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The new normal: bank lending and negative interest rates in Austria*

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Abstract

Evidence on the effects of negative interest rates on bank lending is inconclusive so far. By applying a difference-in-difference estimation using granular loan level data with a large coverage from Austria, I show, contrary to some previous findings, that the introduction of a negative deposit facility rate by the European Central Bank led to an increased credit supply by high-deposit financed banks. Given the importance of relationship banking, the extended credit is granted mainly by smaller banks and via existing credit relationships to firms and households. Banks lend more often to indebted customers and to clients with higher probabilities of default, confirming the previous found increased risk-taking behavior in negative interest rate environment.

Keywords: Monetary policy transmission, negative interest rate policy, portfolio rebalancing channel, bank lending, financial stability

JEL Codes: E44, E51, E52, E58, G21

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Non-technical summary

In June 2014, the European Central Bank decided as the first major central bank to lower a key policy interest rate below zero to guide the expectations for future changes in policy rates. Negative interest rates, however, also affect banks' profitability and, subsequently, the ability to engage in credit supply, where the direction of the impact is prior to its introduction unclear. Moreover, empirical evidence on the effects of negative interest rates on the engagement of banks in credit granting is mixed so far.

In this paper, I take a step in broadening the understanding of the bank effects of negative interest rates by investigating the impact on lending and risk taking behavior in Austria. Hereby, I use credit registry data that consists of individual credit information for non-financial corporations and households with a credit exposure of at least EUR 350,000. Using difference-in-difference estimations, lending of banks that are more affected by negative interest rates (banks with high degree of deposit financing) is compared to lending of banks that are less affected by negative interest rates (banks with low degree of deposit financing). Besides controlling for standard bank characteristics that influence credit supply, fixed effects are included in the estimations to ensure that changes in lending are not driven my clients' credit demand but by banks' credit supply.

I show that the introduction of negative interest rates led to an increase of lending by more-affected banks compared to less-affected banks in Austria. The increase in credit supply is mainly observed for smaller banks and the credit is mainly granted to existing bank clients. In addition, banks affected by negative interest rates lend more often to clients that have higher probabilities of default and to firms that have higher debt ratios.

1 Introduction

The decision to enter into a negative nominal interest rate environment in 2014 was a paradigm shift in the monetary policy strategy of the European Central Bank (ECB). The decrease of the deposit facility rate (DFR) to -0.1% in June 2014 and the further reductions to -0.5% divided the monetary policy frameworks of major advanced economies into two camps: Central banks having positive rates such as the Bank of England as well as the Federal Reserve and central banks charging negative rates as the European Central Bank and the Bank of Japan (see Figure 1). While previously mainly considered as an intellectual game, the shift of the ECB set an example and included negative interest rate policy (NIRP) in the monetary policy toolbox of central banks. The objective for this move has been explained by the former president of the ECB as follows:

> *"Negative [policy] rates were introduced for one specific reason: when interest rates reached the zero lower bound, the expectations for the future rates in the long term are only that the rates can go up. So with negative rates we were successful in taking these expectations down."* (Draghi (2016))

While NIRP might have achieved the goal of guiding the expectation on future policy rate changes, potential side effects on banks such as threats to profitability and the consequences for engaging in credit supply are ex ante unclear. Depending on inter alia banks' holdings of longer term fixed-income assets and the deposit supply elasticity faced by banks, monetary policy stimulus can become contractionary for bank lending when the interest rate is sufficiently low as shown by Brunnermeier and Koby (2018).

Complementing on the increasing literature on the bank effects of negative nominal interest rates, this paper investigates differences in the transmission of negative rates and estimates the impact on bank lending as a case study in Austria. Besides the general broadening of the understanding of negative rates effects in the Eurozone, focusing on the Austrian economy provides a key advantage: the available granular credit registry data in Austria is particu-

larly well-suited for the analysis. While most of the literature relies either only on bank-level data or can use only a rather limited scope of credit transactions, the Austrian data is more comprehensive in multiple dimensions. Firstly, as there are no reporting exemptions on the level of the bank, *all* credit institutions in Austria are obliged to report outstanding credit above the threshold of €350,000. Secondly, contrary to other credit data sets, the loan-level data in Austria includes not only firm debtors, but also households and therefore covers a large share of overall bank lending activities to customers (ca. 60% in terms of lending volume).[1] Thirdly, the available data points in the credit registry allow an analysis of the lending characteristics that are applied after the introduction of negative interest rates. In particular, information on the type of lending, the degree of collateralization as well as the estimated probability of default by the credit institution is available. This provides an additional view on risk-taking behavior in terms of the banks' credit conditions and recognized risk by banks' internal models that is, to the best of my knowledge, new in the literature.

Differences in the monetary policy transmission to bank lending between interest rate cuts in the positive and negative rate territory depend to which degree banks are affected by negative rates. Given the banks' inability or unwillingness to charge negative rates on (retail) deposits, the share of deposit financing serves as an exposure variable to negative interest rates (Heider et al. (2019)). Thus, the deposit ratio before the introduction of negative interest rates is the treatment intensity in a difference-in-difference setting around June 2014 to compare the lending of high- and low-deposit financed banks. A key threat to identification is time-varying differences between low- and high-deposit financed banks, which would violate the parallel trends assumption and therefore hinder the causal interpretation of the results. Controlling for credit demand with industry-location-size-time fixed effects (Degryse et al. (2019)) and limiting the potential effects from confounding factors by relying on a relatively short period around the cut-off reduce a potential bias in the estimation.

In line with a portfolio re-balancing mechanism from safe to riskier assets, I show that high-

[1]This is in contrast to empirical studies by Heider et al. (2019) and Grandi and Guille (2020) who focus on either a specific lending market or on only a limited number of lending relationships in general.

deposit financed banks in Austria increase lending compared to low-deposit financed banks as a reaction to negative rates. Banks in Austria with an above median deposit ratio increase lending by ca. 2%[2] compared to banks with below median deposit ratios. This is in contrast to previous findings by Heider et al. (2019) and Eggertsson et al. (2019). I argue that my results are driven by the broader data coverage on credits granted, i.e. including lending to small and medium-sized enterprises as well as households. Heterogeneous effects within the banking market are observed, where an increase in lending is shown for smaller banks such as Cooperative banks and Volksbanks. On the other hand, larger NIRP-affected banks such as private stock banks reduce lending compared to non-affected banks, which is consistent with findings by Heider et al. (2019). Further analyzing the loan characteristics, I show that the increase in loan supply is mainly channeled via existing credit relationships and by using on-balance credit instruments. The increased lending of high-deposit financed banks is associated with an increase in risk-taking as measured by increased lending to customers with higher debt ratios. The higher risk incurred is recognized by the banks' internal models as they report higher probabilities of default for clients with extended credit lines.

The paper is structured as follows: Section 2 provides an overview of the literature on the bank effects of negative interest rates and develops the hypotheses for the potential mechanisms at play. Section 3 describes the identification strategy, the used data and the econometric framework. In sections 4 and 5, the results on the impact of negative interest rates on bank lending are summarized. The impact on risk taking behavior of banks is shown in Section 6. Section 7 concludes.

2 Literature review and hypothesis development

The literature on the effects of the introduction of negative nominal rates has been incomplete so far. Especially with respect to potential interaction effects between monetary policy

[2]Depending of the econometric specification, values between 1.7% and 2.7% are estimated.

rate changes into negative territory and the impact on banks such as profitability, bank rates, lending volumes and risk taking appetite, the literature is lacking comprehensive empirical evidence so far. However, the current state of the research on the effects of negative rates on banks will be summarized.

Ex ante, negative rates could have both, positive as well as negative effects on bank profits. While negative rates might reduce banks' net worth due to the pressure on net interest margin (NIM), this could be outweighted by positive effects stemming from higher loan demand driven by an alleviated macroeconomic environment (Brandao-Marques et al. (2021)). Evidence by Altavilla et al. (2018) suggests that the effect of negative rates on profitability of Eurozone banks is limited so far. In particular, banks seem to compensate the decrease of interest income through an increase of non-interest income stemming from fees and commissions (Lopez et al. (2020), Basten and Mariathasan (2020), Bottero et al. (2019)). In addition, reductions in banks' loan loss provisions from eased economic conditions had a positive net worth effect as shown by Urbschat (2018) for German banks.

With respect to the pass-through of policy rate changes below zero to bank rates, empirical evidence shows that the pass-through to deposit rates depends on the counterparty type. While virtually no deposit rates for households moved below zero, an increased share of deposit rates for non-financial corporations became negative in the Eurozone recently (Heider et al. (2021)).[3] In this context, Altavilla et al. (2021) show that the pass-through of negative interest rates to corporate deposit rates does not come with a contraction in funding. Particularly healthy banks approximated by i.a. the level of non-performing loans are more likely to charge negative interest rates for corporations. In terms of lending, Bech and Malkhozov (2016) show that loan rates increased in Switzerland after the implementation of NIRP. In addition, by investigating the Italian mortgage market, Amzallag et al. (2019) show that banks with higher share of overnight retail deposits increase lending rates for fixed rate mortgages. Contrary, other empirical evidence suggests that the introduction of NIRP

[3]The reasons for a hard zero bound for retail deposits are manifold and include legal restrictions and the zero nominal return for cash.

was associated with a reduction in lending rates (Bottero et al. (2019) for Italy).

Heterogeneous empirical findings with respect to the effects on bank lending are also observed. Heider et al. (2019), using Eurozone syndicated loan data, and Eggertsson et al. (2019), relying on household lending in Sweden, show that NIRP-affected banks lend less compared to non-affected banks, where the affectedness is captured by the share of deposit financing. However, Bittner et al. (2020) find heterogeneity within the Eurozone by analyzing credit registry data from Portugal and Germany. While the banks' funding structure does not seem to matter in explaining differences in credit supply during times of NIRP in Portugal, high-deposit financed banks in Germany increase lending compared to low-deposit financed banks. Similar results on increased lending by NIRP-affected institutions are found by Grandi and Guille (2020), Tan (2019), Schelling et al. (2020) and Adolfsen and Spange (2020) who investigate credit markets in the Eurozone, Switzerland and Denmark. As found by numerous studies (e.g. Heider et al. (2019), Bottero et al. (2019), Basten and Mariathasan (2020)), the increase in lending is often associated with an increase in risk-taking. However, the increased risk appetite is not necessarily excessive that would cause financial imbalances and therefore poses a risk on financial stability. Indeed, Bittner et al. (2020) show that riskier borrowers who received credit from high-deposit banks in Germany increased investment and employment.

