Life Below Zero: Bank Lending Under Negative Policy Rates

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Abstract

We show that negative policy rates transmit to the real sector via bank lending in a novel way. The European Central Bank's lowering of the policy rate into negative territory in June 2014 induces banks with more deposits to lend less and to riskier borrowers. Banks do not adjust loan terms, and the risk taking is concentrated in poorly capitalized banks. New risky borrowers appear financially constrained, and invest more after receiving a loan. Besides highlighting the role of bank net worth for the supply of credit, our results point to distributional consequences of negative rates in the banking sector.

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

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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 and quantifies the transmission of negative policy rates to the real sector via the lending behavior of banks. We find that negative policy rates transmit in a novel way. When the ECB reduced the deposit facility (DF) rate from 0 to -0.10% in June 2014, banks with more deposits concentrated their lending on riskier firms in the market for syndicated loans. 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 standard way to think about monetary-policy transmission via bank lending – as described in, for example, Bernanke (2007) – cannot explain our findings. Banks should lend more and take less risk when the policy rate falls, which is the opposite of what we find. Banks have long-term assets and short-term liabilities, and because policy rates transmit to short-term rates first, the transmission of a lower policy rate is stronger on banks' liability side than on their asset side. A lower policy rate therefore increases the net worth of banks, which is the value difference between assets and liabilities. More net worth, in turn, means more "skin-in-the-game," which relaxes banks' financial constraints, increases lending, and reduces risk taking.[2]

[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 (for the ECB's view, see Praet (2014)). 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).

[2] This is the so-called "bank-capital (or bank balance-sheet) channel" of monetary-policy transmission (see Boivin, Kiley, and Mishkin (2010) for a survey of the literature) which, in turn, is closely related to the "bank risk-taking channel" (see our literature review for more details).

To explain our findings, we augment the standard view with a new effect that kicks in when the policy rate becomes negative. When the policy rate is negative, a stronger reliance on deposits has an adverse effect on bank net worth. The extent to which a bank's short-term liabilities consist of deposits now matters because banks are unwilling to pass on negative rates to their depositors. Fearing withdrawals, banks can no longer benefit from a decrease in the cost of short-term debt if this debt consists of deposits.

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

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

To examine and quantify the transmission of monetary policy via bank lending empirically is challenging for two reasons. First, monetary policy is endogenous. Policy rates not only transmit to the economy, but they also respond to economic conditions. Second, bank lending is endogenous. It not only depends on banks' loan supply but also on firms' loan demand, both of which respond to changes in interest rates.

To address these identification challenges, we use a difference-in-differences approach. We compare the lending behavior of high-deposit banks and low-deposit banks around the time when the policy rate becomes negative. Ideally, the control group of low-deposit banks provides the counterfactual to disentangle the effect of negative policy rates on bank lending from other forces that shape both monetary policy and bank lending.

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

Next, suppose a lower policy rate increases the net worth of firms (Bernanke and Gertler (1989)). By the same logic as for banks, firms would then seek more outside financing and act more prudently. As observed bank lending depends on both firms' loan demand and banks' loan supply, our result would be biased downward. If firms did not borrow more and act more prudently in response to the lower rate, there would be (even) less bank lending and borrowers would be riskier. Again, taking the difference between high-deposit and low-deposit banks removes this bias because both ideally face the same loan demand.

The main threat to our identification strategy is that the control group may be inappropriate. This occurs 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).[3] Such a time-varying difference violates the parallel-trends assumption, which is key to the identification of a causal effect in a difference-in-differences setup. In terms of the examples above, do high-deposit and low-deposit banks actually face different lending opportunities (or different loan-demand curves) and, importantly, does the difference change when the policy rate becomes negative?

Our empirical design takes several steps to mitigate this threat to identification. First, we verify that pre-treatment trends are parallel. High-deposit and low-deposit banks exhibit parallel trends in terms of their lending behavior before the ECB sets a negative policy rate.

Second, we conduct a placebo test in July 2012, which is the last time the ECB lowered its policy rates prior to going negative. Because our argument rests on banks' unwillingness to pass on *negative* rates to depositors, there should be no effect in July 2012. This is what

[3] Note that time-invariant differences between high-deposit and low-deposit banks – e.g., high-deposit banks having a different business model or lending to different types of firms – do not matter. They are differenced out when comparing each type of bank before and after the policy-rate change.

we find. In mid 2012, the difference-in-differences estimate is zero for various measures of bank lending behavior.

Third, the granularity of our data allows us to refine the comparison between high-deposit and low-deposit banks. We add borrowers' country-year and borrowers' industry-year fixed effects. This eliminates any time-varying difference in lending opportunities between high-deposit and low-deposit banks that may be derived from unobserved time-varying country and industry factors. Adding such fixed effects does not affect our estimate substantially. The inclusion of bank-level controls does not affect our estimate either. Typical bank-level control variables when assessing the transmission of (non-negative) policy rates are bank size, the amount of securities relative to loans, and the amount of equity. None of these typical control variables matter when we examine the transmission of negative policy rates, which is another confirmation of the validity of low-deposit banks as the control group.

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. We can examine the lending behavior of different banks to the same firm because in a syndicated loan, several banks jointly lend to the same firm, and the loan share captures the lending volume of each bank in the syndicate to that firm.

Finally, we address the concern that the introduction of negative policy rates possibly coincides with other ECB actions or changes in the regulatory landscape. We observe that open market operations, asset-purchase programs, and other regulatory changes either do not coincide with the introduction of negative policy rates or do not plausibly affect high-deposit and low-deposit banks differentially. Nevertheless, we examine the issue formally using confidential supervisory data on whether bank deposits are held by households or corporates. In contrast to possible confounds, the impact of negative rates depends on who holds the deposits. 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. Indeed, we find that our difference-in-differences estimate is not only larger but also more precisely estimated for high-deposit banks funded by household deposits.

The lending behavior of high-deposit banks implies a risk to financial stability via less screening and less monitoring of borrowers. Their lending to riskier borrowers is not offset by higher loan spreads or more stringent loan terms such as higher collateral, higher loan shares retained by the lead arrangers in the syndicate, or more covenants. Moreover, the risk taking of high-deposit banks is concentrated in banks with little equity.

The adverse shock of the negative policy rate to the net worth of high-deposit banks, and the ensuing risk taking, also show up in the market's view of these banks. High-deposit banks earn lower stock returns than low-deposit banks only after June 2014. Moreover, high-deposit banks exhibit higher stock-return volatility and a stronger increase in their CDS spreads when the policy rate becomes negative. These bank-level results complement our findings using syndicated-loan data, confirming their external validity.

We also identify the real effects and distributional consequences of negative policy rates. The risk taking of high-deposit banks benefits credit-constrained firms. High-deposit banks lend to firms that previously did not borrow in the syndicated-loan market, and new risky borrowers receive larger loans. Moreover, the risk taking is concentrated in private firms and in firms operating in industries known to the bank.

High-deposit banks lend less and at the same time to new risky borrowers. This begs the question whether safe borrowers are rationed under negative rates. This is not the case, as we document a switching of safe borrowers from high-deposit to low-deposit banks.

The risk taking of high-deposit banks does not lead to "zombie" lending. Firms receiving funding from high-deposit banks after June 2014 have less debt, but are no less profitable than those firms receiving funding from low-deposit banks. We conclude that negative policy rates relax credit constraints for risky firms, as they experience a higher growth rate of investment upon receiving a loan from high-deposit banks.

Related literature. Our analysis makes the following contributions. First, negative policy rates truly are unchartered territory, both theoretically and empirically.[4] To the best of our knowledge, ours is the first paper to show how negative policy rates transmit to the real economy via bank lending.

Brunnermeier and Koby (2017) propose a theory of the "reversal rate" below which accommodative monetary policy becomes contractionary. Moreover, the reversal rate may vary across banks. Our results suggest the existence of such a reversal rate for high-deposit banks.[5] Their theory, however, does not explicitly consider banks' reluctance to charge negative rates on deposits. Moreover, negative rates are not entirely contractionary. According to our results, they induce risk taking, which relaxes credit constraints. Rognlie (2016) presents a New Keynesian macroeconomic model to evaluate the impact of negative policy rates. In the model, which does not feature a banking sector, negative rates are costly because they subsidize holding currency, which offers a zero nominal return. Our results show that negative rates impose a cost on banks maintaining a zero nominal return on deposits.

Second, by considering policy-rate reductions into negative territory, we extend the literature on how policy-rate changes transmit to the economy via the supply of bank credit. The common starting point of this literature is that the composition of banks' balance sheets matters for the transmission (Bernanke and Gertler (1995)). The 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 (2015) show how asymmetric information between banks and their borrowers modifies the response of bank lending to funding-cost shocks, e.g., those induced by policy-rate changes. Drechsler, Savov, and Schnabl (2017) examine banks' ability to raise deposit rates and attract deposits when the policy rate increases, depending on banks' market power in deposit markets. In that

[4] 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.

[5] As the ECB lowered the policy rate in a discrete step (see Section 2.1), we cannot state where exactly this reversal rate is.

respect, a literature going back to Hannan and Berger (1991) examines the pricing of deposits (see Driscoll and Judson (2013) for a recent contribution). The sensitivity of deposit rates to (positive) policy rates is asymmetric: while deposit rates are upward sticky, they are downward flexible. We show that negative policy rates are special because they lead to downward-sticky deposit rates.

Third, 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)) to negative rates. The reluctance of banks to pass on negative rates to their depositors constitutes a negative shock to the net worth of banks, especially those with considerable deposit funding. The bank behavior we characterize – lending less and to riskier firms – is in line with theoretical models in which lower bank net worth increases agency problems (e.g., Keeley (1990); Holmström and Tirole (1997); Hellmann, Murdock, and Stiglitz (2000); Dell'Ariccia, Laeven, and Marquez (2014)).[6] In that vein, our characterization of bank lending behavior connects the risk-taking channel with the above literature on the supply of bank credit, both of which derive their implications from similar information frictions.

Fourth, we contribute to the recent literature assessing the impact of non-standard monetary-policy measures on the real economy. Chakraborty, Goldstein, and MacKinlay (2016), Di Maggio, Kermani, and Palmer (2016), as well as Kandrac and Schlusche (2016) investigate the impact of large-scale asset purchases of Treasuries and mortgage-backed securities (MBS) in the United States. Scharfstein and Sunderam (2016) show that the pass-through of monetary policy to credit conditions in the housing market via MBS depends on banks' market power in mortgage lending. Chodorow-Reich (2014) studies the impact of the policy mix – including asset purchases, forward guidance, and ultra-low interest rates – on banks, life insurers, and money market funds in the U.S. Crosignani and Carpinelli (2016) examine the ECB's three-year long-term refinancing operations, which provided liquidity to

[6] 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.

euro-area banks. Lastly, Ferrando, Popov, and Udell (2015) and Acharya, Eisert, Eufinger, and Hirsch (2016) analyze the ECB's outright monetary transactions program to buy (potentially unlimited) amounts of euro-area sovereign bonds.

