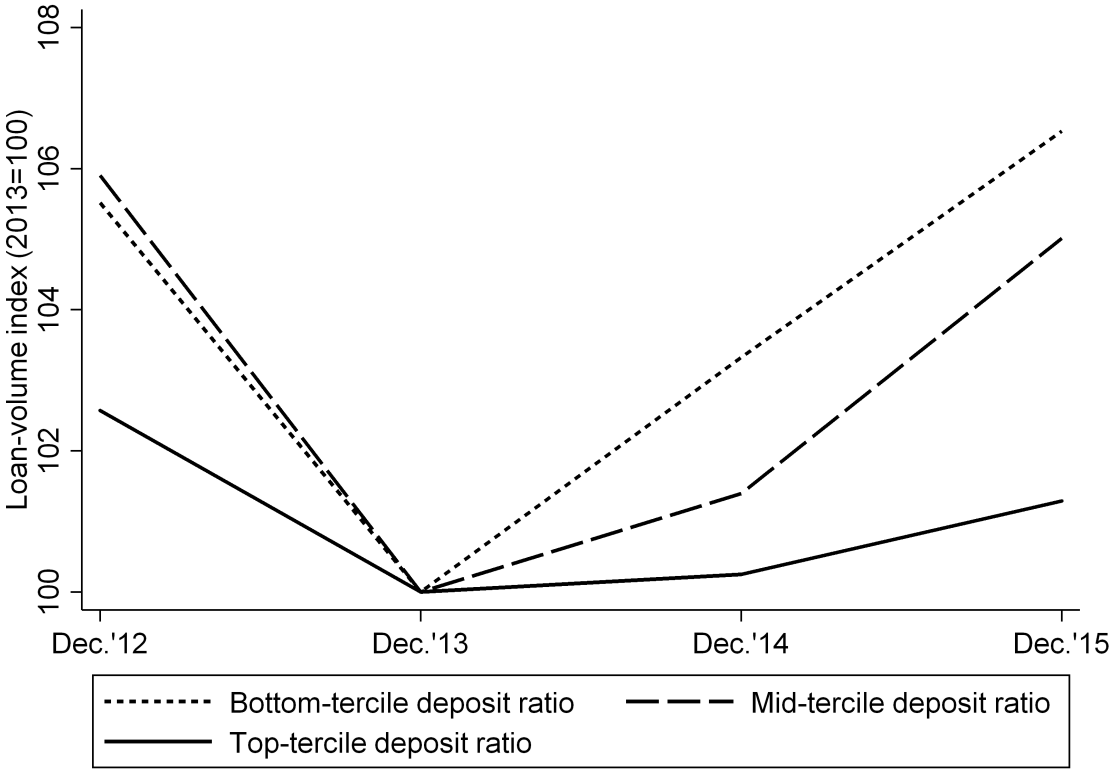


Figure 6: **Total Bank Lending by Banks as a Function of their Deposit Ratios.** This figure shows the evolution of an annual lending index (December 2013 = 100) for euro-area banks in our sample between 2012 and 2015. We split our sample in terciles based on the deposit-ratio distribution in 2013. For each tercile, we calculate the annual total loan volume. We then index the total loan volumes such that December 2013 = 100, and plot the index for the the top (solid line), middle (long-dashed line), and bottom terciles (short-dashed line). All data series are taken from SNL Financial.

7 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
Euro-area 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 euro-area 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 monthly 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 euro-area lead arrangers j in 2013. *Euro-area firm*$_i$ is an indicator for whether firm i is headquartered in the euro area. 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 euro-area banks included in the baseline sample. All bank-level variables are calculated using annual balance-sheet and P&L data for the year 2013.

Table 2: **Summary Statistics: High-deposit vs. Low-deposit Banks**

	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 as lead arranger	Bottom	23	150.65	231.35	1.47
	Top	23	71.26	116.96	
Proportion of loans as lead arranger	Bottom	23	0.87	0.15	1.20
	Top	23	0.81	0.18	
Average loan size in 2016 €bn	Bottom	23	1.19	0.68	0.97
	Top	23	1.02	0.53	
Average loan share in %	Bottom	23	16.68	18.15	0.32
	Top	23	14.99	17.02	
Proportion of leveraged loans $\in [0, 1]$	Bottom	23	0.16	0.21	0.41
	Top	23	0.14	0.12	

Notes: This table compares the characteristics of 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 deposit-ratio distribution in 2013. The deposit ratio is defined as total deposits over total assets. The last column shows the absolute value of the t-statistic for a test whether the difference in means between both groups is equal to zero. The sample period for the summary statistics in the top panel is the year 2013. The summary statistics in the bottom panel are based on the sample of all completed syndicated loans of both private and publicly listed firms granted by any euro-area (participating or lead) bank from January 2013 to December 2015.