Given the heterogeneous effects of NIRP on bank lending across the economies observed in the literature, in general two alternative bank mechanisms could be at play in reaction to NIRP.[4] On the one hand, banks affected by NIRP might be willing to recover from the pressure on the profitability by engaging in risk-taking activities such as investing in securities yielding a higher return (Bubeck et al. (2020)) or increase in lending to high-risk clients (Basten and Mariathasan (2020) among others). This is in line with the standard risk-taking channel of monetary policy in the positive interest rate environment (Jiménez et al.

[4]The reasoning follows closely the argumentation by Grandi and Guille (2020) that provide a more detailed description of the potential channels of NIRP via banks.

(2012), Borio and Zhu (2012)). The key difference in the case of negative monetary policy rates is that they potentially encourage higher risk-taking for institutions that are affected by NIRP, i.e. institutions that are reliant on deposit funding. To put it differently, due to the zero bound on deposit rates (especially retail deposit rates), high-deposit financed banks are incentivized to engage in risk-taking behavior to compensate for the reduction of net interest income. This *Portfolio Re-balancing mechanism* would expect that high-deposit financed banks increase lending and holdings of high-yield securities to a larger extent compared to low-deposit financed banks.

On the other hand, negative interest rates might cause a decline in the bank's value of equity that lead to a need to restore regulatory capital ratios for NIRP-affected institutions (Eggertsson et al. (2019), Ampudia and Van den Heuvel (2019)). While policy rate cuts above the zero bound increase banks' net worth due to the reduction of cost of funding, the effect for negative interest cuts depend on the banks' financing structure. High-deposit financed banks have a lower reduction of funding costs compared to low-deposit financed banks and thus have a negative relative impact on their net worth which limit their ability to perform credit intermediation (Heider et al. (2019), Bernanke and Gertler (1995)). Based on Brunnermeier and Koby (2018), a low enough monetary policy rate may become a "reversal rate" at which accommodative monetary policy becomes contractionary for lending. Thus, the *Reversal rate mechanism* would expect that high-deposit financed banks have less lending compared to low-deposit financed banks following the introduction of NIRP.

One aim of this paper is to find evidence for the dominating mechanism that is at play in Austria. For this purpose, the empirical strategy discussed in the subsequent section will be applied.

3 Empirical strategy

I start the discussion on the empirical strategy by providing information on the research design intended to solve the problem of identification. Subsequently, the data and the econometric models are presented.

3.1 Identification

The literature on the monetary policy transmission of negative rates on bank behavior identifies the role of deposits as a key difference compared to changes in the policy rates in the positive environment. While rate cuts in the positive interest rate era are translated into a reduction of banks' cost of funding, irrespective of the structure of funding, this changes for rate cuts below zero. Cuts in negative territory affect banks differently, depending on their type of funding: deposit vs. market-based funding. While short-term interbank rates follow the DFR closely into negative territory, the rates for deposits, especially household deposits, are usually stuck above zero. This is shown by Heider et al. (2021) for the Eurozone, but also applicable for Austria as presented in Figure 2. As the DFR entered into negative territory in June 2014, the EONIA followed after a short adaption phase. However, the deposit rates on new business for HH and NFC remained above the zero line. Only at the beginning of 2019, the NFC deposit rate on new business started to become negative. In addition, when looking on the distributions of deposit rates across banks, not a single institution in Austria has charged negative deposit rates on outstanding amount with year-end 2015 (Figure 3).

Given the incomplete pass-through of cuts in the policy rate below zero to deposit rates, the share of deposit financing is considered as bank-specific exposure to negative rates. Following Heider et al. (2019), I use a difference-in-difference approach where the average share of deposits over total assets in 2013, i.e. before the introduction of negative rates, serves as a treatment intensity variable. To be concrete, banks with a low share of deposit financing

will be compared to banks with a high share of deposit financing before and after the introduction of negative DFR.

The econometric validity of the difference-in-difference approach lies on critical assumptions that are discussed in the following. Firstly, the composition of the control and treatment group should not change over time ("Time-invariant composition assumption"). As shown by Eisenschmidt and Smets (2019) and Lopez et al. (2020), the reliance on deposit funding increased after the introduction of NIRP in some case in the Eurozone. Thus, if banks in Austria would endogenously change their share of deposit financing as a reaction to the introduction of negative rates, this assumption would be violated. To check this, the deposit ratios as of year-end 2013 and year-end 2015 are plotted for each institution in the sample in Figure 4a. As depicted, for the vast majority of the banks, the share of deposit financing did not change significantly from 2013 to 2015, indicating no violation of the time-invariant composition assumption. Secondly, low- and high-deposit financed banks should have parallel trends in the absence of the treatment, i.e. in case the deposit facility rate would not have been decreased below zero, differences between low- and high-deposit banks in terms of loan growth would have stayed constant. While this assumption is generally not testable, the pre-treatment trends provide an indication. Thus, the growth rate of the aggregated credit line is plotted for low- and high-deposit banks in Figure 4b. The Figure reveals an evolution of growth rates that is consistent with parallel pre-trends. In addition, Figure 4b provides a first visual evidence on the changed trend in bank lending of low- and high-deposit banks. The growth rate of lending increased for high-deposit banks compared to low-deposit banks.

A general concern on the reliability of the identification is the introduction of multiple additional (unconventional) monetary policy changes such as extensive asset purchase programs (APPs) and Targeted longer-term refinancing operations (TLTROs). Even though it is ex-ante unclear how APPs should affect bank lending of high- and low-deposit financed banks in Austria differently, the period under investigation is limited to a rather short period around the treatment date (2013-2015) in the baseline estimation, i.e. before the monthly asset

purchases reached its maximum of € 80bn in April 2016. In addition, potential confounding effects from the TLTROs will be considered by including a control variable that measures the bank take-up capacity under the TLTRO program.

3.2 Data

The literature on investigating the effects of negative nominal interest rates on bank behavior relies in general on two levels of data granularity: bank-level data (e.g. Tan (2019)) and credit-level data (e.g. Bottero et al. (2019)). While the benefit of bank-level data is its wide availability across jurisdictions, a key disadvantage is the lack of information on counterparty level, including data on the riskiness of the debtor. Granular credit-level data, especially with respect to historical time series, is only available in limited scope. Thus, the reliance on credit registry data for estimating the effect on NIRP on bank lending emerged mainly as case studies for specific economic regions such as Italy (Bottero et al. (2019)) and France (Grandi and Guille (2020)). I contribute to this literature by investigating the credit registry data from Austria. Key advantage is the comprehensiveness of the available data set in Austria. While the majority of credit registries only cover information on firms, the Austrian credit registry also includes household debtors. This results in the fact that ca. 60% of credit volumes granted to households and non-financial corporations in Austria are included in the data set. The coverage is particularly high for credit to non-financial corporations (ca. 94%), whereas significantly lower for credit to households (ca. 10%).[5] In addition, the registry includes information on the type of credit (e.g. on- vs. off-balance) as well as credit risk indicators (e.g. degree of collateralization, probability of default) that enable an investigation on the lending characteristics that are applied after the introduction of NIRP.[6]

[5]The reporting threshold of € 350,000 reduces the reported household lending mainly to residential real estate lending.

[6]In general, due to the richness of the credit registry, credit level data will be used for estimating the effect of NIRP on bank lending. However, to rule out that the results are driven by the subset of bank lending activities available in the credit registry, estimations on bank level have been performed in Table 9 in Annex A.2.

For the analysis of the impact on bank lending in Austria, monthly data for the period 2011-2015 will be investigated. The reporting population includes credit institutions resident in Austria as well as foreign branches of credit institutions resident in a member state of the European Union. To capture the effects of NIRP on bank lending via the deposit channel, non-deposit taking credit institutions will be discarded for the analysis. In addition, banks that are not active in the whole reporting period will be excluded. This amounts to 625 credit institutions and foreign branches of credit institutions in the baseline estimation.

Based on the reporting regulation, the threshold for triggering a reporting obligation is € 350,000 which is calculated taking on-balance exposures, off-balance items as well as exposures resulting from derivatives and securitizations into account. The main variable identifying the outstanding credit amount is "Total credit line" which is the maximum limit announced to the debtor up to which credit is granted or liability assumed by the bank.[7] Total credit line includes the already utilised limits and consists of on- and off-balance sheet exposure. Debtors with $Total\ credit\ line = 0$, indicating that the reporting obligation was triggered by derivative and/ or securitizations exposure, are excluded. Credit relationships need to be reported regardless of the debtor type and residency. To focus on the lending to the real economy in Austria, public organizations, financial institutions and extraterritorial organizations as well as debtors not resident in Austria are excluded. For a detailed description on the data cleaning steps, see Appendix A.1.

For bank level information, credit data is enriched with supervisory reporting data from the unconsolidated VERA reporting[8] for items from the balance sheet and income statement as well as CoRep (common reporting framework) for capital information. For data on non-household debtors, additional information are retrieved from the Bureau van Dijk Sabina database.

[7]Please note that as a robustness check, an alternative binary metric for an increase in outstanding amount is used in Annex A.2 Table 11 (see also Bittner et al. (2020)):

$$New.credit = \begin{Bmatrix} 1, & \text{for } Total\ credit\ line_{ijt} > Total\ credit\ line_{ijt-1} \\ 0, & \text{otherwise} \end{Bmatrix}$$

[8]VERA means "Vermögens-, Erfolgs- und Risikoausweis" (statements on assets, income and risk).