2 Empirical Strategy and Data

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

2.1 Institutional Background and Hypothesis Development

On June 5, 2014, the European Central Bank (ECB) Governing Council lowered the marginal lending facility (MLF) rate to 0.40%, the main refinancing operations (MRO) rate to 0.15%, and the deposit facility (DF) rate to -0.10% (see Figure 1). Shortly after, on September 4, 2014, the rates were lowered again: the MLF rate to 0.30%, the MRO rate to 0.05%, and the DF rate to -0.20%. With these actions, the ECB ventured into negative territory for policy rates for the first time in its history. Ever since, the DF rate has continued to drop, to -0.40% on March 10, 2016.

The main goal of lowering the rates was to provide monetary-policy accommodation (in accordance with the ECB's forward guidance). In order to preserve the difference between the cost of borrowing from the ECB (at the MRO rate) and the benefit of depositing with the ECB (at the DF rate), thereby incentivizing banks to lend in the interbank market, the deposit facility rate became negative. The evolution of the euro overnight interbank rate (Eonia) in Figure 1 illustrates that the negative DF rate led to negative interbank rates. When banks hold significant amounts of excess liquidity, short-term market rates closely track the deposit facility rate.[7] Since October 2008, when the ECB started to provide unlimited liquidity (against collateral), the deposit facility rate has become the relevant policy rate in the euro area.

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 is the rate of interest at which Swedish banks can borrow or deposit funds at the Riksbank. The Swedish experience is preceded by the Danish central bank, Nationalbanken, lowering the deposit rate to -0.20% on July 5, 2012. While the Danish deposit rate was raised to 0.05% on April 24, 2014, it was brought back to negative territory, -0.05%, on September 5, 2014. Furthermore, the Swiss National Bank went negative on December 18, 2014, by imposing a negative interest rate of -0.25% on sight deposits exceeding a given exemption threshold (see Bech and Malkhozov (2016) for further details on the implementation of negative policy rates in Europe and the transmission to other interest rates). We exploit these additional instances of negative policy rates as a robustness check.

The starting point for the transmission of monetary policy through banks is the existence of an external-finance premium for banks (see Bernanke and Gertler (1995)). Raising funds from outsiders is costly because they know less about the quality of bank assets (adverse selection, e.g., Stein (1998)) and the quality of management's decision making (moral hazard, e.g., Holmström and Tirole (1997)). The external-finance premium is inversely related to a bank's net worth, i.e., the difference between assets and liabilities. When a bank's net worth is high, the external-finance premium is low and banks lend more, because adverse-selection and moral-hazard problems are less severe. When net worth is high, banks also take less risk, e.g., by carefully screening and monitoring loans, because insiders have "skin-in-the-game"

[7] Excess liquidity refers to banks holding more central-bank reserves than needed to satisfy reserve requirements. In the current economic and institutional environment, banks hold excess liquidity as insurance against liquidity shocks, and because reserves serve as a means of payment free of counterparty risk.

– they want to preserve the rents accruing from high net worth (Keeley (1990); Hellmann, Murdock, and Stiglitz (2000)).[8]

Normally – i.e., when rates are positive – a lower policy rate is accommodative because it increases bank net worth. Even though a lower policy rate reduces both the return on assets and the cost of funding, which in principle has an ambiguous effect on net worth, the liability-side effect typically dominates because banks engage in maturity transformation (Bernanke (2007); Dell'Ariccia, Laeven, and Marquez (2014)). Banks have short-term liabilities and long-term assets, and rate changes transmit more immediately to short-term rates than to long-term rates (because of risk and term premia).

The ECB's introduction of negative policy rates offers a unique opportunity to test the transmission of policy-rate changes to bank lending behavior via banks' net worth. Setting a negative policy rate affects bank liabilities differentially, as it induces a wedge between deposit and non-deposit funding. Figure 2 depicts the evolution of the overnight unsecured interbank rate (Eonia), a proxy for market-based short-term funding that closely follows the relevant ECB policy rate (as shown in Figure 1), as well as the rates on overnight deposits held by households (HH) and non-financial corporations (NFC). Prior to June 2014, a lower Eonia rate is associated with lower deposit rates, e.g., in early 2009, late 2011, and mid 2012. This is in line with evidence from the U.S. that deposit rates normally are downward flexible (Hannan and Berger (1991), Driscoll and Judson (2013)).

But when the policy rate becomes negative, deposit rates are no longer downward flexible. Instead, they become downward sticky as banks appear reluctant to charge negative rates to depositors (e.g., because depositors can hold currency or take their deposits to another bank that does not charge negative deposit rates). After June 2014, Eonia becomes negative (in line with the negative policy rate) while deposit rates level off at zero. A significant lasting gap emerges between the falling cost of market-based short-term funding and the now constant cost of deposit funding.[9]

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

[9] The leveling off at zero is also present in the rates on longer-term deposits with an agreed maturity below one year (available upon request).

The reluctance to charge negative rates to depositors constitutes a negative shock to the net worth of banks with a lot of deposit funding relative to banks with little deposit funding. This is because the negative policy rate leads to a lower cost of market-based short-term (non-deposit) funding, but *not* to a lower cost of deposit funding. On the other hand, loan rates have been falling since the end of 2011 (for syndicated loans originated by euro-area banks to both euro-area and non-euro-area borrowers (Figure A.1), as well as for long-term loans (Figure A.2)). A negative shock to bank net worth, in turn, leads to more risk taking and less lending. We summarize our argument about the impact of negative policy rates on the real economy via bank lending in the following testable hypothesis:

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

2.2 Identification Strategy

The setting at hand lends itself to 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.

To test the impact of negative policy rates on firms financed with loans from differentially treated banks, we estimate the following baseline specification at the level of a syndicated loan granted to firm i at date t by euro-area lead arrangers j in the syndicate:

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

where y_{ijt} is an outcome variable reflecting, for instance, a firm/loan characteristic associated with firm i's loan provided by lead arrangers j at time t, such as firm risk or loan terms. To directly infer percent changes, we often use the dependent variable in logs. $Deposit\ ratio_j$ is the average ratio (in %) of deposits over total assets in 2013 across all euro-area lead arrangers j in the syndicate, $After(06/2014)_t$ is a dummy variable for the period from June 2014 onwards, X_{it} denotes firm-level control variables, namely country(-year) and industry(-

year) fixed effects, and δ_t and η_j denote month-year and bank fixed effects, respectively. Standard errors are clustered at the bank level.

The coefficient of interest is the difference-in-differences estimate β_1. For identification, we use a relatively short window around the June-2014 event, from January 2013 to December 2015. To control for between-month time trends and time-invariant unobserved bank heterogeneity, we always control for month-year and bank fixed effects. Bank fixed effects are included for all euro-area lead arrangers of a given loan, which underlie the calculation of the average $Deposit\ ratio_j$ in 2013. Thus, we effectively estimate the average effect associated with loans granted by banks with different average deposit ratios before and after June 2014.

In this setting, concerns regarding the identification of a causal chain from negative policy rates to bank lending are differences between high-deposit and low-deposit banks that affect their lending, and change when the policy rate becomes negative. For instance, central banks lower interest rates when the economy is doing badly, which is also when lending opportunities tend to be scarce and risky. This makes it potentially difficult to distinguish between our supply-side explanation, i.e., banks extending fewer loans but to riskier borrowers, and an alternative demand-side channel, i.e., fewer but riskier borrowers demanding credit in times of negative policy rates, especially from high-deposit banks.

We take several steps to mitigate such threats to identification. For example, we use the reduction of the deposit facility rate from 0.25% to zero in July 2012 as a placebo treatment, and show that high-deposit and low-deposit banks were not differentially affected in their lending behavior. We chose the policy-rate reduction in July 2012 because it was the last time the ECB lowered the DF rate prior to going negative. The rate reductions in early 2009 and late 2011 are unusual because they occurred at the height of the financial crisis and the sovereign debt crisis, respectively, and are therefore ill-suited for a placebo test. To implement the placebo test, we extend our sample to the period from January 2011 to December 2015, and include the interaction $Deposit\ ratio_j \times After(07/2012)_t$ in specification (1), where $After(07/2012)_t$ is a dummy variable for the period from July 2012 onwards. The placebo lends support to the idea that low-deposit banks deliver the counterfactual for high-deposit banks if policy rates had not become negative.

Furthermore, we exploit the granularity of our transaction-level data to better control for firm-level drivers of loan demand. For instance, we include borrowers' country-year and borrowers' industry-year fixed effects to capture any time-varying unobserved heterogeneity of borrowers that could be explained by their country or industry dynamics.

In our most restrictive specification, we unfold the structure of syndicated loans, and explain the shares retained by high-deposit and low-deposit banks for loans granted to the *same* borrower. This enables us to include firm-year fixed effects, thereby eliminating any time-varying unobserved heterogeneity at the firm level, including but not limited to loan demand.

We perform several additional robustness tests to establish a causal effect of negative policy rates on bank lending. First, 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 composition of borrowers. Importantly, we show that only the average deposit ratio of *euro-area lead arrangers*, but not that of non-euro-area ones, matters for the riskiness of non-euro-area borrowers following the introduction of negative policy rates. Second, only the ratio of household deposits, but not that of corporate deposits, matters for the exposure of banks to negative rates. This limits the scope for coincidental changes (other than negative policy rates) that could possibly affect the lending of high-deposit and low-deposit banks differentially. Third, we control for those bank characteristics that, according to the previous literature, matter for the transmission of (non-negative) policy rates. Finally, in the Online Appendix, we report that our results are robust to adding the instances of negative rates in Denmark, Sweden, and Switzerland. This renders it unlikely that some other omitted factor drives the results for the euro area.

2.3 Empirical Implementation and Data Description

All our data come from public sources. To link borrowers and lenders, and obtain loan-level information, we use data on 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. We consider the lead arrangers when identifying the types of banks that granted a loan. We determine their ratio of deposits over total assets at the bank-group level as our treatment-intensity measure.