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

	$\ln(\sigma(ROA_i)^{5y})$						
Sample	$2013-2015$				$2011-2015$	$2011-2015$	
						non-euro-area borrowers,	
						euro-area lenders	non-euro-area lenders
Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Deposit ratio × After(06/2014)	0.017***	0.016***	0.018***	0.020***	0.020***	0.033**	0.009
	(0.005)	(0.005)	(0.005)	(0.005)	(0.006)	(0.014)	(0.020)
Deposit ratio × After(07/2012)					-0.007	-0.012	-0.009
					(0.004)	(0.010)	(0.012)
Bank FE	Y	Y	Y	Y	Y	Y	Y
Month-year FE	Y	Y	Y	Y	Y	Y	Y
Country FE	N	Y	N	N	N	N	N
Industry FE	N	Y	Y	N	N	N	N
Country-year FE	N	N	Y	Y	Y	Y	Y
Industry-year FE	N	N	N	Y	Y	Y	Y
N	1,576	1,576	1,576	1,576	2,490	542	666

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 euro-area lead arranger(s) j, from January 2013 to December 2015 in the first four columns and from January 2011 to December 2015 in the fifth and sixth column. The sample in the last column consists of all completed syndicated loans (package level) of both private and publicly listed firms i at date t granted by any non-euro-area lead arranger(s) j from January 2011 to December 2015. In the last two columns, we furthermore limit the sample to non-euro-area 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 $t-1$. In the first six columns, *Deposit ratio*$_j$ is the average ratio (in %) of deposits over total assets across all euro-area lead arrangers j in 2013. In the last column, *Deposit ratio*$_j$ is the average ratio (in %) of deposits over total assets across all non-euro-area 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 euro-area and, if applicable, non-euro-area lead arrangers. Country(-year) fixed effects are based on the firm's country of origin. Industry(-year) fixed effects are based on two-digit SIC codes. Public-service, energy, and financial-services firms are dropped. Robust standard errors (clustered at the bank level) are in parentheses.

Table 4: **Impact of Negative Policy Rates on Banks' Lending Volume**

	ln(Syndicated-loan volume)			
Sample	$2013-2015$	$2013-2015$	$2011-2015$	$2011-2015$ non-euro-area lenders
Variable	(1)	(2)	(3)	(4)
Deposit ratio × After(06/2014)	-0.009*	-0.010**	-0.009**	-0.004
	(0.004)	(0.005)	(0.004)	(0.007)
Deposit ratio × After(07/2012)			0.008	0.001
			(0.006)	(0.011)
Deposit ratio		-0.003		
		(0.009)		
Bank FE	Y	N	Y	Y
Month-year FE	Y	Y	Y	Y
N	759	759	1,371	399

Notes: The level of observation is a bank's month-year, based on all completed syndicated loans granted by euro-area 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 third column. In the last column, the sample is based on all completed syndicated loans granted by non-euro-area lead arrangers from January 2011 to December 2015. 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 5: **Effect of Changes in the Deposit Facility Rate on Banks' Risk Taking and Lending Volume**

	$\ln(\sigma(ROA_i)^{5y})$		ln(Syndicated-loan vol.)	
Sample		$2009-2015$		
Variable	(1)	(2)	(3)	(4)
Deposit ratio$_{t-1}$ × DF rate × After(06/2014)	-0.083***	-0.087***	0.078**	0.055*
	(0.030)	(0.031)	(0.033)	(0.033)
Deposit ratio$_{t-1}$ × DF rate	0.005	0.004	0.002	0.003
	(0.012)	(0.012)	(0.011)	(0.012)
Deposit ratio$_{t-1}$ × After(06/2014)	-0.008	-0.008	0.023**	0.010
	(0.005)	(0.005)	(0.010)	(0.007)
Deposit ratio$_{t-1}$	0.002	0.003	-0.025***	-0.021*
	(0.004)	(0.004)	(0.009)	(0.012)
Bank FE	N	Y	N	Y
Month-year FE	Y	Y	Y	Y
N	3,005	3,005	1,765	1,765

Notes: In the first two columns, the sample consists of all completed syndicated loans (package level) of both private and publicly listed firms i at date t granted by any euro-area lead arranger(s) j from January 2009 to December 2015. In the last two columns, the level of observation is a bank's month-year, based on all completed syndicated loans granted by euro-area lead arranger j at date t from January 2009 to December 2015. Furthermore, in the last two columns, the sample of banks is limited to those that consistently – at least for 30 months – act as lead arrangers in syndicated loans. The dependent variable in the first two columns is the logged five-year standard deviation of firm i's return on assets (ROA, using P&L before tax) from year $t-5$ to $t-1$. The dependent variable in the last two columns 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. In the first two columns, *Deposit ratio*$_{j,t-1}$ is the average ratio (in %) of deposits over total assets across all euro-area lead arrangers j in year $t-1$. In the last two columns, *Deposit ratio*$_{j,t-1}$ is bank j's ratio (in %) of deposits over total assets in year $t-1$. *DF rate*$_t$ is the ECB's deposit facility rate (in %) at the monthly level. $After(06/2014)_t$ is a dummy variable for the period from June 2014 onwards. Bank fixed effects are included for all euro-area lead arrangers. Robust standard errors (clustered at the bank level) are in parentheses.

