Negative interest rates, deposit funding and bank lending*

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Abstract

After several central banks pushed their monetary policy rates into negative territory, banks generally proved reluctant to pass on negative interest rates to their retail customers. With market interest rates dropping below zero, banks more dependent on deposit funding face higher funding costs relative to other banks. In this paper, we investigate how such banks in Switzerland responded to negative interest rates. To this end, we focus on the Swiss National Bank's large and unexpected rate cut on 15 January 2015. Using a difference-in-differences approach, we analyze its impact with detailed micro data on corporate loans. Our results indicate that when market rates are negative, banks with a lot of deposits try to offset their relatively higher funding costs by offering more generous lending terms and thereby capturing market shares.

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1 Introduction

Since 2012, several central banks have introduced negative interest rate policies for the first time in history. Market rates generally followed suit, some dropping below zero. Banks' retail deposit rates, however, have been stuck at zero. This was probably because banks feared that they would lose customers to competitors if they moved into negative territory first or that customers would convert their deposits into cash (Eggertsson et al., 2017; Eisenschmidt and Smets, 2017; Heider et al., 2018). The resulting asymmetry between market and deposit funding puts banks with a high share of deposit funding at a relative disadvantage. A crucial question is then if and how those banks adjust their lending. This matters both for financial stability and monetary policy transmission.

To study the effects of deposit funding in a negative interest rate environment on the lending decisions of banks in Switzerland, we make use of a comprehensive and granular data set on individual Swiss corporate loans.

Our identification strategy relies on three pillars. First, we focus on a monetary policy change that was unexpected, exogenous to domestic economic conditions, and large. On 15 January 2015, the Swiss National Bank (SNB) took an unscheduled monetary policy decision and lowered the interest rate on central bank deposits by minus 50 basis points to minus 75 basis points. At the same time, it discontinued its minimum exchange rate floor vis-vis the euro. There was a strong and sudden reaction of market interest rates folllowing the announcement, showing that the decision was not anticipated. Furthermore, the decision was taken due to developments in the euro dollar exchange rate, which are exogenous to the Swiss economy. By focusing on this event, we avoid biases that arise when rate cuts are anticipated or endogenous to domestic economic conditions.

Second, we conduct a difference-in-differences analysis by comparing lending conditions i) before and after the rate cut and ii) between banks with different deposit to asset ratios (Heider et al., 2018). Put differently, we investigate how the deposit ratio influences the response of banks to negative interest rates. This set up allows to control both for time-invariant differences in lending supply between high and low deposit ratio banks and any common changes in credit demand before and after the policy change.

Third, we use granular information on firm characteristics from our loan-level data set to control for heterogeneous changes in credit demand. We follow a similar approach as Khwaja and Mian (2008) and compare lending decisions of multiple banks to the same firm type within the same time period. The identification assumption is that when multiple banks grant a loan to the same firm type within the same time period, any differences in lending decisions are due to changes in lending supply. Our data set does not allow us to identify individual firms, but each loan has detailed information on firm characteristics. Firm types are constructed by combining these characteristics (see also Auer and Ongena, 2016). Loans are assigned to a firm type according to the borrowing firm's industry sector, its headquarter location, and its number of employees. In our baseline specification, this yields around 72'000 loans assigned to about 7'500 firm type*month effects in a +- 180 day window around the policy decision.

Theory on the interplay between negative interest rates and deposit funding is

scarce. Eggertsson et al. (2017) argue that due to a lower bound on deposit rates, a policy rate cut loses its expansionary effect on lending. In addition, interest rates charged on the banks' assets may even hurt profitability and lead to a contraction in lending. Similarly, Brunnermeier and Koby (2018) identify a policy rate threshold ("reversal interest rate"), below which a rate cut is contractionary, as the drag on profitability due to squeezed interest rate margins and the subsequent decrease in bank net worth limits the bank's lending capacity and its ability to take risks. In sum, the contractionary effect of deposit funding occurs because the marginal costs of lending increase.

However, deposit funding in a negative rate environment may also induce banks to loosen their lending terms and thereby act expansionary. One reason is that banks target a specific level of profits. They then compensate decreasing profits by taking more risk (Alessandri and Haldane, 2009; Pennacchi and Santos, 2018). Similarly, Rajan (2005) argues that insurers and pension funds may take more risk in a low interest rate environment to cover their fixed-rate liabilities. When deposit rates are stuck at zero and safe securities yield less, banks may search for yield in riskier assets such as loans instead of safe securities. Expansionary effects of deposit funding occur by way of portfolio reallocation, i.e when banks, for a given balance sheet size and given liabilities, reallocate away from safer assets towards riskier assets in order to compensate their higher funding costs.

Our results indicate that deposit funding under negative interest rates has an expansionary effect: as market rates go negative, banks that are more reliant on deposits loosen their lending terms and lend more. Regarding lending terms, we find that more deposit funding leads to lower lending spreads: a one standard deviation increase in the deposit to asset ratio decreases spreads by 14 basis points. Since we control for borrower risk, the decline in the spread corresponds to an increase in risk-taking. As Paligorova and Santos (2017) argue, increased risk-appetite may manifest itself in lower required compensation for risk. Ioannidou et al. (2015) point out that if granting riskier loans is supply-driven, the average price per unit of risk should drop.

The lower spreads are not compensated with tighter non-price lending terms. To the contrary, banks tend to grant larger individual loans, are more likely to issue fixed interest rate loans and are less likely to charge a commission in addition to interest payments. Furthermore, they do not offset tighter spreads with shorter maturities or more collateralization.

Regarding lending volumes, we find that more deposit funding encourages banks to increase lending both at the intensive (granting credit within existing firm type relationships) and the extensive margin (entering new relationships or terminating existing relationships). At the intensive margin, a one standard deviation increase in the deposit ratio raises the volume of new loan agreements in a given month by 27 percent. At the extensive margin, a one standard deviation increase in the deposit ratio raises the likelihood that a credit granted is obtained by firm type that has previously not received credit from the bank by 2.7 percentage points and makes it 0.6 percentage points less likely to terminate an existing firm type relationship after the rate cut.

We conclude that high deposit ratio banks have been gaining market share since the interest rate cut on 15 January 2015. The banks captured these market shares by taking more risk, i.e. by relaxing their lending terms relative to their peers. High deposit banks therefore became more risky as compared to low deposit banks.