In the top panel of Table 1, we present summary statistics for our baseline sample: 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. Note, furthermore, that all loans in our sample are floating-rate loans. Importantly, while roughly half of the loans in our sample have a unique lead arranger, the average number of lead arrangers is 3.6. The set of lead arrangers serves as the basis for $Deposit\ ratio_j$, which is the average ratio (in percentage points) of deposits over total assets in 2013 across relevant lead arrangers j in the syndicate of the loan to firm i. 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).[10]

Table 2 zooms in on any potential differences in bank characteristics between high-deposit and low-deposit banks, i.e., our treatment and control groups. High-deposit (low-deposit) banks are defined as banks in the highest (lowest) tercile of the deposit-ratio distribution. The average deposit ratio in the high-deposit group is almost three times as high as in the low-deposit group (61.13% vs. 21.58%). High-deposit banks are also smaller, have higher equity ratios (6.19 % vs 4.98%), higher loans-to-assets ratios (68.44% vs 39.92%), and higher net interest margins (1.53% vs. 0.78%). In our empirical setup, permanent differences between both groups are taken into account by including bank fixed effects. As such, only the variation over time of these variables could have an impact on our results.

[10] 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.

Although we conduct a number of formal robustness tests to address the concern of time-varying differences across banks with different deposit ratios, it is useful to examine raw bank characteristics of high-deposit and low-deposit banks over time. Reassuringly, the deposit ratio, our treatment-intensity variable, is fairly stable over time (Figure A.3a). To the extent that high-deposit banks experience a slight increase in the deposit ratio, we would somewhat underestimate the impact of negative policy rates on their lending behavior by using their 2013 deposit ratio. Banks' equity and securities ratios, both potentially important determinants of bank behavior, move roughly in parallel since 2011, well before the start of our sample period in 2013 (Figures A.3b and A.3c).

A concern may be that instead of charging negative deposit rates, high-deposit banks charge higher fees. Figure A.3d in the Online Appendix 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. The absence of higher fees charged by high-deposit banks potentially strengthens their treatment by the introduction of negative policy rates.

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 only 71 syndicated loans. The difference, however, 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 share retained by high- and low-deposit banks (in any capacity, i.e., as lead arrangers or participants) are significantly different.

Lastly, we characterize lending by focusing on the lead arrangers of a syndicated loan. Loan shares retained by lead arrangers typically are not sold off in the secondary market, so we can indeed assume that lead arrangers leave the loan on their books. However, in the subset of so-called leveraged loans, this may not necessarily be the case, even for lead shares.

Following the definition of leveraged loans in Bruche, Malherbe, and Meisenzahl (2017),[11] we find that high- and low-deposit banks relatively seldom, and not differentially so, hold loan facilities that one could label as leveraged loans (in our main sample, this concerns 194 out of 1,576 observations). All results in our paper are robust to dropping leveraged loans.

3 Results

We present our results in four main steps. First, we document the effect of negative policy rates on bank risk taking, as characterized by the ex-ante volatility of firms financed by euro-area banks. We then discuss the effect on the volume of bank lending, and further characterize the nature of bank risk taking alongside potential underlying mechanisms. Finally, we assess the real effects among loan-financed firms.

3.1 Effect of Negative Policy Rates on Bank Risk Taking

In 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. A one-standard-deviation increase in *Deposit ratio*$_j$ (= 9.45 percentage points) translates into a 16% increase in ROA volatility ($9.45 \times 0.017 = 0.161$), which is substantial.

Figure 3 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-

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

deposit banks (treated group) and low-deposit banks (control group) move in parallel.[12] It decreases, with high-deposit 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 (column 4), we increase the difference-in-differences estimate from 0.017 to 0.020.

In column 5, we extend the sample to the period from January 2011 to December 2015, and include the interaction $\textit{Deposit ratio}_j \times After(07/2012)_t$ to test the (placebo) impact of reducing policy rates to zero in July 2012. In line with our logic – banks' reluctance to charge negative deposit rates only matters when the policy rate actually becomes negative – the coefficient on the placebo treatment (of lower but still non-negative rates) is close to zero and insignificant. The placebo indicates that low-deposit banks are a valid control group in our setting.

In the last two columns of Table 3, we reduce the sample to European borrowers outside the euro area.[13] The idea is to filter out the impact of euro-area economic conditions that might simultaneously affect euro-area monetary policy and borrowers. Moreover, the loan demand of non-euro-area firms should be less affected by economic conditions and policies in the euro area, other than through trade and other connections to euro-area firms.

In column 6, the coefficient on our treatment $\textit{Deposit ratio}_j \times After(06/2014)_t$ is stronger, while the coefficient on the placebo $\textit{Deposit ratio}_j \times After(07/2012)_t$ 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.

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

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

In column 7, we perform a falsification test using *non-euro-area lenders* to non-euro-area borrowers.[14] 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. In line with our expectation, the coefficient on the treatment variable *Deposit* $ratio_j \times After(06/2014)_t$ becomes much smaller and insignificant.

We provide several robustness checks in Table 4. In the first column, we exclude government entities and an insurance company with the lowest deposit ratios from the definition of *Deposit* $ratio_j$. The difference-in-differences estimate is unchanged.[15]

Next, we ensure that our findings are robust to alternative definitions of our treatment-intensity variable. In the second column, our difference-in-differences estimate is robust to using the ratio of deposits over total liabilities (rather than assets). 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.

One possible concern is that the introduction of negative policy rates in June 2014 coincides with other events that affect the risk taking of banks differentially according to their deposit ratio. As long as other coincidental events affect the risk taking of high-deposit and low-deposit banks in the same way, these other concurrent policy measures are differenced out. 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 bonds (for a total monthly amount of initially €60bn). Although it is not clear ex ante why the PSPP would impact bank risk taking differentially according to the deposit ratio of banks, we address this potential confound by shortening our sample period and setting its

[14] 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.

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

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.

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 differentially (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.[16] As a result, it is unlikely that TLTROs are driving our findings.

To more formally rule out possible coincidental confounds, we provide more granular evidence of our specific identification mechanism in columns 3 and 4 of Table 4, using confidential data from the Single Supervisory Mechanism (SSM). Our mechanism relies on banks' reluctance to charge negative deposit rates. The reluctance should be stronger for household deposits than for corporate deposits. Households typically find it easier to withdraw their deposits, and either relocate them to another bank or hold cash, because they have fewer and much smaller deposit accounts. In contrast, neither the LCR, the PSPP, nor the TLTROs should affect household and non-financial-corporation deposits differentially. In other words, in the (unlikely) event that (i) these policy measures coincide sufficiently with the setting of

[16] 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.

negative policy rates and (ii) their impact on lending depends on banks' funding structure, the *type* of deposits should not play any role.[17] On the other hand, a stronger effect for household deposits would confirm that we are effectively capturing the impact of negative policy rates, as the withdrawal risk is higher for household deposits.

In column 3 of Table 4, 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 those syndicates in which all lead arrangers come from this group of 43 banks. We re-run our baseline regression specification with two separate deposit ratios, one for household deposits and the other for non-financial-corporation deposits. 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.

Our placebo test suggests that low-deposit banks provide a valid counterfactual for the treated high-deposit banks had the policy rate not become negative. We refine the comparison between the treated and the control group in columns 5 to 8 of Table 4 by adding control variables. In columns 5, 6, and 7, we add size, the securities ratio, and the equity ratio, respectively. The previous literature identifies these balance-sheet characteristics as important for the transmission of monetary policy. In column 8, we include all these control variables together with our placebo treatment. In this manner, we compare high-deposit and low-deposit banks, holding constant these other balance-sheet characteristics. Adding control variables leaves the difference-in-differences estimate virtually unchanged.

We also ensure that our results are not driven by our choice of how to measure the ex-ante risk of borrowers. Moreover, lenders may care about the risk of their debt claim rather than the risk of the overall firm. 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). Last, we multiply the standard deviation of the return on assets of the borrowing firm with

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

its leverage in year $t-1$ (Table B.6 of the Online Appendix). This way, a firm with volatile profits and low leverage has less risk than a firm with volatile profits and high leverage. None of these alternative risk measures changes our main finding.

Finally, we expand our sample to include the introduction of negative rates in Denmark, Sweden, and Switzerland.[18] Again, high-deposit banks engage in more risk taking when policy rates become negative (Table B.7 in the Online Appendix). The extra, staggered number of treatments makes it unlikely that, despite our numerous robustness tests, there may be still some omitted factor in June 2014 that drives the risk taking of high-deposit banks.

3.2 Impact on Bank Lending

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 5 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 5, we regress the log of the total volume of newly issued syndicated loans at the bank-month-year level on the interaction $\textit{Deposit ratio}_j \times After(06/2014)_t$ and $\textit{Deposit ratio}_j$, which is replaced by bank fixed effects in the second column. In the last column, we extend our sample period to include the placebo treatment ($\textit{Deposit ratio}_j \times After(07/2012)_t$). The difference-in-differences estimate is negative and significant (at the 5% level in columns 1 and 3, and at the 10% level in column 2) across all specifications. Taking the estimate from the last 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 decrease in lending of 13% ($14.76 \times 0.009 = 0.133$).[19] In contrast, the coefficient on the placebo treatment is insignificant.

[18] 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.

[19] The effect is also visible in the raw data when plotting lending by high- and low-deposit banks over time in Figure A.4.

To eliminate any remaining concern about time-varying differences in lending opportunities between banks with different deposit ratios, we examine the lending of these banks to the *same* borrower in Table 6. For this purpose, we move our analysis to the loan-bank level. That is, for each syndicated loan, we now have multiple observations that record each (participating or lead) bank's loan share. To keep the borrower constant across different types of banks, we include firm-year fixed effects, and change the dependent variable to the *share* of a syndicated loan retained by a bank. We use bank-firm fixed effects, so that the treatment effect ($Deposit\ ratio_j \times After(06/2014)_t$) is identified by comparing the same banks that lend to the same firm before and after June 2014.[20] Finally, we add banks' country-year fixed effects to control for time-varying differences across banks driven by factors at the level of their home countries.

In the first column of Table 6, we run this within-borrower specification, and find a negative and significant difference-in-differences estimate. Not only do high-deposit banks reduce the total volume of syndicated loans they grant once the policy rate becomes negative (Table 5), but they also reduce their share in syndicated loans to the same firm. As before, we find no significant effect for our placebo treatment (column 2).

In columns 3 to 6 of Table 6, we use the within-borrower specification to test the robustness of our risk-taking results. To do this, we sort borrowers into the bottom and top halves according to their ROA volatility (our baseline measure of ex-ante risk). Within safe borrowers, high-deposit banks reduce their loan shares (column 3), while within risky borrowers, they increase their loan shares (column 4). We repeat the same exercise using firms' loan spreads on previous syndicated loans (prior to our sample period) in the last two columns.[21] Again, we find that high-deposit banks reduce their loan share within safe borrowers with low previous loan spreads (column 5), *but not* within borrowers with higher previous loan spreads (column 6). Overall, these results using loan shares confirm our previous finding on

[20] Note that these banks are not necessarily part of the same syndicate, nor are they all lead arrangers now.