Table 6: **ROA Volatility of Firms Financed by Banks Following Negative Policy Rates – Robustness**

	$\ln(\sigma(ROA_i)^{5y})$						
Sample	2013 – 2015	2013 – 2015	2013 – 2015	2013 – 2015	2013 – 2015	2011 – 2015	2013 – 2015
Robustness	No low deposits	Alternative deposit ratio	Deposit decomposition, any coverage	Deposit decomposition, full coverage			
Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Deposit ratio × After(06/2014)	0.020***	0.018***			0.022***	0.020***	0.027***
	(0.006)	(0.005)			(0.006)	(0.006)	(0.007)
HH deposit ratio × After(06/2014)			0.027***	0.029***			
			(0.007)	(0.009)			
NFC deposit ratio × After(06/2014)			0.013	0.010			
			(0.009)	(0.010)			
Deposit ratio × After(07/2012)						-0.008*	
						(0.005)	
Assets_{t-1}					0.032	0.076	0.065
					(0.062)	(0.054)	(0.082)
Assets × After(06/2014)							-0.082
							(0.097)
$\text{Equity ratio}_{t-1}$					0.108**	0.058	0.092
					(0.049)	(0.039)	(0.058)
Equity ratio × After(06/2014)							0.023
							(0.064)
$\text{Securities ratio}_{t-1}$					0.014**	0.001	0.011
					(0.006)	(0.005)	(0.007)
Securities ratio × After(06/2014)							0.011
							(0.009)
Bank FE	Y	Y	Y	Y	Y	Y	Y
Month-year FE	Y	Y	Y	Y	Y	Y	Y
Country-year FE	Y	Y	Y	Y	Y	Y	Y
Industry-year FE	Y	Y	Y	Y	Y	Y	Y
N	1,571	1,576	1,500	763	1,576	2,490	1,576

Notes: The sample consists of all completed syndicated loans (package level) of both private and publicly listed firms i at date t granted by any euro-area lead arranger(s) j, from January 2013 to December 2015 in the first five columns and the last one, and from January 2011 to December 2015 in the sixth 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 euro-area 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 euro-area lead arrangers j in 2013. In the remaining columns, *Deposit ratio*$_j$ is the average ratio (in %) of deposits over total assets across all euro-area lead arrangers j in 2013. In the third and fourth column, *HH deposit ratio*$_j$ (*NFC deposit ratio*$_j$) is the average ratio (in %) of household (non-financial-corporation) deposits over total assets across all euro-area lead arrangers j in the fourth quarter of 2014, as there is no decomposition of deposits available before that quarter. The sample in the third column is limited to syndicated loans with *any one* of the 43 euro-area lead arrangers for which we have the respective deposit-decomposition data from the Single Supervisory Mechanism. The sample in the fourth column is furthermore limited to syndicated loans for *all* lead arrangers of which we have the respective deposit-decomposition data from the Single Supervisory Mechanism. *Assets*$_{j,t-1}$ is the logged average value of total assets across all euro-area lead arrangers j in year $t-1$. *Equity ratio*$_{j,t-1}$ is the average ratio (in %) of equity over total assets across all euro-area lead arrangers j in year $t-1$. *Securities ratio*$_{j,t-1}$ is the average ratio (in %) of securities over total assets across all euro-area lead arrangers j in year $t-1$. *Assets*$_j$ is the logged average value of total assets across all euro-area lead arrangers j in 2013. *Equity ratio*$_j$ is the average ratio (in %) of equity over total assets across all euro-area lead arrangers j in 2013. *Securities ratio*$_j$ is the average ratio (in %) of securities over total assets across all euro-area 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 euro-area lead arrangers. Country-year fixed effects are based on the firm's country of origin. Industry-year fixed effects are based on two-digit SIC codes. 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 Banks' Lending Volume – Robustness**

	ln(Syndicated-loan volume)				
Sample	2013 – 2015	2013 – 2015	2013 – 2015	2013 – 2015	2011 – 2015
Robustness	No low deposits	Alternative deposit ratio	Deposit decomposition		
Variable	(1)	(2)	(3)	(4)	(5)
Deposit ratio × After(06/2014)	-0.011*	-0.009*		-0.009**	-0.010**
	(0.006)	(0.005)		(0.004)	(0.004)
HH deposit ratio × After(06/2014)			-0.013		
			(0.010)		
NFC deposit ratio × After(06/2014)			-0.002		
			(0.010)		
Deposit ratio × After(07/2012)					0.008
					(0.006)
Assets_{t-1}				-3.161***	-0.010
				(1.085)	(0.246)
$\text{Equity ratio}_{t-1}$				-0.261***	-0.110*
				(0.068)	(0.064)
$\text{Securities ratio}_{t-1}$				0.046	-0.004
				(0.030)	(0.012)
Bank FE	Y	Y	Y	Y	Y
Month-year FE	Y	Y	Y	Y	Y
N	739	759	592	733	1,340

Notes: The level of observation is a bank's month-year, based on all completed syndicated loans granted by euro-area lead arranger j at date t, from January 2013 to December 2015 in the first four 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. In the first column, we drop from the sample all 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 bank j's ratio (in %) of deposits over total liabilities in 2013. In the remaining columns, *Deposit ratio*$_j$ is bank j's

ratio (in %) of deposits over total assets in 2013. In the third column, *HH deposit ratio*$_j$ (*NFC deposit ratio*$_j$) is bank j's ratio (in %) of household (non-financial-corporation) deposits over total assets in the fourth quarter of 2014, as there is no decomposition of deposits available before that quarter. $Assets_{j,t-1}$ is the natural logarithm of bank j's total assets in year $t-1$. *Equity ratio*$_{j,t-1}$ is bank j's ratio (in %) of equity over total assets in year $t-1$. *Securities ratio*$_{j,t-1}$ is bank j's ratio (in %) of securities over total assets in year $t-1$. $After(06/2014)_t$ 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 Shares: Borrower-time Fixed Effects**

