The deposits channel: the effect of bank deposit funding on lending behaviour during NIRP

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Abstract

In this thesis I examined the effect of bank deposits on the banks' lending behavior after the introduction of negative interest rate policy (NIRP). The reluctance by banks to pass-through negative policy rates to the deposit rates – the so-called deposit channel – forms the basis for my research. In theory, high-deposit banks should experience a reduction in profitability following from compressed deposit margins resulting in a lower net worth relative to low-deposit banks. I assume this channel is active, since I find no evidence that banks increase their fee income in accordance with their dependence on deposits. I proceed by studying the market for syndicated loans and provide empirical that volume and risk have both significantly increased for high-deposit banks relative to low-deposit banks measured over the years 2013 to 2015. This finding is robust to alternative deposit ratio measurements. However, I find evidence that banks already change their volumes in anticipation of NIRP over the years 2011 to 2015, which violates the difference-in-difference identifying assumption. My results on ex-ante risk are robust to this falsification test.

Contents

1. Introduction

In the post-crisis economy with low growth and low inflation, various European central banks - the European Central Bank (ECB), Denmark Nationalbanken (DNB), the Swiss National Bank (SNB) and the Swedish Sveriges Riksbank (SR) - have experimented with setting negative policy rates[1]. Either by directly charging negative policy rates through negative interest rate on reserve deposits at the central bank (Euro-area, Denmark, and Sweden) or indirectly by charging negative interest rates on 'on sight deposits' with the aim of lowering the policy rate target range (Switzerland). Long believed to be unrealistic, the historically low policy rates are a significant innovation in monetary policy and may become even more important in the future as central banks need room to cut interest rates (Bottero, 2019). Even though the use of negative interest rates policy (NIRP) has become more widespread, no consensus exists on the medium to long-term effectiveness and impact on financial stability - both theoretically and empirically. In line with these concerns, the Federal Reserve and the Bank of England have refrained from implementing a NIRP (Bernanke, 2016). With US Federal Reserve Chairman Jerome Powell stating "I do not think we'd be looking at using negative rates" after the 2019 Federal Open Market Committee meeting, when asked about what tools the Fed would consider using if economic weakness continues. From a theoretical point of view, the effect of negative rates on the real economy is priori unknown due to the zero lower bound (ZLB) problem that occurs when short-term money markets rates are at or near zero, causing a liquidity trap[2] and limiting the capacity the central bank has to stimulate economic growth. At the end of 2014, short-term money market rates were approaching the theoretical ZLB in the Euro-area while headline inflation had fallen significantly to dangerously low levels at only 40 bp, normally at 200 bp. In line with the ZLB, the expectations for the long-term future rates were that rates could only go up which were successfully taking down with introduction of negative rates according to Mario Draghi (2016), the President of the ECB. The risk inherent in high expectations about future rates relates to the role of the policy rate in the intemporal trade-off between saving and investment decisions. Unlike, the motivation by the SNB, and the Swedish Riksbank, where it was introduced to diminish capital inflows and exchange rate appreciation. Highlighting the dual role that the policy rate plays in monetary policy.

[1] The IMF definition on the central bank policy rate (CBPR) is adopted: the rate that is used by central bank to implement or signal it monetary policy stance.

[2] After the rate of interest has fallen to a certain level, liquidity preference may become virtually absolute in the sense that almost everyone prefers holding cash rather than holding a debt which yields so low a rate of interest.

Despite the importance of NIRP for our broader understanding of finance and macroeconomics, empirical evidence on the transmission to the real economy via the banking sector remains limited. While macroeconomic theory suggests that aggregate demand expands in response to a policy rate cut, thereby increasing economic growth and inflation, it also suggests that the ZLB is a binding constraint (Bernanke, 2017). The experience so far suggests that modestly negative policy rates transmit to money market rates in the same way as positive rates do except for retail deposit rates and some mortgages rates (Bech and Malkhozov, 2016). In case the policy rates are low or even negative, financial intermediaries[3] have been known to search-for-yield through increased risk-taking behavior (Rajan, 2005; Dell'Ariccia et al., 2017), formally known as the risk-taking channel of monetary policy (Borio and Zhu, 2012). It refers to the notion that the policy rate affects, besides quantity, the quality of bank credit. Within the literature on the risk-taking channel, two distinct banking channels are described for the transmission of monetary policy to the real economy. In the deposits channel, sticky retail deposit rates (at zero) lead to lower credit supply and increased risk taking by banks more dependent on retail deposits (Heider et al., 2019) and, in some cases, to weak pass-through to loan rates to protect their profitability (Eggertsson, 2019). And alternatively, the portfolio rebalancing channel in which negative rates penalize the holding of low- or negative-yield liquid and safer assets (securities), incentivize banks to rebalance towards higher-yield assets, such as corporate loans (Bernanke, 2016), and has an expansionary effect on credit supply (Bottero et al., 2019).

By now it should be evident that introduction of negative policy rates could pose a risk to the economies financial stability via increased risk-taking behavior. Even if NIRP has an expansionary effect on the credit supply (Drechsler et al. 2019; Bottero et al. (2019), one should consider the desirability of the credit expansion by examining the distribution. Two major questions remain. First, how does the NIRP affect the supply of bank credit to the real economy once the policy rate breaks through the zero-lower bound? Second, does the effect of negative policy rates on the credit supply differ from policy rates just above the zero-lower bound? In this thesis, I answer these questions by studying the supply of syndicated bank credit by Euro-area and Swiss lead arrangers around the introduction of negative policy rates at the end of 2014. My findings on the years 2013 to 2015 suggest that high-deposits bank increase the volume of bank credit after the introduction of negative interest rate policy (NIRP) relative to low-deposit banks. With high-deposits bank financing more risky firms, measured as the average five-year standard deviation of the return-on-assets, relative to low-deposit banks after the introduction of NIRP. However, I find evidence that banks already change their volumes in

[3] Laeven, and Suarez (2017) argue that risk taking is more likely when a financial institution has long-term assets and short-term liabilities, like a bank.

anticipation of NIRP over the years 2011 to 2015, which violates the difference-in-difference identifying assumption. My results on ex-ante risk are robust to this falsification test.

My analysis contributes to the existing literature on the transmission of NIRP to bank lending primarily in two ways. First, I am the first to apply a unified framework to investigate two countries with different motivations for adopting NIRP. That is, the ECB's decision is motivated by depressed aggregate demand and the risk of deflation in the Euro-area, while the SNB's decision focused on mitigating the currency appreciation and strong capital inflows in Switzerland. Second, my results inform macro models on the transmission channels of negative rates to the real economy via the banking sector by reviewing both the deposit channel and the portfolio rebalancing channel.

This thesis proceeds as follows. In Section 2, I provide the reader with an institutional background on the monetary policy. In Section 3, I provide an overview of literature on the monetary transmission channels and the preceding empirical literature. In Section 4, I form the hypothesis and discuss the methodology. In Section 5, I describe my data more generally. Presenting the empirical results in Section 6. Robustness checks are in Section 7. Concluding in Section 8.

2. Institutional background

In this section I discuss the institutional background surrounding the introduction of negative rates by the ECB in the Euro-area and the SNB in Switzerland. To illustrate that while the monetary policy intervention may seem similar, their respective motivations are different and relate to the dual role of the policy rate. On the one hand, the policy rate relates to the intertemporal trade-off between saving and investment decisions. On the other hand, the relative rate determines whether foreign investors are incentivized hold domestic currency investments and thereby acts as a lever over the exchange rate.

In Euro-area, the introduction of NIRP was motivated by fragile current economic prospects feeding into low investments and concerns about the effect of continuously weak inflation on price stability. European Central Bank President Mario Draghi emphasized during a September 2014 press conference[4], following the announcement of deposit facility (DF) rate cut to minus 10 bp, the risk that a too prolonged period of low inflation becomes embedded in medium to long-term inflation expectations (Draghi, 2014). If lower inflation levels are expected to prevail, the real interest rises, which is the rate an investor receives (or expects to receive) after allowing for inflation and calculated by subtracting the inflation rate from the nominal rate. And because nominal short-term money-

[4] Announcement ECB 2019: https://www.reuters.com/article/us-ecb-policy-rates-statement/statement-from-the-ecb-following-policy-meeting-idUSKCN1VX1DN

market rates in the euro area had already reached the effective lower bound, they cannot be adjusted downwards to compensate for this. In other words, lower inflation expectations (normally at 2%) would cause an effective contractionary effect on the real economy - the exact opposite of what is desired. As a result, the ECB continued their large scale repurchase program of asset-back securities (ABS) and government bonds accompanied by a reduction of the DF rate into negative territory for the first time in history.

In Switzerland (and Denmark), the NIRP was introduced to avoid an undesirable tightening of monetary conditions resulting from Swiss franc appreciation pressures. The appreciation pressure already led the SNB to impose a hard floor in 2011 of at least 1.2 francs per euro, successfully enforcing the costly exchange rate target by buying large quantities of foreign currency. Before abandoning the hard exchange rate floor in January 2015, the SNB announced on the 18th of December 2014[5] a rate cut to minus 25 bp on commercial banks' deposits. With the aim of taking the three-month Libor into negative territory, making it less attractive to hold Swiss franc investments and thereby diminishing appreciation pressures. Worthwhile to note, however, the exemption threshold (after which the rate applied) was set at 20 times the required reserves meaning that the average negative rate imposed on deposits of commercial banks at the SNB is much lower than the marginal rate. At the same time, the SNB announced its willingness to purchase foreign currency in unlimited quantities to support the "soft" floor, which traders believe to be at about 1.08 francs per euro[6]. Indeed, substantial intervention proved necessary with the SNB spending 86.1 billion CHF in 2015 and 67.1 billion CHF in 2016 according to SNB Annual Reports.

[5] SNB announcement: https://www.snb.ch/en/mmr/reference/pre_20141218/source/pre_20141218.en.pdf
[6]https://ftalphaville.ft.com/2017/06/02/2189554/have-the-swiss-national-banks-currency-interventions-actually-been-good-for-switzerland/

3. Transmission channels and empirical literature

3.1 Monetary policy transmission channels

While most economist would agree that, at least in the short run, monetary policy can significantly influence the course of the real economy, far less agreement exits about how exactly monetary policy exerts its influence. According to many textbooks, monetary policymakers use their leverage over short-term interest rates (among other tools) to influence the cost of capital and, consequently, consumption, including investments (Bernanke and Gertler, 1995). However, the cost of capital transmission channel has found only limited empirical support and the monetary policy transmission largely remained a black box. This has led various economists to explore whether 'imperfect information' and other frictions in the credit market might help explain the observed strong impact of monetary policy, loosely known in the literature as the credit channel of monetary policy (ref). According to the credit channel, the direct effects of monetary policy on interest rates are amplified by changes in the external finance premium which is the difference in cost between funds raised externally (equity) and funds raised internally (earnings). The size of the external finance premium represents frictions in the credit markets that drive a wedge between expected return by lenders and the costs faced by potential borrowers. This highlights that the external finance premium is driven by both changes in the *supply and demand* for credit.

On the demand side, the *borrowers net worth channel*[7] (BNWC) introduced by Bernanke and Blinder (1988) emphasizes the potential impact of monetary policy on the borrowers' balance sheets and income statements, such as borrowers' net worth and cash flow. According to the BNWC, the policy rate is inversely related the borrowers' balance sheet through the discount value, since smaller discount values result in higher collateral values and, consequently, lower debt services (repayment amounts). In this way NIRP has an expansionary effect on the credit demand by firms and households.

On the supply side, the *bank lending channel* (BLC) focuses on the impact of monetary policy on the supply of loans by depository institutions through reserve requirements. According to the BLC, lower policy rates correspond to lower reserve requirements (lower discount value), leaving more deposit funds available to bank loans. However, this binding constraint (among other assumptions[8]) has become less relevant with the evolution of the financial system putting the validity of the bank lending channel into question (Romer and Romer, 1990; Woodford, 2010). Today, two alternative

[7] Sometimes referred to as the balance sheet channel (Bernanke and Gertler, 1995).

[8] Assumption: an important subset of borrowers lacked sources of credit other than commercial banks. Nonbank financial intermediaries became increasingly important as sources of credit around 1980s and 1990s. (Adrian and Shin, 2009).

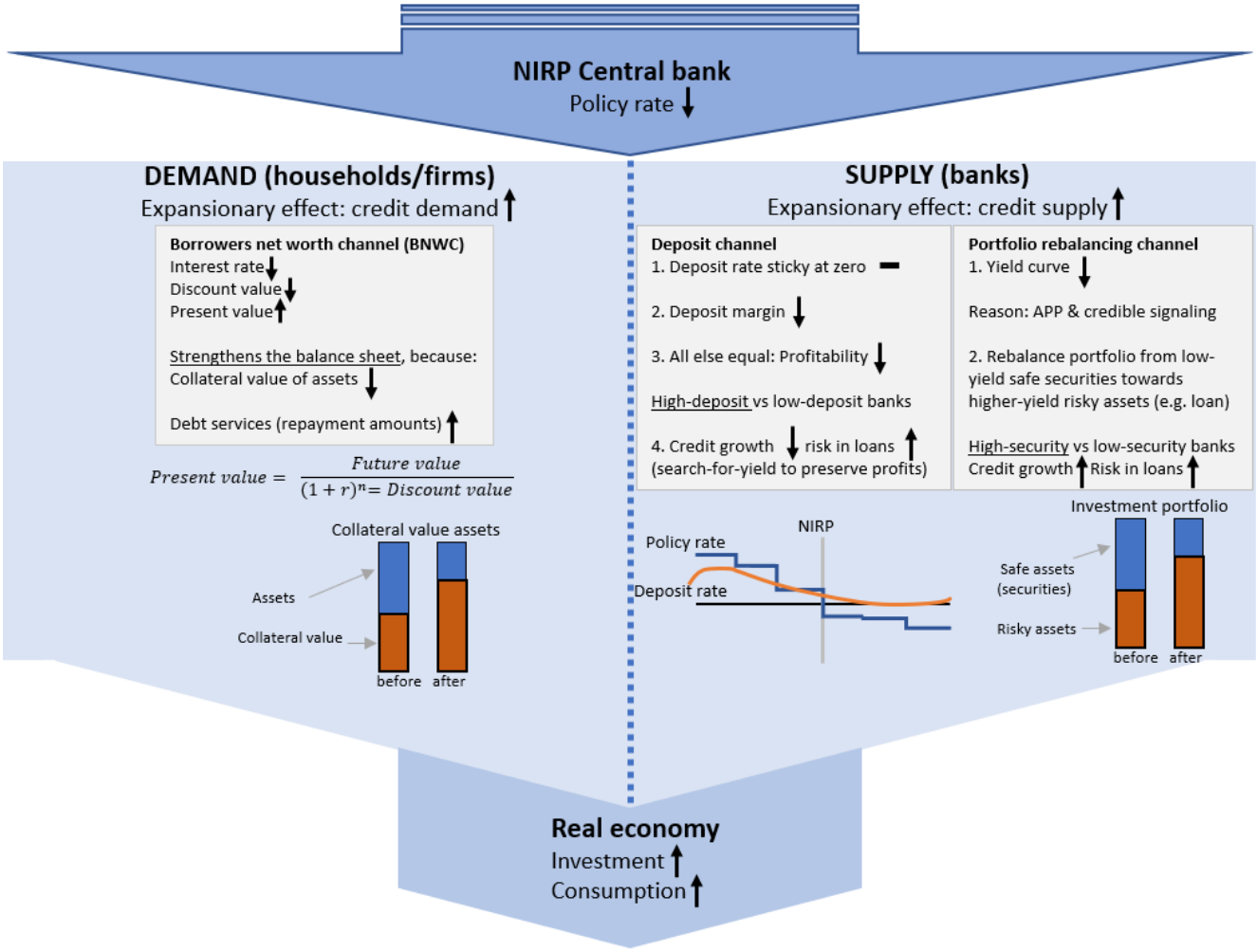
transmission are believed to primarily account for the transmission of NIRP to the real economy via the banking sector, specifically the *deposits channel* and the *portfolio rebalancing channel*.