[21] 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.

bank risk taking: the riskiness of the loan portfolio of high-deposit banks increases when the policy rate becomes negative.

3.3 Characterizing the Nature of Bank Risk Taking

In this section, we characterize the nature of bank risk taking by examining loan terms and the role of bank capitalization. Moreover, we show the external validity of our findings beyond the sample of syndicated loans. Our results indicate that setting negative policy rates constitutes an adverse shock to the net worth of high-deposit banks, thereby increasing agency problems, e.g., banks take risk through less costly screening and monitoring of loans.

High-deposit banks lend less and to riskier borrowers once the policy rate becomes negative. But does this lending behavior lead to higher loan rates charged? If not, then one can view the behavior of high-deposit banks as "true risk taking." High-deposit banks do not offset a potentially higher probability of loan default with a higher loan rate. If, instead, high-deposit banks charged higher loan rates, then one could view their lending behavior as a "search for yield" (see Rajan (2005)).[22]

To distinguish risk taking from a search for yield, we re-estimate regression specification (1) with the all-in-drawn spread as the dependent variable y_{ijt}, and present the results in Table 7. The five columns replicate the specifications in the first five columns of Table 3, i.e., different fixed effects and the placebo. 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).

[22] Dell'Ariccia, Laeven, and Marquez (2014) and Dell'Ariccia, Laeven, and Suarez (2017) provide more detail on the distinction between bank risk taking and search for yield when interest rates change. Risk taking is more likely when a financial institution has long-term assets and short-term liabilities, like a bank. 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 (as in Kacperczyk and Di Maggio (2017)).

In Table B.9 of the Online Appendix, we further investigate the nature of bank risk taking. 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 shows that high-deposit banks do little to counteract a potentially higher probability of loan default.

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 8, we re-run our baseline specification from the fourth column 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 remains to hold true when we add the placebo treatment in the last two columns.

To show that our results are not only internally valid in the market for syndicated loans but also exhibit external validity, we provide further evidence for our proposed mechanism at the overall bank level. So far, we have characterized banks' lending behavior under negative policy rates using syndicated loans, because this allows us to link borrowers and lenders. 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.[23]

Central to our argument is the adverse effect of a negative policy rate on the net worth of high-deposit banks. For a subsample of 30 listed banks we can use stock prices as a proxy for their net worth. Figure 4 shows an (unweighted) stock price index for banks in the highest

[23] 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)).

and the lowest tercile of the deposit-ratio distribution. The stock prices of high-deposit and low-deposit banks evolve strikingly similar between January 2013 and May 2014, prior to the introduction of negative policy rates. But there is a clear disconnect since June 2014: high-deposit banks perform worse since the policy rate becomes negative, which is in line with our argument.

The first two columns of Table 9 confirm the adverse effect on the net worth of high-deposit banks. The columns show bank-level regressions, with a bank's monthly stock return as the dependent variable (the sample ends in February 2015 to exclude the market's reaction to the ECB's public sector purchase program starting in March 2015). We find significantly lower stock returns for banks with a higher deposit ratio after the introduction of negative rates in June 2014 (but not after lower positive rates in July 2012, our placebo). In terms of economic significance, a one-standard-deviation increase in a bank's deposit ratio (= 16.63 percentage points in this particular sample) corresponds to a stock-return drop of 1.26 percentage points ($= 16.63 \times 0.076$) in a month.

Similarly, we also inspect the external validity of our results on risk taking using the market's view of bank behavior. In the third and fourth column of Table 9, we re-run the bank-level regressions of the first two columns using the log of the (unlevered) monthly standard deviation of daily bank stock returns as the dependent variable. In the last two columns, we repeat the exercise using banks' credit-default swap (CDS) returns. Both market-based risk measures confirm that high-deposit banks become riskier (relative to low-deposit banks) after the introduction of negative policy rates in June 2014, but not after lower positive rates in July 2012 (the placebo).

3.4 Real Effects

In this section, we document the characteristics and investment behavior of borrowers. Our results indicate that the risk taking by high-deposit banks is not necessarily an undesirable outcome as it appears to relax credit constraints. At the same time, however, the negative policy rate changes the allocation of borrowers (with different risk) and lenders (with different deposit ratios) in the banking sector.

In Tables 10 and 11, we examine whether high-deposit banks take risk by lending to new borrowers. We restrict the observations after June 2014 to syndicated loans of firms that had no outstanding syndicated loan between January 2013 and June 2014. To the extent that these risky firms did not borrow before the policy rate is negative because they were unable to do so, the ability to borrow after June 2014 is a positive effect of the greater risk taking by high-deposit banks.

The results in Table 10 are very similar to our full-sample results in Table 3. High-deposit banks indeed lend to riskier new borrowers after June 2014. In Table 11, we examine the impact of negative policy rates on the size of loans to new borrowers. On average, high-deposit banks do not grant larger loans to new borrowers than low-deposit banks (columns 1 to 4). But they do grant larger loans to *riskier* new borrowers, as shown by the positive and significant coefficient on the interaction term of the treatment, $\textit{Deposit ratio}_j \times After(06/2014)_t$, and our baseline measure of firm risk, $\sigma(ROA_i)^{5y}$.

In Tables B.10 and B.11 of the Online Appendix, we repeat the analysis for existing borrowers, i.e., firms that borrowed in the syndicated-loan market both before and after June 2014. While high-deposit banks also lend to riskier existing borrowers, they do not provide them with larger loans.

High-deposit banks lend less overall (Table 5), and yet lend to new risky firms, granting them larger loans (Tables 10 and 11). This begs the question what happens to safe firms that borrowed from high-deposit banks prior to June 2014. Do they obtain loans from other, i.e., low-deposit, banks? Figure 5 shows that this is indeed the case. When plotting the ROA volatility of firms that switch banks once the policy rate becomes negative against the difference in the average 2013 deposit ratio of their lenders, we see a positive relationship. Safe borrowers switch to banks with lower deposit ratios, while risky borrowers switch to banks with higher deposit ratios.

We investigate the characteristics of borrowers, other than risk, in Table 12. 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. As private firms are typically seen as more credit constrained than public firms, which have access to other sources of financing, the risk taking appears to expand the availability of credit.

The third column of Table 12 supports the interpretation of greater credit availability to some firms. The dependent variable is now the leverage (debt-to-assets ratio) of the loan-financed firm, measured in the year before receiving the loan. The negative and significant difference-in-differences estimate indicates that high-deposit banks lend more to low-leverage firms than low-deposit banks do once the policy rate becomes negative. The low leverage of these borrowers is consistent with them not having been able to borrow before.

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 the fourth column of Table 12, we interact the treatment $\textit{Deposit ratio}_j \times After(06/2014)_t$ with an indicator variable $\textit{Exposure}_{ij}$ 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.

The risk taking of high-deposit banks does not look like "zombie" lending, i.e., giving new loans to a firm in order to avoid default on existing debt. The dependent variable in the last column of Table 12 is the return on assets of the loan-financed firm, 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. Both sets of firms are should be equally able to use internal funds to repay existing debt.

Finally, the risk taking of high-deposit banks spurs borrower investment. In Table 13, the dependent variable is the one-year difference in the logged value of a firm's investment, as measured by the change in tangible fixed assets, after a loan is granted. We distinguish between safe and risky borrowers according to whether they are in the top or bottom tercile of the distribution of ROA volatility. We know that high-deposit banks lend more to riskier firms under negative policy rates (see, e.g., Tables 3 and 11). Column 2 of Table 13 shows that the risky firms borrowing from high-deposit banks invest more than the risky firms borrowing from low-deposit banks. For safe firms, it does not matter whether they borrow from high-deposit or low-deposit banks (column 1). Once we enlarge the sample period to include the placebo treatment in July 2012, the difference-in-differences estimate remains small and insignificant for safe borrowers (column 3), while it loses significance but remains large and positive for risky borrowers (column 4).

4 Conclusion

When central banks charge negative policy rates to stimulate a post-crisis economy, 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. At first glance, the transmission of negative policy rates appears contractionary rather than accommodative, contradicting conventional wisdom about how policy-rate changes transmit to the real economy via bank lending. We explain how the conventional view, when augmented by banks' reluctance to charge negative rates on deposits, can still explain the transmission of negative policy rates.

Although high-deposit banks lend less, their risk taking overcomes rationing. Firms that did not borrow before receive loans from high-deposit banks. The firms that receive new loans appear financially constrained, and do not resemble "zombie" firms. Moreover, upon receiving a new loan, risky firms experience a higher growth rate of investment. Negative policy rates may therefore stimulate the economy in an unexpected but crucial way.

Our results also indicate potential costs of negative policy rates in terms of financial stability. The risk taking by banks we identify is consistent with an increase in the moral hazard of managing loans. The market subsequently views high-deposit banks as less valuable and riskier under negative rates. In addition, negative rates change the matching of borrowers and lenders. It is, however, an open question whether it is efficient when risky firms borrow from high-deposit banks, while safe firms borrow from low-deposit banks.

Standard interest-rate policy does not have to stop at zero. Negative policy rates can stimulate the economy, even though there are financial-stability concerns and the long-term consequences are unclear. Therefore, if additional monetary stimulus is needed in the future, setting negative rates is a valuable option for policymakers. This may be even more so when the case for extraordinary, and highly controversial, measures – such as large-scale asset purchases or the provision of unlimited amounts of reserves – is not strong enough (Bernanke (2016)).

References

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

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

Angeloni, I., E. Faia, and M. Lo Duca (2015): "Monetary Policy and Risk Taking," *Journal of Economic Dynamics and Control*, 52(C), 285–307.

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

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

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

——— (2016): "What Tools Does the Fed Have Left? Part 1: Negative Interest Rates," *Entry on Ben Bernanke's blog at The Brookings Institution on March 18, 2016.*

Bernanke, B. S., and M. Gertler (1989): "Agency Costs, Net Worth, and Business Fluctuations," *American Economic Review*, 79(1), 14–31.

——— (1995): "Inside the Black Box: The Credit Channel of Monetary Policy Transmission," *Journal of Economic Perspectives*, 9(4), 27–48.

BIS (2013): "Basel III: The Liquidity Coverage Ratio and Liquidity Risk Monitoring Tools," *Basel Committee on Banking Supervision.*

Boivin, J., M. Kiley, and F. S. Mishkin (2010): "How Has the Monetary Transmission Mechanism Evolved over Time?," in *Handbook of Monetary Economics*, ed. by B. M. Friedman, and M. Woodford, pp. 369–422. Elsevier, New York, NY.

Bruche, M., F. Malherbe, and R. Meisenzahl (2017): "Pipeline Risk in Leveraged Loan Syndication," *Cass Business School Working Paper.*

Brunnermeier, M. K., and Y. Koby (2017): "The Reversal Interest Rate: An Effective Lower Bound on Monetary Policy," *Princeton University Working Paper.*

Carney, M. (2016): "Inflation Report Q&A," Bank of England press conference, August 4, 2016.