	Loan share $\in [0, 100]$					
Sample	$2013-2015$	$2011-2015$	Bottom-half ROA volatility	Top-half ROA volatility	Bottom-half loan spread	Top-half loan spread
Variable	(1)	(2)	(3)	(4)	(5)	(6)
Deposit ratio × After(06/2014)	-0.032*	-0.037**	-0.150**	0.031**	-0.071***	-0.024
	(0.019)	(0.016)	(0.071)	(0.011)	(0.014)	(0.026)
Deposit ratio × After(07/2012)		0.071				
		(0.052)				
Firm-year FE	Y	Y	Y	Y	Y	Y
Bank-firm FE	Y	Y	Y	Y	Y	Y
Bank-country-year FE	Y	Y	Y	Y	Y	Y
N	1,712	3,045	287	282	631	634

Notes: The sample consists of all completed syndicated loans of both private and publicly listed firms i at date t granted by any euro-area (participating or lead) bank j, from January 2011 to December 2015 in the second column and from January 2013 to December 2015 in all remaining 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 third and fourth column, the sample is limited to borrower firms in the bottom and top half, respectively, 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 $t-1$. In the fifth and sixth column, the sample is limited to borrower firms in the bottom and top half, 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.4). The dependent variable is the loan share (in %) retained by (participating or lead) bank j. $Deposit\ ratio_j$ is bank j's ratio (in %) of deposits over total assets in 2013. $After(06/2014)_t$ is a dummy variable for the period from June 2014 onwards. $After(07/2012)_t$ is a dummy variable for the period from July 2012 onwards. Bank-country-year fixed effects are based on the bank group's country of origin in the euro area. Public-service, energy, and financial-services borrower firms are dropped. Robust standard errors (clustered at the bank level) are in parentheses.

Table 9: **Impact of Negative Policy Rates on Loan Spreads**

	ln(All-in-drawn spread)				
Sample	$2013-2015$				$2011-2015$
Variable	(1)	(2)	(3)	(4)	(5)
Deposit ratio × After(06/2014)	-0.009	-0.006	-0.003	-0.002	-0.001
	(0.006)	(0.005)	(0.006)	(0.007)	(0.006)
Deposit ratio × After(07/2012)					-0.002
					(0.004)
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	791	791	791	791	1,332

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 euro-area 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 column. The dependent variable is the log of the all-in-drawn spread (in bps), which is the sum of the spread over LIBOR and any annual fees paid to the lender syndicate. $Deposit\ ratio_j$ is the average ratio (in %) of deposits over total assets across all euro-area 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 euro-area lead arrangers. Country(-year) fixed effects are based on the firm's country of origin. Industry(-year) fixed effects are based on two-digit SIC codes. Public-service, energy, and financial-services firms are dropped. Robust standard errors (clustered at the bank level) are in parentheses.

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

	ln(Loan size)				
Variable	(1)	(2)	(3)	(4)	(5)
Deposit ratio × After(06/2014)	-0.004	-0.007	-0.008	-0.007	-0.010
	(0.005)	(0.005)	(0.005)	(0.006)	(0.007)
Deposit ratio × After(06/2014) × $\sigma(ROA_i)^{5y}$					0.217*
					(0.133)
Deposit ratio × $\sigma(ROA_i)^{5y}$					-0.247**
					(0.104)
$\sigma(ROA_i)^{5y}$ × After(06/2014)					-5.596
					(5.590)
$\sigma(ROA_i)^{5y}$					7.189
					(4.371)
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	1,576	1,576	1,576	1,576	1,576

Notes: The sample consists of all completed syndicated loans (package level) of both private and publicly listed firms i at date t granted by any euro-area lead arranger(s) j from January 2013 to December 2015. The dependent variable is the log of the individual loan size. $Deposit\ ratio_j$ is the average ratio (in %) of deposits over total assets across all euro-area 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 euro-area lead arrangers. Country(-year) fixed effects are based on the firm's country of origin. Industry(-year) fixed effects are based on two-digit SIC codes. Public-service, energy, and financial-services firms are dropped. Robust standard errors (clustered at the bank level) are in parentheses.

Table 11: **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
Variable	(1)	(2)	(3)	(4)
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 euro-area 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 is limited to euro-area 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 euro-area 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 euro-area lead arrangers. Country-year fixed effects are based on the firm's country of origin. Industry-year fixed effects are based on two-digit SIC codes. Public-service, energy, and financial-services firms are dropped. Robust standard errors (clustered at the bank level) are in parentheses.