We control for other bank characteristics that may influence bank's response to negative interest rate policies. In particular, we account for central bank deposits that are charged negative interest rates (charged reserves). We further include standard bank controls, namely the capital ratio and balance sheet size. In extension, we additionally control for banks' business models, liquidity positions, foreign exchange exposures, and profitability.

The results are robust to a variety of modifications: For example, we vary the estimation window from +-45 days to +-720 days around the date of the rate cut, exclude banks and firm types with a large sample weight and control for loan characteristics. We also estimate our baseline regression for interest rate cuts in positive territory, where the above described asymmetry between deposit and market rates is not present. As expected, we do not find an effect stemming from differences in the deposit ratio.

Our results extend beyond the corporate loans market. Using less granular data, we analyze lending spreads on residential mortgage loans. The results point in the same direction: under negative interest rates, high deposit banks decreases lending spread. The effect is present for long maturities only. This indicates that high deposit banks primarily tried to gain market share in the long maturity segment, where yields are higher.

In addition to deposit funding, we also analyze the role of reserves that are charged negative interest rates. Two recent studies (Basten and Mariathasan, 2018; Bottero et al., 2018) have investigated the role of charged reserves or close equivalents as a separate bank characteristic that may affect transmission through a portfolio rebalancing mechanism. We do find evidence that banks with more charged reserves price lower spreads in our baseline. However, the effects fades out for longer estimation windows. This indicates that differences in charged reserves are predominantly arbitraged away on the interbank market over the medium term. Furthermore, we find no evidence that differences in charged reserves are associated with more lending, neither at the intensive nor at the extensive margin.

In the remainder of the paper, we discuss below our contribution to the literature. Section 3 provides institutional information on the rate cut and presents empirical hypotheses. Section 4 discusses empirical strategy data. Section 5 presents the results. Section 6 summarizes and discusses our main findings.

2 Related Literature and Contribution

Our research contributes to the recent empirical literature on the transmission of negative interest rates to bank lending. Naturally, these studies focus on the Euro area, Switzerland, Sweden, and Japan, where negative interest rate policies have been introduced.

In addition to the more established literature on the impact of monetary policy on lending and bank risk taking in a positive interest rate environment (see e.g. Stein and Kashyap, 2000; Jiménez et al., 2012; Jimenéz et al., 2014; Ioannidou et al., 2015; Beutler et al., 2017; Paligorova and Santos, 2017; Dell'Ariccia et al., 2017), these studies typically focus on factors that might play a special role in a negative interest rate environment. On the liability side, the role of deposit funding has been investigated (Heider et al.,

2018; Eggertsson et al., 2017; Bottero et al., 2018). On the asset side, the role of central bank deposits and other assets subject to negative interest rates has been analyzed (Basten and Mariathasan, 2018; Bottero et al., 2018). Demiralp et al. (2017) additionally look at the role of different bank business models. Summary measures uniting asset and liability side impacts of negative interest rates have been deployed by Arce et al. (2018); Hong and Kandrac (2018). These studies come to different conclusions regarding the impact of negative interest rates on bank risk-taking and lending.[1] In addition to the studies cited above, there are further studies that investigate the effect of negative interest rates on systemic risk (Nucera et al., 2017) and profitability (Altavilla et al., 2017).

We contribute to the literature along two lines: First, we use a data set that is granular (loan- level), high frequency (daily), and detailed with regard to loan terms. Most of the other studies use data aggregated at bank level at monthly frequency. Granular loan level data combined with detailed information on borrowers allows us to control for demand effects. High frequency data allows for exact distinction between the period before and after a monetary shock. Information on multiple relevant loan terms provides a complete picture on the dimensions along which banks took risks. Thus, we can check whether risk-taking in one dimension might have been compensated with less risk-taking in another dimension.

Second, the rate cut in Switzerland was exogenous to domestic economic conditions, unexpected, and large. This makes the Swiss case different from other jurisdictions with negative interest rates. In Sweden, Japan, and the euro area, central banks motivated their decisions with domestic economic conditions, namely deflationary pressures and the intention to boost lending. These measures were also part of a package that included quantitative easing measures, i.e. other policy measures to affect market rates.[2] Furthermore, the decisions were announced at scheduled dates and at least in the in the euro area, some decisions were to some extent anticipated [3] Both anticipations and endogenous monetary policy decisions pose challenges for identification. The rate cut in Switzerland (50 bp) was large compared to rate cuts in other jurisdiction (single rate cuts amounted to 10-20 basis points, see Grisse et al. (2017)). A large rate cut makes it unlikely that our results are materially contaminated by other shocks to interest rates over the narrow time window studied.

Bottero et al. (2018) and Heider et al. (2018) also use loan level data, but focus on the euro, where the policy decision was triggered by domestic economic conditions. Compared to Heider et al. (2018) we also cover a larger market, as they focus on syndi-

[1]Concretely, Heider et al. (2018); Basten and Mariathasan (2018); Hong and Kandrac (2018) find an increase in risk-taking for more negatively affected banks, while (Arce et al., 2018) find a decrease in risk-taking. Regarding lending volumes, Demiralp et al. (2017); Basten and Mariathasan (2018); Bottero et al. (2018); Hong and Kandrac (2018) find an expansionary effect, Heider et al. (2018); Eggertsson et al. (2017) find a contractionary effect and (Arce et al., 2018) find no effect.

[2]The ECB stated "[t]oday we decided on a combination of measures to provide additional monetary policy accommodation and to support lending to the real economy"(European Central Bank, 2014). The Bank of Japan explained the decision "to maintain momentum toward achieving the price stability target of 2 percent" (Bank of Japan, 2016). According to the press release of Swedish central bank "[t]he Executive Board of the Riksbank assesses that a more expansionary monetary policy is needed to support the upturn in underlying inflation"(Riksbank, 2015).

[3]See Wu and Xia (2018) for evidence on the euro area and Grisse et al. (2017) for a more general overview to what extent negative rates were anticipated.

cated loans, which are only a subset of corporate loans. Basten and Mariathasan (2018) are the only study that looks at bank reactions following the surprise monetary policy change in Switzerland, but focus on the role of variation in the charged reserves, using less granular data, that is aggregated at the bank level.