Summary statistics on the data used can be found in Table 1. Key observations are summarized below: (i) Austrian banks are largely deposit-financed institutions. With a mean (median) deposit ratio of 67% (74%) as of year-end 2013, deposits are the main source of financing. (ii) The Austrian banking sector is composed of a large number of banks, where the majority of institutions are of a relatively small size. The discrepancy between the median and mean balance sheet total show the relatively importance of a few large credit institutions. (iii) The number of loans and debtors in the data indicate the significance of relationship banking in the Austrian banking sector as also indicated by Liebeg and Schwaiger (2006). The majority of debtors have a credit relationship (above the reporting threshold) with only one bank as of YE 2013. (iv) Given the large reliance on bank based funding of firms in Austria, the more than 63,000 firms included in the data set represent ca. 20% of total firms in Austria. This is a significant larger coverage compared to studies by Bottero et al. (2019) for Italy (ca. 5% of firms included) and Grandi and Guille (2020) for France (ca. 0.1% of firms included).[9]

3.3 Econometric models

To estimate the effect of the introduction of negative nominal interest rates on bank lending in Austria, a difference-in-difference (DiD) approach initially suggested by Heider et al. (2019) will be considered:

$$log(Total\ credit\ line)_{ijt} = \beta_0 Post.06.14_t \times Dep.ratio_i + \gamma X_{it-1} + \eta_i + \delta_t + \epsilon_{ijt} \qquad (1)$$

where $log(Total\ credit\ line)_{ijt}$ is the log Total credit line granted by bank i to debtor j at time t. $Post.06.14$ is a dummy variable that is 1 if the DFR is negative and 0 otherwise. $Dep.ratio \in (0, 1)$ is a continuous treatment variable calculated as the mean deposit ratio in

[9] See Muller et al. (2016).

2013 and X_{it-1} are lagged control variables on bank level that are considered as drivers for credit supply in the standard literature (e.g. Kashyap and Stein (1995)): balance sheet total, Tier 1 capital ratio and securities ratio. Bank variables are lagged by one year to control for potential endogeneity between bank balance sheet items and lending. η_i and δ_t are bank- and time-fixed effects, respectively. As suggested by Bertrand et al. (2004), standard errors are clustered on the bank level to overcome the problem of serial correlation.

The baseline DiD specification is refined by multiple dimensions to (i) underpin the identification strategy, (ii) control for potential confounding factors as well as credit demand and (iii) check for robustness of estimation results.

Firstly, total deposits are separated into HH and NFC deposits. As shown in Figure 2, HH deposit rates are more reluctant to breach the zero lower bound compared to NFC deposit rates, where negative rates on new business are observed since early 2019. Thus, when separating the treatment variable into HH and NFC deposit ratios, a stronger effect is expected for HH deposit ratio. This expectation is supported by a Supreme Court decision that prohibits banks to charge negative interest rates on retail deposits and therefore acts as a hard floor of HH deposit rates at zero in Austria.[10] This expectation that would reinforce the validity of the identification strategy will be tested with the following alternative specification:

$$log(Total\ credit\ line)_{ijt} = \beta_1 Post.06.14_t \times Dep.ratio.HH_i + \\ + \beta_2 Post.06.14_t \times Dep.ratio.NFC_i + \gamma X_{it-1} + \eta_i + \delta_t + \epsilon_{ijt}, \quad (2)$$

where $Dep.ratio.HH_i$ ($Dep.ratio.NFC_i$) is the average HH (NFC) deposit ratio in 2013 for bank i.

Additionally, Bottero et al. (2019) identified the role of liquid assets in the transmission

[10] See court case decision 5 Ob 138/09v of the Supreme Court of Justice (October 13, 2009).

of negative rates to bank lending in Italy. The authors find that the degree of banks' affectedness by NIRP depends on the share of liquid assets rather than the magnitude of deposit financing. Thus, to evaluate this line of reasoning, the following specification will be considered:

$$log(Total\ credit\ line)_{ijt} = \beta_0 Post.06.14_t \times Dep.ratio_i + \\ + \beta_3 Post.06.14_t \times Liquidity_i + \gamma X_{it-1} + \eta_i + \delta_t + \epsilon_{ijt}, \quad (3)$$

where $Liquidity_i = \frac{\text{Cash + Securities}}{\text{BS total}}$ is the mean share of liquid assets of bank i in 2013.
Furthermore, as specified is Section 3.1, to rule out a potential bias resulting from the first series of TLTROs announced in June 2014, the following refined estimation is considered:

$$log(Total\ credit\ line)_{ijt} = \beta_0 Post.06.14_t \times Dep.ratio_i + \\ + \beta_4 Post.06.14_t \times TLTRO_i + \gamma X_{it-1} + \eta_i + \delta_t + \epsilon_{ijt}, \quad (4)$$

where $TLTRO_i = \frac{\text{Loans to NFC + HH (excl. for house purchase)}}{\text{BS total}}$ captures the banks' average take-up capacity in 2013 under the TLTRO program.
Another threat to identification is that the increase in lending might be driven by credit demand rather than credit supply. In the literature, it is usually controlled for credit demand by including firm-time fixed effects μ_{it} that capture time-varying unobserved heterogeneity at the level of the firm that affect credit over time (see for example Jiménez et al. (2012)). However, the limitation is that debtors receiving credit from only one bank are dropped out in the estimation. This is critical for at least two reasons: (i) Single-bank borrowers might react to credit supply shocks differently compared to multiple-bank borrowers, given the discrepancies in firm characteristics as suggested by Degryse et al. (2019) and (ii) single-bank borrowers make up the majority of debtors in multiple economic areas, e.g. for non-HH debtors, single-bank borrowers represent 84% of the overall number of non-HH borrowers in

Austria. Thus, excluding single-bank borrowers would limit the scope only to a fraction of overall bank lending activities.

As suggested by Degryse et al. (2019), I include industry-location-size-time (ILST) fixed effects μ_{ILSt} to capture loan demand, assuming that firms from the same industry sector, the same region and with a similar size have the same credit demand. Industry, location and size clusters are based on the level 2 NACE codes (division level), first two digits of the postal code and the firm's total assets (grouped in deciles):

$$log(Total\ credit\ line)_{ijt} = \beta_0 Post.06.14_t \times Dep.ratio_i + \gamma X_{it-1} + \eta_i + \mu_{ILSt} + \epsilon_{ijt}, \quad (5)$$

Lastly, two further refined specifications will be estimated to check for robustness of results. The time window will be expanded to 2011-2015 and a placebo test will be conducted. If nothing would be considered as special about the cut in the DFR below zero in June 2014, results that are not significantly different from the most recent cut in the DFR in positive interest rate era in July 2012 are expected. This will be tested by including $Post.07.12_t$ as a time dummy variable in the econometric specification.

4 Negative interest and bank lending

As discussed in Section 2, in general two alternative mechanisms could be at play when analyzing the impact of negative rates on bank lending. The *Reversal rate mechanism* expects that, given the pressure on bank's equity, high-deposit financed banks lend less compared to low-deposit financed banks, expecting $\hat{\beta}_0 < 0$. On the other hand, the *Rebalancing mechanism* expects that high-deposit financed banks increase lending compared to low-deposit financed banks to compensate for the pressure on profitability, i.e. $\hat{\beta}_0 > 0$.

Results of the baseline estimation as well as refined versions are shown in Table 2. The estimates indicate a positive and significant influence of NIRP on bank lending of high-deposit financed banks compared to low-deposit financed banks in Austria.

For the purpose of interpreting the results, $\hat{\beta}_0 = 0.05$ indicate that an exclusively deposit-financed institution (i.e. $Dep.ratio = 1$) increases lending compared to a bank without deposits (i.e. $Dep.ratio = 0$) by 5% in reaction to the introduction of NIRP. As only a limited number of banks are at or close to the tails of the deposit-financing distribution, the estimation is also performed using a discrete treatment variable. The results are shown in Table 10 in Appendix A.2, where *Dep.type* is a dummy variable that is 1 if the bank has an above median average deposit ratio in 2013 and 0 otherwise. The results show that above-median deposit financed banks increase lending by 1.7-2.7% compared to below-median deposit financed banks as a reaction to NIRP.

In general, the estimation is robust to a wide range of alternative specifications. While the inclusion of bank control variables reduces the point estimate, the overall interpretation does not change. As expected due to the supreme court ruling on negative HH deposit rates, the retail deposit ratio explains the difference in lending after June 2014 between high- and low-deposit financed banks better than the share of NFC deposits. Contrary to the findings by Bottero et al. (2019) on the Italian banking market, the share of liquid assets do not seem to be a driver for an increase in bank lending in Austria. Additionally, the inclusion of a TLTRO take-up capacity variable only slightly reduces the estimate in model (5), suggesting robustness against the conjecture that the banks' favourable borrowing conditions from the TLTRO programs are drivers for changes in bank lending between high- and low-deposit banks.

In Table 3, the estimation results controlling for credit demand and with a varying time window are shown. The inclusion of industry-location-size-time fixed effects as suggested by Degryse et al. (2019) do not change the interpretation of the results. However, it is important to note here that the number of observations are significantly reduced due to the withdrawal of HH debtors and debtors where no data on postal code, industry sector or balance sheet total is available. In model (4), the investigation period is extended to 2011 to 2015 as a further robustness check. Additionally, a placebo test is performed in model (5). As the

estimate for the interaction term $Post.07.12 \times Dep.ratio$ is statistically not different from 0, this indicates that the rate cut in July 2012 did not affect high- and low-deposit financed banks differently. Thus, the results reinforce the assumed difference in the transmission of negative rates to banks.

Based on the proposed mechanism in Section 2, the results indicate a portfolio re-balancing of high-deposit financed banks in Austria towards an increase in lending. As high-deposit financed banks in Austria do face a particular burden on profitability,[11] they aim to mitigate this pressure by increasing the lending volumes ("volume effect"). The portfolio re-balancing towards an increase in lending is also found by Klein (2020) who shows that European banks facing a pressure on NIM increase lending volumes.[12] The re-balancing of the asset portfolio is further investigated by looking at the evolution of holdings of low-risk and high-risk assets in Figure 5. While the Figures 5a and 5b show that low-deposit financed banks increase the share of safe assets such as cash and government bonds to a larger extent compared to high-deposit financed banks, this is reversed for risky asset classes (see Figure 5c and 5d). Besides the increase in lending, high-deposit financed banks also increase the share of equity and debt securities of non-financial corporations. This indicates a "search-for-yield" behavior of NIRP-affected banks as a reaction to negative rates as also found by Bubeck et al. (2020) and Grandi and Guille (2020). To which extent the increase in lending is also associated with lending to high-risk clients in Austria will be shown in Section 6.