Table 12: **Impact of Negative Policy Rates on Banks' Loan Portfolio**

	$\ln(\sigma(ROA_i)^{5y})$	$\ln(\sigma(ROA_i)^{5y})$	$ROA_{i,t-1}$	$Leverage_{i,t-1}$	$\ln(\sigma(ROA_i)^{5y})$
Sample	Private firms	Public firms	Private and public firms		
Variable	(1)	(2)	(3)	(4)	(5)
Deposit ratio × After(06/2014)	0.027***	0.011	-0.036	-0.238**	0.012*
	(0.009)	(0.007)	(0.083)	(0.110)	(0.007)
Deposit ratio × Exposure × After(06/2014)					0.019*
					(0.011)
Deposit ratio × Exposure					-0.006
					(0.006)
Exposure × After(06/2014)					-0.923**
					(0.451)
Exposure					0.328
					(0.274)
Bank FE	Y	Y	Y	Y	Y
Month-year FE	Y	Y	Y	Y	Y
Country-year FE	Y	Y	Y	Y	Y
Industry-year FE	Y	Y	Y	Y	Y
N	904	672	1,576	1,569	1,576

Notes: The sample consists of all completed syndicated loans (package level) of only private (in the first column), only publicly listed (in the second column), and both private and publicly listed firms i (in the remaining columns) at date t granted by any euro-area lead arranger(s) j from January 2013 to December 2015. The dependent variable in the first, second, and 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 third 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 fourth column is firm i's leverage in year $t-1$, measured in % ($\in [0, 100]$). $Deposit\ ratio_j$ is the average ratio (in %) of deposits over total assets across all euro-area 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 in the total loan portfolio of all euro-area lead arrangers j in 2013 is above the sample median. $After(06/2014)_t$ is a dummy variable for the period from June 2014 onwards. Bank fixed effects are included for all euro-area lead arrangers. Country-year fixed effects are based on the firm's country of origin. Industry-year fixed effects are based on two-digit SIC codes. Public-service, energy, and financial-services firms are dropped. Robust standard errors (clustered at the bank level) are in parentheses.

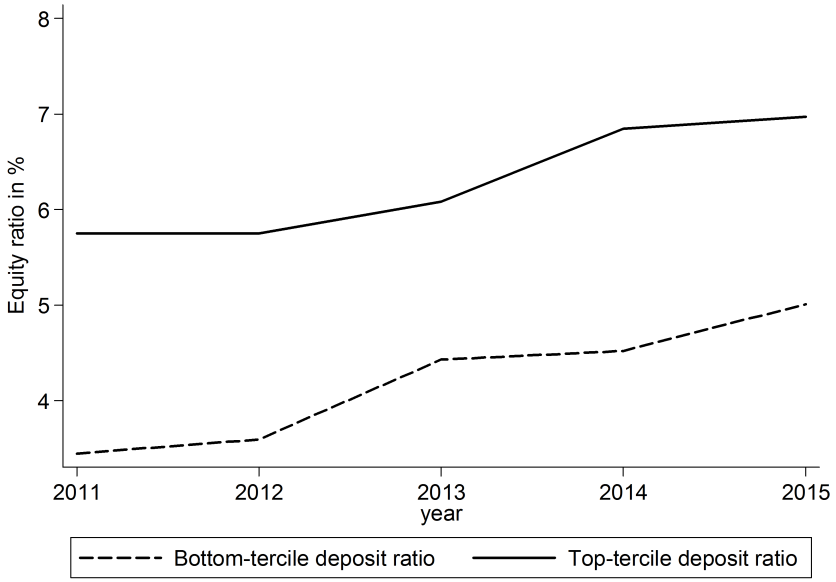
Table 13: **Bank-level Stock-return Volatility and CDS Returns**

	$\ln(\sigma(return_j)^{1m})$		$CDS\ return_j^{1m}$	
Sample	$2013-2015$	$2011-2015$	$2013-2015$	$2011-2015$
Variable	(1)	(2)	(3)	(4)
Deposit ratio × After(06/2014)	0.012*	0.013**	0.141**	0.126**
	(0.007)	(0.005)	(0.062)	(0.058)
Deposit ratio × After(07/2012)		-0.006		-0.043
		(0.016)		(0.047)
Bank FE	Y	Y	Y	Y
Month-year FE	Y	Y	Y	Y
N	775	1,471	898	1,689

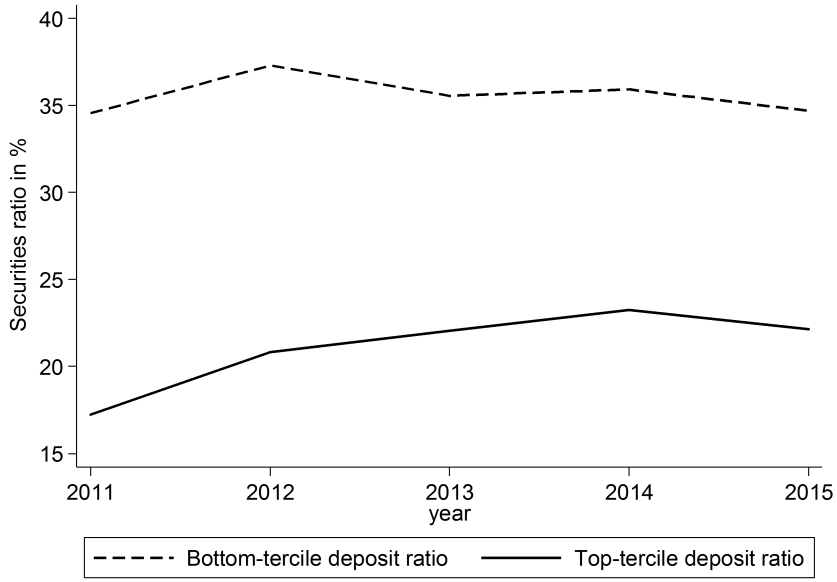
Notes: The level of observation is a bank's month-year. We use stock-market data on 30 listed banks, from January 2013 to February 2015 in the first and from January 2011 to February 2015 in the second column. The dependent variable in the first two columns is the logged unlevered monthly standard deviation of bank stock returns. 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 third 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.