Drechsler, Savov and Schnabl (2017) propose and test the deposits channel for the transmission of monetary policy in positive territory, that does not work through the disregarded required reserve mechanism. Instead, the loan supply by banks depends on the level of deposit funds over total assets, the deposit ratio. In the model by Drechsler et al. (2017), households hold a preference for liquidity in the form of deposits and cash. Highly liquid cash offers no return while less-liquid deposits offer some return, the deposit rate. The deposit rate is set by banks and depends on the degree of market power the bank has over their local deposit markets. Households also have the option to invest in non-liquid bonds (government bonds) in return for a competitive open-market rate set by the central bank, the policy rate. This implies that, at any point in time, the difference between policy rate and the deposit rate - the so-called deposit spread – equals the cost of holding deposits and the cost of holding cash is equal to the policy rate (see figure 1). Using branch-level data on US banks, Drechsler et al. (2017) find that an increase in the policy rate leads to a less than corresponding increase in the deposit rate, larger deposit spread, and observe that the increase is largest in concentrated markets (few banks, more market power). Arguing that banks raise the deposit spread (higher profit margin) in response to an increasing policy rate because cash becomes relatively more expense to hold, safety premium goes up. Households respond by moving money out of deposits and into bonds, which offers a rate equal to the policy rate, so that less loanable funds are available to high-deposit banks, relative to low-deposit banks. Resulting in a contractionary effect on bank lending according to the bank's dependence on retail deposits. Drechsler et al. (2019) test the deposits channel during NIRP, which works differently from positive policy rates because retail deposit rates are generally believed to be sticky at zero. Banks seem reluctant to charge negative rates to prevent account holders from substituting deposits for cash. Given the stickiness of deposit rates, NIRP has a compressing effect on deposit margins and potentially profitability, resulting in lower credit growth and even to increased risk-taking. This effect would be more pronounced for banks more dependent on deposits in case the deposits channel is active (see, Heider et al., 2019 for Euro-area, Eggertsson et al. (2019) for Sweden, Schelling and Towbin (2018) for Switzerland). However, recent evidence suggests that banks may offset lower deposit margins by charging higher fees (Bottero et al., 2019) leaving profitability unaffected (Basten and Mariathasan, 2018) and casting doubt on the validity of the deposits channel in the transmission of negative rates.

An alternative transmission channel of monetary policy that does work through deposits is the portfolio rebalancing channel. In this channel, banks seek to rebalance their investment portfolios from liquid low- or negative-return securities towards less-liquid higher-return assets and thereby

works through the banks' safe liquid assets (securities) (Bernanke, 2016). Banks are incentivized to rebalance their portfolio in case the yield curve[9] of safe assets is flattened and moves downwards (see appendix figure A.1). This adjustment occurs first through credible signaling by the central bank, so that market participants may expect the negative rates to remain in place (and low) for a long time, reinforced by large-scale Asset Purchase Programmes (APP) that lower long-term risk premia on bonds (ECB, 2017). If returns on safe securities are compressed, banks are incentivized to lower the lending rates on risky loans (ceteris paribus) in order to rebalance their portfolio from safe low-return securities towards more risky higher-return loans (Brunnermeier and Koby, 2018). The result is an expansionary effect on the supply of bank credit and is expected to be strongest in banks with a high ratio of securities over assets, the security ratio.

Figure 1: overview transmission channels under NIRP



[9] Some rates in the euro area economy – such as corporate bond rates or mortgage loan rates – are based on longer-term risk-free yields, while others – such as bank loan rates for firms – are mostly priced off shorter maturities.

3.2 Empirical literature

My thesis is closely related to preceding studies on the transmission of NIRP via bank lending. Heider, Saidi and Schepens (2019) study the effect of NIRP on the lending behavior by Euro-area banks in the syndicated loan market around mid-2014. Using a difference-in-difference approach to examine the effect of NIRP, the authors provide evidence that banks more reliant on deposits[10] finance riskier firms and exhibit lower growth in corporate loan lending volumes, compared to banks less reliant on deposits. The authors take this result as evidence in favor of the deposits channel, since high deposit banks are more constrained in passing negative rates to depositors. At the same time, the authors do find that loan volumes are on average higher (irrespective of the deposit ratio) after the introduction of negative rates suggesting that NIRP indeed has an expansionary effect on bank lending. Eggertsson et al. (2019) study the effect of negative rates according the variation in the deposit ratio across Swedish banks. Using bank-level data[11], they also find that credit growth is lower for banks which rely heavily on deposit financing consistent with the findings by Heider et al. (2019) on European banks. Similarly, Schelling and Towbin (2018) examine the effect of NIRP on Swiss banks through the deposit channel and find that high-deposit Swiss banks offer more generous lending terms in response to the unexpected rate cut on the 15th of January 2015. A notable difference, however, is the macroeconomic environment motivating the monetary policy decision to adopt NIRP. The decision in the Euro-area was motivated by depressed demand and the risk of deflation, while Switzerland, a safe-haven country, was facing currency appreciation pressures and strong capital inflows.

Despite these results, the deposit channel may also be inactive for two reasons. First, even though deposit rates are generally considered to be sticky at zero, in practice this floor may not be binding due to the costs[12] associated with holding cash (Bech and Malkhozov, 2016; Bottero et al., 2019). Second, recent evidence suggests that bank interest margins and bank profitability remained broadly stable following the NIRP because the compression of deposit margins was simultaneously offset by reductions in wholesale funding costs and higher fee income (see, e.g. Bottero et al., 2019 for Italy, Turk (2016) for Denmark and Sweden). Basten and Mariathasan (2018) confirm, using Swiss bank-level data, that bank profitability is unaffected by the negative rates as banks offset lower-interest margins with higher fees. Their identification strategy exploits the cross-bank variation in excess reserves at the central bank as a measure of sensitivity to NIRP, instead of bank deposits. Bottero et al. (2019)

[10] While checking for parallel trends using annual bank balance sheet data - in fee income, securities and the equity ratio - finding no evidence that high-deposit banks offset higher funding costs in other dimensions.
[11] Which cannot control for firm-level credit demand and risk.
[12] Given transport, storage, insurance and other costs associated with holding cash in size, the effective lower bound on nominal interest rates is somewhere below zero.

explore the effect of NIRP on Italy, using more granular and comprehensive data, on the banks credit supply through both the deposits channel and portfolio rebalancing channel, which could operate simultaneously. They find that the negative rates have an expansionary effect on the real economy via bank credit through the portfolio rebalancing channel, while finding no support in favor of the deposit channel.

4. Hypotheses, specification and methodology

In this section I formulate testable hypotheses and describe, in detail, the specifications and methodology considerations used to obtain my results. This section consists of three subsections corresponding to the three testable hypotheses.

4.1 Policy rate pass-through

A natural starting point for my analysis is to validate that the differential pass-through of negative policy rates to deposit rates differs from other rates, short- and long-term money market rates. Indeed, this differential transmission potentially would expose banks differently to NIRP depending on their liability structure, either through the deposit ratio (deposits channel) or/and the security ratio (portfolio rebalancing channel). Using aggregate annual data from the European Central Bank (ECB) and the Swiss national banks (SNB), I construct graphs to evaluate whether the deposits rates are 'sticky' at zero given weight to an explanation of the deposit channel as one of the transmission channels of negative interest rate policy (NIRP) to the real economy.

4.2 The deposits channel vs portfolio rebalancing channel

If deposit rates are found to be sticky at zero, banks with a greater reliance on deposits experience a lower reduction of their costs of funding (in case other market rates are downward flexible), and, thus, a negative shock to their profitability (and consequently their net worth). However, the deposits channel may be inactive, as suggested in and Turk (2016) and Bottero et al. (2019), in case banks offset the lower deposit margins by charging higher fees to depositors.

Hypothesis 1: Banks do not increase the fee income following NIRP in accordance with their dependence on deposits in their liability structure and, thus, the deposits channel is active.

The specification is:

$$(1) \quad \ln(feeincome)_{jt} = \alpha + \beta_1 After(6/2014) + \beta_2 Deposit\ ratio_j + \beta_3\left(After(6/2014)x\ Deposit\ ratio_j\right) + \beta_4 X_{jt} + \delta_j + \delta_t + \epsilon_{jt}$$

Where $\ln(feeincome)_{jt}$ is the natural logarithm of the fee income of bank j; $\text{After}(6/2014)$ is a dummy variable that is equal to one after the policy rate became negative; $Deposit\ ratio_j$ is measured as the deposit-to-assets ratio (in %) of bank j in 2013 or the deposit ratio in t-1 ; X_{jt} is a vector of bank-level controls, including the Size $_{t-1}$, Security ratio $_{t-1}$, Capital ratio $_{t-1}$; ϵ_{jt} is measurement error.

If banks respond to compressed deposit margins by increasing their fees, the coefficient β_1 is expected to be insignificant, indicating that banks do not increase their fee income according their deposit ratio, suggesting the deposit channel is active. In other words, fee income does not increase in the banks' deposit share following the negative rates. Suggesting banks more reliant on deposits experience a larger increase in funding costs under the NIRP, relative to low-deposit banks. If, however, β_1 is significant the deposits channel is potentially inactive, implying that the portfolio rebalancing channel is possibly more important for the effect of NIRP on the real economy via the credit supply.

4.3 The deposits channel and syndicated loans

Conditional on finding no evidence in support of an inactive deposits channel, I proceed by evaluating the effect of NIRP on the lending behavior by Euro-area and Swiss banks (only quality[13]) in accordance with their reliance on deposit funding in two dimensions: volume (quantity) and risk-taking (quality).

4.3.1 Syndicated loan volume: specification

Investigating total lending volumes of banks around the introduction of NIRP is a worthwhile exercise because the implementation of NIRP by the ECB was intended to stimulate the economy by expanding the ECB banks' credit supply. I formulate the following testable hypothesis:

Hypothesis 2: The syndicated lending volumes of banks are decreasing in the deposit ratio under NIRP, while syndicated loan volumes overall have expanded (irrespective of the deposit ratio).

Next, I formulate the specifications needed to implement my difference-in-difference strategy. My identification strategy is to compare the syndicated loan volumes of banks with varying deposit ratios around the introduction of negative policy rates. With baseline specification (2), I effectively examine whether the deposit ratio of bank j (in 2013) matters for the total syndicated loan volume of bank j at year-month t after the introduction of the negatives rates. In line with the results in preceding papers

[13] Unfortunately, none of the Swiss banks in my sample are consistently, at least 30 months, lending to euro-area borrowers during my respective sample period. I am therefore only able to review the quantity of lending ($VOLUME_{jt}$) by ECB banks.

(Heider et al., 2016; Eggertsson, 2017), the expectation is that β_1 in the baseline specification (1) will be significant and negative. The baseline specification is:

$$(2) \qquad VOLUME_{jt} = \alpha + \beta_1 \text{After}(6/2014) + \beta_2 Deposit\ ratio\ 2013_j + \beta_3 \big(\text{After}(6/2014) x\ Deposit\ ratio\ 2013_j\big) + \delta_j + \delta_t + \epsilon_{jt}$$

Where $VOLUME_{jt}$ is bank lending volume (borrower) measured as the log of the total volume of newly issued syndicated loans by bank j in its function as lead arranger in month-year t; $\text{After}(6/2014)$ is a dummy variable that is equal to one after the policy rate became negative; $Deposit\ ratio\ 2013_j$ is measured as the deposit-to-assets ratio (in %) of bank j in 2013 (the year before the negative policy rate); δ_j is bank fixed effects; $\delta_t$is the time fixed effects (month-year); ϵ_{jt} is measurement error.

I proceed estimating the less-restrictive specification (3). Less restrictive because the deposit rate now varies over time instead of the time-invariant $Deposit\ ratio\ 2013_j$. The specification looks as follows:

$$(3) \qquad VOLUME_{jt} = \alpha + \beta_1 \text{After}(6/2014) + \beta_2 Deposit\ ratio_{j,t-1} + \beta_3 \big(\text{After}(6/2014) x\ Deposit\ ratio_{j,t-1}\big) + \delta_j + \delta_t + \epsilon_{jt}$$

Where $VOLUME_{jt}$ is bank lending volume (borrower) measured as the log of the total volume of newly issued syndicated loans by bank j in its function as lead arranger in month-year t; $\text{After}(6/2014)$ is a dummy variable that is equal to one after the policy rate became negative; $Deposit\ ratio_{j,t-1}$ is measured as the deposit-to-assets ratio (in %) of bank j in year t-1; δ_j is bank fixed effects; $\delta_t$is the time fixed effects (month-year); ϵ_{jt} is measurement error.