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

Chodorow-Reich, G. (2014): "Effects of Unconventional Monetary Policy on Financial Institutions," *Brookings Papers on Economic Activity*, 45(1), 155–227.

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

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

Dell'Ariccia, G., L. Laeven, and G. A. Suarez (2017): "Bank Leverage and Monetary Policy's Risk-Taking Channel: Evidence from the United States," *Journal of Finance*, 72(2), 613–654.

Di Maggio, M., A. Kermani, and C. Palmer (2016): "How Quantitative Easing Works: Evidence on the Refinancing Channel," *NBER Working Paper No. 22638*.

Drechsler, I., A. Savov, and P. Schnabl (2017): "The Deposit Channel of Monetary Policy," *Quarterly Journal of Economics*, forthcoming.

Driscoll, J. C., and R. Judson (2013): "Sticky Deposit Rates," *Federal Reserve Board Working Paper*.

Ferrando, A., A. Popov, and G. F. Udell (2015): "Sovereign Stress, Unconventional Monetary Policy, and SME Access to Finance," *ECB Working Paper No. 1820*.

Gomez, M., A. Landier, D. Sraer, and D. Thesmar (2016): "Banks' Exposure to Interest Rate Risk and the Transmission of Monetary Policy," *UC Berkeley Working Paper*.

Hannan, T., and A. Berger (1991): "The Rigidity of Prices: Evidence from the Banking Industry," *American Economic Review*, 81(4), 938–945.

Hellmann, T. F., K. C. Murdock, and J. E. Stiglitz (2000): "Liberalization, Moral Hazard in Banking, and Prudential Regulation: Are Capital Requirements Enough?," *American Economic Review*, 90(1), 147–165.

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

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

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

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

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

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

Kacperczyk, M. T., and M. Di Maggio (2017): "The Unintended Consequences of the Zero Lower Bound Policy," *Journal of Financial Economics*, 123(1), 59–80.

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

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

Keeley, M. C. (1990): "Deposit Insurance, Risk, and Market Power in Banking," *American Economic Review*, 80(5), 1183–1200.

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

Paligorova, T., and J. A. C. Santos (2017): "Monetary Policy and Bank Risk-Taking: Evidence from the Corporate Loan Market," *Journal of Financial Intermediation*, 30, 35–49.

Praet, P. (2014): "Current Issues of Monetary Policy," Speech, 8th Kiel Institute Summer School on Economic Policy, July 3, 2014.

Rajan, R. G. (2005): "Has Financial Development Made the World Riskier?," in *Proceedings, Federal Reserve Bank of Kansas City*, pp. 313–369.

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

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

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

Stein, J. C. (1998): "An adverse-selection Model of Bank Asset and Liability Management with Implications for the Transmission of Monetary Policy," *RAND Journal of Economics*, 29, 466–486.

5 Figures

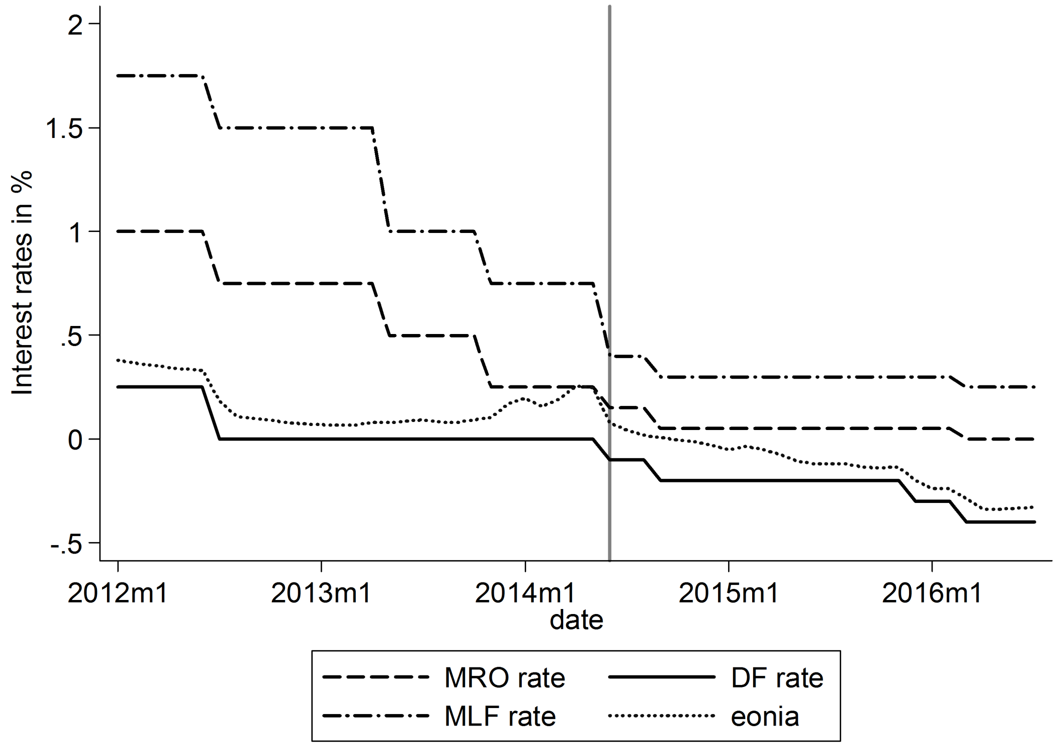


Figure 1: **ECB Key Policy Rates and Interbank Lending Rate.** This figure shows the evolution of the ECB Marginal Lending Facility (MLF) rate, the ECB Main Refinancing Operations Rate (MRO) rate, the ECB Deposit Facility (DF) rate, and the Euro OverNight Index Average (Eonia) rate between January 2012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

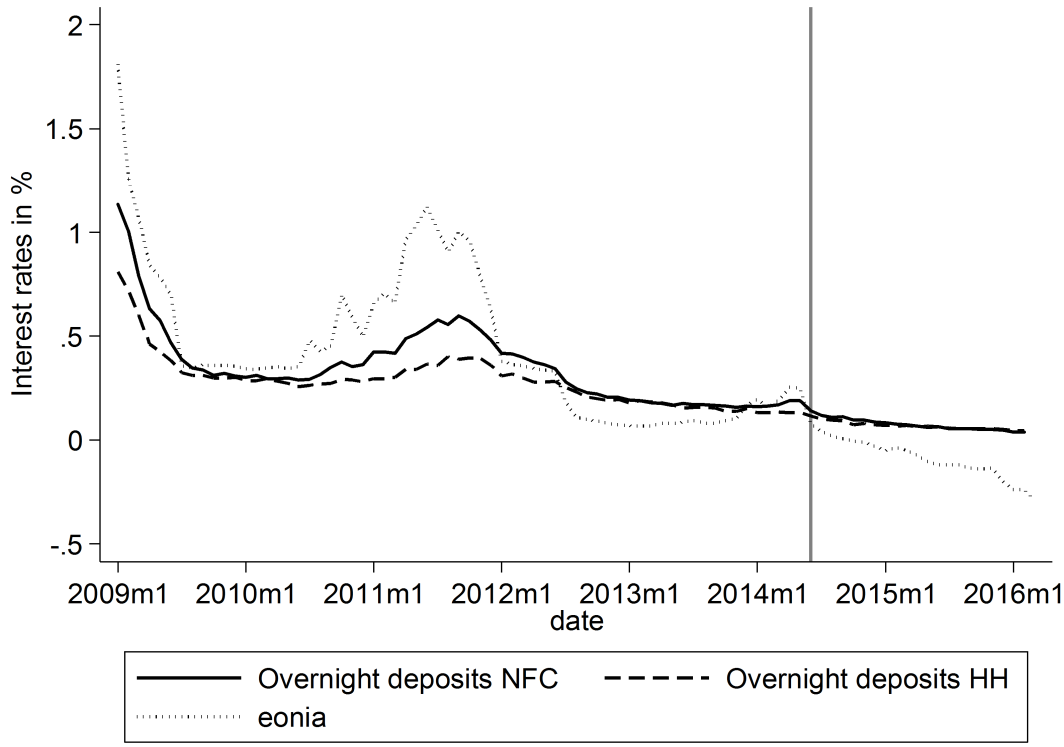


Figure 2: **Deposit Rates on Overnight Deposits (Households and Non-financial Corporations).** This figure shows the evolution of the median overnight deposit rates at euro-area banks between January 2009 and March 2016, in comparison to the Euro OverNight Index Average (Eonia) of overnight unsecured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

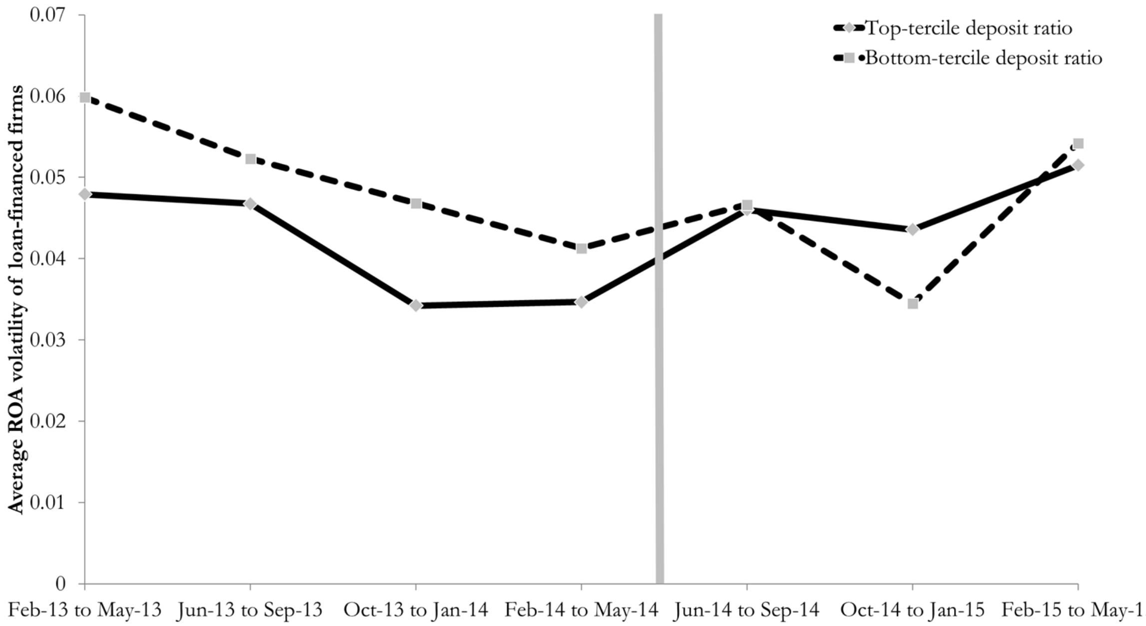


Figure 3: **ROA Volatility of Firms Associated with Loans Granted by Banks with High vs. Low Deposit Ratios.** This figure plots the four-month (forward-looking) average of ROA volatility of both private and publicly listed firms that received loans from euro-area lead arrangers in the top (solid line)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