Online Appendix

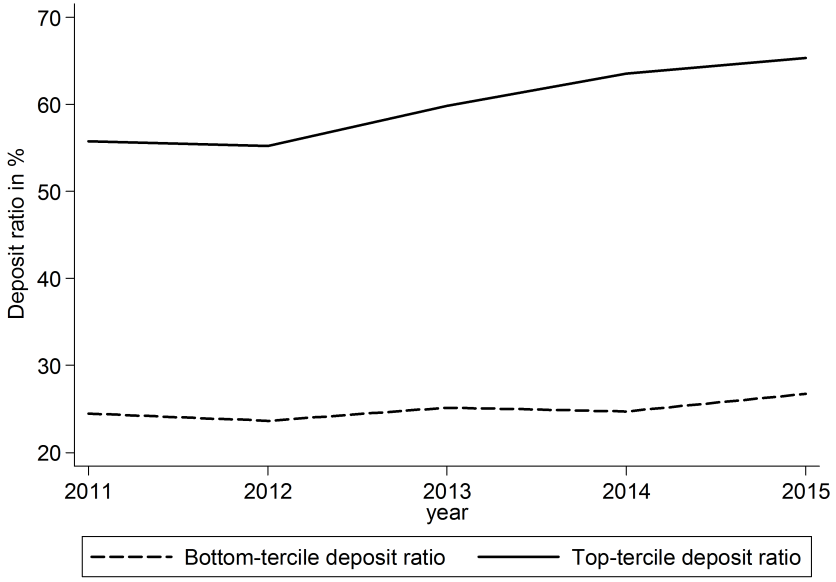
A Supplementary Figures



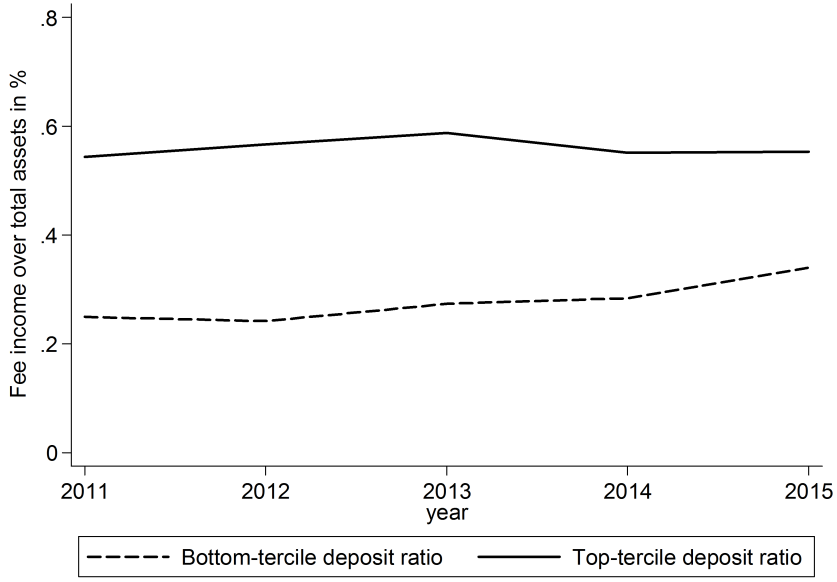
(a) Equity ratio



(b) Securities ratio



(c) Deposit ratio



(d) Fee income

Figure A.1: **Evolution of Balance-sheet Characteristics of Banks with High vs. Low Deposit Ratios.** This figure shows the evolution of the average equity ratio (total equity over total assets), securities ratio (total securities over total assets), deposit ratio (total deposits over total assets), and fee-income ratio (total fee income over total assets) for euro-area banks in the top (solid line) and bottom tercile (dashed line) of the deposit-ratio distribution in 2013. Averages are calculated using annual bank-level information for all banks included in the baseline sample.