As seen above, studies have found different results on how banks respond to negative interest rates. Apart from the identification challenges described above, there may be important economic reasons for the differing results.

For one, domestic economic conditions and the capital positions of banks might have an impact on the banks' reactions to an interest rate cut (Dell'Ariccia et al., 2017; Eggertsson et al., 2017; Heider et al., 2018). In Switzerland, negative interest rates were introduced in an overall benign economic environment, with bank capital generally well above minimum requirements, and historically low levels of non-performing loans. For another, the zero lower bound on the deposit rate may not be binding because of risk premia and banks still have room to cut deposit rates further. In the euro area, for example, de Sola and Kasongo (2017) report that in March 2015 more that half of all banks still paid positive retail deposit rates. Eisenschmidt and Smets (2017) show that in the more vulnerable euro area member states, banks cut deposit rates substantially after the introduction of negative interest rate policies.

3 Institutional Information and Empirical Hypotheses

3.1 Institutional Information

On 15 January 2015, the Swiss National Bank announced two decisions: First, it discontinued its minimum exchange rate vis-à-vis the euro. Second, it lowered its remuneration rate on central bank sight deposit account balances from minus 25 basis points to minus 75 basis points. The SNB only charges negative interest if a bank's sight deposit account balance exceeds a bank-specific exemption threshold (charged reserves).[4] Both decisions were taken at unscheduled monetary policy meetings.

The two policy decisions were taken because of exogenous foreign developments and came as a surprise for market participants. In its press release, the SNB (Swiss National Bank, 2015) stated that the "euro has depreciated considerably against the US dollar and this, in turn, has caused the Swiss franc to weaken against the US dollar". It concluded "that enforcing and maintaining the exchange rate floor against the euro is no longer justified." The SNB lowered its policy rate to minus 75 basis points at the same time "to ensure that the discontinuation of the floor did not lead to an inappropriate tightening of monetary conditions." The stated motivations in the press release clearly point to exogenous developments as triggers for the policy moves.

Moreover, the decisions haven taken market participants completely by surprise. The surprise element is inherent to a policy decision which involves discontinuing a minimum exchange rate. Any hints or guidance as to when the SNB planned to exit would have fueled speculations and thus would have made it harder for the SNB to defend the minimum exchange rate. Right after the announcement, the Swiss franc ex-

[4]Specifically, the exemption threshold is calculated as 20 times the minimum reserve requirement for the reporting period 20 October 2014 to 19 November 2014, adjusted for changes in holding physical cash. See Swiss National Bank (2014) for details

change rate vis-à-vis the euro jumped to a new level. More important for the purposes of this paper, market interest rates adjusted quickly and there were no anticipation effects, as can be see from Figure 1.

The exogeneity and surprise element of the two policy decisions play an important role in our identification to analyze the banks' reactions to a rate cut in negative territory.

Figure 1 shows that the Libor and swap rates turned negative. Deposit rates, on the other hand, were stuck at zero, possibly because banks were unwilling to charge customers negative interest because they feared losing deposits to competitors. The interest rate cut therefore introduced an asymmetry between market and deposit funding costs. Note that market participants expected interest rates to remain negative for an extended period of time, as evident from the 5 year swap rate turning negative as well.

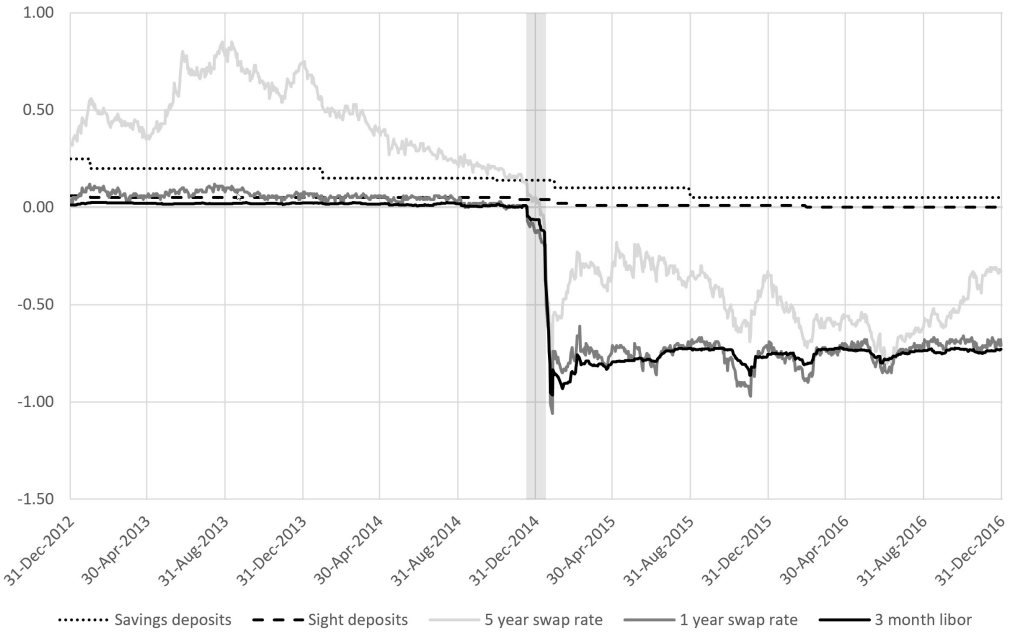
Our analysis focuses on the effects of the rate cut on 15 January 2015. The SNB announced the introduction of negative interest rate policies and the definition of bank specific exemption thresholds on 18 December 2014. The remuneration of central bank deposits was lowered from 0 to minus 25 basis point, but effective only from 22 January onwards, making identification less clean due to timing issues. This earlier announcement also had much smaller effects on market rates (12 month swap rate remained close to zero). In robustness checks we will exclude the period between 18 December 2014 and 15 January 2015.

3.2 Empirical Hypotheses

Recent theoretical studies argue that rate cuts in a negative interest environment may worsen bank lending terms when banks rely mainly on deposit funding. Eggertsson et al. (2017) argue that due to a lower bound on deposit rates, a policy rate cut loses its expansionary effect on lending. In addition, interest rates charged on the banks' assets may even hurt profitability and lead to a contraction in lending. Similarly, Brunnermeier and Koby (2018) identify a policy rate threshold ("reversal interest rate"), below which a rate cut is contractionary, as the drag on profitability due to squeezed interest rate margins and the subsequent decrease in bank net worth limits the bank's lending capacity and its ability to take risks. In sum, the contractionary effect of deposit funding occurs because the marginal costs of lending increase.