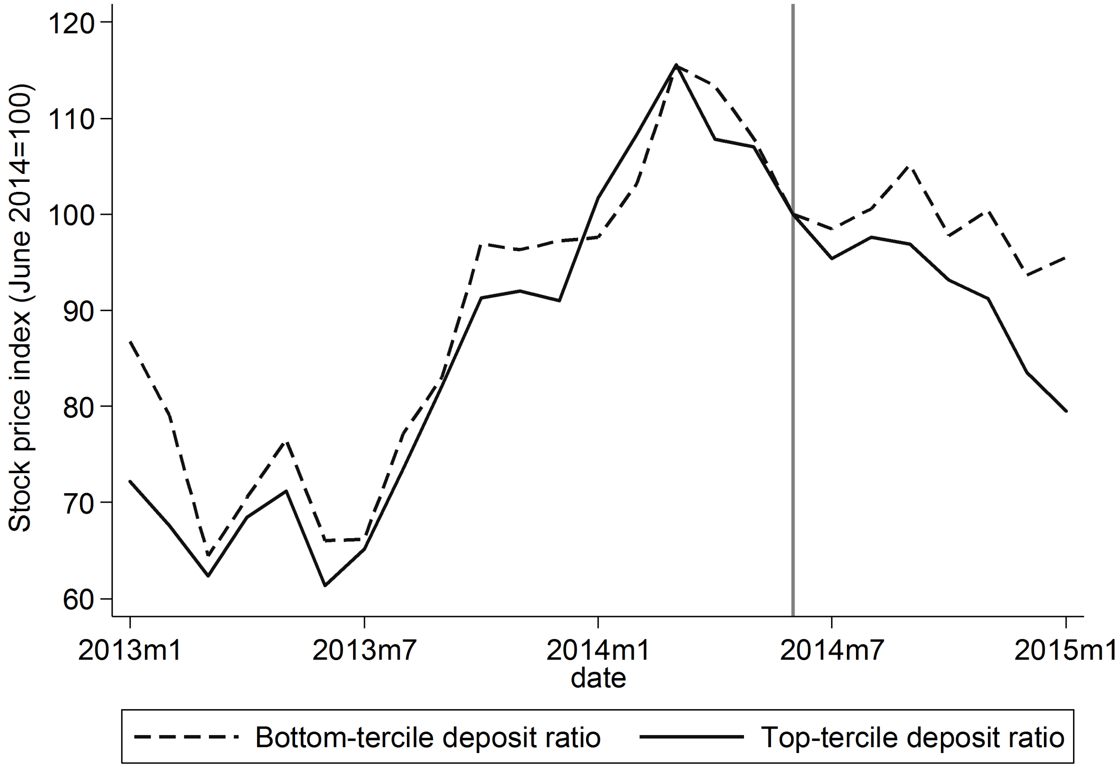


Figure 4: **Stock Price Index of Listed Banks with High vs. Low Deposit Ratios.** This figure shows the evolution of a monthly stock price index (June 2014 = 100) for the listed euro-area banks in our sample between January 2013 and February 2015. We calculate a price index for each bank, and plot the 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.

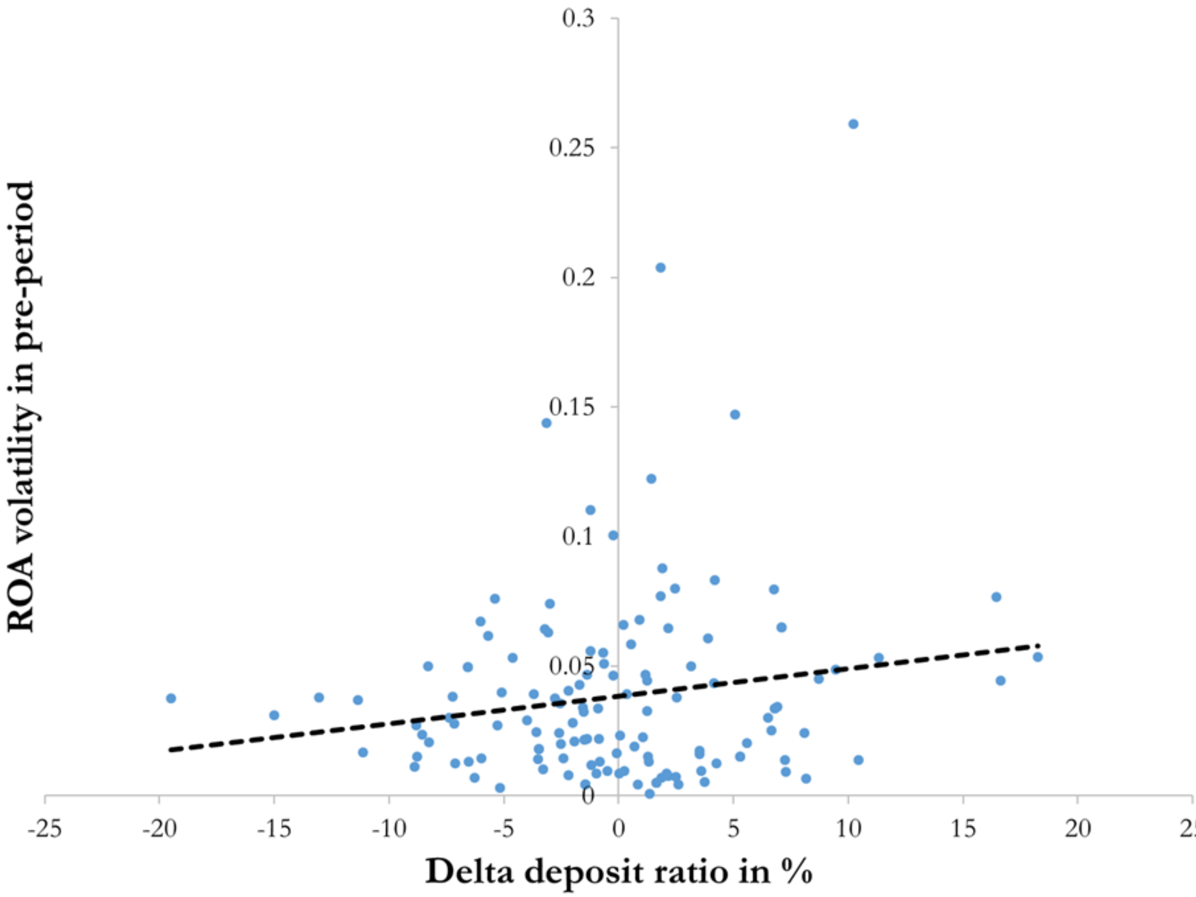


Figure 5: **ROA Volatility of Firms Switching Banks.** The sample consists of both private and publicly listed firms that received at least one loan in both the period from January 2013 leading up to June 2014 (pre-period) and in the period thereafter until December 2015 (post-period). This figure plots firms' ex-ante riskiness, as measured by their ROA volatility in the pre-period, against the difference in the average 2013 deposit ratio of euro-area lenders from which firms received loans in the post-period vs. pre-period. The figure furthermore includes only firms that had a non-zero change in said average deposit ratio between the pre-period and the post-period, i.e., firms switching banks.

6 Tables

Table 1: **Summary Statistics**

Loans sample	Mean	Std. dev.	Min	Max	N
$\sigma(ROA_i)^{5y}$	0.041	0.046	0.001	0.488	1,576
$\sigma(return_i)^{36m}$	0.085	0.036	0.030	0.329	665
ROA in %	4.351	9.144	-98.060	80.010	1,576
Leverage in %	35.902	20.147	0.000	99.985	1,569
No. of employees in thousands	21.687	56.339	0.000	610.989	1,456
Deposit ratio in %	40.793	9.452	0.486	64.527	2,450
Equity ratio in %	5.369	1.088	3.398	13.608	2,450
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: **Further Bank-level Summary Statistics**

	Tercile	N	Mean	Std. dev	t-stat
Deposit ratio in %	Bottom	23	21.58	12.60	13.82
	Top	23	61.13	6.04	
Equity ratio in %	Bottom	23	4.98	2.26	1.94
	Top	23	6.19	2.04	
ln(Total assets)	Bottom	23	12.22	1.61	2.00
	Top	23	11.46	0.94	
Loans-to-assets ratio in %	Bottom	23	39.92	17.97	6.75
	Top	23	68.44	8.56	
Return on assets in %	Bottom	23	0.04	0.44	0.54
	Top	23	0.17	1.05	
Net interest margin in %	Bottom	23	0.78	0.44	4.98
	Top	23	1.53	0.57	
Number of loans 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
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: **ROA Volatility of Firms Financed by Banks Following Negative Policy Rates – Robustness**

	$\ln(\sigma(ROA_i)^{5y})$							
Sample	2013 – 2015							2011 – 2015
Robustness	No low deposits	Alternative deposit ratio	Deposit decomposition, any coverage	Deposit decomposition, full coverage				
Deposit ratio × After(06/2014)	0.020***	0.019***			0.021***	0.023***	0.019***	0.020***
	(0.006)	(0.005)			(0.005)	(0.006)	(0.006)	(0.006)
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)
$\ln(\text{Assets})_{t-1}$					0.082			0.078
					(0.059)			(0.054)
Securities ratio_{t-1}						0.009**		0.000
						(0.004)		(0.005)
Equity ratio_{t-1}							0.036	0.056
							(0.054)	(0.039)
Bank FE	Y	Y	Y	Y	Y	Y	Y	Y
Month-year FE	Y	Y	Y	Y	Y	Y	Y	Y
Country-year FE	Y	Y	Y	Y	Y	Y	Y	Y
Industry-year FE	Y	Y	Y	Y	Y	Y	Y	Y
N	1,571	1,576	1,500	763	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 seven columns and from January 2011 to December 2015 in the last column. The dependent variable is the logged five-year standard deviation of firm i's return on assets (ROA, using P&L before tax) from year $t-5$ to $t-1$. In the first column, *Deposit ratio*$_j$ is the average ratio (in %) of deposits over total assets across all 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 corporations') 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 $t-1$. $Securities\ ratio_{j,t-1}$ is the average ratio (in %) of securities over total assets across all euro-area lead arrangers j in year $t-1$. $Equity\ ratio_{j,t-1}$ is the average ratio (in %) of equity over total assets across all euro-area lead arrangers j in year $t-1$. $After(06/2014)_t$ 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 5: **Impact of Negative Policy Rates on Total Bank Lending**