In order to establish a robust result, I estimate an alternative specification that includes various controls to reduce the chance of omitted variable bias and make the in-sample banks 'as equal as possible'. One may be concerned that the role of deposit funding in bank lending does not depend on negative policy rates through the zero-lower bound (ZLB) on deposit rates. If negative policy rates are nothing special, the coefficient β_4 (and possibly β_5) is expected to be significant, indicating one or two things: (1) the general effect of deposit funding on bank lending during policy rate cuts in both negative and positive territory (2) the possibility that some other unobserved bank characteristic, a confounding factor, exposes banks differently to policy rate cuts in both negative and positive territory. If, on the other hand, the deposit channel is active as previously outlined then β_4 is expected to be insignificant while β_5 is significant and similar in magnitude to the estimate obtained through specification (3). To address this concern, I estimate the following specification:

$$(4)\ VOLUME_{jt} = \alpha + \beta_1(7/2012 - 5/2014) + \beta_2 \text{After}(6/2014) + \beta_3 Deposit\ ratio_{j,t-1} + \beta_4\big((7/2012 - 5/2014) x\ Deposit\ ratio_{j,t-1}\big) + \beta_5\big(\text{After}(6/2014) x\ Deposit\ ratio_{j,t-1}\big) + \beta_6 X_{jt-1} + \delta_j + \delta_t + \epsilon_{jt}$$

Where $VOLUME_{jt}$ is bank lending volume (borrower) measured as the log of the total volume of newly issued syndicated loans by bank j in its function as lead arranger in month-year t; $(7/2012 - 5/2014)$ is equal to one from the last positive policy rate cut to zero until the rate cut into negative territory; $\text{After}(6/2014)$ is a dummy variable that is equal to one after the policy rate became negative; $Deposit\ ratio_{j,t-1}$ is measured as the deposit-to-assets ratio (in %) of bank j in year t-1; X_{jt} is a vector of bank-level control , incl. $size_{j,t-1}$, $equtiy\ ratio_{j,t-1}$ and $security\ ratio_{j,t-1}$; δ_j is bank fixed effects; $\delta_t$is the time fixed effects (month-year); ϵ_{jt} is measurement error.

4.3.2 Syndicated loan risk-taking: specification

After considering the effect of deposits on syndicated loan volumes (quantity) around NIRP, I now examine the effect of deposits on the quality of syndicated loan volumes around NIRP. In case the policy rates are low or even negative, financial intermediaries[14] have been known to search-for-yield through increased risk-taking behavior (Rajan, 2005; Dell'Ariccia et al., 2017), formally known as the risk-taking channel of monetary policy (Borio and Zhu, 2012). In the deposits channel, the reluctance by high-deposit banks to pass on negative rates to depositors would increase their funding costs relative to low-deposit banks (Heider et al, 2019). This would incentivize high-deposit banks to search-for-yield by funding more risky firms. Indeed, if I find evidence in support of increased risk-taking behavior after the introduction of negative rates then NIRP could pose a threat to the financial stability with important policy implications. I formulate the following testable hypothesis:

Hypothesis 3: Negative policy rates lead to greater risk taking by banks with more deposit funding.

The specifications used to investigate the risk inherent in the borrowing firms closely resembles my approach to examine the syndicated loan volumes and will therefore be discussed less extensively. However, different to before, I will estimate and present results for both Euro-area banks and Swiss banks. This allows me to examine: (1) whether negative policy rates lead to increased risk-taking overall in the Euro-area and Switzerland (2) whether the deposits channel is important for the degree of risk-taking after the introduction of negative policy rates in the Euro-area and Switzerland.

[14] Laeven, and Suarez (2017) argue that risk taking is more likely when a financial institution has long-term assets and short-term liabilities, like a bank.

Overview measurements by economic area

Economy	Event window	Intro NIRP	$Deposit\ ratio\ 2013_j$	$I_t^{pre\ zero} = 1$	$I_t^{post\ zero} = 1$
Euro-area	1/2013 – 12/2015	6/2014	2013	(7/2012-5/2014)	After 6/2014
Switzerland	1/2013 – 12/2015	12/2014	2013	(8/2011-11/2014)	After 12/2014

Again, my identification strategy is to compare the risk-taking inherent in the firms financed by banks with varying deposit ratios around the introduction of negative policy rates. By estimating baseline specification (5), I effectively examine whether the deposit ratio of bank j (in 2013) matters for the risk-taking by bank j at year-month t after the introduction of the negatives rates. In line with Heider et al. (2019) the expectation is that β_1 in the baseline specification (1) will be significant and positive.

The baseline specification is:

$$(5) \qquad \sigma(ROA)^{5y}{}_{jt} = \alpha + \beta_1 I_t^{post\ zero} + \beta_2 Deposit\ ratio\ 2013_j + \beta_3 \left(I_t^{post\ zero}\ x\ Deposit\ ratio\ 2013_j\right) + \delta_j + \delta_t + \epsilon_{jt}$$

Where $\sigma(ROA)^{5y}{}_{jt}$ is bank j's risk in borrowing firm i firm-risk (borrower) measured as the logged five-year standard deviation of firm i's average return on assets - ROA, using P&L before tax – over the years t-5 to t-1; $I_t^{post\ zero}$ is a dummy variable that is equal to one after the policy rate became negative (6/2014 for Euro-area sample; 12/2014 for Swiss sample); $Deposit\ ratio\ 2013_j$ is measured as the deposit-to-assets ratio (in %) of bank j in 2013 $Deposit\ ratio\ 2013_j$ is measured as the deposit-to-assets ratio (in %) of bank j in 2013 (the year before the negative policy rate); ; δ_j is bank j loan to borrowing-country fixed effects (less restrictive area fixed effects for Switzerland) and borrowing industry fixed effects (based on the two-digit SIC code); δ_t is the time fixed effects (month-year); ϵ_{jt} is measurement error.

Next, I proceed by adjusting specification (5) to include a 'placebo' time dummy to check whether the effect of deposits on risk-taking in lending is specific to NIRP. The placebo dummy ($I_t^{pre\ zero}$) is equal to one from the last positive rate cut towards zero until the introduction of the negative policy rates. This setup also functions as a formal test of anticipatory effects, which refers to the possibility that banks may adjust their risk-taking behavior in the period preceding the NIRP. If anticipatory effects are present, I expect to find a significant β_4 (the placebo). However, if the deposits channel is only active during NIRP then the expectation is that β_4 is insignificant and β_5 is significant. To address this possibility, I estimate the following specification:

$$(6) \qquad \sigma(ROA)^{5y}{}_{jt} = \alpha + \beta_1 I_t^{pre\ zero} + \beta_2 I_t^{post\ zero} + \beta_3 Deposit\ ratio\ 2013_j + \beta_4 \left(I_t^{pre\ zero}\ x\ Deposit\ ratio\ 2013_j\right) + \beta_5 \left(I_t^{post\ zero}\ x\ Deposit\ ratio\ 2013_j\right) + \delta_j + \delta_t + \epsilon_{jt}$$

Where $\sigma(ROA)^{5y}{}_{jt}$ is bank j's risk in borrowing firm i firm-risk (borrower) measured as the logged five-year standard deviation of firm i's average return on assets - ROA, using P&L before tax – over the years t-5 to t-1; $I_t^{pre\ zero}$ is equal to one from the last positive policy rate cut to zero until the rate cut into negative territory (7/2012 - 5/2014 for Euro-the area sample; 8/2011 - 11/2014 for the Swiss sample); $I_t^{post\ zero}$ is a dummy variable that is equal to one after the policy rate became negative (6/2014 for the Euro-area sample; 12/2014 for the Swiss sample); $Deposit\ ratio\ 2013_j$ is measured as the deposit-to-assets ratio (in %) of bank j in 2013 (the year before the negative policy rate); δ_j is bank j's loan to country fixed effects (and the less restrictive Area[15] fixed effects for Switzerland) and bank j's loan to industry fixed effects (based on the two-digit SIC code); $\delta_t$is the time fixed effects (month-year); ϵ_{jt} is measurement error.

With the aim of establishing a robust result on risk-taking by ECB and Swiss banks around NIRP, I estimate the less-restrictive specification (7). In line with specification (2) on volume, the deposit ratio now varies over time instead of being time-invariant ($Deposit\ ratio\ 2013_j$). Moreover, I include varies controls to account for time-varying differences across banks resulting in more accurate estimates. The last specification looks as follows:

$$(7) \qquad \sigma(ROA)^{5y}{}_{jt} = \alpha + \beta_1 I_t^{post\ zero} + \beta_2 Deposit\ ratio_{j,t-1} + \beta_3 \left(I_t^{post\ zero}\ x\ Deposit\ ratio_{j,t-1}\right) + \beta_4 X_{jt-1} + \delta_j + \delta_t + \epsilon_{jt}$$

Where $\sigma(ROA)^{5y}{}_{jt}$ is bank j's risk in borrowing firm i firm-risk (borrower) measured as the logged five-year standard deviation of firm i's average return on assets - ROA, using P&L before tax – over the years t-5 to t-1; $I_t^{post\ zero}$ is a dummy variable that is equal to one after the policy rate became negative (6/2014 for Euro-area sample; 12/2014 for Swiss sample) $Deposit\ ratio_{j,t-1}$ is measured as the deposit-to-assets ratio (in %) of bank j in year t-1; X_{jt} is a vector of bank-level control , incl. $size_{j,t-1}$, $equtiy\ ratio_{j,t-1}$ and $security\ ratio_{j,t-1}$; δ_j is bank j's loan to country fixed effects (and the less restrictive Area fixed effects for Switzerland) and bank j's loan to industry fixed effects (based on the two-digit SIC code); $\delta_t$is the time fixed effects (month-year); ϵ_{jt} is measurement error.

[15] Since Switzerland has fewer observations, I include the less-restrictive Area FE instead of borrowing country FE. Area is a categorical variable with three values: Euro-area, Switzerland and VS.

4.3.3 Syndicated loans: estimation

The hypotheses are tested by implementing a difference-in-difference method to effectively compare the syndicated loan lending behavior of banks with a varying dependency on deposit funding before and after introduction of negative policy rate. This estimation technique suits my purpose well as it allows me to deal with the endogeneity of monetary policy, which is clearly not predetermined[16] and depends on current economic conditions. By reviewing the difference between high- and low-deposit banks, all time-varying differences are simply differenced out if they affect both groups in the same way. This point also illustrates that the estimate under the diff-in-diff approach is only valid in case the main identifying assumption is satisfied, known as the *common trend assumption*. In my setup, low-deposit banks provide the counterfactual for the lending behavior of high-deposit banks in the absence of the negative policy rate. Graphing volume and ROA by basket over time shows that the two groups approach a common trend, see appendix A.8 (Volume) and A.9 (ROA). Moreover, I include several control variables (as a robustness exercise) that, according to the literature, matter for the transmission of (positive) policy rates to bank lending, including size (Kashyap and Stein, 2000), security ratio and equity ratio (Jiménez et al. 2012). Furthermore, several fixed effects are added to control for unobserved heterogeneity in bank lending such as bank (lender), country (lender), industry (lender) and month-year fixed effects.

Another threat to the validity of the common trend assumption are time-varying differences across high- and low-deposit banks that affect syndicated loan volume. Preceding evidence suggests that the impact of monetary policy on credit supply is stronger for low security ratio banks (Kashyap and Stein, 2000) and that high short-term interest rates have a more pronounced negative effect on the credit supply of banks with low equity ratios (Jiménez et al. 2012). Another possibly time-varying difference would be if high-deposit banks start charging higher loan-fees to compensate for the relatively larger reduction in their net worth. As argued above, permanent differences do no matter in my setup while time-varying differences could pose a threat. To rule out these possibilities, four bank characteristics are explored over time. As can be seen in Appendix Figure A.3, the deposit-, equity-, security- and fee -ratio seem to approximate a common trend during the years 2011 to 2015 (the sample period).

Time-varying differences in credit demand between high- and low-deposit banks are another concern. To illustrate, if high-deposit banks face fewer investment opportunities compared to low-deposit banks when the policy rate is negative then the difference does no longer equal the causal effect of deposit funding on the syndicated loan volume. Instead, the estimate will be equal to the causal effect

[16] For instance, the ECB states: “Our main aim is to maintain price stability... price stability is essential for economic growth and job creation and it represents the most important contribution monetary policy can make in that area”.

plus the effect of fewer high-deposit bank investment opportunities, i.e. bias (+/-). To address this concern I limit my construct my volume measure by aggregating only over Euro-area loans. This allows me to at least partially control for variations in credit demand across economies.

Another potential threat to my identification strategy is events that coincide with the introduction of the negative policy rate. Coinciding events that affect all banks in the same way pose no threat since they are simply differenced out, whereas events affecting the lending volume by high- and low-deposit banks differently would bias the results. An example of a potentially confounding, coincidental event is the introduction of the liquidity coverage ratio (LCR) under Basel III, which requires banks to hold a larger capital buffer against outflows during stress periods. Although this could plausible effect banks differently according to their deposit ratio, the introduction of the LCR requirements was only introduced on the 1st of January 2015 with a four-year roll-out period. To diminish the influence of coinciding events and time-varying differences, I elect to use a relatively short window (2 years). around the introduction of negative policy rates in most estimations.

5.1 Data

The final dataset will be constructed using three databases. First, in order to link lender(s) and borrowers, DealScan (available through Thomson Reuters) provides me with loan-level data on the issuance of syndicated loans. A syndicated loan is financing offered by multiple lenders, most commonly banks. Syndicate lenders can be assigned into two groups: (1) arrangers (2) other syndicated members. The arrangers are responsible for the loan making, incl. monitoring and screening, and typically hold on to their loan share until the end, while syndicate members often sell their share prematurely in the secondary markets.

With the list of all DealScan lenders in hand, I set out to obtain additional information on their characteristics. To that end, I consult the Orbis Bank Focus database, the second database, provides me with annual information on key financial bank balance-sheet items (the lenders), including the amount of deposits, total assets, total securities, total equity and fee income. Unfortunately, DealScan and Orbis Bank Focus lack a common identifier. I therefore manually match the banks active in the syndicate loan market to the banks available through Orbis BankFocus. This procedure results in the identification of 1087 banks worldwide; 99 Euro-area banks, 17 Swiss banks and 971 foreign banks.