There is, however, also the opposite argument that higher costs induce banks to take more risk and loosen lending terms to gain market share in risky activities. This is the case when banks aim to maintain a certain level of profits and compensate higher costs with more risk. For example, Pennacchi and Santos (2018) and Alessandri and Haldane (2009) provide evidence that banks target a specific return on equity level, if their profitability falls, they increase risk taking. This may be a rational response of the bank management to state guarantees and lower franchise value (Pennacchi and Santos, 2018). Similarly, Rajan (2005) argues that insurances and pension funds will take more risk in a low interest rate environment to cover their fixed-rate liabilities. In Switzerland, negative interest rate policies turned deposit funding effectively into a fixed-rate liability for banks and similar considerations may apply to pension funds

Figure 1: Deposit, Libor, and swap rates



Notes: Deposit rates are calculated as the median of reported average private household deposit rates. The shaded area indicates the period between the first rate cut into negative territory (0pp to -0.25pp on December 18 2014) and the second (-0.25pp to -0.72pp on January 15 2015). As of end-2014, 91 banks reported deposit rates. Dispersion around the mean is low, with a standard deviation of 0.0003 and 0.0009 for sight deposits and savings deposits, respectively. No bank reported average negative deposit rates at any point in time. The same is true for corporate payment accounts. Data on corporate payment accounts are available from June 2017 on and is not reported here.

and insurances.[5]

In our setting, the hypothesis that higher costs lead to more risk taking would imply that banks with more deposit funding loosen their lending terms to attract more customers and expand lending in comparison to other banks. There is a portfolio reallocation. They will try to move out of relatively safe assets such as central bank deposits, government bonds or other liquid assets and expand their lending.[6]

As a first stylized fact, Figure 2 compares the average lending interest rates to non-financial corporates of banks with a deposit ratio above the median to those with a deposit ratio below the median. Before the rate cut, high deposit banks on average charge interest rates that are about 25 basis points higher. After the rate cut, the difference narrows to about 10 basis points, as high deposit banks lower their lending rates and low deposit banks increase them. Thus, high deposit banks lowered spreads relative to low deposit banks, providing support to theories that predict expansionary effects of deposit funding. In our empirical section, whether that results also hold in more sophisticated specifications.

In addition to deposit funding, the amount of excess liquidity that is subject to negative interest rates may be another channel of monetary transmission that is specific to a negative rate environment (Basten and Mariathasan, 2018; Bottero et al., 2018). More precisely, there is the possibility of a portfolio rebalancing channel that would work similar to quantitative easing policies (Kandrac and Schlusche, 2017; Christensen and Krogstrup, 2018): negative interest rates correspond to a tax on central bank balances, which produces a shift in the bank's portfolio towards higher yielding assets. Under that hypothesis, we would expect banks with more charged reserves to grant more credit at more attractive terms.

Finally, there are good reasons to expect that neither deposit funding nor charged reserves matter for transmission of negative interest rates. For example: in perfectly competitive credit markets all banks will charge the same interest rate irrespective of their funding costs or asset structure. Banks could charge higher fees on deposits to compensate for zero deposit rates. Differences in charged reserves can be arbitraged away in frictionless interbank markets. In sum, theory is ambiguous on how banks respond to negative interest rates and it remains an empirical question.

4 Empirical Strategy and Data

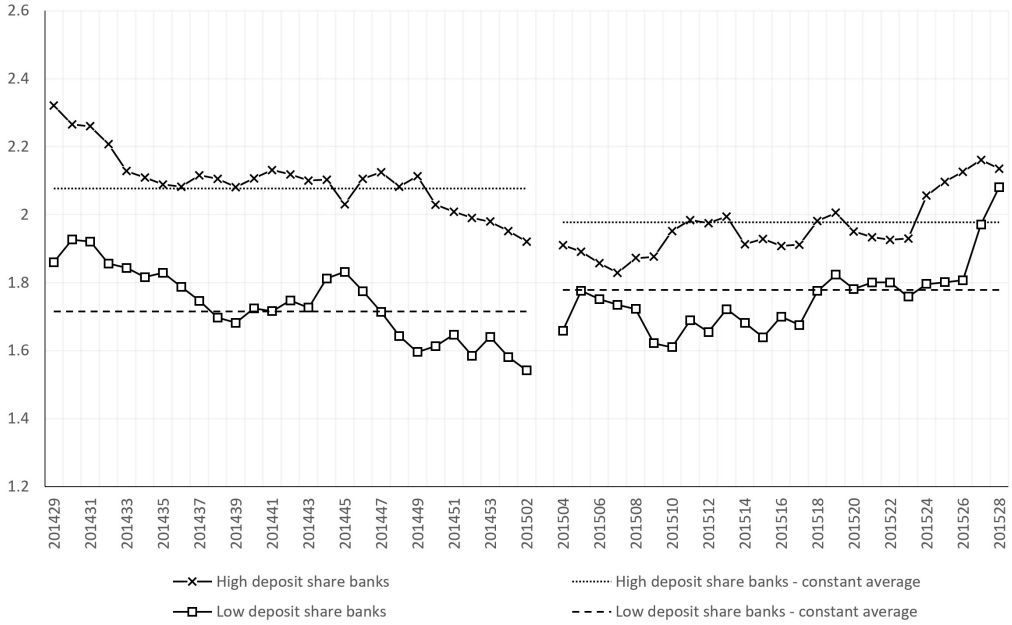
4.1 Data

We use confidential loan-level data on non-financial corporate loans. Corporate loans make up around a third of total domestic credit in Switzerland. We match this data

[5]Stuck at zero, deposit rates cannot adjust downwards any further. At the time of the policy announcement, any medium term upward adjustment was very unlikely, since markets expected negative interest rate policies to persist for an extended period (see section above).