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

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

Table 6: **Impact of Negative Policy Rates on the Development of Loan Shares within Bank-firm Relationships**

	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
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 7: **Impact of Negative Policy Rates on Loan Spreads**

	ln(All-in-drawn spread)				
Sample	2013 – 2015				2011 – 2015
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 8: **Negative Policy Rates and Firms' ROA Volatility: Interaction of Treatment with Bank Capitalization**

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

Notes: The sample consists of all completed syndicated loans (package level) of both private and publicly listed firms i at date t granted by any 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 9: **Bank-level Stock Returns, Stock-return Volatility, and CDS Returns**

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

Notes: The level of observation is a bank's month-year. In the first four columns, we use stock-market data on 30 listed banks, from January 2013 to February 2015 in the first and third column, and from January 2011 to February 2015 in the second and fourth column. The dependent variable in the first two columns is the monthly stock return (in %) at the bank level and the logged unlevered monthly standard deviation of bank stock returns in the third and fourth column. For each bank, the monthly standard deviation is calculated using daily stock returns. Standard deviations are unlevered by multiplying them with the ratio of bank equity over total assets. In the last two columns, we use monthly CDS-spread returns (in %) for 36 banks. The sample period runs from January 2013 to February 2015 in the fifth column, and from January 2011 to February 2015 in the last column. *Deposit ratio$_j$* is bank j's ratio (in %) of deposits over total assets in 2013. $After(06/2014)_t$ is a dummy variable for the period from June 2014 onwards. $After(07/2012)_t$ is a dummy variable for the period from July 2012 onwards. Robust standard errors (clustered at the bank level) are in parentheses.

Table 10: **ROA Volatility of Firms Financed by Banks Following Negative Policy Rates: New Borrowers**

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

Notes: The sample consists of all completed syndicated loans (package level) of both private and publicly listed firms i at date t granted by any euro-area lead arranger(s) j from January 2013 to December 2015, where borrowers that received a loan (from a euro-area lender) in the period from June 2014 onwards had no outstanding syndicated loan (from any bank) in the period leading up to June 2014. The dependent variable is the logged five-year standard deviation of firm i's return on assets (ROA, using P&L before tax) from year $t-5$ to $t-1$. $Deposit\ ratio_j$ is the average ratio (in %) of deposits over total assets across all 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.

Table 11: **Impact of Negative Policy Rates on Loan Size: New Borrowers**

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

Notes: The sample consists of all completed syndicated loans (package level) of both private and publicly listed firms i at date t granted by any euro-area lead arranger(s) j from January 2013 to December 2015, where borrowers that received a loan (from a euro-area lender) in the period from June 2014 onwards had no outstanding syndicated loan (from any bank) in the period leading up to June 2014. 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 12: **Impact of Negative Policy Rates on Banks' Loan Portfolio**

Sample	$\ln(\sigma(ROA_i)^{5y})$ Private firms	$\ln(\sigma(ROA_i)^{5y})$ Public firms	$Leverage_{i,t-1}$	$\ln(\sigma(ROA_i)^{5y})$ Private and public firms	$ROA_{i,t-1}$
Deposit ratio × After(06/2014)	0.027***	0.011	-0.238**	0.012*	-0.036
	(0.009)	(0.007)	(0.110)	(0.007)	(0.083)
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	1,569	1,576	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 fourth 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 leverage in year $t-1$, measured in % ($\in [0, 100]$). The dependent variable in the fifth column is firm i's return on assets (ROA, using P&L before tax) 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: **Real Effects of Negative Policy Rates: Investment**

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

Notes: The sample consists of all completed syndicated loans (package level) of both private and publicly listed firms i at date t granted by any euro-area lead arranger(s) j, from January 2013 to December 2014 in the first two columns and from January 2011 to December 2014 in the last two columns. In the first and third (second and fourth) column, the sample is limited to borrower firms in the bottom (top) tercile of the distribution of the five-year standard deviation of firms' return on assets (ROA, using P&L before tax) from year $t-5$ to $t-1$. The dependent variable is the difference (between year $t+1$ and t) in the logged value of firm i's investment, where investment is measured as the change in tangible fixed assets between year t and $t-1$. *Deposit ratio*$_j$ is the average ratio (in %) of deposits over total assets across all 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.

Supplementary Appendix (Not for Publication)

A Supplementary Figures

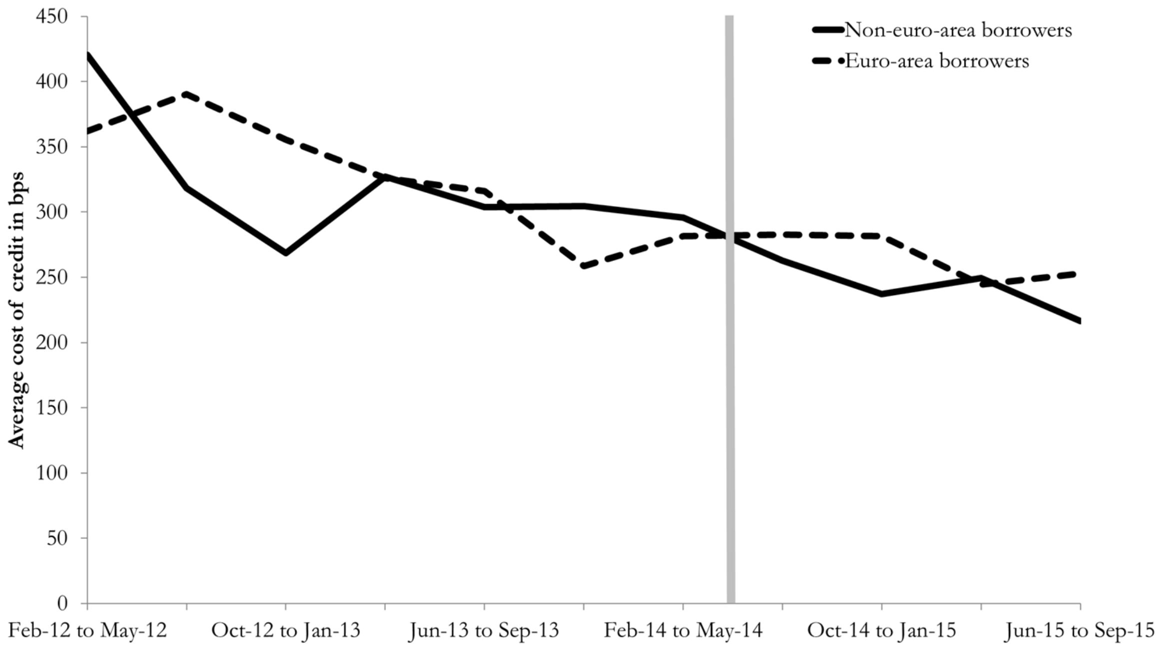


Figure A.1: **Evolution of Cost of Debt for Syndicated Loans Granted by Euro-area Banks.** This figure plots the four-month (forward-looking) average of the total cost of credit charged by euro-area lead arrangers in syndicated loans, separately for euro-area and non-euro-area borrowers. The data are taken from the DealScan database.

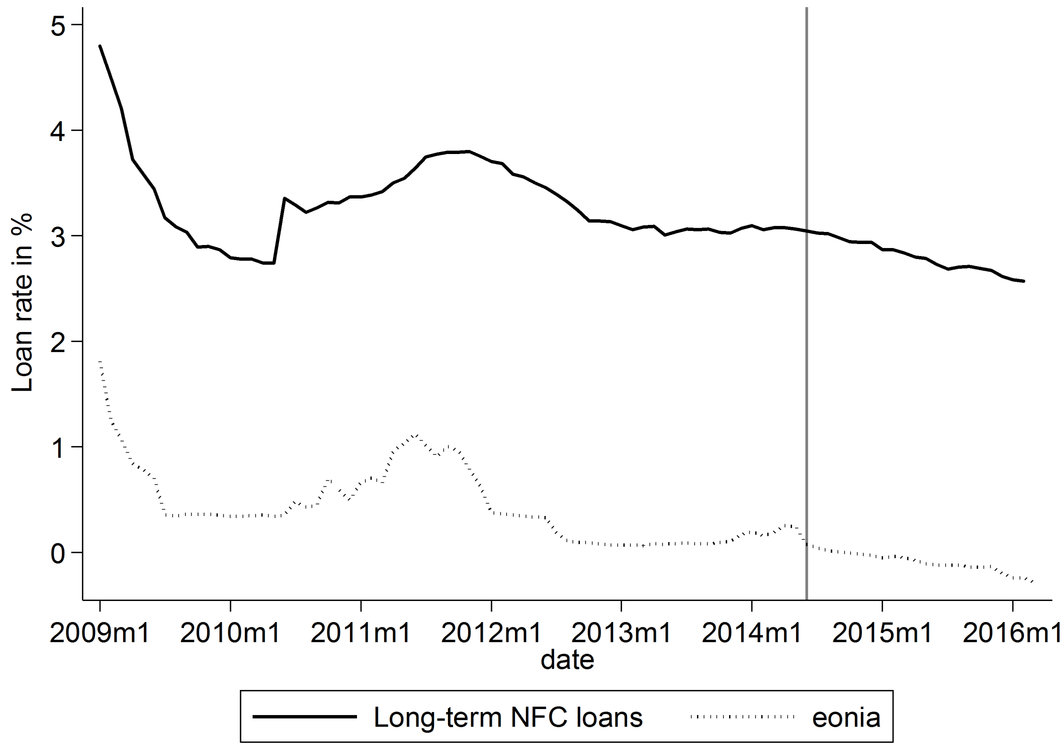
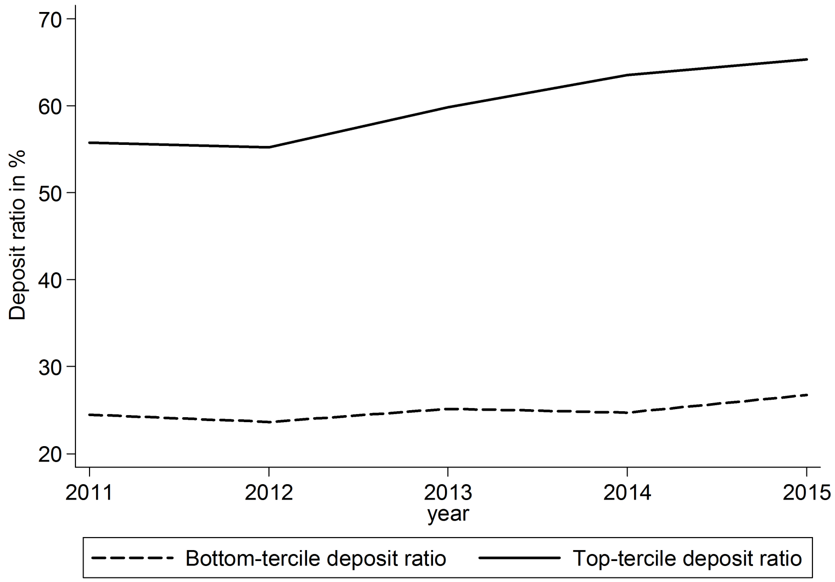
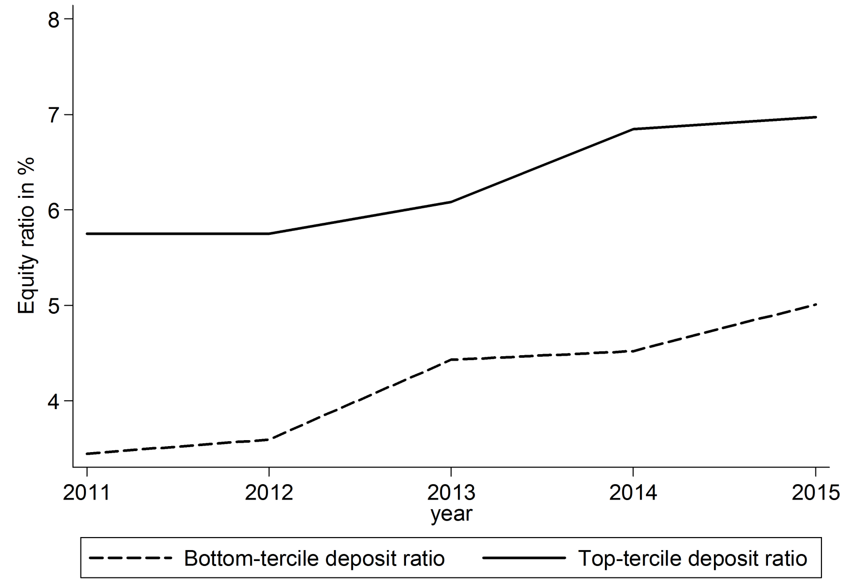