Third, I consult the Compustat database, the third database, on firm financials (the borrower) needed for my analysis of the risk inherent in the borrowers. Matching the firm financial data with the Dealscan facilities through the linking file made available by Chava and Roberts (2008)[17]. Obtaining information on the borrowers' return-on-assets (ROA), industry and country at date t for firm i. Unfortunately, Compustat only reports information on public firms and not all firms report their ROA information. This means that of the 15,393 packages (2013-2015) I obtain, and match, the borrowing firm information on 2874 packages, which includes loans by non-Euro area and non-Swiss lenders.

[17] Their linking table identifies the facility id (Dealscan: facid) together with the firm id (Compustat: gvkey) allowing me to match 2,874 packages (including packages with a foreign bank lead arranger).

5.2 Summary Statistics

In this section, I provide the reader with a complete overview of the initial sample used to investigate bank lending in two dimensions across two monetary unions. Table 1 provides an overview of the monthly syndicated loan sample covering 2013 to 2015. A syndicated loan (package-level) is included in case data on the banking characteristics (i.e. deposit ratio) is available through Orbis BankFocus for at least one lead-arranger involved. This procedure results in the identification of 99 Euro-area banks involved in 4,999 packages (15,748 facilities) and 17 Swiss banks involved in 1,217 packages (2,490 facilities)[18]. See for a complete overview of the Euro-area banks see Appendix Table A.6 and for Swiss banks see Appendix Table A.7. At the top of Panel A, I provide an overview of the distribution of firms receiving the syndicated loans (borrowers); 70.79 percent US firms, 21 percent Euro-area firms, 7.2 percent UK firms and only .64 percent Swiss firms. The Euro-area banks (Swiss banks) act, on average, as lead arranger in 126 loans (127) amounting to 62 percent (31 percent) of the loans they are involved in. In case Euro-area banks act as lead arranger in a syndicate loan, they hold on average 26 percent of the total loan amount, where Swiss banks hold a little less at 20 percent. The syndicated loan packages that include a Euro-area bank lead arranger are on average 881 million against 1.36 billion for syndicated loans with a Swiss bank lead arranger. In panel B, I compare the loan characteristics of banks with high (top-tercile) and low-deposit ratios (bottom-tercile) based on the 2013 deposit ratio distribution. This is an important exercise since it could be that high and low deposit banks systematically differ in their involvement in the syndicated loan market. The t-tests on the inequality of means does not reach significance in any of the dimensions I review for both Euro-area banks and Swiss banks.

Next, I evaluate the banks included in my sample. Table 2 provides an overview of the annual bank-level sample, the lenders. A bank is included in case it is involved in at least one syndicated loan as a lead arranger during the period 2013 to 2015. In line with syndicated loan sample, the banking-level sample includes; 99 Euro-area banks, 17 Swiss banks and 971 foreign banks (worldwide). Euro-area banks (Swiss banks) have, on average, a deposit ratio of 45 percent (58.58 percent). Other dimensions that are explored are the equity ratio, ROA and size. In Panel B, a t-test on the equality of means only provides evidence that the deposit ratio of high- and low-deposit banks differ significantly, while providing no evidence for a difference in the remaining dimensions based on the 2013 deposit ratio distribution.

[18] Additionally, the sample includes syndicated loans by 971 foreign banks (non-ECB and non-Swiss).

Table 1: **Syndicated loan sample**

Panel A	N	%								
Syndicated loans in sample (%)	15,393	100								
To Euro-area firms (%)	3,290	21.37								
To Swiss firms (%)	98	0.64								
To United Kingdom firms (%)	1,108	7.20								
To United States firms (%)	10,897	70.79								
			Euro-area					Switzerland		
	N	Mean	Std. dev	Min	Max	N	Mean	Std. dev	Min	Max
Number of loans as lead arranger	99	126.41	193.68	6	769	17	127.42	263.94	2	1057
Proportion of loans as lead arranger	99	0.62	0.24	0.12	0.99	17	0.31	0.31	0.1	0.9
Maturity of loan in months	4,815	63.26	39.16	0	376	1,189	62.16	20.70	0	264
Number of lead arrangers	4,999	5.77	4.55	1	20	1,217	7.25	4.78	1	20
Loan share in % (participants & leads)	4,999	26.26	25.47	1.35	100	1,217	19.90	19.49	1.28	100
Loan share in % (lead arrangers only)	4,999	26.41	25.64	1.12	100	1,217	20.05	19.57	1.28	100
Average loan size package (bn euros)	4,999	0.881	1.67	0.00	30.5	1,217	1.36	2.22	0.018	30.5
Average loan size facility (bn euros)	15,748	0.097	0.161	0.00	4.54	2,490	0.146	2.32	0.00	4.95
Panel B			Euro-area				Switzerland			
	Tercile	N	Mean	St. dev	t-stat	N	Mean	St. dev	t-stat	
Number of loans as lead arranger	Bottom	33	162.36	248.34	1.89	6	187.33	426.22	0.52	
	Top	33	71.18	122.43		6	89	185.79		
Proportion of loans as lead arranger	Bottom	33	.67	.23	1.69	6	0.34	0.31	0.006	
	Top	33	.57	.25		6	0.33	0.31		
Loan share in % (lead arrangers only)	Bottom	33	21.26	19.84	1.91	6	11.48	11.50	1.17	
	Top	33	12.39	17.95		6	5.76	3.27		
Average loan size package (bn euros)	Bottom	33	.66	0.84	0.64	6	1.60	1.95	0.75	
	Top	33	.51	1.04		6	2.48	2.12		
Average loan size facility (bn euros)	Bottom	33	0.087	0.10	1.16	6	0.086	0.063	0.41	
	Top	33	0.053	0.13		6	0.071	0.058		

Table 2: **Bank level sample (lenders)**

Panel A	N	%								
Total banks in sample	1,087	100								
Foreign banks	971	89.33								
Euro-area banks	99	9.11								
Swiss banks	17	1.56								
	Euro-area					Switzerland				
	N	Mean	Std. dev	Min	Max	N	Mean	Std. dev	Min	Max
Deposit ratio (%)	99	45.81	22.60	0.19	88.73	17	58.58	16.71	21.48	82.32
Equity ratio (%)	99	1.33	2.25	-16.12	4.80	17	6.39	3.93	0.93	13.32
ROA (%)	99	0.85	1.13	-3.64	3.97	17	0.54	0.19	0.25	0.90
LN(Total assets)	99	18.26	1.90	9.93	21.52	17	17.39	1.67	14.70	20.85
Panel B	Euro-area					Switzerland				
	Tercile	N	Mean	Std. dev	t-stat	N	Mean	Std. dev	t-stat	
Deposit ratio 2013(%)	Bottom	33	19.19	11.87	19.36	6	40.31	13.52	5.58	
	Top	33	69.10	8.86		6	73.20	5.06		
Equity ratio (%)	Bottom	33	9.35	15.29	0.84	6	4.57	3.28	1.15	
	Top	33	7.06	3.04		6	7.00	3.99		
ROA (%)	Bottom	33	0.69	0.95	0.06	6	0.40	0.51	0.60	
	Top	33	0.67	0.80		6	0.55	0.27		
LN(Total assets)	Bottom	33	18.42	2.43	1.23	6	17.78	1.79	0.21	
	Top	33	17.79	1.57		6	17.57	1.67		

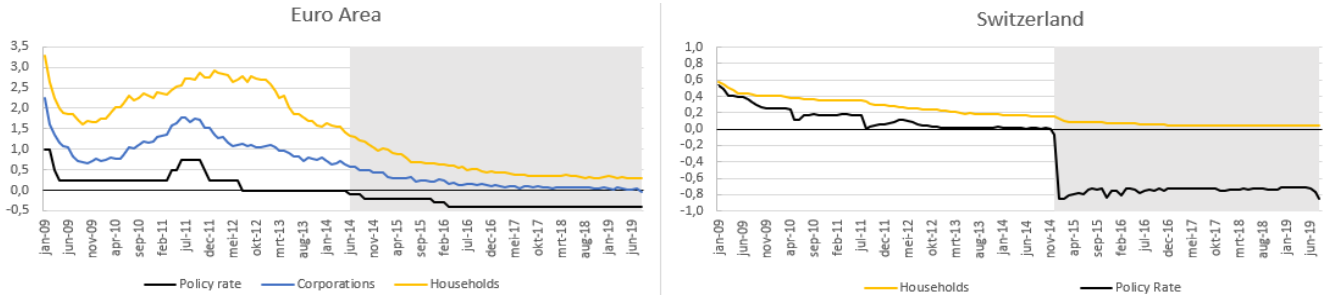
6. Results

In this section I present the results in five steps. First, I evaluate the pass-through of negative policy rates to deposit rates (as well as other bank and market rates). I then test whether the banks' dependence on deposits effects the fee income around the introduction of the negative interest policy. Thereafter, I turn to syndicated loans and I examine the effect of negative interest rates on the total loan volume granted by banks around the introduction of negative rates. Lastly, I examine whether the banks' dependence on deposits effects the risk inherent in the syndicated loans around NIRP as measured by the average volatility of the borrowing firms' return-on-assets (ROA).

6.1 Policy rate pass-through

The rationale behind the deposits channel (Eggertsson, 2019) is that banks are reluctant to pass-through the policy rate to the deposits rates in case the policy rates moves below zero. This reluctance by banks would be driven by the fact that deposits would effectively become inferior to cash, which offers a zero rate of return (assuming zero storage costs). This would create wedge between banks in accordance with their dependence on the deposits in their liability structure. Compressed deposit margins would ceteris paribus (all else equal) result in lower profitability, leading to lower credit growth and increased risk-taking behavior (Heider et al, 2019) and, in some cases, to weak pass-through to loan rates to protect their profitability (Eggertsson, 2019). To evaluate this possibility, Figure 1 plots the policy rate set by the central bank and the deposit rate payed by banks over time. In the Euro-area, the deposit rate payed by the bank in return for storing household deposits has yet to reach the 'theoretical' zero lower bound, while the corporate deposit rate is close to zero at 0.09 percent in February 2017 onwards. In Switzerland, however, the graph tells a clearer story with the deposits rates clearly being stuck at zero in response to the introduction of the negative policy rate (SNB: the deposit rate on 'on sight deposits')[19]. In contrast, the pass-through to other money market rates seems to be complete with various short-term money market rates, an alternative funding rate for banks, following the negative policy rate into negative territory (see Appendix A.5 and A.6)

Figure 1: limited pass-through of negative policy rates to deposit rates banks



[19] Similarly, in Sweden (NIRP from 2/2015) household and corporate deposit rates seem to be sticky at zero, while corporate deposit rates in Denmark (NIRP from 7/2012) are in fact slightly negative (see appendix A.4).

6.2 The deposits channel vs portfolio rebalancing channel

The literature on the transmission channel of negative policy rates describes two channels by which negative policy rates are transmitted to the real economy through the banking sector, namely the deposits channel (Heider et al, 2019) and the portfolio rebalancing channel (Bernanke, 2016). The deposits channel operates through the banks' deposit ratio, whereas the portfolio rebalancing channel works through the banks' security ratio (securities over assets). The (lagged) security ratio would matter because banks are incentivized to lower the lending rates on risky loans (ceteris paribus) in order to rebalance their portfolio from safe low-return securities towards riskier higher-return loans which would increase the banks' fee income[20]. Interestingly, recent evidence by Bottero et al. (2019, p.51) suggests that banks increase fee income (charge higher fees) to offset lower deposit margin, leaving profitability unaffected (Basten and Mariathasan, 2018) and casting doubt on the validity of the deposits channel in the transmission of negative rates. To investigate this possibility, I examine the annual fee income of 94 ECB banks from 2009 to 2015. Empirically validating that banks do not increase the fee income following NIRP in accordance with the dependence on deposits in their liability structure and, thus, the deposits channel is active (hypothesis 1).

The variation in fee income is valuable because, if both are active, the deposit channel would decrease fees and the security ratio would increase fees. The results from estimating equation (1) are presented in Table 3. The first column shows the basic difference-in-difference specification with the deposit ratio in 2013 (time invariant) and year fixed effects only. The interaction between the deposit ratio and the After(2014) dummy for the introduction of the NIRP has a negative sign and does not reach significance. Finding no support that higher deposit ratios in 2013 are associated with higher fee income. In remaining columns, the deposit ratio is measured as the lagged deposit ratio allowing me to include bank fixed effects thereby removing time invariant differences between banks. The coefficient on the interaction term of interest remains negative and insignificant. Based on these results I accept hypothesis 1, banks do not increase the fee income following NIRP in accordance with their dependence on deposits in their liability structure and, thus, the deposits channel is active. This conclusion is supported by Figure A.5 in the Appendix, graphing the annual average fee income separately for banks based on the 2013 deposit distribution. Furthermore, the security ratio control is significant in most specifications providing evidence that the security ratio matters for fee income[21] and suggesting that the portfolio rebalancing channel is potentially active (although this would require additional research).

[20] More loans would result in higher fee income (service compensation for arranging the loan).
[21] The security ratio will be included as a control (robustness) since it would also matter for VOLUME and ROA.

Table 3: **Effect of negative rates on the annual Fee income of ECB banks**

Dependent	ln(Fee income)			
Sample	2013-2015		2011-2015	2009-2015
Variables	(1)	(2)	(3)	(4)
Depratio 2013	0.00857			
	(0.00862)			
Depratio 2013 x After(2014)	-0.00211			
	(0.00248)			
Depratio $_{t-1}$		0.00812	0.00939	0.00968
		(0.0128)	(0.0112)	(0.0102)
Depratio $_{t-1}$ x After(2014)		-0.00391	-0.00382	-0.00400
		(0.00238)	(0.00253)	(0.00253)
Size $_{t-1}$	0.812***	0.00906	0.377**	0.405**
	(0.126)	(0.149)	(0.164)	(0.170)
Security ratio $_{t-1}$	0.0124*	0.00750	0.0163**	0.0156**
	(0.00694)	(0.00587)	(0.00771)	(0.00722)
Capital ratio $_{t-1}$	0.110	-0.883	-0.905*	-0.884*
	(0.138)	(0.662)	(0.523)	(0.480)
Bank FE	NO	YES	YES	YES
Year FE	YES	YES	YES	YES
N	245	243	351	375
Banks	94	94	94	94

Notes: the dependent variable across all specifications is ln(Fee income) measured as the logged fee income by bank j in year t. In the first column, Deposit ratio 2013 is bank j's ratio (in %) of deposits over total assets in 2013. In the remaining columns, Deposit ratio $_{t-1}$ is bank j's deposit ratio in t-1. Size $_{t-1}$ is the logarithm of bank j's total assets in year t-1. Security ratio $_{t-1}$ is bank j's securities over total assets in year t-1. Capital ratio $_{t-1}$ is bank j's reserves over total assets in year t-1. Bank and year fixed effects are included. Robust standard errors, clustered at the bank-level, are in parentheses. Significance levels are included: * at the 10%, ** at the 5%, *** at the 1%.