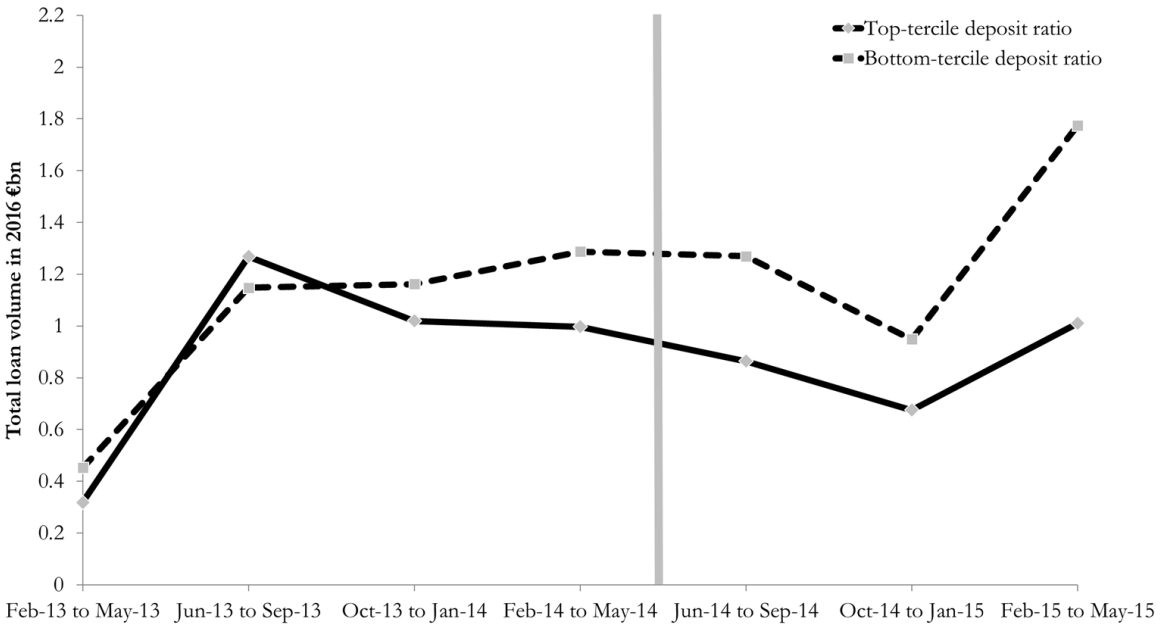


Figure A.2: **Total Volume of Syndicated Loans by Banks with High vs. Low Deposit Ratios.** This figure plots the four-month (forward-looking) total loan volume granted by euro-area lead arrangers, separately as averages for lead arrangers in the top (solid line) and bottom tercile (dashed line) of the deposit-ratio distribution in 2013. The sample is aligned with that from Table 4.

B Supplementary Tables

Table B.1: **List of Euro-area 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 B.2: **ROA Volatility of Firms Financed by Banks Following Negative Policy Rates – Robustness to Definition of Deposit Ratio**

	$\ln(\sigma(ROA_i)^{5y})$				
Sample	$2013-2015$				$2011-2015$
Variable	(1)	(2)	(3)	(4)	(5)
Deposit ratio × After(06/2014)	0.018***	0.017***	0.019***	0.022***	0.021***
	(0.005)	(0.005)	(0.006)	(0.006)	(0.007)
Deposit ratio × After(07/2012)					-0.006
					(0.005)
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	1,576	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 euro-area 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 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 $t-1$. *Deposit ratio*$_j$ is the average ratio (in %) of deposits over total assets across all euro-area 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 euro-area lead arrangers. Country(-year) fixed effects are based on the firm's country of origin. Industry(-year) fixed effects are based on two-digit SIC codes. Public-service, energy, and financial-services firms are dropped. Robust standard errors (clustered at the bank level) are in parentheses.

Table B.3: **ROA Volatility of Firms Financed and Volume of Syndicated Lending by Banks Following Negative Policy Rates – End Sample in February 2015**

	$\ln(\sigma(ROA_i)^{5y})$		ln(Syndicated-loan volume)	
Variable	(1)	(2)	(3)	(4)
Deposit ratio × After(06/2014)	0.012**	0.013(*)	-0.014**	-0.011*
	(0.006)	(0.008)	(0.007)	(0.006)
Deposit ratio			-0.003	
			(0.009)	
Bank FE	Y	Y	N	Y
Month-year FE	Y	Y	Y	Y
Country-year FE	N	Y	N	N
Industry-year FE	N	Y	N	N
N	1,147	1,147	523	523

Notes: In the first two columns, the sample consists of all completed syndicated loans (package level) of both private and publicly listed firms i at date t granted by any euro-area lead arranger(s) j from January 2013 to February 2015. In the last two columns, the level of observation is a bank's month-year, based on all completed syndicated loans granted by euro-area lead arranger j at date t from January 2013 to February 2015. Furthermore, in the last two columns, the sample of banks is limited to those that consistently – at least for 30 months – act as lead arrangers in syndicated loans. The dependent variable in the first two columns is the logged five-year standard deviation of firm i's return on assets (ROA, using P&L before tax) from year $t-5$ to $t-1$. The dependent variable in the last two columns 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. In the first two columns, *Deposit ratio*$_j$ is the average ratio (in %) of deposits over total assets across all euro-area lead arrangers j in 2013. In the last two columns, *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 fixed effects are included for all euro-area lead arrangers. Country-year fixed effects are based on the firm's country of origin. Industry-year fixed effects are based on two-digit SIC codes. Public-service, energy, and financial-services firms are dropped from the first two columns. Robust standard errors (clustered at the bank level) are in parentheses.