Given the heterogeneity in the effects of NIRP on bank lending in the literature in terms of the evaluated credit data (e.g. household lending by Eggertsson et al. (2019) and syndicated loans by Heider et al. (2019)) as well as the investigated banking markets, differences within banking sectors and across the lending segments in the impact of NIRP are expected. Given

[11] As shown by Kerbl and Sigmund (2016), using an ARIMA simulation approach. In addition the evolution of NIM is also presented in Figure 7 in Appendix A.3: High-deposit financed banks in Austria face a reduction in median NIM, whereas the NIM for low-deposit financed banks increased after the introduction of NIRP.

[12] A volume effect is also found by Tan (2019), where the increase in lending volumes of NIRP-affected banks is particularly observed for mortgage lending.

the large coverage of the credit registry data of overall bank lending in Austria , I am able to differentiate the results by counterparty type and bank sectors.

Table 4 shows the results of separate estimations for lending to households and non-financial corporations. The increase in lending of high-deposit financed banks compared to low-deposit financed banks is observed in the most refined specifications for both, lending to households and non-financial corporations. A larger increase in lending is observed for credit to non-financial corporations (5.5%) compared to households (3.4%). These results are contrary to findings by Eggertsson et al. (2019) who find less household lending of high-deposit financed banks in Sweden. However, the following limitations need to be considered when interpreting the results. A significant positive estimate is only observed when including ILST fixed effects, indicating that taking credit demand into account is crucial in estimating the impact of negative interest rates on lending. However, controlling for credit demand is not possible for household lending, where significant positive estimates are observed for all specifications. Relying on the bank registry of Oesterreichische Nationalbank as of 12/2014, institutions are classified into the following six bank sectors: Cooperative banks, Savings banks, Volksbanks, Private stock banks, Special banks and Foreign branches. As shown in Table 5, the bank sectors differ significantly in terms of their number of banks and lending activities. While the Cooperative banks sector has with 76% of the banks (476 of 625 total banks) by far the largest share of banks, the share of Total credit line of the Cooperative banks sector is less than 1/3 of all banks in the data set (31.1% as of YE 2014). On the other hand, despite the relative small number (30 banks), Private stock banks account for 30.5% of Total credit line as of YE 2014. The estimation results distinguishing by bank type are shown in Table 5. While NIRP is associated with an increase of high-deposit bank lending for the Cooperative banks and Volksbanks sector, the opposite is observed for Savings banks and Private stock banks. One explanation for the heterogeneous results is that the bank sectors differ with respect to debtor characteristics. Compared with other bank sectors in Austria, Cooperative banks have the largest share of household lending. In addition, with respect to lending to

NFC, the median size of firms, measured as balance sheet total and turnover, vary significantly across the banking sector. The firms median balance sheet total (turnover) of debtors to Private stock banks is 106% (74%) larger than of debtors to Cooperative banks. The decrease in lending of high-deposit financed banks compared to low-deposit financed banks to large firms is also shown by Heider et al. (2019) who analyze the syndicated loan market.

5 Negative interest and lending characteristics

While the existing literature mainly focus on the overall impact of negative rates on bank lending, the research on the characteristics of the changed lending behavior remains scarce. This is particularly important as different lending characteristics can have different implications on banks' risk-taking appetite and have heterogeneous real effects. I make a step in closing this gap by analyzing the terms of lending with respect to the following questions: (i) Was the increased lending of high-deposit banks channeled via new lending relationships or existing clients? (ii) Is a difference observed between on-balance and off-balance sheet financing? (iii) To which degree are the increased lending activities covered by collaterals? Firstly, bank lending will be distinguished between the intensive margin (increase of credit line for existing customers) and extensive margin (increase of credit line for new customers) of credit supply. For capturing the intensive margin, bank-debtor fixed effects ϕ_{ij} will be included in the regression model to capture changes in the credit line within the same bank-debtor relationship (Bittner et al. (2020)):

$$log(Total\ credit\ line)_{ijt} = \beta_0 Post.06.14_t \times Dep.ratio_i + \gamma X_{it-1} + \phi_{ij} + \delta_t + \epsilon_{ijt} \qquad (6)$$

For the extensive margin, the data set will be filled up for each bank-debtor relationship, where no outstanding credit was reported, i.e. $Total\ credit\ line_{ijt} = 0$ for each credit relationship in non-reported periods. Thus, the variable $Ext.credit_{ijt}$ is constructed to cover

the extensive margin of bank lending:[13]

$$Ext.credit_{ijt} = \begin{cases} 1, & \text{for } Total\ credit\ line_{ijt} > Total\ credit\ line_{ijt-1} \text{ and} \\ & Total\ credit\ line_{ijt-1} = 0 \\ 0, & \text{otherwise} \end{cases}$$

As shown in Table 6, the increase in bank lending of high-deposit financed banks compared to low-deposit financed banks is mainly conducted on the intensive margin of credit supply, i.e. a positive significant effect is observed when including bank-debtor fixed effects. With respect to the extensive margin, a slight insignificant reduction in credit supply is observed. The increase in lending on the intensive margin as a reduction to NIRP is supported by the importance of relationship banking especially for small- and medium-sized banks in Austria (Gunter et al. (2013)).

Secondly, the type of credit is investigated. Hereby, the credit line is separated into on-balance and off-balance credit supply. On-balance sheet credit include i.a. revolving loans, one-off loans and leases.[14] Off-balance credit include other liability loans, lines for transitory credit and promissory notes (legally binding credit promises).

In addition, the Total credit line is separated into an uncollateralized and a collateralized part of the credit line. Only collaterals that are eligible under Regulation (EU) No. 575/2013 are considered and therefore, no collaterals recognized under the banks' internal risk management approach are taken into account.

The estimation results for the distinctions between on- and off-balance exposure as well as the separation of collateralized and uncollateralized part of the credit line is shown in

[13]To be precise, an increase in Total credit line is considered to be extensive if the bank-debtor relationship has not been reported in the previous month. However, in reality, the increase in Total credit line could also be on the intensive margin, e.g. when the bank-debtor relationship already existed, but the Total credit line was below the reporting threshold.

[14]In detail, on-balance sheet credit include all credit claims that are included in the Annex 1a (balance sheet items 1-7 and balances at central banks) in the unconsolidated VERA reporting in the statements on assets ("Vermögensausweis")

Table 7. Models (1) and (2) show that the increased lending of high-deposit financed banks was operationalized via on-balance credit instruments rather than off-balance sheet items. Models (4) and (5) show that there is no statistically difference in increased lending between the collateralized and uncollateralized part of the credit line. However, given the sign of the estimates (negative for collateralized and positive for uncollateralized), the estimation results hint towards an increased risk-taking that is investigated in the subsequent section.

6 Negative interest and risk-taking

Given the literature on the impact of negative interest rates on bank behavior, there is strong evidence of an increased risk-taking behavior of financial institutions in the Eurozone (e.g. Heider et al. (2019), Bubeck et al. (2020)). One theoretical argument is based on models in which the reduction banks' net worth increases agency problems when screening and monitoring borrowers (e.g. Holmstrom and Tirole (1997)). Assuming that screening of clients is costly for banks, they might be willing to reduce screening activities for risky borrowers in order to preserve the value of the bank. This would assume that higher risk-taking is observed for high-deposit financed banks with low levels of equity as shown by Bittner et al. (2020), among others.

To analyze whether the increase in bank lending is associated with higher risk-taking also by Austrian banks, three different risk indicators are used: (i) To capture the indebtedness of the debtor prior to the inception of the credit relationship, $Debtratio_{t-1}$ which is the share of debt over total assets of the debtor is calculated. (ii) For analyzing whether banks recognize changes in the risk appetite also in their estimates for the probability of default, the PD is used.[15] (iii) For measuring the firm's risk with respect to a longer term sustainability, the 5-year return on asset volatility prior to the inception of the credit relationship $\sigma(ROA)^{5yr}$ is

[15]The reporting of a debtor's probability of default is only mandatory for banks using an internal-ratings based approach. Thus, the sample of banks in this estimation is biased towards larger banks in Austria.

calculated[16]. For each of the risk indicators, the debtors are classified as low-risk (high-risk), when having a value that is below (above) the median value. To be precise, the focus on the indicators allows an analysis on the changed risk-taking behavior, however, they do not allow for conclusions on whether the risk-taking is excessive and leads to financial stability concerns. This is beyond the scope of this paper.

The estimation results are shown in Table 8. The positive and significant estimates in Models (1) and (3) show that lending of high-deposit banks was increased to firms with higher ex ante debt ratios and higher probability of defaults in reaction to the introduction of negative interest rates. When looking at the 5-year return on asset volatility as the risk metric, the estimator in Model (5) remains positive but becomes insignificant. This could be explained by the large decrease of observations due to limited data availability for the return on asset volatility. The estimation results for the low-risk clients (Models (2), (4) and (6)) are not significantly different from 0, indicating that increased lending was not channeled via low-risk clients. To show whether the increased risk-taking is observed for existing or new customers, Figure 6 plots the median risk indicators for new business on the extensive (Figures 6a, 6c and 6e) and intensive margin (Figures 6b, 6d and 6f) for high- and low-deposit financed banks. The graphs show that the increase is mainly concentrated on the extensive margin, where the probability of default and ROA volatility increases for high-deposit financed banks (see Figure 6c and 6e).

7 Conclusion

The contribution of this paper to the literature is manifold. Firstly, while the main body of the literature focuses on the effect of negative rates on large credit markets, this paper sheds light on bank lending and risk taking in a small bank-based economy such as Austria. Similarly to findings in France and Germany, negative rates led to an increase of bank lending

[16]In case the return on asset is not available for the full 5-year time span, the available observations are used to calculate σ.

of high-deposit financed banks compared to low-deposit financed banks. This supports the existence of a portfolio re-balancing mechanism from safer to riskier assets. Secondly, due to the large coverage of credit registry data, distinctions in the transmission to bank lending by bank type, counterparty type and the type of credit (i.e. intensive vs. extensive margin, on- vs. off-balance and collateralized vs. uncollateralized) have been made. The findings suggest that the increased lending of high-deposit financed banks was driven by Cooperative banks as well as Volksbanks. The credit was mainly supplied to existing customers and using on-balance credit instruments.