[6]The motivation for banks to move away from safe securities towards loans is also apparent in a statement of the CEO of PostFinance, the Swiss postal bank, which relies mainly on deposit funding. The law prohibits this bank to grant loans (see PostFinance, Annual Report Post 2017). "[The fall in revenue from the interest differential business] makes it clear that in the current negative interest rate environment in particular, it is a serious disadvantage for us not to be able to issue our own loans and mortgages. There is a need for action in this area, because our interest margin remains under pressure."

Figure 2: Weekly rolling average lending rates of high and low deposit share banks



Notes: Banks are split into two groups according to their deposit ratios. The deposit ratio is defined as the sum of Swiss franc sight and savings deposits over total assets, as of December 2014. From these two groups, 4 week rolling averages of lending rates were calculated from our loan-level data set for a window of +-180 days around the 15 January 2015 rate cut. In addition, constant pre- and post-rate cut averages were calculated for the two groups.

with individual bank balance sheet information and regulatory reportings. All data is collected by the SNB and publicly available only in aggregate form.

The corporate loan-level data are taken from the SNB lending rate statistic. For each loan agreement we have information on various lending terms (interest rate, maturity, fixed or variable rate, etc.) and borrower characteristics (sector, number of employees, headquarters location , bank-internal credit rating). The statistic also covers off-balance sheet loan commitments. For each loan, we know the exact date when it was paid out, which allows us to distinguish between loans paid out before and after the interest rate cut.

The data cover all banks whose loans to non-financial domestic companies exceed CHF 2 bn. Coverage is comprehensive, as the 20 banks that have to report their loans cover around 80% of corporate loans in Switzerland. The banks are required to report information on all new loan agreements with non-financial firms in Swiss francs that exceed CHF 50k. New loan agreements comprise newly granted loans as well as major modifications in conditions of existing loans.[7] All reported loans have either a fixed maturity of at least one month or are open ended. Banks report since mid-2006 and as of end 2017, the whole data set contained around 1.3 million loan agreements.

Our main source for bank balance sheet information is the SNB monthly banking statistic, which contains detailed information on the composition of banks' assets and liabilities. We combine this information with regulatory data on minimum reserves, capital adequacy and liquidity.

To check whether our results also apply to other loan markets, we use data on residential mortgage loans. The data are from the SNB's interest rate survey. Banks report published end-of-month interest rates for new transactions. Our analysis focuses on fixed residential mortgage rates for different maturities (one to ten years). This data set differs from our corporate loan-level data set in several ways: First, banks report published interest rates as opposed to actual loan transactions. Second, there is no information about borrowers. Third, it covers a broader sample of banks than the corporate loan data (45 banks).[8] Therefore, the corporate loan-level data allows for a more granular analysis, whereas the aggregate residential mortgage data set comprises a larger number of banks. It also covers a larger share of overall credit (at end-2014, residential mortgages account for about two thirds of total domestic bank credit to the private sector).

4.2 Empirical Strategy

In general, analyzing the transmission of monetary policy through banks faces three important challenges. First, lending supply and demand need to be disentangled. Second, the policy rate may be endogenous to domestic lending conditions. Third, market participants may anticipate policy rate moves and thus frontload adjustments in their lending behavior. To tackle these challenges, we base our identification on three pillars.

[7] Major modification are defined as changes in loan terms that can be considered the result of renegations. In particular, new loan agreements include: changes from a variable rate to a fixed rate, prolongations of fixed term loan contracts, changes in ratings for open ended contracts.

[8] Banks whose total Swiss-franc denominated customer deposits and cash bonds in Switzerland exceed CHF 500 million

In our first pillar, we exploit the fact that the interest rate cut on 15 January 2015 was unexpected, exogenous to the domestic economy, and large. Figure 1 shows that there were no anticipation effects, as market rates suddenly dropped at the exact date of the rate cut. This is important for our empirical strategy, because our estimates would likely underestimate the effect of the rate cut if it was anticipated. Also, anticipation would violate the common trends assumption behind the difference-in-differences approach explained below.

Furthermore, the monetary policy move was a response to exogenous foreign developments. This alleviates any endogeneity concerns which arise if the monetary policy decision was influenced by developments in the domestic lending market. According to its press release, the SNB discontinued the minimum exchange rate and introduced negative interest rates because of divergences between the monetary policies of the euro area and the US (Swiss National Bank, 2015). Monetary policy in these large currency areas is exogenous to a small economy such as Switzerland (Auer et al., 2018).

The monetary policy decision on 15 January 2015 was clearly the most important shock to market interest rates in the sample period we study. This is, for example, evident in Figure 1, where we observe large movements at the decision date, but neither before or afterwards. A large event ensures that our results are not driven by smaller shocks before or after the monetary policy decision.

A possible concern is that the concurrent exchange rate appreciation had a separate supply effect due to currency mismatches on bank balance sheets. This channel is prominent in many emerging markets (Eichengreen and Hausmann, 1999). We consider it unlikely that currency mismatches played an important role. No bank in our sample reported large valuation losses or gains because of exchange rates in the three years since. This is because these banks had either small FX exposures (median net FX long position: -1% of total assets) or were well hedged. In extension, we nonetheless add controls for currency mismatches.

Our second pillar is a difference-in-differences specification similar to Heider et al. (2018). We compare lending i) before and after the rate cut and ii) between banks with different deposit ratios. With this approach, we account for changes in demand which are the same for all banks and time-invariant changes in the supply polices of banks.

Our third pillar is the use of granular firm characteristics to control for changes in credit demand specific to firm types. We follow a similar approach as Khwaja and Mian (2008) and compare loan terms of multiple banks to the same firm type in the same time period. The identification assumption is that when all banks grant a loan to the same firm type, any differences in lending decisions are due to supply, i.e. bank characteristics. Changes in a firm type's credit demand or credit worthiness are absorbed by the firm type*time fixed effect. Different from Khwaja and Mian (2008), our data set does not come with a firm identifier. We have, however, detailed information on firm characteristics from which we construct firm types (see Auer and Ongena, 2016, for a similar approach).

Granular firm controls are potentially important because at the same time as the policy rate was lowered on 15 January 2015, the minimum exchange rate was discontinued. Efing et al. (2015) show that export-oriented firms with costs primarily denominated in Swiss francs suffered from larger declines in profits. If the composition of credit portfolios is correlated with funding structure (e.g. if banks that lend

to export oriented-firm rely less on deposit funding), assuming only a common credit demand effect would bias our results.