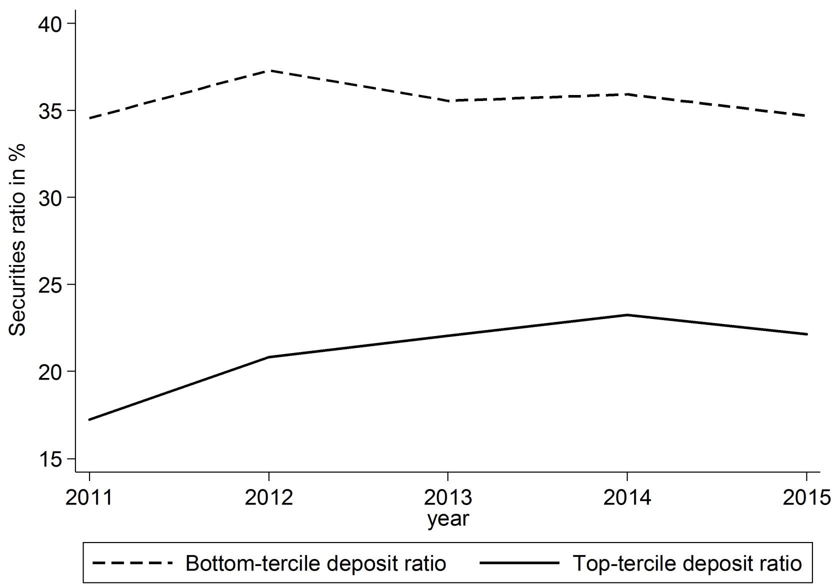
Figure A.2: **Loan Rates on Long-term (>5y) Loans (NFCs).** The solid line shows the evolution of the median rate on outstanding long-term (above five years) loans for non-financial corporations (NFCs) in the euro area between January 2009 and March 2016. The dotted line represents the Euro OverNight Index Average (Eonia) of overnight unsecured lending transactions in the interbank market. The data are taken from the ECB IBSI and IMIR database, which provides monthly bank balance-sheet and interest-rate data for euro-area banks at the monetary financial institution (MFI) level.



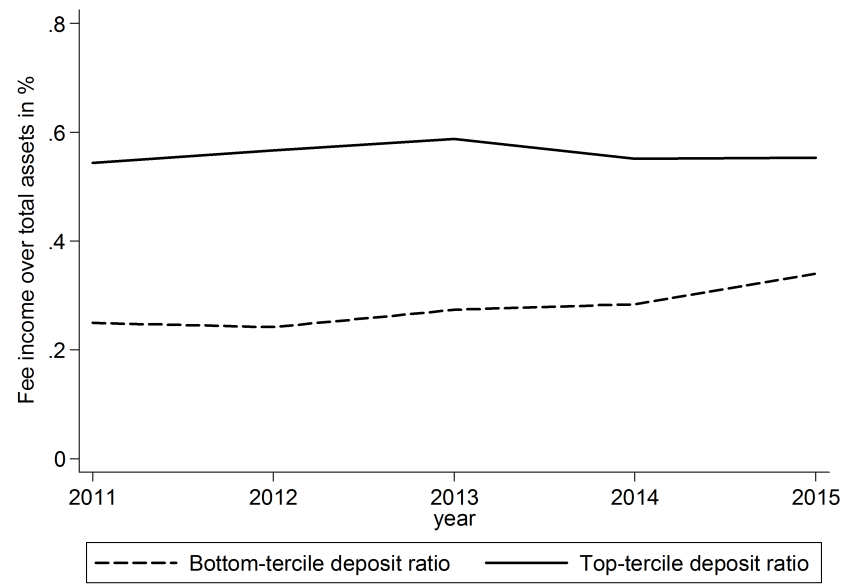
(a) Deposit ratio



(b) Equity ratio



(c) Securities ratio



(d) Fee income

Figure A.3: **Evolution of Balance-sheet Characteristics of Banks with High vs. Low Deposit Ratios.** This figure shows the evolution of the average deposit ratio (total deposits over total assets), equity ratio (total equity over total assets), securities ratio (total securities 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.

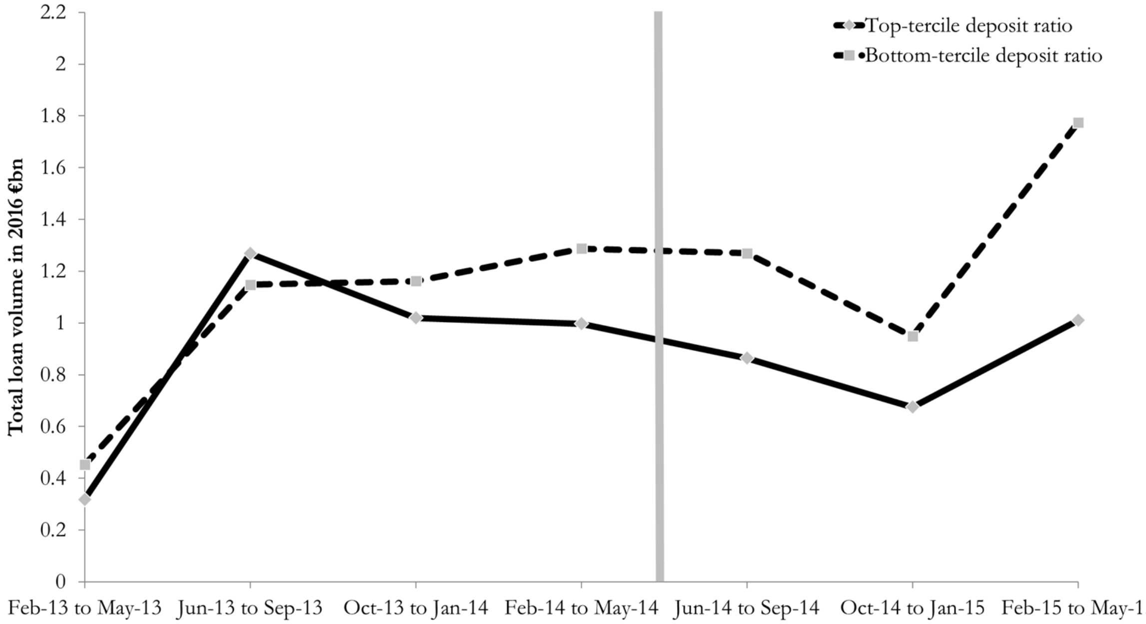


Figure A.4: **Total Volume of Syndicated Loans by Banks with High vs. Low Deposit Ratios.** This figure plots the four-month (forward-looking) total loan volume granted by euro-area lead arrangers, separately as averages for lead arrangers in the top (solid line) and bottom tercile (dashed line) of the deposit-ratio distribution in 2013. The sample is aligned with that from Table 5.

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
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 by Banks Following Negative Policy Rates – End Sample in February 2015**

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

Notes: The sample consists of all completed syndicated loans (package level) of both private and publicly listed firms i at date t granted by any euro-area lead arranger(s) j from August 2013 to February 2015. The dependent variable is the logged five-year standard deviation of firm i's return on assets (ROA, using P&L before tax) from year $t-5$ to $t-1$. *Deposit ratio*$_j$ is the average ratio (in %) of deposits over total assets across all 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.

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

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

Notes: The sample consists of all completed syndicated loans (package level) of both private and publicly listed firms i at date t granted by granted by any mutually exclusive 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
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**

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

Notes: The sample consists of all completed syndicated loans (package level) of both private and publicly listed firms i at date t granted by any 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. $\textit{Deposit ratio}_j$ 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.

Table B.10: **ROA Volatility of Firms Financed by Banks Following Negative Policy Rates: Potential Switchers**

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

Notes: The sample consists of all completed syndicated loans (package level) of both private and publicly listed firms i at date t granted by any euro-area lead arranger(s) j from January 2013 to December 2015, where borrowers had loans outstanding in both the period leading up to June 2014 and in the period thereafter. The dependent variable is the logged five-year standard deviation of firm i's return on assets (ROA, using P&L before tax) from year $t-5$ to $t-1$. $Deposit\ ratio_j$ is the average ratio (in %) of deposits over total assets across all 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.

Table B.11: **Impact of Negative Policy Rates on Loan Size: Potential Switchers**

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

Notes: The sample consists of all completed syndicated loans (package level) of both private and publicly listed firms i at date t granted by any euro-area lead arranger(s) j from January 2013 to December 2015, where borrowers had loans outstanding in both the period leading up to June 2014 and in the period thereafter. The dependent variable is the 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.