Gates for future research remain. Given the increased risk-taking of banks in Austria, it is important to understand to which degree the risk is considered as excessive. While the increase in risk could be considered as a "feature rather than a bug" (Schnabel (2020)), threats to financial stability need to be further researched. In addition, this paper focuses on the short term impact of negative rates on bank lending. More research needs to be performed on bank lending and risk-taking in a "negative-for-longer" scenario. Arce et al. (2021) pioneered this work by using Spanish data. They show that NIRP-affected banks decrease credit supply only after a few years of negative nominal rates. However, additional evidence on heterogeneous effects across NIRP-economies should shed further light on the impact of prolonged negative rates.

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Tables

	10% quantile	Mean	Median	90% quantile	Std. deviation
Bank-level data: 625 banks					
Balance sheet total	47,227,200	1,258,900,272	165,969,000	1,072,263,200	6,949,211,456
Total deposits	34,693,400	395,829,682	108,699,000	548,707,600	1,738,185,756
Deposit ratio (in %)	41.09	67.36	73.99	83.67	19.53
HH Deposit ratio (in %)	32.92	60.91	67.68	79.37	20.37
NFC Deposit ratio (in %)	1.54	6.46	4.82	13.74	5.57
Tier 1 capital ratio (in %)	4.76	9.13	8.53	14.02	4.21
Liquid assets share (in %)	2.28	11.59	9.51	21.79	9.05
Loan-level data: 95,895 loans					
Total credit line	373,000	2,260,259.00	632,000	3,500,000	10,426,323
Credit line (on balance)	353,000	1,936,475	580,000	3,000,000	9,033,310
Credit line (off balance)	0	323,783	0	232,000	4,060,074
Drawn amount	326,000	1,835,699	564,000	2,954,000	8,053,075
Collateral value	0	726,026	213,000	1,110,000	4,466,272
PD (in %)	0.13	5.57	0.88	6.67	18.07
Debtor-level data: 63,075 firms*					
Balance sheet total	644,818	23,707,265.00	2,538,684	20,430,525.00	345,715,096.00
Turnover	900,000	72,331,459	6,700,000	105,869,768	684,133,724
Debt ratio (in %)	29.65	177.82	74.11	110.28	10,791.24
RoA volatility	0.80	515.80	35.36	515.72	6,377.55

**20,611 household debtors are excluded in this data description.*

Table 1: **Summary statistics as of 31/12/2013.** Bank-level data is retrieved from supervisory reporting, including VERA and CoRep reporting. Loan-level data is taken from the central credit registry reporting. Non-household debtor information are retrieved from the Bureau van Dijk Sabina database.

Dependent Variable:	log(Total credit line)				
Model:	(1)	(2)	(3)	(4)	(5)
Variables					
Post.06.14 × Dep.ratio	0.0861**	0.0512**		0.0523**	0.0434*
	(0.0370)	(0.0242)		(0.0260)	(0.0252)
Post.06.14 × Dep.ratio.HH			0.0516**		
			(0.0242)		
Post.06.14 × Dep.ratio.NFC			0.0367		
			(0.0762)		
Post.06.14 × Liquidity				0.0095	
				(0.0458)	
Post.06.14 × TLTRO					0.0314
					(0.0333)
Bank controls	No	Yes	Yes	Yes	Yes
Fixed effects					
Bank	Yes	Yes	Yes	Yes	Yes
Year×Month	Yes	Yes	Yes	Yes	Yes
Fit statistics					
Observations	3,598,197	3,290,636	3,290,636	3,290,636	3,017,987
No. of banks	625	553	553	553	279
R^2	0.10681	0.10166	0.10166	0.10166	0.09263
Within R^2	0.0001	0.00035	0.00035	0.00035	0.00035

*Signif. Codes: ***: 0.01, **: 0.05, *: 0.1*

Table 2: **Estimation: overall bank lending I**: *Total credit line* is the maximum limit announced to the borrower up to which credit is granted or liability assumed by a bank. Total credit line also includes the already utilised limits and consists of on- and off-balance sheet exposure. *Post*.06.14 is a dummy variable that is 1 after June 2014 and 0 otherwise. *Dep.ratio* is the mean deposit ratio on bank level in 2013 and *Dep.ratio.HH* (*Dep.ratio.NFC*) is the mean deposit ratio on bank level in 2013, considering only deposits from households (non-financial corporations). *Liquidity* is the average share of liquid assets over balance sheet total in 2013. Equity and fixed income securities and cash (Euro and foreign currency) are considered as liquid assets. *TLTRO* is the average share of banks' loans to households (excluding loans for house purchases) and non-financial corporations in 2013. Lagged bank controls are balance sheet total, Tier 1 capital ratio and securities ratio. Observation period is from 2013 to 2015. Standard-errors clustered at the bank level are in parentheses.

Dependent Variable:	log(Total credit line)				
	2013-2015			2011-2015	
Model:	(1)	(2)	(3)	(4)	(5)
Variables					
Post.06.14 × Dep.ratio	0.0345*	0.0340*	0.0529**	0.0503**	0.0531**
	(0.0181)	(0.0201)	(0.0234)	(0.0251)	(0.0253)
Post.07.12 × Dep.ratio					-0.0139
					(0.0154)
Bank controls	Yes	Yes	Yes	Yes	Yes
Fixed effects					
Bank	Yes	Yes	Yes	Yes	Yes
Month×Year				Yes	Yes
Month×Year×Location	Yes				
Month×Year×Location× Industry		Yes			
Month×Year×Location× Industry×Size			Yes		
Fit statistics					
Observations	1,214,871	1,214,871	1,179,218	4,360,472	4,360,472
No. of banks	546	546	546	557	557
R^2	0.15731	0.23393	0.52862	0.10147	0.10147
Within R^2	0.00008	0.00009	0.00016	0.00026	0.00026

*Signif. Codes: ***: 0.01, **: 0.05, *: 0.1*

Table 3: **Estimation: overall bank lending II**: *Total credit line* is the maximum limit announced to the borrower up to which credit is granted or liability assumed by a bank. Total credit line also includes the already utilised limits and consists of on- and off-balance sheet exposure. *Post*.06.14 (*Post*.07.12) is a dummy variable that is 1 after June 2014 (July 2012) and 0 otherwise. *Dep.ratio* is the mean deposit ratio on bank level in 2013. Lagged bank controls are balance sheet total, Tier 1 capital ratio and securities ratio. Location, industry and size clusters are based on the first two digits of the postal code, the level 2 NACE codes (division level) and the firm's balance sheet total (grouped in deciles). Standard-errors clustered at the bank level are in parentheses.

Dependent Variable:	log(Total credit line)				
Counterparty type	Households		Non-financial corporations		
Model:	(1)	(2)	(3)	(4)	(5)
Variables					
Post.06.14 × Dep.ratio	0.0396***	0.0335***	0.0282	0.0039	0.0545**
	(0.0139)	(0.0116)	(0.0195)	(0.0194)	(0.0257)
Bank controls	No	Yes	No	Yes	Yes
Fixed effects					
Bank	Yes	Yes	Yes	Yes	Yes
Month×Year	Yes	Yes	Yes	Yes	
Month×Year×Location× Industry×Size					Yes
Fit statistics					
Observations	1,515,539	1,399,962	2,082,658	1,890,674	1,179,178
No. of banks	616	553	623	552	546
R^2	0.05714	0.05134	0.15334	0.14562	0.57595
Within R^2	0.00007	0.00025	0.00001	0.00006	0.00015

*Signif. Codes: ***: 0.01, **: 0.05, *: 0.1*

Table 4: **Estimation: bank lending by counterparty type**: *Total credit line* is the maximum limit announced to the borrower up to which credit is granted or liability assumed by a bank. Total credit line also includes the already utilised limits and consists of on- and off-balance sheet exposure. The percentage share of the Total credit line referring to the counterparty type are in parentheses. *Post*.06.14 is a dummy variable that is 1 after June 2014 and 0 otherwise. *Dep.ratio* is the mean deposit ratio on bank level in 2013. Lagged bank controls are balance sheet total, Tier 1 capital ratio and securities ratio. Location, industry and size clusters are based on the first two digits of the postal code, the level 2 NACE codes (division level) and the firm's balance sheet total (grouped in deciles). Observation period is from 2013 to 2015. Standard-errors clustered at the bank level are in parentheses.

Dependent Variable:	log(Total credit line)					
Bank type	Cooperative banks	Savings banks	Volks-banks	Private stock banks	Special banks	Foreign branches
Model:	(1)	(2)	(3)	(4)	(5)	(6)
Variables						
Post.06.14 ×	0.0460*	-0.1238**	0.0652**	-0.0716*	0.0009	0.1097
Dep.ratio	(0.0266)	(0.0563)	(0.0243)	(0.0392)	(0.0331)	(0.5024)
Bank controls	Yes	Yes	Yes	Yes	No	No
Fixed effects						
Bank	Yes	Yes	Yes	Yes	Yes	Yes
Month×Year	Yes	Yes	Yes	Yes	Yes	Yes
Fit statistics						
Observations	1,172,501	774,051	258,369	797,566	334,154	13,891
No. of banks	429	48	41	24	19	11
R^2	0.20232	0.07407	0.08154	0.02102	0.08974	0.23389
Within R^2	0.00015	0.00023	0.00018	0.00060	0	0.00005

*Signif. Codes: ***: 0.01, **: 0.05, *: 0.1*

Table 5: **Estimation: overall bank lending by bank sectors**: *Total credit line* is the maximum limit announced to the borrower up to which credit is granted or liability assumed by a bank. Total credit line also includes the already utilised limits and consists of on- and off-balance sheet exposure. *Post*.06.14 is a dummy variable that is 1 after June 2014 and 0 otherwise. *Dep.ratio* is the mean deposit ratio on bank level in 2013. Lagged bank controls are balance sheet total, Tier 1 capital ratio and securities ratio. Observation period is from 2013 to 2015. Bank sector definition is based on the bank registry of Oesterreichische Nationalbank. Special banks include special purpose financial institutions as well as housing banks and building and loan associations. Observation period is from 2013 to 2015. Standard-errors clustered at the bank level are in parentheses.