In addition, we use bank*firm type fixed effects to control special lender-borrower relationships. For example, some banks and firm types might keep long-standing relationships, which could result in systematically lower loan spreads (Boot, 2000). Or, since some cantonal banks are legally required to promote lending to small and medium enterprises in their home cantons, they might charge lower spreads to the respective firm types.

In the following, we give more detailed information on the construction of firm type*time fixed effects. Each loan agreement contains information on the borrowers' sector (81 sectors), location (26 cantons, administrative divisions in Switzerland) and number of employees (4 categories) and the time the loan was granted (14 periods in our baseline). To be assigned to the same firm type, a loan must be granted to a firm in the same sector, in the same location, with the same number-of-employees category in the same time period. As a result, in our baseline sample, we have 89'756 loans assigned to 18'788 firm type*time fixed effects.[9]

We require every firm type in a given period to receive loans from at least two distinct banks. As a result of this restriction, our sample reduces to 7'476 firm type*time fixed effects (72'204 observations). On average, a firm type fixed*time effect has 2.9 relationships, with a maximum of 14 and a median of 2. There is some concentration in firm characteristics. For example, about 28% of all observations in our baseline specification are in the real estate sector and about 14% observations are in the canton of Zurich. In robustness checks, we will verify that our results are not driven by these characteristics.

In many cases, the firm types are unlikely to identify individual firms as in Khwaja and Mian (2008). Only about 25% of small and medium enterprises keep multiple bank relationships for loans in Switzerland (Dietrich et al., 2017). We argue, however, that our firm information is detailed enough to capture even granular demand effects. To check that our results are not driven by residual variation of borrower riskiness within a given firm type, we will in extensions combine firm characteristics with information about the banks' internal rating of the loan (five categories), i.e. compare loans of at least two banks to the same firm type with the same internal rating in a given time period.[10]

4.3 Variables

4.3.1 Dependent variables

Descriptive statistics for the dependent variables are shown in Table 1. We look both at lending terms and lending volumes.

Our first main variable of interest is the lending spread, which is defined as the difference between the interest charged on a loan and the yield on a Swiss government

[9]We exclude all observation where a category is not reported, which is why the total number observations is different from those reported in Table 2. Our results are similar if we treat "not reported" as a separate category

[10]Our baseline does not contain ratings, because there may be differences across banks, e.g. a bank with higher risk appetite may assign better ratings for the same risk, giving rise to endogeneity concerns.

Table 1: Dependent Variable: Descriptive statistics

	N	mean	median	std	p1	p99
Section lending terms						
lending spread (in pp)	106,997	2.520	1.958	1.634	0.501	7.288
interest rate (in pp)	106,997	2.179	1.590	1.551	0.500	6.500
log(loan size) (in CHF k)	106,997	6.112	5.991	1.368	3.912	9.616
loan size (in CHF mn)	106,997	1.311	0.400	3.120	0.050	15.000
fixed rate	106,997	0.614	1.000	0.487	0.000	1.000
commission	106,997	0.170	0.000	0.375	0.000	1.000
maturity (in years)	74,838	2.312	0.733	2.879	0.081	10.147
collateralized	106,997	0.812	1.000	0.391	0.000	1.000
Section lending volume						
vol. of new loan agreements (in CHF mn)	12,934	9.727	1.264	70.350	0.050	118.781
log(vol. of new loan agreements) (in CHF k)	12,934	7.249	7.142	1.782	3.912	11.685
log(Net Revenue)(in CHF k)	12,934	8.150	8.023	1.621	5.107	12.168
log(lending spread) (in pp)	12,934	0.901	0.880	0.585	-0.471	1.994
new firm-type post rate cut	6,801	0.074	0.000	0.262	0.000	1.000
exit firm-type post rate cut	13,682	0.028	0.000	0.164	0.000	1.000

bond with the same maturity (daily government bond yields are calculated with a Nelson and Siegel (1987) term structure model). For variable rate loans, we use the maturity of the base rate and where the base rate is not reported, we assume a maturity of 90 days. As a simpler measure of loan pricing, we also look at the lending rate, i.e. without subtracting the risk-free rate.

The lending spread may be interpreted as an indicator for bank risk-taking when firm risk is properly controlled for. As Paligorova and Santos (2017) argue, increased risk-appetite may manifest itself in lower required compensation for risk, i.e. loan spread. In the same vein, Ioannidou et al. (2015) point out that if granting riskier loans is supply-driven, the average price per unit of risk should drop. In a theoretical model of Martinez-Miera and Repullo (2017) with asymmetric information and costly monitoring, lower spreads induce banks to monitor less, thereby increasing the riskiness of their loan portfolios.

For the above interpretation to be valid, we have to control for other possible factors that might impact our difference-in-differences estimates. First, changes in borrower credit quality, in particular expected losses, will affect spreads. Firm type*time fixed effects control for this possibility. Second, in addition to borrower quality, the market power of a bank is another alternative determinant of loan spreads (i.e. competitors may have entered or exited certain segments after the policy event). Firm type*month fixed effects control for this possibility, because changes in market structure affects all banks that grant loans to a specific firm type equally. Finally, lending spreads may change because the operational efficiency of the bank changes. For example, negative interest rates may be a trigger for high deposit share banks to streamline their operations, allowing for lower spreads because of higher efficiency. We do not directly control for this possibility, but consider in extensions short horizons where such an adjustment is unlikely.

To ensure that movements in the lending spread are not offset by opposite movements in other lending terms, we also look at the following relevant non-price lending

terms:

- *Loan size*: If a bank grants a larger loan, it increases its exposure.
- *Fixed / variable rate loan*: If a bank grants more fixed rate loans, it increases duration risk.
- *Maturity*: If a bank grants longer maturity loans, it takes more risk since the probability of unforeseen bad events over the life of the loan increases.[11]
- *Commission*: A bank may try to offset lower lending spreads by demanding higher commissions. Lepetit et al. (2008) found that banks may rely more on fees to try to compensate for lower lending rates.

For lending volumes, we analyze both the intensive margin (lending to existing firm type relationships) and the extensive margin (entering new firm type relationships and exiting existing relationships).