6.3 The deposits channel and syndicated loan volume

Given that I found no evidence that the deposit channel is inactive, I proceed by evaluating the total volume of bank lending in the syndicated loan market around the introduction of NIRP. The volume measure is constructed by aggregating the newly issued loans shares of bank j at year-month t. In line with the result by Heider et al. (2019), the expectation is that the syndicated loan volume is decreasing in the deposit ratio under NIRP, while syndicated loan volumes overall have expanded (irrespective of the deposit ratio). In contrast to Heider et al. (2019), I only consider loans to European firms so that I can, at least partially, account for varying borrowing firm-country conditions. This is important because the volume of bank lending will also depend on the demand for credit by firms[22]. The results from estimating specification (2) are presented in Table 4. The results in Table 4 are constructed by using the time-invariant 2013 deposit ratio, while only considering banks that loan consistently (at least 30 months) from January 2013 to December 2015[23]. This last point is important since it will diminish the influence of outliers resulting in more accurate and more externally valid estimates of

[22] Which will depend on the market conditions, ergo the borrowing-firm country.

[23] Unfortunately, none of the seventeen Swiss banks in my sample meet this criteria so that this part of the analysis cannot be executed on the Swiss sample.

the deposit ratio effect on bank lending. In columns 1 to 3, I consider only the syndicated loan volumes by Euro-area banks (lenders) with twenty ECB banks meeting the conditions. The deposit ratio 2013 coefficient in column 2 implies that before the introduction of negative rates, lending volumes are decreasing in the 2013 deposit ratio. In contrast to the expectation, the difference-in-difference estimate in column 2 implies that high-deposit banks increase their lending volumes after the introduction. Moving from column 2 to 3 of Table 4 I add bank fixed effects to control for unobserved time-invariant bank characteristics. The difference-in-difference estimate decreases from 0.0143 to 0.0140, while remaining highly significant at the 1 percent level. Taking the estimate from the third column, a 10% increase in the 2013 deposit ratio leads to an economically relevant increase in lending of 14% after June 2014[24]. Moreover, the After(6/2014) dummy coefficient has a positive sign and is highly significant implying that all ECB bank lending volumes (regardless of the deposit ratio) are higher after the introduction of negative rates. In columns 4 to 6, I perform a falsification test with only non-euro banks to euro-area borrowing firms. In the most restrictive specification of column 6, I find no effect as should be the case for non-euro area lenders that are not directly affects by the negative ECB policy rates.

Table 4: Impact of negative policy rates on ECB Banks' Lending Volumes to Euro area borrowers (Deposit ratio 2013)

Dependent	ln(Syndicated-loan volume)					
Sample	2013-2015					
Lenders	Euro-area banks			Non-euro banks		
Variables	(1)	(2)	(3)	(4)	(5)	(6)
Deposit ratio 2013	-0.0477*	-0.0556**		0.0103	0.00381	
	(0.0258)	(0.0271)		(0.0158)	(0.0157)	
After(6/2014)	2.292***	1.749***	1.779***	1.439**	1.006	1.113
	(0.380)	(0.430)	(0.433)	(0.680)	(0.656)	(0.657)
Deposit ratio 2013* After(6/2014)		0.0143***	0.0140***		0.0125	0.0130
		(0.00441)	(0.00446)		(0.00838)	(0.00861)
Bank FE	NO	NO	YES	NO	NO	YES
Month-Year FE	YES	YES	YES	YES	YES	YES
N	684	684	684	269	269	269
Banks	20	20	20	8	8	8

Notes: the dependent variable across all specifications is ln(Syndicated-loan volume) measured as the logged syndicated loan volume by bank j in year-month t to Euro-area borrowers in its function as lead arranger from January 2013 to December 2015.. Only banks that loan at least 30 months during the respective sample period are considered. Deposit ratio 2013 is bank j's ratio (in %) of deposits over total assets in 2013. After(6/2014) is a dummy that is equal to one after the introduction of negative policy rates by the ECB (6/2014) and zero otherwise. Bank and month-year fixed effects are included. Robust standard errors, clustered at the bank-level, are in parentheses. Significance levels are included: * at the 10%, ** at the 5%, *** at the 1%.

[24] Because a 1 change in the deposit rate (measured in %) leads to 1.4% increase in volume after 6/2014.

Table 5 shows the results of estimating specification (3). The deposit ratio is now defined as the deposit ratio in the year preceding the volume measure (t-1) and, as such, varies over time. In the first four columns all months between 2013 to 2015 are considered. Similar to Table 4, the difference-in-difference estimate in column 2 of Table 5 is 0.0134 and significant, whereas the estimate for non-euro lender in column 4 is not. Highlighting that the original time-invariant 2013 deposit ratio does well in capturing the variation in the syndicated loan volumes. In the last two columns, the sample period is extended to include the years 2011 and 2012. When considering the extended event window, the interaction term on euro-area lenders in column 5 does not reach significance, while the coefficient for non-area lenders remains insignificant as expected. As mentioned under estimation, coinciding events that affect the lending volume by high- and low-deposit banks differently would bias the estimate motivating my choice to consider a small event window (2013 – 2015) in most estimations. As such, it could be that the insignificance on the difference-in-difference coefficient in column 4 follows from to coinciding events.

Table 5: Impact of negative policy rates on ECB Banks' Lending Volumes to Euro area borrowers (Deposit ratio$_{t-1}$)

Dependent	ln(Syndicated-loan volume)					
Sample	2013-2015				2011-2015	
	Euro-area lenders	Euro-area lenders	Non-euro area lenders	Non-euro area lenders	Euro-area lenders	Non-area area lenders
Variables	(1)	(2)	(3)	(4)	(5)	(6)
Deposit ratio$_{t-1}$	-0.0231*	-0.0220*	-0.000452	-0.0105	-0.0273**	-0.00472
	(0.0132)	(0.0111)	(0.00336)	(0.00713)	(0.0119)	(0.0106)
After(6/2014)	2.436***	1.875***	1.565*	1.148	3.162***	0.421
	(0.380)	(0.363)	(0.677)	(0.647)	(0.491)	(0.629)
Deposit ratio$_{t-1}$ x		0.0134**		0.0134	0.00389	0.0103
After(6/2014)		(0.00473)		(0.00952)	(0.00685)	(0.0100)
Bank FE	YES	YES	YES	YES	YES	YES
Month-Year FE	YES	YES	YES	YES	YES	YES
N	684	684	269	269	1,347	476
Banks	20	20	8	8	26	10

Notes: the dependent variable across all specifications is ln(Syndicated-loan volume) measured as the logged syndicated loan volume by bank j in year-month t to Euro-area borrowers in its function as lead arranger from January 2013 to December 2015 in the first four columns and from January 2011 to December 2015 in the last two columns. Banks that loan at least 30 months during the respective sample period are considered. Deposit ratio $_{t-1}$ is bank j's deposit ratio in year t-1. After(6/2014) is a dummy that is equal to one after the introduction of negative policy rates by the ECB (6/2014) and zero otherwise. Bank and month-year fixed effects are included. Robust standard errors, clustered at the bank-level, are in parentheses. Significance levels are included: * at the 10%, ** at the 5%, *** at the 1%.

6.4 The deposits channel and syndicated loan risk-taking

Now that I provided results in support of higher loan volumes (quantity) in accordance with the banks' dependence on deposits around NIRP, I proceed by investigating the quality of bank lending for both ECB- and Swiss-banks. As mentioned earlier, in case banks finance riskier firms after the introduction of negative rates then NIRP could pose a threat to the financial stability. The riskiness of a loan to firm i by bank j at month-year t is measured as the logged average five-year standard deviation of firm i's average return on assets - ROA, using P&L before tax – over the years t-5 to t-1. Heider et al. (2019) apply a similar measure of risk and find evidence that suggests that high-deposits banks loan to riskier firms after the introduction of negative rates in the Euro-area relative to low-deposit banks. In contrast to Heider et al. (2019), I first only consider syndicated loans with a single[25] lead arranger bank (lender) over the years 2013 to 2015. to be able to include bank fixed effects in estimating my results[26]. Table 6 shows the results of estimating specification (5). Moving from the second to the third column, bank fixed effects are included. The difference-in-difference estimate is reduced from 0.0197 to 0.0152, while the estimate remains insignificant and positive. Thereafter, I estimate a similar less-restrictive model[27] on the single Swiss lead arranger loans. Unfortunately, borrowing firm information was only available for the largest public firms resulting in few Swiss loans remaining in the syndicated loan risk-taking sample[28]. Even though the difference-in-difference estimates in the sixth and seventh column are significant and positive, I am cautious in taking these results at face value. In columns four and eight, I re-estimate both specifications for non-euro area and non-swiss lenders including bank fixed effects in both. I find no evidence in support of increased risk-taking behavior by these lenders, which makes sense since they are not directly affected by the negative rates.

Having restricted the sample to single lead arrangers before, I elect to led to go of this criterion and now consider all loans for which I have the firm information, single and multiple lead arrangers. This decision comes at the cost of not being able to include bank fixed effects. The results are presented in Table 7. All specifications include month-year, industry and borrowing country fixed effects. By doing so, I account for variation in the level of borrowing firm risk across time periods, across industries and the borrowing country. In Table 7, I first re-estimate specification (5) with the extended sample (single and multiple lead arrangers) in the first, second, fifth and sixth column. Presenting the estimates from specification (6) in the remaining columns of Table 7 that include the years 2011 and 2012.

[25] Single meaning only one Euro-area bank or only one non-Euro area bank that I have information on.
[26] In Heider et al. (2019), the authors take the average over all bank characteristics in case multiple ECB banks are involved in a syndicated loan. This way they obtain a single deposit ratio for each firm i ROA at date month-year t. Applying bank fixed effects as they do would surely result in incorrect estimates in my opinion.
[27] Only Area FE are included in the estimation given the small number of banks (3) and loans (41).
[28] These loans were granted by the larger Swiss banks: Credit Suisse AG, Zurcher Kantonalbank and UBS AG.

Table 6: ROA volatility of firms financed by a single lead arranger around the introduction of negative rates

Dependent	$\ln(\sigma(\text{Return on assets borrower}_i)^{5y})$								
Sample	2013-2015								
Lenders	Euro-area lenders			Non-euro area lenders		Swiss lenders			Non-swiss lenders
Variables	(1)	(2)	(3)	(4)	Variables	(5)	(6)	(7)	(8)
Deposit ratio 2013	0.0171**	0.00666			Deposit ratio 2013	0.0570***	-0.0924***		
	(0.00698)	(0.00917)				(0.0210)	(0.0336)		
After(6/2014)	-0.625	-1.160	0.0517	-1.315	After(12/2014)	-1.621***	-103.1***	-124.4***	-1.438
	(1.466)	(1.569)	(0.976)	(1.272)		(0.00966)	(0.838)	(1.53e-05)	(1.020)
Deposit ratio 2013		0.0197	0.0152	0.0115	Deposit ratio 2013		2.664***	3.234***	0.0115
x After(6/2014)		(0.0129)	(0.0120)	(0.0236)	x After(12/2014)		(0.0224)	(4.19e-07)	(0.0115)
Bank FE	NO	NO	YES	YES	Bank FE	NO	NO	YES	YES
Month-year FE	YES	YES	YES	YES	Month-year FE	YES	YES	YES	YES
Industry FE	YES	YES	YES	YES	Industry FE	NO	NO	NO	NO
Country FE	YES	YES	YES	YES	Country FE	NO	NO	NO	NO
Area FE	NO	NO	NO	NO	Area FE	YES	YES	YES	YES
N	187	187	187	159	N	41	41	41	159
Banks	34	34	34	50	Banks	3	3	3	50

Notes: the dependent variable across all specifications is $\ln(\sigma(\text{Return on assets borrower}_i)^{5y})$ measured as the logged volatility of the return-on-assets average over t-1 to t-5 of firm i financed by bank j in year-month t in its function as lead arranger from January 2013 to December 2015. Deposit ratio 2013 is bank j's ratio (in %) of deposits over total assets in 2013. After(6/2014) is a dummy that is equal to one after the introduction of negative policy rates by the ECB (6/2014) and zero otherwise. After(12/2014) is a dummy that is equal to one after the introduction of negative policy rates by the SNB (12/2014) and zero otherwise. Bank FE, Month-year FE, Industry FE (based on two-digit SIC codes), Borrowing country FE (based on the borrowing-firm country) and Area FE (categorical variable: VS, Euro-area, Switzerland) are included. Robust standard errors, clustered at the bank-level, are in parentheses. Significance levels are included: * at the 10%, ** at the 5%, *** at the 1%.

In the second column of Table 7, the After(6/2014) coefficient is negative and significant indicating that the risk inherent in the borrowing firms overall has decreased following the NIRP. While the coefficient on the 2013 Deposit ratio is insignificant, which I take as evidence that deposit ratios do not play a special role during 'normal' positive policy rate territory. Interestingly, the estimate on the interaction term in column two is 0.0134 and significant at the 5 percent level. The significance of this coefficient tells me that deposits only affect the level of risk after the introduction of NIRP. The magnitude of the coefficient implies that 10% increase in the 2013 deposit ratio leads to an economically relevant increase in risk-taking of 13.4% after June 2014. The result on Swiss banks in column five and six are insignificant and again should be reviewed with caution given the limited amount of observations[29].