Dependent Variables:	Intensive margin log(Total credit line)		Extensive margin Ext. credit		
Model:	(1)	(2)	(3)	(4)	(5)
Variables					
Post.06.14 × Dep.ratio	0.0387***	0.0272***	-0.0009	-0.0021	-0.0024
	(0.0092)	(0.0088)	(0.0022)	(0.0014)	(0.0022)
Bank controls	No	Yes	No	Yes	Yes
Fixed effects					
Bank×Debtor	Yes	Yes			
Month×Year	Yes	Yes	Yes	Yes	
Bank			Yes	Yes	Yes
Month×Year×Location× Industry×Size					Yes
Fit statistics					
Observations	3,598,197	3,290,636	6,863,497	6,290,630	1,179,218
R^2	0.95726	0.95828	0.00233	0.00235	0.37356
Within R^2	0.00037	0.00085	0	0.00006	0.00002

*Signif. Codes: ***: 0.01, **: 0.05, *: 0.1*

Table 6: **Estimation: intensive and extensive margin**: $Total credit line$ is the maximum limit announced to the borrower up to which credit is granted or liability assumed by a bank. Total credit line also includes the already utilised limits and consists of on- and off-balance sheet exposure. *Ext. credit* is a dummy variable that is 1 if the credit relationship is newly reported and 0 otherwise. *Post*.06.14 is a dummy variable that is 1 after June 2014 and 0 otherwise. *Dep.ratio* is the mean deposit ratio on bank level in 2013. Lagged bank controls are balance sheet total, Tier 1 capital ratio and securities ratio. Location, industry and size clusters are based on the first two digits of the postal code, the level 2 NACE codes (division level) and the firm's balance sheet total (grouped in deciles). Standard-errors clustered at the bank level are in parentheses.

Dependent Variables:	log(Credit line)			
	On-balance	Off-balance	Collateralized	Uncollateralized
Model:	(1)	(2)	(3)	(4)
Variables				
Post.06.14 × Dep.ratio	0.0603**	-0.0279	-0.0102	0.1344
	(0.0244)	(0.0562)	(0.0653)	(0.0877)
Bank controls	Yes	Yes	Yes	Yes
Fixed effects				
Bank	Yes	Yes	Yes	Yes
Month×Year	Yes	Yes	Yes	Yes
Fit statistics				
Observations	3,088,733	540,212	2,119,506	2,980,490
R^2	0.09182	0.22308	0.08597	0.11060
Within R^2	0.00033	0.00013	0.00030	0.00030

*Signif. Codes: ***: 0.01, **: 0.05, *: 0.1*

Table 7: **Estimation: characteristics of bank lending - balance sheet recognition and collateralization**: *Credit line* equals *Total credit line* but divided by balance sheet recognition and collateralization. On-balance (off-balance) exposure includes outstanding amounts as defined in "Vermögensausweis" of VERA reporting (Annex I of Regulation (EU) No. 575/2013). Collateralized (uncollateralized) credit line is the part of the $Total credit line$ that is covered (not covered) by an eligible collateral under Regulation (EU) No. 575/2013. *Post*.06.14 is a dummy variable that is 1 after June 2014 and 0 otherwise. *Dep.ratio* is the mean deposit ratio on bank level in 2013. Lagged bank controls are balance sheet total, Tier 1 capital ratio and securities ratio. Observation period is from 2013 to 2015. Standard-errors clustered at the bank level are in parentheses.

Dependent Variable:	log(Total credit line)					
	$Debt\ ratio_{t-1}$		PD		$\sigma(ROA)^{5yr}$	
	high	low	high	low	high	low
Model:	(1)	(2)	(3)	(4)	(5)	(6)
Variables						
Post.06.14 × Dep.ratio	0.0578***	0.0206	0.0673*	0.0192	0.0126	-0.0052
	(0.0200)	(0.0250)	(0.0377)	(0.0383)	(0.0405)	(0.0438)
Bank controls	Yes	Yes	Yes	Yes	Yes	Yes
Fixed effects						
Bank	Yes	Yes	Yes	Yes	Yes	Yes
Month×Year	Yes	Yes	Yes	Yes	Yes	Yes
Fit statistics						
Observations	621,654	638,357	904,762	881,444	172,020	174,542
R^2	0.14503	0.14637	0.04799	0.11769	0.12318	0.22848
Within R^2	0.00009	0.00014	0.00073	0.00032	0.00028	0.00007

*Signif. Codes: ***: 0.01, **: 0.05, *: 0.1*

Table 8: **Estimation: risk taking**: *Total credit line* is the maximum limit announced to the borrower up to which credit is granted or liability assumed by a bank. Total credit line also includes the already utilised limits and consists of on- and off-balance sheet exposure. High-risk (low-risk) clients are classified as having an above (below) median value for the respective risk indicators. *Post*.06.14 is a dummy variable that is 1 after June 2014 and 0 otherwise. *Dep.ratio* is the mean deposit ratio on bank level in 2013. Lagged bank controls are balance sheet total, Tier 1 capital ratio and securities ratio. Standard-errors clustered at the bank level are in parentheses.

Figures

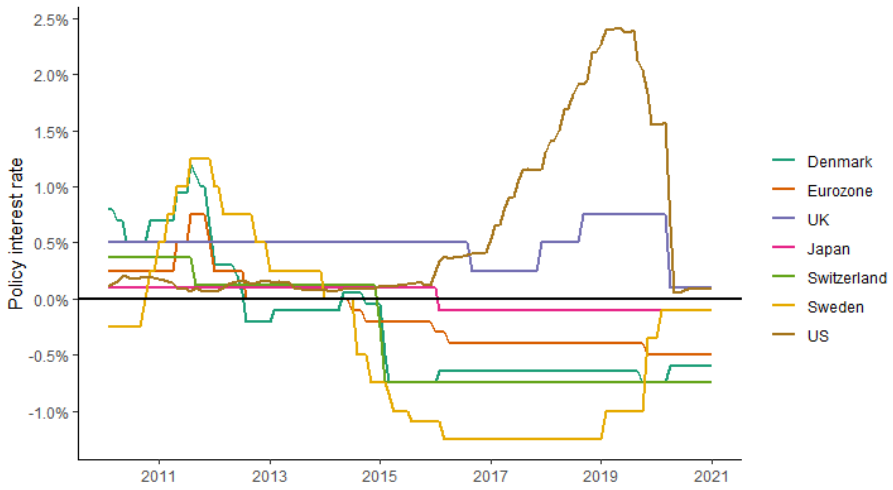


Figure 1: **Evolution of the key monetary policy rates.** The following monetary policy rates are shown: DK: Rate on certificates of deposits, EU: Deposit facility rate, UK: Bank of England base rate, JP: Uncollateralised Overnight Call Rate, CH: SNB policy rate, SE: Deposit rate, US: Federal Funds Rate.

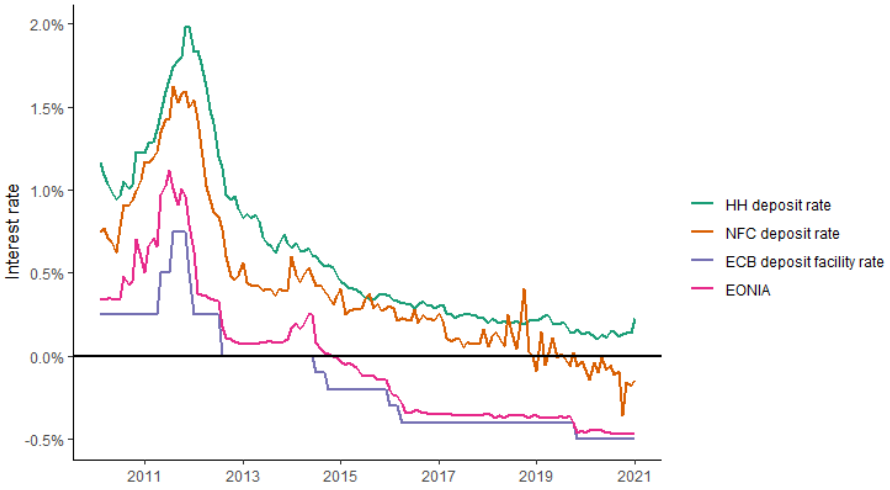


Figure 2: **Evolution of the ECB deposit facility rate, EONIA as well as the deposit rates for HH and NFC** on new business with an agreed maturity of up to 1 year in Austria.