To analyze changes at the intensive margin, we aggregate all individual new loan agreements for each bank/firm type pair in the periods before and after the rate cut and then take the log. The volume is calculated as a simple sum.NEW [12] Thus, we end up with a two-period panel of bank/firm types. We restrict our data set to firm types that received a loan from the same bank both before and after the rate cut.

For the extensive margin, we follow Khwaja and Mian (2008) and compute two sets of dummies. One set designates newly created bank/firm type relationships (entry), the other designates bank/firm type relationships that expired (exit). Regarding entry, we check for each loan granted by a bank to a firm type after the rate cut whether that bank has granted the same firm type a loan in the previous five years. If this is not the case, we interpret this as a newly formed relationship and the entry dummy equals one. Regarding exit, we check if all loan agreements in place from a bank to a firm type before the rate cut expire after the rate cut. If that is the case and no new loan is granted after the rate cute, we interpret this as an expired bank/firm type relationship and the dummy equals one.[13] Note that to the extent that the previously discussed firm characteristics are stable (e.g. a firm does not switch region or sector), the extensive margin analysis should effectively identify entry and exit decision with regard to firms, not only firm types. For example, if a bank lets all loans to a specific firm type expire, all loans to a specific firm expire as well. However, we probably ignore entries and exits that are part of large firm type clusters, because, as previously discussed, our data set does not allow to identify single firms.

[11] We exclude all loans with open ended maturity in these regressions. The number of observations is therefore smaller

[12] As described above, new loan agreements covers new loans and major modification to existing contracts, with no separate identification. For loan contracts with open ended maturities, a change in the bank internal rating is classified as modification. To ensure that our results for lending volumes are not driven by changes in the internal rating, we exclude loan contracts with open ended maturities as a robustness checks. Results are not affected.

[13] Since we have no information on when loans with open-ended maturities are paid back, we exclude loans with open-ended maturities from the exit analysis.

Table 2: Bank Characteristics: Descriptive statistics

	N	mean	median	std	p1	p99
Deposit Ratio	20	0.482	0.526	0.144	0.125	0.688
Charged Reserve Ratio	20	-0.045	-0.039	0.042	-0.145	0.043
Total Assets (in CHF bn)	20	0.136	0.026	0.297	0.013	1.062
log(Total Assets) (in CHF k)	20	17.543	17.077	1.269	16.394	20.784
Capital Ratio	20	0.074	0.077	0.012	0.053	0.102
LCR	20	1.530	1.349	0.491	0.790	2.631
Loan Ratio	20	0.742	0.814	0.186	0.296	0.908
SME Loan Ratio	20	0.454	0.495	0.163	0.087	0.652
Net FX Pos./TA	20	-0.017	-0.011	0.027	-0.078	0.023
RoA (in pp)	20	0.245	0.243	0.087	0.075	0.401

4.3.2 Independent Variables

Descriptive statistics of the independent variables are shown in Table 2

Our main dependent variable is the ratio of Swiss franc deposits over total assets. Deposits are the sum of sight and savings deposits. We include further balance sheet characteristics to make sure that our results are not driven by other banking characteristics. In our baseline specification, we employ the following controls. The charged reserve ratio is the difference between Swiss franc central bank deposits and the exemption threshold (see Section 3), i.e. the bank-specific amount of deposits subject to negative interest rates. The charged reserve ratio accounts for the possibility of a portfolio rebalancing channel acting through the asset side of the balance sheet (Basten and Mariathasan, 2018; Bottero et al., 2018). This channel is specific to negative interest rates. The other control variables measure bank characteristics that may influence monetary transmission also for positive rates. The total capital ratio is defined as total regulatory capital over total assets and accounts for the bank capital channel of monetary policy (Van den Heuvel, 2006). Finally, the log of total assets controls for the possibility that the response may be affected by bank size (Stein and Kashyap, 2000).

In extensions, we look at the following further controls for bank characteristics. The ratio of loans and loan commitments to small and medium enterprises (SME) to total assets accounts for differences in business models. The FX ratio, defined as the net long position in foreign currency (assets minus liabilities) divided by total assets, controls for possible supply side effects of currency mismatches. The regulatory liquidity coverage ratio (LCR) measures the liquidity position. The return on assets (RoA), defined as total profit over total assets, captures the profitability of the banks.

For all bank characteristics, we use ex-ante information to avoid endogeneity problems, i.e. that banks adjusted their balance sheet because of the rate cut. Specifically, we take the latest value of the bank characteristic before the rate change, i.e. as of 31 December 2014.

In extensions we also control for other lending terms (see above), when analyzing the lending spread. Since these lending terms can also be a function of the bank's risk appetite and are decided on simultaneously by the banks as part of lending term package, this specification suffers from endogeneity problems. Nonetheless, it may helpful to detect irregularities, e.g. if a lower spread is only due to better collateralization.

4.4 Specification

To analyze lending terms, our most simple specification takes the following form

$$y_{l,b,f,t} = \beta depRatio_b \cdot D_t + \alpha_1 \cdot D_t + \alpha_2 \cdot depRatio_b + \epsilon_{l,b,f,t} \quad (1)$$

where $y_{l,b,f,t}$ is the lending spread charged on loan l by bank b to firm type f at paid out at date t (t measured in days).[14] As described above, in addition to the lending spread, we will employ alternative dependent variables in extensions. D_t is a dummy indicating the period after Jan 15 2015 (i.e. after the rate cut), $depRatio_b$ is the ratio of Swiss franc sight and saving deposits to total assets at the end of Dec 2014. $\epsilon_{l,b,f,t}$ is the error term.

The coefficient of interest is β. A negative β means that after the rate cut, banks with a high deposit ratio lowered the lending spread more when compared to banks with a low deposit ratio. This would confirm that reliance deposit funding acts expansionary under negative interest rates, i.e. high deposit banks loosen lending terms. A positive β, by contrast, would support a contractionary effect of a deposit centered funding structure.

Starting from this simple specification, we then successively add controls and increase the granularity of the fixed effects. Our main regression specification takes the following form:

$$y_{l,b,f,t} = \beta depRatio_b * D_t + \gamma BChar_b * D_t + F_{f,m} + F_{b,f} + \epsilon_{l,b,f,t}, \quad (2)$$

$BChar_b$ stands for other bank characteristics (size, capitalization, and charged reserves) that may affect the response to the rate cut. $F_{f,m}$ are firm type*month fixed effects, which control for firm type and year-month specific demand effects.[15] $F_{b,f}$ are bank*firm type fixed effect to control for time invariant unobserved bank heterogeneity that is allowed to vary over firm type.