The results of specification (6) are presented in the remaining columns. In specification (6), I include a so-called placebo time dummy, which is equal to one from the last policy rate cut prior to going negative until the introduction of NIRP. Interestingly, the estimate on Euro-area banks in column three is identical to the estimate in column two with the placebo dummy showing an insignificant positive coefficient. This result supports the claim that the effect of deposits on the risk inherent in the borrowing firms indeed is higher only when negative policy rates are introduced. Also, the After(6/2014) coefficient remains negative and significant implying that overall riskiness of borrowing firms has actually decreased after the introduction of NIRP. Furthermore, the estimates of specification (6) for non-euro area lenders are all insignificant. This strengthens the result of column three since the effect of deposits on risk under NIRP seems to be specific to Euro-area banks, the banks that are directly affected by the ECB's policy decisions. In column seven, I present the results for Swiss banks. The difference-in-difference estimate remains insignificant and similar in magnitude to column six. Finding no support that the few Swiss banks included in the sample finance riskier firms following negative rates from December 2014 onwards[30]. Again, risk-taking by foreign banks has not significantly increased after December 2014 and I find no evidence in favor of an active deposits channel for foreign banks during the NIRP by the Swiss National Bank (SNB).

[29] Although the amount of loans considered is now 63 against 41 in Table 6.

[30] Noting that additional research, with an extended sample of Swiss banks, is required to validate this result.

Table 7: ROA volatility of firms financed by both single and multiple lead arrangers around the introduction of negative rates

Dependent	ln(σ(Return on assets borrower$_i$)^{5y})								
Sample	2013-2015		2011-2015			2013-2015		2011-2015	
Lenders	Euro-area lenders	Euro-area lenders	Euro-area lenders	Non-euro area lenders		Swiss lenders	Swiss lenders	Swiss lenders	Non-swiss lenders
Variables	(1)	(2)	(3)	(4)	Variables	(5)	(6)	(7)	(8)
Deposit ratio 2013	0.00524	0.000748	4.82e-06	0.00123	Deposit ratio 2013	0.0328	0.0328	0.0133	-0.00112
	(0.00369)	(0.00426)	(0.00483)	(0.00339)		(0.0413)	(0.0413)	(0.116)	(0.00435)
(7/2012 – 6/2014)			0.192	0.139	(8/2011 – 12/2014)			0.301	-0.0434
			(0.479)	(0.377)				(5.214)	(0.550)
Deposit ratio 2013			0.00205	0.00299	Deposit ratio 2013			0.0200	0.00221
x (7/2012 – 6/2014)			(0.00625)	(0.00405)	x (8/2011 – 12/2014)			(0.110)	(0.00508)
After(6/2014)	-0.641	-1.105**	-1.112**	-0.363	After(12/2014)	-0.720	-84.52	-88.49	0.330
	(0.488)	(0.535)	(0.536)	(0.498)		(0.86)	(74.74)	(81.27)	(0.603)
Deposit ratio 2013		0.0134**	0.0134**	-0.000468	Deposit ratio 2013		2.199	2.299	-0.00772
x After(6/2014)		(0.00643)	(0.00643)	(0.00490)	x After(12/2014)		(1.972)	(2.137)	(0.00775)
Month-year FE	YES	YES	YES	YES	Month-year FE	YES	YES	YES	YES
Industry FE	YES	YES	YES	YES	Industry FE	NO	NO	NO	NO
Country FE	YES	YES	YES	YES	Country FE	NO	NO	NO	NO
Area FE	NO	NO	NO	NO	Area FE	YES	YES	YES	YES
N	697	697	697	1,039	N	63	63	63	1,039
Banks	72	72	72	108	Banks	3	3	3	108

Notes: the dependent variable across all specifications is ln(σ(Return on assets borrower$_i$)^{5y}) measured as the logged volatility of the return-on-assets average over t-1 to t-5 of firm i financed by bank j in year-month t in its function as lead arranger from January 2013 to December 2015 in columns (1),(2),(4) and (6) and from January 2011 to December 2015 in columns (3), (4), (7) and (8). Deposit ratio 2013 is bank j's ratio (in %) of deposits over total assets in 2013. (7/2012 – 6/2014) is a dummy that is equal to one between 7/2012 and 6/2014, the last ECB policy rate reduction before turning negative, and zero otherwise. After(6/2014) is a dummy that is equal to one after the introduction of negative policy rates by the ECB (6/2014) and zero otherwise. (8/2011 – 12/2014) is a dummy that is equal to one between 8/2011 and 12/2014, the last policy rate reduction by the SNB before turning negative, and zero otherwise. After(12/2014) is a dummy that is equal to one after the introduction of negative policy rates by the SNB (12/2014) and zero otherwise. Month-year FE, Industry FE (based on two-digit SIC codes), Country FE (based on the borrowing-firm country) and Area FE (categorical variable: VS, Euro-area, Switzerland) are included. Significance levels are included: * at the 10%, ** at the 5%, *** at the 1%.

6. Robustness

In this section I present various robustness checks for my results on the volume of bank credit and risk-taking. The results in this section are constructed using my more reliable sample of Euro-area banks.

I present the robustness checks on bank credit volume in Table 8. Starting in the first column, I exclude all lenders with a deposit ratio smaller than five percent from my definition of the Deposit ratio $_{t-1}$.[31] The difference-in-difference estimate remains highly significant and of similar size as the original estimate. The results of the second robustness checks are presented in column two. Here, I validate my choice to use the deposit ratio as my treatment variable by applying an alternative deposit ratio measure. The deposit ratio is now measured as deposits over liabilities (instead of assets). The estimate in column remains significant and similar in size. Indicating that my results reflect the different funding structures of banks and are not driven by variations in size. In column three I present the original estimate from specification (3)[32] in order to provide the reader with a base case. Here, the difference-in-difference estimate is insignificant with a positive sign. By extending the event window the probability of coinciding events and confounding factors is clearly higher which could be the reason for the loss of significance.

The remaining columns of Table 8 show the results of estimating specification (4). This specification includes a placebo time dummy to formally test for anticipatory effects and various controls that have been found to be important in explaining volume of bank credit. While the interaction term between the lagged deposit ratio and the placebo dummy is insignificant and negative in column four, it does reach significance in column five after the controls are included. This highlights that the controls are individually important in explaining the volume of bank credit and do a good job in reducing the bias previously captured in my difference-in-difference estimates. Taking these findings together, the results suggest that there are anticipatory effects which pose a threat to the validity of my identification strategy. Although the exact mechanism driving this result is underdetermined[33], the placebo interaction estimate does imply, at the very minimum, that the effect of deposits on volume is not special to rate cuts into negative territory.

[31] 31 volume measure are dropped from the sample following the exclusion of KfW (2,43%).
[32] This specification does not include the (7/2012 – 6/2014) time dummy and interaction term.
[33] Two possibilities (1) The general effect of deposit funding on bank lending during policy rate cuts in both negative and positive territory (2) the possibility that some other unobserved bank characteristic, a confounding factor, exposes banks differently to policy rate cuts in both negative and positive territory.

Table 8: Impact of negative policy rates on ECB banks' lending volume to Euro-area borrowers - Robustness

Dependent	ln(Syndicated-loan volume)				
Sample	2013 - 2015		2011 - 2015		
Robustness check	Exclude deposit ratios < 5%	Alternative deposit ratio	(Original)	Placebo dummy without controls	Placebo dummy with controls
Variables	(1)	(2)	(3)	(4)	(5)
Deposit ratio $_{t-1}$			-0.0273**	-0.0206	-0.0173
			(0.0119)	(0.0146)	(0.0133)
(7/2012 – 6/2014)				1.705**	2.218**
				(0.650)	(0.754)
Deposit ratio $_{t-1}$ x (7/2012 – 6/2014)				-0.00986	-0.0166**
				(0.00790)	(0.00573)
After(6/2014)	1.580***	1.763***	3.162***	3.369***	3.590***
	(0.441)	(0.428)	(0.491)	(0.600)	(0.519)
Deposit ratio $_{t-1}$ x After(6/2014)	0.0169***	0.0145***	0.00389	-0.00236	0.000101
	(0.00473)	(0.00444)	(0.00685)	(0.0104)	(0.00833)
Size$_{t-1}$					0.803***
					(0.239)
Securities ratio$_{t-1}$					0.0258*
					(0.0123)
Equity ratio$_{t-1}$					0.127***
					(0.0344)
Bank FE	YES	YES	YES	YES	YES
Month-Year FE	YES	YES	YES	YES	YES
N	653	684	1,347	1,347	734
Banks	19	20	26	26	14

Robustness checks: In column (1) all banks with a deposit ratio smaller than 5% are excluded. In column (2) the deposit ratio is defined as deposits over liabilities. Column (3) is the original estimate of Table 5 column 5. In column (4) and (5) testing for anticipatory effects with the Deposit ratio $_{t-1.}$

Notes: the dependent variable across all specifications is ln(Syndicated-loan volume) measured as the logged syndicated loan volume by bank j in year-month t to Euro-area borrowers in its function as lead arranger from January 2013 to December 2015 in the first four columns and from January 2011 to December 2015 in the last two columns. Banks that loan at least 30 months during the respective sample period are considered. Deposit ratio is bank j's ratio (in %) of deposits over total assets in 2013 in column (3) and (4), and the Deposit ratio $_{t-1}$ in columns (5) and (6). (7/2012 – 6/2014) is a dummy that is equal to one between 7/2012 and 6/2014, the last ECB policy rate reduction before turning negative, and zero otherwise. After(6/2014) is a dummy that is equal to one after the introduction of negative policy rates by the ECB (6/2014) and zero otherwise. Size $_{t-1}$ is the logarithm of bank j's total assets in year t-1. Security ratio $_{t-1}$ is bank j's securities over total assets in year t-1. Equity ratio $_{t-1}$ is bank j's equity over assets in year t-1. Bank FE and Month-year FE are included. Robust standard errors, clustered at the bank-level, are in parentheses. Significance levels are included: * at the 10%, ** at the 5%, *** at the 1%.

I present the robustness checks on risk-taking in Table 9. I estimate specification (7) without the placebo dummy in the first four columns and the complete specification in the last two columns. The results in Table 9 apply to all loans financed by single and multiple Euro-area lenders. Considering January 2013 to December 2015 in the first three columns, whereas the last three columns are based on January 2011 to December 2015. Contrary to my results on risk-taking, I apply the lagged deposit ratio in specification (7) since it important that the treatment variable (the deposit ratio) is predetermined[34]. In column one, I find a significant difference-in-difference estimate. The coefficient implies that a 10% increase in the deposit ratio (in the preceding year) is associated with 21.3% higher risk inherent in the borrowing firm i financed by bank j when rates are negative. Next, I exclude banks with a deposit ratio below five percent and re-estimate the model. The interaction term loses a significance level but remains significant at the 10%-level. In the third column I replace the deposit-over-assets ratio with the deposits-over-liabilities ratio. Again, the result does not change with deposits still having a significant effect on risk-taking when rates are negative.

In the remaining columns of Table 9, I extend the sample to test for anticipatory effects. First, in column four, I estimate a base case for the extended sample allowing me to determine whether the estimates change when I add the placebo dummy. Thereafter estimating specification (7) which includes a placebo time dummy, presenting the results in column five and six. Notice that in column five the placebo interaction term is insignificant while the main difference-in-difference remains significant and is almost identical to the original estimate on risk taking. Moreover, adding controls in the last column hardly changes the estimates. Based on these findings, I find no evidence of anticipatory effects in the risk-taking behavior of Euro-area banks. Indicating that the results on risk-taking are in fact robust to alternative specifications.

[34] Testing for anticipatory effects can only be done by considering 2011-2015 and the original treatment variable Deposit ratio 2013 would be in the future and therefore unsuitable for this test.

Table 9: ROA volatility of firms financed by a single and multiple ECB lead arranger around the introduction of negative rates - Robustness

Dependent	ln(σ(Return on assets borrower$_i$)^{5y})					
Sample	2013 - 2015			2011 - 2015		
Robustness check	Original	Exclude deposit ratios < 5%	Alternative deposit ratio	Original	Placebo dummy without controls	Placebo dummy with controls
Variables	(3)	(1)	(2)	(4)	(5)	(6)
Deposit ratio $_{t-1}$	-0.00529	-0.00572	-0.00839	0.000783	0.000101	0.00124
	(0.00800)	(0.00803)	(0.00742)	(0.00475)	(0.00586)	(0.00590)
(7/2012 -6/2014)					0.205	0.196
					(0.501)	(0.510)
Deposit ratio$_{t-1}$ x					0.00127	0.000367
(7/2012 -6/2014)					(0.00640)	(0.00651)
After(6/2014)	-0.281	0.185	-0.0904	-1.148*	-1.156*	-1.126*
	(0.862)	(0.832)	(0.0842)	(0.655)	(0.657)	(0.660)
Deposit ratio$_{t-1}$ x	0.0213**	0.0172*	0.0153*	0.0172***	0.0173***	0.0175***
After(6/2014)	(0.00918)	(0.00957)	(0.00803)	(0.00637)	(0.00640)	(0.00645)
Size$_{t-1}$						0.0280
						(0.0406)
Securities ratio$_{t-1}$						1.040*
						(0.547)
Equity ratio$_{t-1}$						0.367
						(1.286)
Month-year FE	YES	YES	YES	YES	YES	YES
Industry FE	YES	YES	YES	YES	YES	YES
Country FE	YES	YES	YES	YES	YES	YES
N	312	309	323	516	516	516
Banks	48	46	53	64	64	64

Robustness checks: In column (1) estimating the original specification (base case). In column (2) all banks with a deposit ratio smaller than 5% are excluded. In column (3) the deposit ratio is defined as deposits over liabilities. In column (4) estimating the original specification without the placebo dummy. In column (5) estimating specification 7 to check for anticipatory effects. In column (6) check whether adding controls changes the estimates.

Notes: the dependent variable across all specifications is ln(σ(Return on assets borrower$_i$)^{5y}) measured as the logged volatility of the return-on-assets average over t-1 to t-5 of firm i financed by bank j in year-month t in its function as lead arranger from January 2013 to December 2015 in the first four columns and from January 2011 to December 2015 in the last two columns. Deposit ratio $_{t-1}$ is the deposit ratio in the year t-1. After(6/2014) is a dummy that is equal to one after the introduction of negative policy rates by the ECB (6/2014) and zero otherwise. Size $_{t-1}$ is the logarithm of bank j's total assets in year t-1. Security ratio $_{t-1}$ is bank j's securities over total assets in year t-1. Equity ratio $_{t-1}$ is bank j's equity over assets in year t-1. Month-year FE, Industry FE (based on two-digit SIC codes), Country FE (based on the borrowing-firm country) are included. Significance levels are included: * at the 10%, ** at the 5%, *** at the 1%.