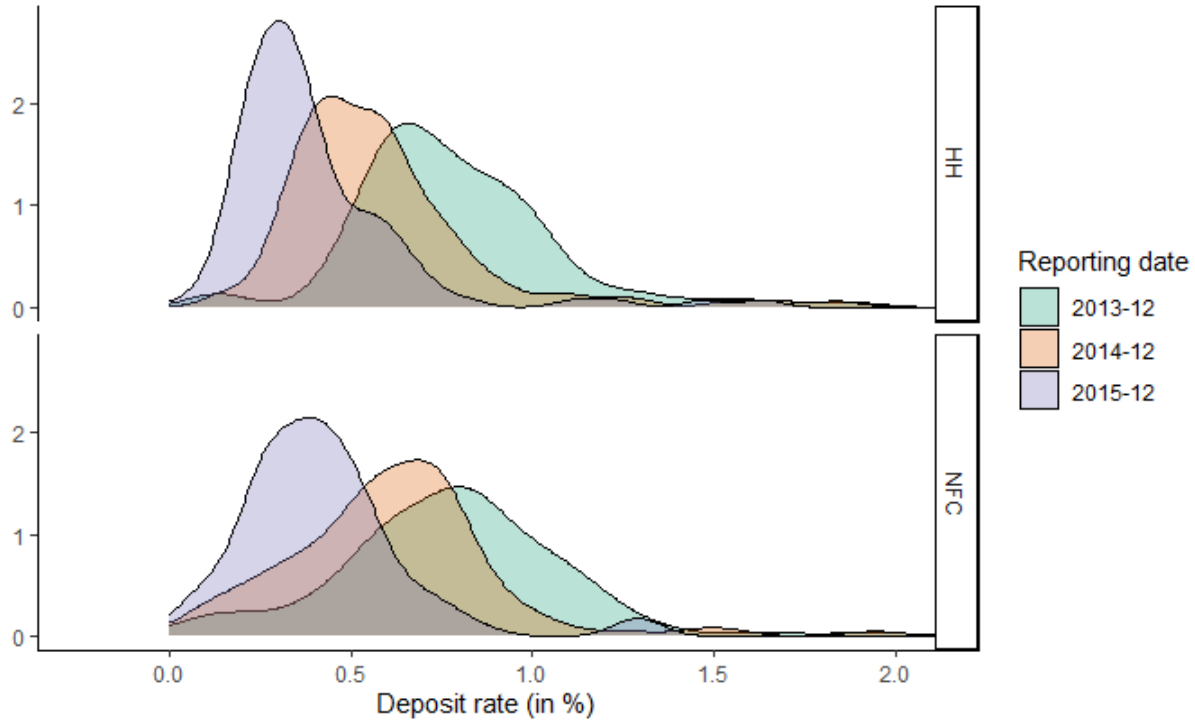
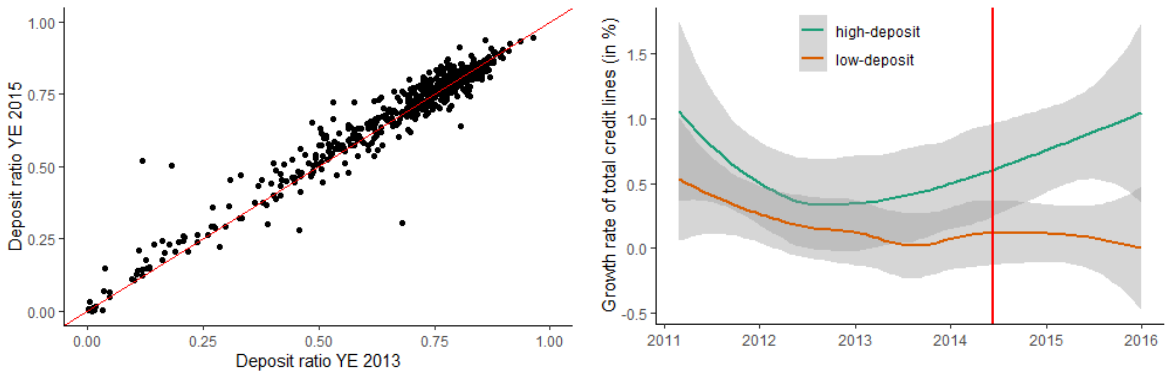


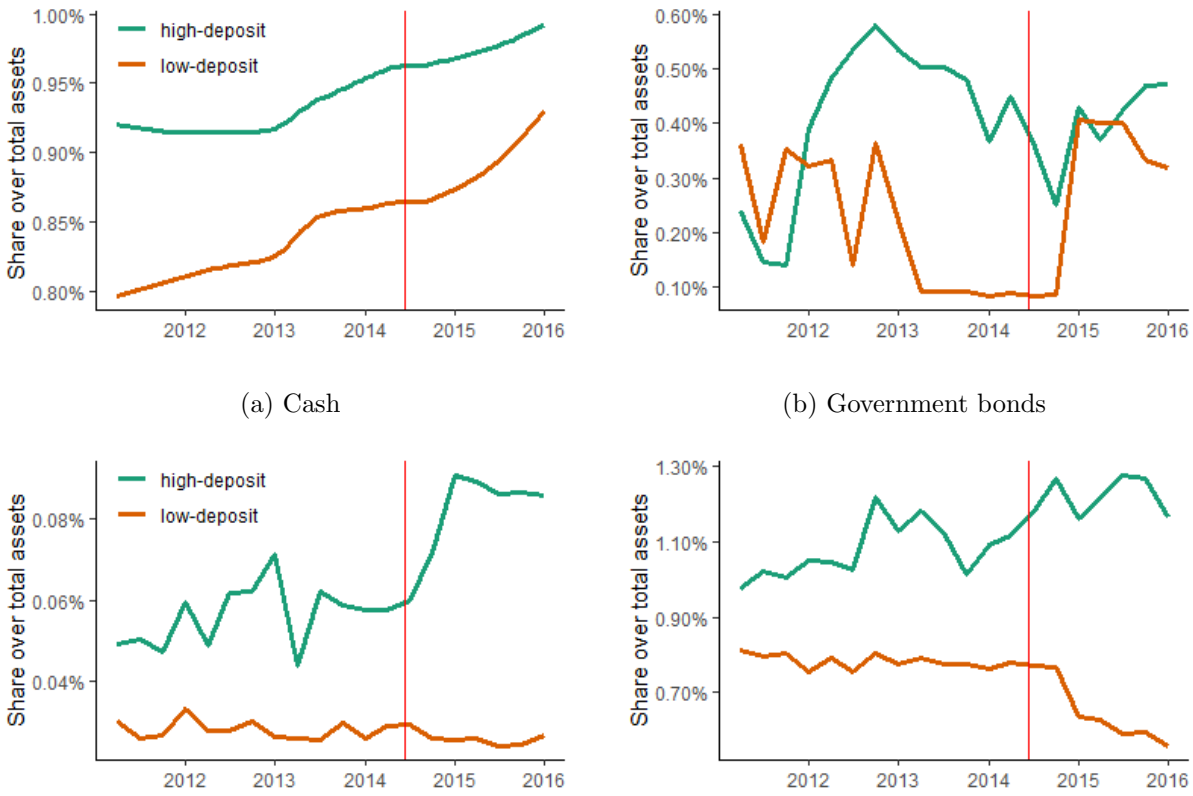
Figure 3: **Distribution of deposit rates** on total outstanding amounts with agreed maturities of up to 2 years for households (HH) and non-financial corporations (NFC) in Austria. Sample consists of 117 credit institutions and foreign subsidiaries of credit institutions. Data is based on ECB's harmonized bank interest rate statistic for monetary financial institutions.



(a) Time-invariant composition assumption

(b) Parallel trends assumption

Figure 4: **Assumptions for difference-in-difference estimation** For (a) Time-invariant composition assumption, the deposit ratio at year-end 2015 and 2013 as are plotted for the banks that are included in the baseline specification. The red line is the 45-degree line, indicating no change in the deposit ratio from 2013 to 2015. The (b) Parallel trends assumption is considered by comparing the growth rate of Total credit line for high- and low-deposit financed banks. High-deposit (low-deposit) financed banks are defined as having an above (below) median average deposit share in 2013. Note that the growth rates are smoothed using the locally weighted scatterplot smoothing method. The confidence interval around the smooth is depicted in grey. The vertical red line indicates the date at which the DFR became negative.



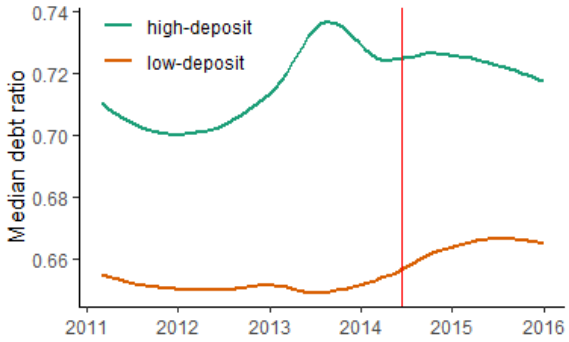
(a) Cash

(b) Government bonds

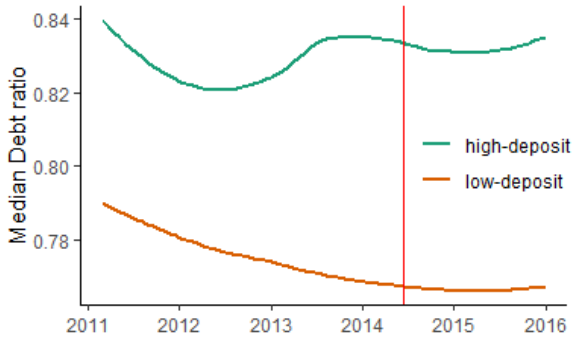
(c) NFC equity

(d) NFC Debt securities

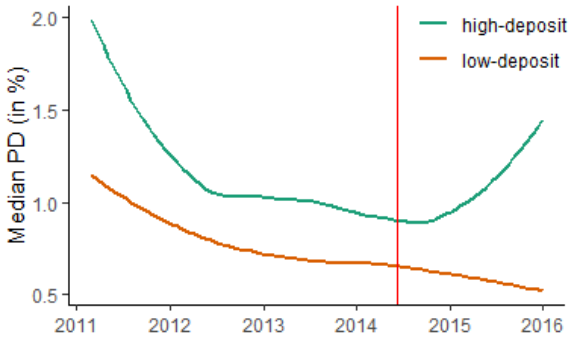
Figure 5: **Evolution of median share of low-risk ((a) Cash, (b) Government bonds) and high-risk ((c) NFC equity and (d) NFC debt securities) asset classes** for high- and low-deposit financed banks. High-deposit (low-deposit) financed banks are defined as having an above (below) median average deposit share in 2013.



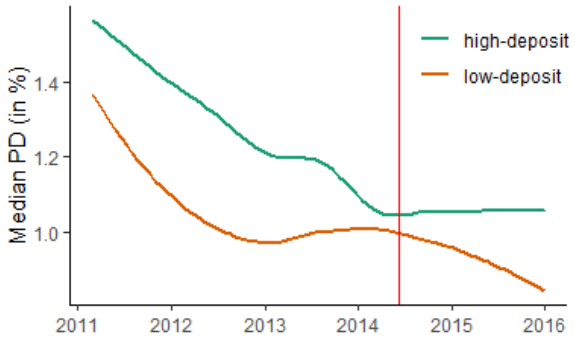
(a) Extensive margin: debt ratio



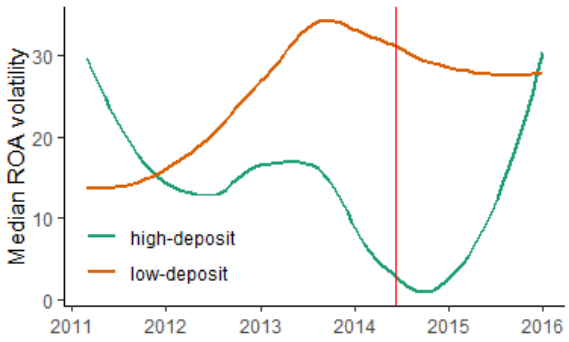
(b) Intensive margin: debt ratio



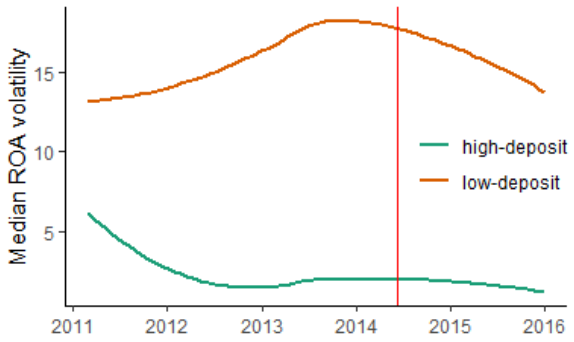
(c) Extensive margin: PD



(d) Intensive margin: PD



(e) Extensive margin: ROA volatility



(f) Intensive margin: ROA volatility

Figure 6: **Evolution of riskiness of new business measured at the extensive margin ((a), (c), (e)) and the intensive margin ((b), (d), (f)) for high- and low-deposit financed banks.** High-deposit (low-deposit) financed banks are defined as having an above (below) median average deposit share in 2013.