Table B.4: **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
Variable	(1)	(2)	(3)	(4)	(5)
Deposit ratio × After(06/2014)	0.012**	0.011**	0.012**	0.010*	0.007
	(0.006)	(0.005)	(0.006)	(0.006)	(0.008)
Deposit ratio × After(07/2012)					-0.003
					(0.007)
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	1,218	1,218	1,218	1,218	1,746

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 euro-area 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 column. 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 column, but no earlier than January 2003. $Deposit\ ratio_j$ is the average ratio (in %) of deposits over total assets across all euro-area 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 euro-area lead arrangers. Country(-year) fixed effects are based on the firm's country of origin. Industry(-year) fixed effects are based on two-digit SIC codes. Public-service, energy, and financial-services firms are dropped. Robust standard errors (clustered at the bank level) are in parentheses.

Table B.5: **Stock-return Volatility of Firms Financed by Banks Following Negative Policy Rates**

	$\ln(\sigma(return_i)^{36m})$				
Sample	$2013-2015$				$2011-2015$
Variable	(1)	(2)	(3)	(4)	(5)
Deposit ratio × After(06/2014)	0.006**	0.006**	0.008***	0.009***	0.006*
	(0.003)	(0.003)	(0.003)	(0.003)	(0.004)
Deposit ratio × After(07/2012)					0.002
					(0.003)
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	665	665	665	665	1,061

Notes: The sample consists of all completed syndicated loans (package level) of publicly listed firms i at date t granted by any euro-area 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 column. The dependent variable is the logged standard deviation of firm i's monthly stock returns in the 36 months before t. *Deposit ratio*$_j$ is the average ratio (in %) of deposits over total assets across all euro-area 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 euro-area lead arrangers. Country(-year) fixed effects are based on the firm's country of origin. Industry(-year) fixed effects are based on two-digit SIC codes. 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 – Incorporation of Leverage**

	$\ln(\sigma(ROA_i)^{5y} \times Leverage_{i,t-1})$				
Sample	$2013-2015$				$2011-2015$
Variable	(1)	(2)	(3)	(4)	(5)
Deposit ratio × After(06/2014)	0.007**	0.007**	0.008**	0.008**	0.009**
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
Deposit ratio × After(07/2012)					-0.004
					(0.003)
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	1,569	1,569	1,569	1,569	2,478

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 euro-area 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 column. 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 euro-area 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 euro-area lead arrangers. Country(-year) fixed effects are based on the firm's country of origin. Industry(-year) fixed effects are based on two-digit SIC codes. 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 – Inclusion of Danish, Swedish, and Swiss Banks**

	$\ln(\sigma(ROA_i)^{5y})$			
Variable	(1)	(2)	(3)	(4)
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 euro-area, 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 euro-area, 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 euro-area (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 euro-area) lead arrangers, respectively. Bank fixed effects are included for all euro-area, Danish, Swedish, and Swiss lead arrangers. Country(-year) fixed effects are based on the firm's country of origin. Industry(-year) fixed effects are based on two-digit SIC codes. Public-service, energy, and financial-services firms are dropped. Robust standard errors (clustered at the bank level) are in parentheses.

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

	ln(Total cost of borrowing)				
Sample		$2013-2015$			$2011-2015$
Variable	(1)	(2)	(3)	(4)	(5)
Deposit ratio × After(06/2014)	-0.016	0.005	-0.004	-0.006	-0.036
	(0.012)	(0.012)	(0.022)	(0.071)	(0.067)
Deposit ratio × After(07/2012)					0.030
					(0.047)
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	174	174	174	174	292

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 euro-area 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 column. 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 euro-area 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 euro-area lead arrangers. Country(-year) fixed effects are based on the firm's country of origin. Industry(-year) fixed effects are based on two-digit SIC codes. 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 Other Loan Terms**

Variable	Secured (1)	Lead share (2)	Covenants (3)	ln(Maturity) (4)
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 euro-area 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 euro-area 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 euro-area 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 euro-area lead arrangers. Country-year fixed effects are based on the firm's country of origin. Industry-year fixed effects are based on two-digit SIC codes. Public-service, energy, and financial-services firms are dropped. Robust standard errors (clustered at the bank level) are in parentheses.

Acknowledgements

We thank Ugo Albertazzi, Tobias Berg, Patrick Bolton, Diana Bonfim, Gabriel Chodorow-Reich, Matteo Crosignani, William Emmons, Ester Faia, Leonardo Gambacorta, Reint Gropp, Espen Henriksen, Victoria Ivashina, Robert Krainer, Claudia Kühne, Luc Laeven, Alexander Ljungqvist, Mike Mariathasan, Gregor Matvos, Ralf Meisenzahl, Benoît Mojon, Teodora Paligorova, Daniel Paravisini, Francesc Rodriguez-Tous, Anthony Saunders, Antoinette Schoar, Sascha Steffen, Per Strömberg, Skander Van den Heuvel and Mirko Wiederholt, as well as audiences at numerous conferences and seminars for their comments and suggestions. We also thank Valentin Klotzbücher and Francesca Barbiero for excellent research assistance. The views expressed do not necessarily reflect those of the European Central Bank or the Eurosystem.

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PDF ISBN 978-92-899-3278-3 ISSN 1725-2806 doi:10.2866/310210, QB-AR-18-053-EN-N