7. Discussion and conclusion

In this thesis I examined the effect of bank deposits on the banks' lending behavior after the introduction of negative interest rates. Studying the market for syndicated loans, I explore the effect NIRP on the volume of bank credit and subsequently the risk inherent in the firms that receive loans. The main mechanism driving my results is the apparent reluctance by banks to pass-through negative policy rates set by the central bank to deposit rates payed to customers, the so-called deposits channel. Given that the pass-through to other short- and long-term money markets appears to be complete, high-deposit banks should experience a reduction in profitability following from compressed deposit margins resulting in a lower net worth relative to low-deposit banks.

Before proceeding with my analysis of bank lending behavior, I start by studying fee income because banks may adjust their fee income in accordance with their reliance on deposits to protect profitability as suggested in Eggertsson (2019). Using a yearly panel from 2009 to 2015, I find no support for this predication and accept hypothesis 1. Banks do not increase the fee income following NIRP in accordance with their dependence on deposits in their liability structure and, thus, the deposits channel is active. I proceed with my analysis using a monthly panel of syndicated loans over the years 2013 to 2015. Here I provide evidence that the syndicated loan volumes of high-deposit banks in the Euro-area are higher following the introduction of NIRP while syndicated loan volumes overall have expanded (higher than before). This finding is robust to the exclusion of low deposit banks (<5%) and an alternative deposit measure. However, I find evidence in support of anticipatory effects over the extended event window (2011-2015), violating the identifying assumption of the difference-in-difference strategy and possibly invalidating my findings on volume. Taking these findings together, I reject hypothesis 2, which states that the banks' syndicated loan volume is decreasing in the deposit ratio under NIRP, while syndicated loan volumes overall have expanded (irrespective of the deposit ratio). After examining the quantity of bank lending (volume), I now consider to the quality of bank lending (risk-taking). According to the risk-taking channel of bank lending under NIRP, financial intermediaries[35] have been known to search-for-yield through increased risk-taking behavior (Rajan, 2005; Dell'Ariccia et al., 2017). Considering a sample of loans granted by single and multiple lead arrangers, I provide evidence that high-deposit banks finance riskier firms after the introduction of NIRP relative to low-deposit banks. This result is robust to the exclusion of low-deposit banks and an alternative deposit ratio measurement. Furthermore, I find no evidence of anticipatory effects in risk-

[35] Laeven, and Suarez (2017) argue that risk taking is more likely when a financial institution has long-term assets and short-term liabilities, like a bank.

taking. Overall, the results on Euro-area banks support hypothesis 3 that negative policy rates lead to greater risk taking by banks with more deposit funding.

This thesis contributes to the existing literature in two ways: methodology improvements and by providing a methodology framework to analyze the effect of NIRP on Swiss banks. In contrast to Heider et al. (2019), I construct my volume measurement by aggregating over loans granted to euro-area borrowers only (instead of including all loan to firms worldwide). In this way, I am at least partially able to account for variations in the demand by borrowing firms. Indeed, firms within the same economic region will most likely face similar market conditions and will therefore on average have similar needs in terms of bank credit. In a more general way, my results inform macro models on the transmission channels of negative rates to the real economy via the banking sector by reviewing both the deposit channel and the portfolio rebalancing channel. Moreover, to my knowledge, I am the first to examine the lending behavior of Swiss banks around the introduction of negative rates. Even though my results on Swiss banks only consider three banks, I do provide a framework to investigate the effect of NIRP on Swiss banks.

Besides the abovementioned contributions, I am also aware of the limitations and shortcomings of my thesis. This ensures that future researchers are aware of potential fruitful areas left to be explored. As mentioned above, my result on the volume of bank lending by Euro-area banks is not robust to a test for anticipatory effects, future research could potentially include dummies for coinciding events around the introduction of NIRP. This would allow researchers to determine more accurately in what way the deposit ratio relates to the volume of bank credit. A limitation of my analysis is that only few Swiss banks are active in the syndicated loan market and a limited amount of borrowing firm information is available, preventing me to reliably estimate a result on the effect of NIRP. Future research could examine the lending behavior of Swiss banks in an alternative credit market, such as the traditional corporate loan market[36]. Another possibility to increase the number of observations on Swiss banks would be to measure ex-ante risk in a different manner that is available more frequently.

[36] Data on traditional corporate loans would be higher in frequency and more reliable since it involves a 1-1 relationship as opposed to syndicated loans where multiple lead arrangers (and participants) loan to one client

8. References

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9. Appendix

Figure A.1: <explain>

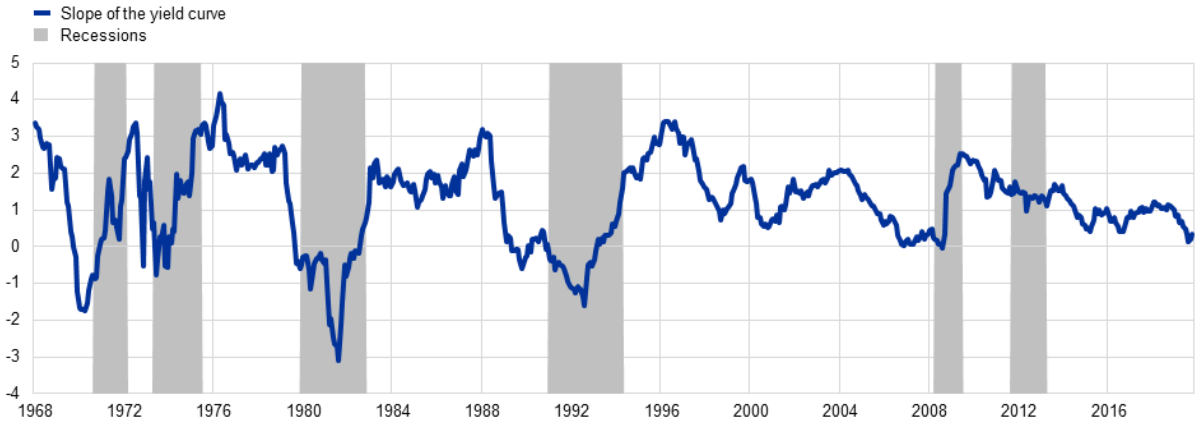
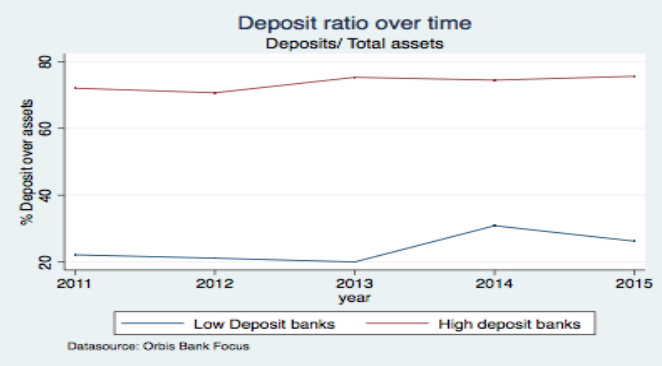
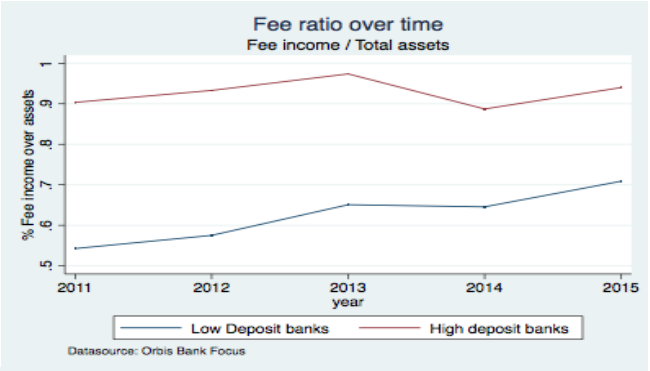


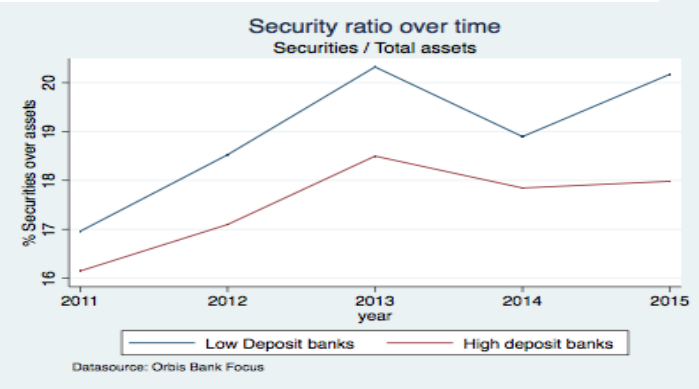
Figure A.2: the introduction of negative policy rates

Country	Date	Policy rate	Deposit rate at CB
			Deposit Facility (DF)
Euro area (ECB)	11-6-2014	MRO (main refinancing rate)	-0,10%
	10-9-2014		-0,20%
	9-12-2015		-0,30%
	16-3-2016		-0,40%
	18-9-2019		-0,50%
		Certificate of Deposit (CD)	
Denmark (Nationalbanken)	jul-12	-0,20%	
	jan-13	-0,10%	
	apr-14	0,50%	
	sep-14	-0,05%	
	feb-15	-0,75%	
	jan-16	-0,65%	
	sep-19	-0,75%	
		Repo Rate	Deposit Rate
Sweden (Riksbank)	9-7-2014	0.25%	-0,50%
	29-10-2014	0.00%	-0,75%
	18-2-2015	-0,10%	-0,85%
	25-3-2015	-0,25%	-1,00%
	8-7-2015	-0,35%	-1,10%
	17-2-2016	-0,50%	-1,25%
	9-1-2019	-0,25%	-1,00%
		Midpoint of 3-month Libor target range (policy rate) / Deposit rate on sight deposits	
Switzerland (Swiss National Bank/ SNB)	nov-14	0,00%	
	dec-14	-0,25%	
	jan-15	-0,75%	
	okt-19	-0,75%	