A Appendix

A.1 Data cleaning

1. **Debtor level**: Debtors meeting the following criteria have been excluded:

   - Debtors from the following sector based on the NACE 2 classification: K - Financial and insurance activities, O - Public administration and defense; compulsory social security, U - Activities of extraterritorial organisations and bodies: 12,731 debtors have been excluded
   - Debtors not resident in Austria: 36,160 debtors have been excluded

2. **Bank level**: Banks meeting the following criteria have been removed:

   - Total deposits = 0 for any of the reporting dates between 2011 and 2015: 104 banks are excluded
   - Average deposit ratio in 2013 larger than 1: 1 bank is excluded
   - Active lending only for parts of the observation period (2011 to 2015), i.e. for each year, the Total credit line to all debtors is larger than 0: 38 banks are excluded

3. **Credit level**: Credit relations that meet the following criteria have been removed:

   - No credit line is reported, i.e. $Total\ credit\ line = 0$; 15,024 credit relations have been excluded
   - Very large Total credit lines, i.e. $Total credit line >$ EUR$100,000,000,000$, driven by a reporting error: 2 credit relations have been excluded

A.2 Additional tables

Dependent Variable:	log(Loans to customers)				
	2013-2015				2011-2015
Model:	(1)	(2)	(3)	(4)	(5)
Variables					
Post.06.14 × Dep.ratio	0.0646	0.1124***	0.1069***	0.0958**	0.1859***
	(0.0485)	(0.0411)	(0.0391)	(0.0394)	(0.0518)
Post.06.14 × Liquidity			-0.1239*		
			(0.0709)		
Post.06.14 × TLTRO				0.0667	
				(0.0906)	
Bank controls	No	Yes	Yes	Yes	Yes
Fixed-effects					
Bank	Yes	Yes	Yes	Yes	Yes
Month x Year	Yes	Yes	Yes	Yes	Yes
Fit statistics					
Observations	8,326	6,455	6,455	3,210	8,751
R^2	0.98834	0.99716	0.99717	0.99586	0.99614
Within R^2	0.00158	0.06856	0.07238	0.09770	0.06046

*Signif. Codes: ***: 0.01, **: 0.05, *: 0.1*

Table 9: **Robustness estimation: Bank level**: *Loans to customers* includes the loans to customers as reported on bank level in the unconsolidated VERA reporting (statements on assets, income and risk). *Post*.06.14 is a dummy variable that is 1 after June 2014 and 0 otherwise. *Dep.ratio* is the mean deposit ratio on bank level in 2013. *Liquidity* is the average share of liquid assets over balance sheet total in 2013. $TLTRO$ is the average share of banks' loans to households (excluding loans for house purchases) and non-financial corporations in 2013. Lagged bank controls are balance sheet total, Tier 1 capital ratio and securities ratio. Standard-errors clustered at the bank level are in parentheses.

Dependent Variable:	log(Total credit line)			
Model:	(1)	(2)	(3)	(4)
Variables				
Post.06.14 × Dep.type	0.0267**	0.0175**	0.0167**	0.0254**
	(0.0130)	(0.0078)	(0.0077)	(0.0129)
Post.06.14 × Liquidity			-0.0448	
			(0.0430)	
Bank controls	No	Yes	Yes	Yes
Fixed effects				
Bank	Yes	Yes	Yes	Yes
Month×Year	Yes	Yes	Yes	
Month×Year×Location×				
Industry×Size				Yes
Fit statistics				
Observations	3,598,197	3,290,636	3,290,636	1,179,218
R^2	0.10674	0.10164	0.10165	0.57594
Within R^2	0.00003	0.00033	0.00033	0.00013

*Signif. Codes: ***: 0.01, **: 0.05, *: 0.1*

Table 10: **Robustness estimation: Discrete variable deposit type**: *Total credit line* is the maximum limit announced to the borrower up to which credit is granted or liability assumed by a bank. Total credit line also includes the already utilised limits and consists of on- and off-balance sheet exposure. *Post*.06.14 is a dummy variable that is 1 after June 2014 and 0 otherwise. *Dep.type* is a dummy variable that is 1 if the bank has an above median average deposit ratio in 2013 and 0 if the bank has a below median average deposit ratio in 2013. *Liquidity* is the average share of liquid assets over balance sheet total in 2013. Lagged bank controls are balance sheet total, Tier 1 capital ratio and securities ratio. Location, industry and size clusters are based on the first two digits of the postal code, the level 2 NACE codes (division level) and the firm's balance sheet total (grouped in deciles), respectively. Observation period is from 2013 to 2015. Standard-errors clustered at the bank level are in parentheses.

Dependent Variable:	New.credit		
Model:	(1)	(2)	(3)
Variables			
Post.06.14 × Dep.ratio	0.0158***	0.0105**	0.0128**
	(0.0038)	(0.0042)	(0.0057)
Post.06.14 × Liquidity		-0.0469***	
		(0.0153)	
Bank controls	Yes	Yes	Yes
Fixed effects			
Bank	Yes	Yes	Yes
Month×Year	Yes	Yes	
Month×Year×Location×Industry×Size			Yes
Fit statistics			
Observations	6,290,630	6,290,630	1,808,916
R^2	0.02743	0.02745	0.27580
Within R^2	0.00014	0.00016	0.00011

*Signif. Codes: ***: 0.01, **: 0.05, *: 0.1*

Table 11: **Robustness estimation: Discrete new credit variable**: *New.credit* is a dummy variable that is 1, if the Total credit line at time t is higher than Total credit line at time t-1 and 0 otherwise. *Post*.06.14 is a dummy variable that is 1 after June 2014 and 0 otherwise. *Dep.ratio* is the mean deposit ratio on bank level in 2013. *Liquidity* is the average share of liquid assets over balance sheet total in 2013. Lagged bank controls are balance sheet total, Tier 1 capital ratio and securities ratio. Location, industry and size clusters are based on the first two digits of the postal code, the level 2 NACE codes (division level) and the firm's balance sheet total (grouped in deciles), respectively. Observation period is from 2013 to 2015. Standard-errors clustered at the bank level are in parentheses.

A.3 Additional figures

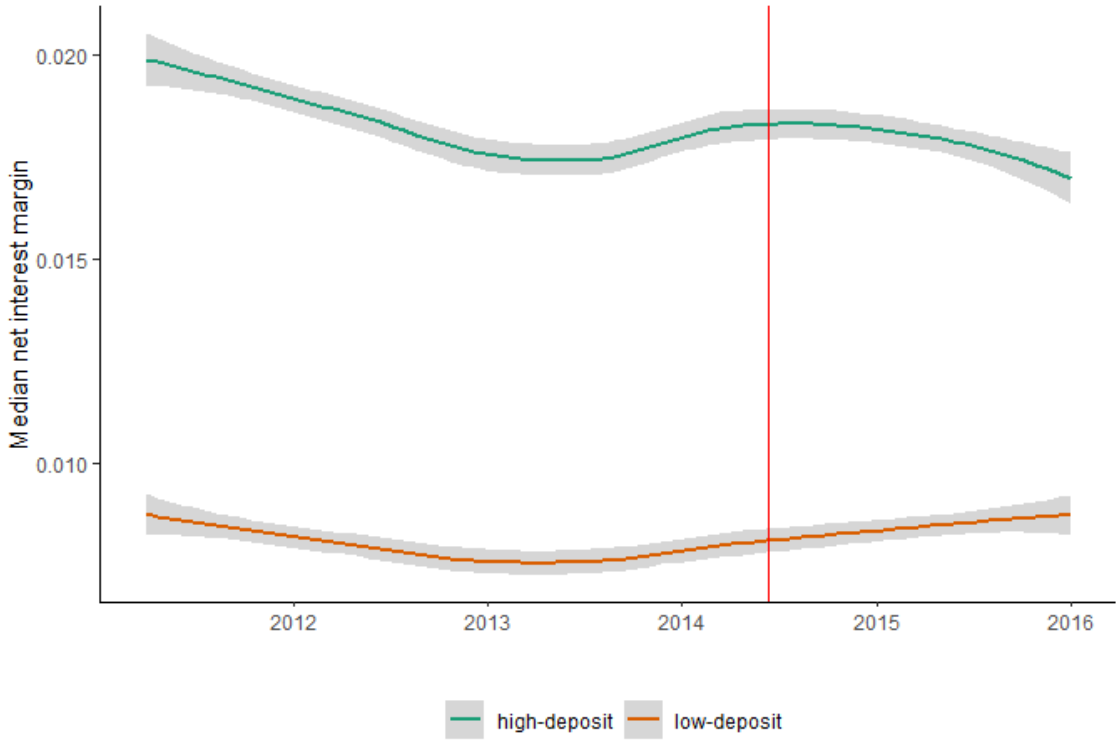


Figure 7: **Evolution of median net interest margin** for high- and low-deposit financed banks in Austria. High-deposit (low-deposit) financed banks are defined as having an above (below) median average deposit share in 2013. Note that the growth rates are smoothed using the locally weighted scatterplot smoothing method. The confidence interval around the smooth is depicted in grey. The vertical red line indicates the date at which the DFR became negative.

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