A.3: ECB banks - common trends in four dimensions







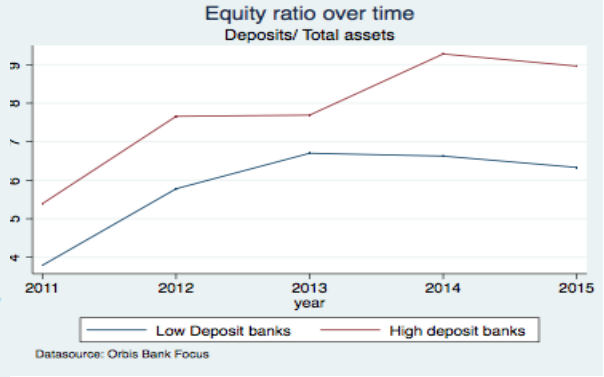


Figure A.4: limited pass-through negative policy rates to banks deposit rates

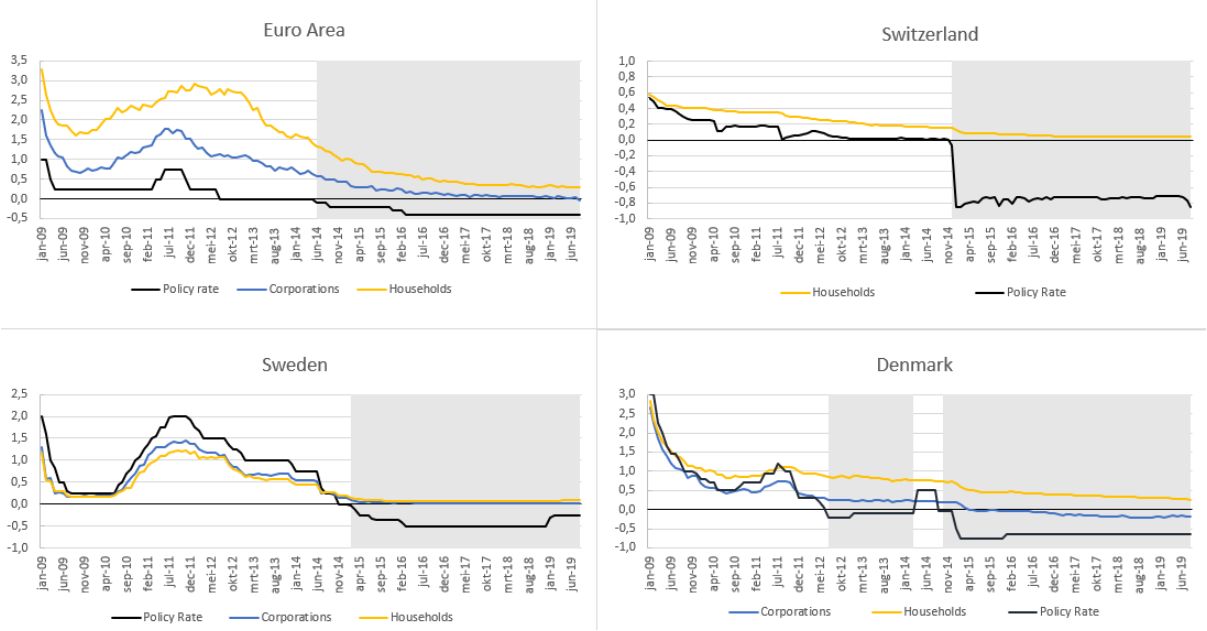


Figure A.5: ECB - pass-through of negative policy rates

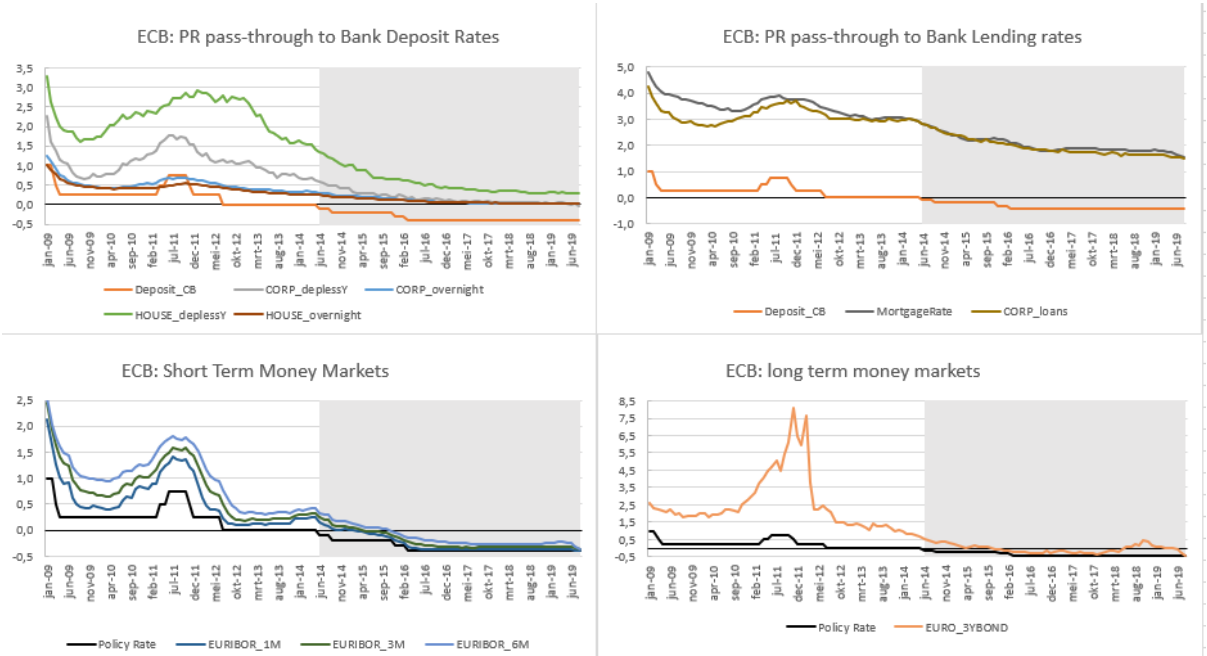


Figure A.6: Switzerland - pass-through of negative policy rates

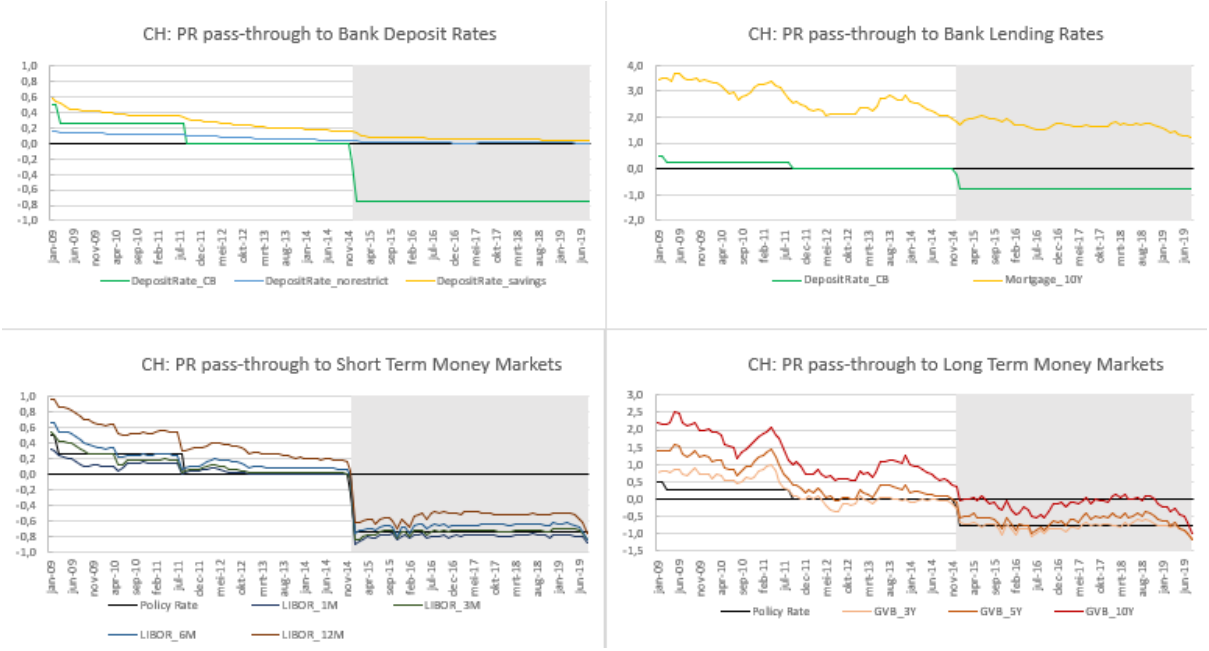


Figure A.5: This figure plots the annual average of fee income of ECB banks separately for ECB banks arrangers in the bottom- (blue), medium (red) and top-tercile (green) of the 2013 deposit distribution. Data on fee income is obtained from Orbis Bank Focus.

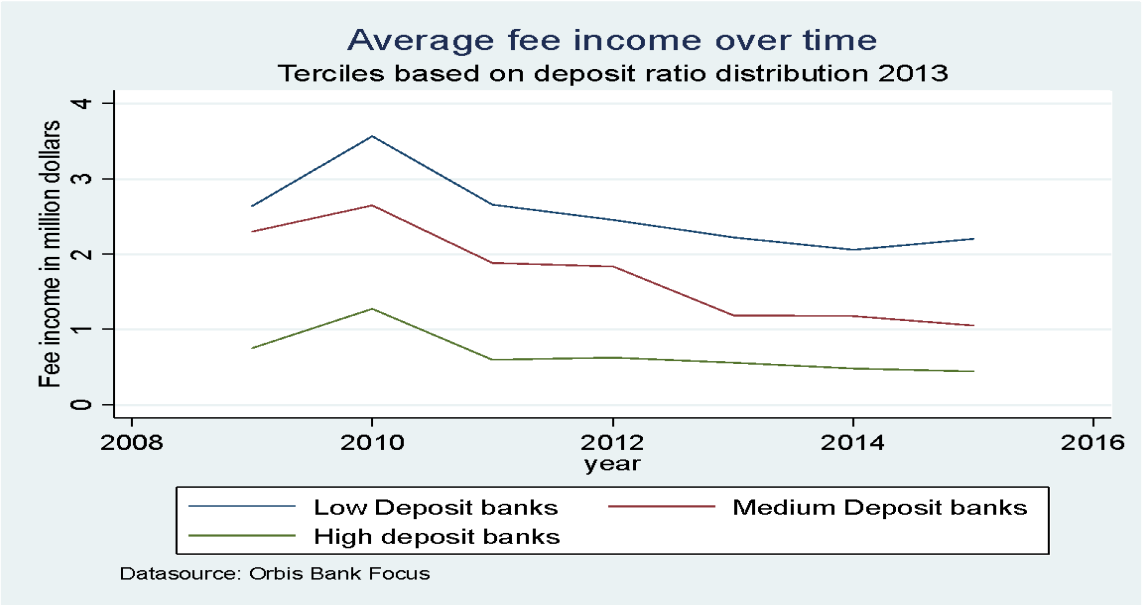


Table A.6: overview of ECB banks aligned with Table 2 (bank-level statistics)

Name (Dealscan)	Country	Deposit ratio in 2013 (%)
Oberbank AG	AT	5,72
BAWAG PSK	AT	60,47
Macquarie Group Ltd	AU	27,55
Macquarie Bank Ltd	AU	30,23
Westpac Banking Corp	AU	54,58
Belfius Bank & Insurance SA/NV	BE	32,69
Banca Monte Paschi Belgio SA	BE	64,30
KBC Bank NV	BE	64,65
equinet Bank AG	DE	0,55
KfW Bankengruppe	DE	2,43
DZ Bank AG	DE	13,54
DekaBank Deutsche Girozentrale	DE	16,97
Portigon AG	DE	22,43
Westdeutsche Genossenschafts-Zentralbank eG [WGZ-Bank]	DE	24,10
Landesbank Hessen-Thuringen GZ [ex-Hessische Landesbank]	DE	24,64
Deutsche Bank AG	DE	25,67
Landesbank Baden-Wurttemberg [ex-Landeskreditbank BW]	DE	26,82
Bayerische Landesbank GZ [BayernLB]	DE	33,73
UniCredit Bank AG	DE	37,19
HSH Nordbank AG	DE	37,27
IKB Deutsche Industrie Bank AG	DE	40,12
Deutsche Pfandbriefbank AG	DE	43,50
Commerzbank AG	DE	50,30
Kreissparkasse Biberach	DE	52,36
Volksbank Karlsruhe eG	DE	60,71
Sparkasse Pforzheim Calw	DE	61,93
HSBC Trinkaus & Burkhardt AG	DE	62,18
Sparkasse Rhein Neckar Nord	DE	65,96
Kreissparkasse Heilbronn	DE	69,27
Sparkasse Neuss	DE	70,58
Kreissparkasse Ostalb	DE	72,43
Deutsche Postbank AG	DE	74,55
Sparkasse Vogtland	DE	79,86
Sparkasse Dortmund	DE	81,28
Frankfurter Sparkasse	DE	82,83
Banco Cooperativo Espanol SA	ES	15,25
Banco Santander SA	ES	46,37
BBVA	ES	46,80
Banco Caixa Geral SA [BCG]	ES	52,36
Abanca [ex-NCG Banco SA [Novagalicia Banco]]	ES	55,64
Bankinter SA	ES	56,98
Ibercaja	ES	59,90
Caja Rural de Navarra	ES	60,28
Banco Sabadell	ES	60,79
Banco Popular Espanol SA	ES	60,86
Banco Mare Nostrum	ES	67,59
Liberbank SA	ES	75,52
Banca March SA	ES	79,72
Nordea Bank Finland Plc	FI	26,64
OP Financial Group [ex-Pohjola Bank Plc]	FI	49,47
Natixis SA	FR	13,13
BPCE	FR	14,04
BNP Paribas SA	FR	21,67
Societe Generale SA	FR	25,87
CIC Credit Mutuel	FR	36,77
Credit Agricole SA	FR	40,14
GE Corporate Finance Bank SAS	FR	42,39
Arkea Banque Entreprises et Institutionnels	FR	44,55
Banque Palatine SA	FR	57,68
Le Credit Lyonnais SA [LCL]	FR	67,94
Banque CIC Est SA	FR	68,67
Banque CIC Nord Ouest SA	FR	71,15
National Bank of Greece SA	GR	56,66
Alpha Bank AE	GR	57,28
Piraeus Bank SA	GR	58,98
Allied Irish Bank	IE	50,86
European Investment Bank [EIB]	II	0,45
Mediocredito Italiano SpA	IT	0,19
Mediobanca SpA	IT	1,96
Iccrea Bancalmpresa SpA	IT	7,99
Unione di Banche Italiane ScpA [UBI Banca]	IT	9,77
Intesa Sanpaolo SpA [ISP]	IT	56,29
UniCredit	IT	30,18
Banca Carige SpA	IT	34,26
Veneto Banca ScpA	IT	35,29
Banca Monte dei Paschi	IT	42,97
Banca Popolare di Vicenza SCaRL	IT	47,91
Banca Popolare di Milano SCaRL [BPM]	IT	50,26
Banco di Sardegna SpA	IT	64,82
Cassa Depositi e Prestiti SpA [CDP]	IT	76,01
UniCredit Luxembourg SA	LU	13,39
Banque LBLux SA	LU	46,57
Bank Nederlandse Gemeenten NV [BNG]	NL	2,31
NIBC Bank NV [NIBC]	NL	38,70
Rabobank	NL	48,54
ABN AMRO Bank NV	NL	55,80
GE Artesia Bank	NL	56,98
ING Bank	NL	60,28
Triodos Bank NV	NL	87,64
Banco Espirito Santo SA [BES]	PT	32,26
Banco BPI SA	PT	59,46
Banco Comercial Portugues SA [BCP]	PT	59,68

Table A.7: overview of Swiss banks aligned with Table 2 (bank-level statistics)

Name (Dealscan)	Country	Deposit ratio in 2013 (%)
Raiffeisen Schweiz Genossenschaft	CH	21,48
Banque de Commerce et de Placements SA [BCP]	CH	27,76
Credit Suisse AG	CH	37,65
Basler Kantonalbank [BKB]	CH	50,25
Migrosbank AG [MIB]	CH	50,53
Zurcher Kantonalbank [ZKB]	CH	54,17
Banca dello Stato del Cantone Ticino	CH	58,58
Banque Cantonale Neuchateloise [BCN]	CH	60,84
Thurgauer Kantonalbank (TKB)	CH	63,47
Schaffhauser Kantonalbank	CH	64,76
St Galler Kantonalbank	CH	67,13
UBS AG	CH	68,87
Banque Cantonale Vaudoise	CH	69,83
Banque Cantonale de Geneve [BCGE]	CH	70,39
Luzerner Kantonalbank	CH	72,19
EFG Eurobank Ergasias SA	CH	75,60
Habib Bank AG [Zurich]	CH	82,32

Figure A.8: This figure plots the quarterly average of total loan volume granted by ECB banks (lead arrangers only), separately for ECB lead arrangers in the bottom- (blue) and top-tercile (red) of the 2013 deposit distribution. A volume measure is constructed by aggregating all loans granted by bank j at date t in its function as lead arranger.

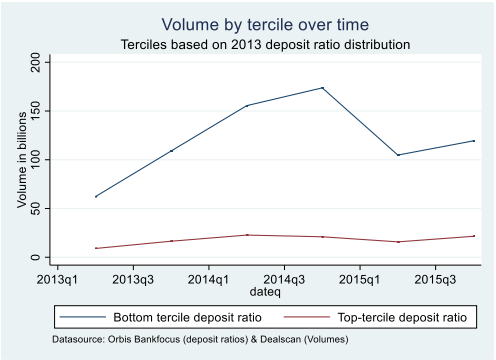


Figure A.9: This figure plots the quarterly average volatility of the ROA (return on assets) of firms financed by ECB banks (lead arranger only), separately for ECB lead arrangers in bottom (blue) and top-tercile (red) of the 2013 deposit distribution. ROA volatility is calculated as the annual average from t-1 to t-5. The sample is aligned with the data of Table 6.