The sample period in the baseline covers the window between 180 days before and 180 days after the rate cute, with loans granted at the date of the rate cut removed from the sample. In extension, we will look at alternative window sizes.

To analyse lending at the intensive margin we use a variant of equation 2, with the difference that there are only two time periods, a pre- and a post-rate cut period. Note that due to bank*firm type fixed effects, by design we only include firm type / bank relations in which a loan was granted in both periods. As for lending terms we use two-sided 180 days window.

For the analysis of the extensive margin, the specification is again similar to equation 2, but because the sample collapses into a cross-section, we drop bank fixed effects and use firm type fixed effects instead of firm type*time fixed effects.

Reported standard errors are clustered at the bank level. To account for small cluster biases, we follow the recommendation of Brewer et al. (2018) and employ a conservative degree of freedom correction for the standard deviation and use for tests the critical values from a t distribution with N-1 degrees of freedom, where N is the number of clusters.

[14] A bank can grant multiple loans to firm type in any period t.

[15] More precisely, we additionally interact the firm* D_t, effectively splitting the month of January into a pre-rate cut and a post-rate cut period.

5 Results

In this section, we first present the effect of a reliance on deposit funding on lending terms in a negative rate environment, in particular on the lending spread. Moving on, we take a look at lending volumes both at the intensive and the extensive margin. Overall, our results point to looser lending terms and more lending by banks with higher deposit funding. This result is statistically significant across a variety of specifications, stable and economically relevant. In extension, we apply a our analysis to lending for residential mortgages and find similar results. At the end of the section, we discuss our results for charged reserves as a separate transmission channel.

5.1 Lending terms

High deposit banks offer looser lending terms than other banks in a negative rate environment. Table 3 focuses on our main lending term, the lending spread. Starting from the simplest specification as described in equation (1) and shown column (1), we successively add more controls until we reach our baseline specification in column (6). The variable of interest is the interaction term *Deposit Ratio*After Rate Cut*. Across all specifications the coefficient on this term is negative and statistically significant. In column 2, we additionally include bank fixed and time fixed effects. In column 3, we interact the monetary policy change dummy with further standard bank balance sheet characteristics to account for alternative channels of transmission. In column 4, we add firm type fixed effects to control for time-invariant differences in lending spreads across firm types. In column 5, we allow differences in firm types to vary over time by interacting them with time fixed effects. This controls for example, for the possibility, that not all firm types are equally affected by the exchange rate shock following the floor removal. In our baseline specification in column 6, we additionally interact bank-fixed effects with firm type fixed effects to control for the possibility that banks systematically offer better terms in some sectors or regions and worse terms in others.

The estimated coefficient from our baseline specification is 0.96. This implies that a one standard deviation increase in the deposit ratio lowers the response of the lending spread to the rate cut by about 14 basis points. This result is economically significant: the average lending spread in our sample amounts to 252 basis points, with a standard deviation of 163 basis points.

Under negative interest rates, banks with high deposit funding do not offset the lower spreads by tightening other lending terms (Table 4). To the contrary, they tend to loosen their terms in comparison to the other banks. In particular, more reliance on deposits increases individual loan size under negative rates (column 1). It also raises the likelihood to issue a fixed rate loan in a negative rate environment (column 2), which, everything else constant, increases duration. Furthermore, more deposit funding also makes it less likely for banks to charge a commission on top of the required interest rate when rates are negative (column 3). Banks do therefore not compensate lower spreads by charging commissions. Finally, relying on deposit funding has no discernable influence on adjusting the maturity of the loan contract or collateralizing a loan in response to negative rates (column 4 and 5).

Table 3: Lending Spread

	(1)	(2)	(3)	(4)	(5)	(6)
Deposit Ratio	-0.00					
	(0.86)					
After Rate Cut	1.28***					
	(0.15)					
Deposit Ratio*After Rate Cut	-1.06***	-1.07***	-1.35***	-1.38***	-1.06***	-0.96***
	(0.29)	(0.26)	(0.37)	(0.33)	(0.18)	(0.12)
Charged Reserve Ratio*After Rate Cut			-3.18**	-3.19***	-2.94***	-3.05***
			(1.25)	(1.03)	(0.86)	(0.77)
Capital Ratio*After Rate Cut			-2.69	-2.64	-0.14	-0.51
			(5.12)	(4.64)	(3.45)	(3.01)
log(Total Assets)*After Rate Cut			-0.03	-0.05	-0.01	-0.01
			(0.05)	(0.05)	(0.03)	(0.03)
Time FE	No	Yes	Yes	Yes	No	No
Bank FE	No	Yes	Yes	Yes	Yes	No
Firm Type FE	No	No	No	Yes	No	No
Firm Type *Time FE	No	No	No	No	Yes	Yes
Bank*Firm Type FE	No	No	No	No	No	Yes
Constant	Yes	No	No	No	No	No
Observations	106997	106997	106997	89202	72704	70794
R^2	0.078	0.215	0.216	0.435	0.497	0.574
Number of Banks	20	20	20	20	20	20

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Standard errors in parentheses.
* p < 0.10, ** p < 0.05, *** p < 0.01

Notes: The table reports the estimated coefficients and bank-clustered robust standard errors (in parentheses) of our difference-in-differences models using least squares. Our main continuous differencing variable is the deposit ratio (Swiss Franc savings and sight deposits divided by total assets). The dependent variable is the lending spread over the risk-free-rate, as defined in section 4.1. We interact it with a dummy variable which takes the value of 1 after the interest rate change. Column (1) shows the result of the simplest regression specification, as defined in equation 1 in section 4.4. We successively add fixed effects (as indicated by "Yes") to control for time bank-fixed effects, firm type-fixed effects, time-fixed effects, or interactions thereof. From column (3) on, we add further balance sheet controls: The ratio of reserves at the Swiss National Bank subject to negative interest rates, normalized by total assets (Charged Reserve Ratio), the overall capital position normalized by total assets (Capital Ratio) and the log of total assets as a measure of bank size (log(Total Assets)). In column (6) we arrive at our baseline specification, which controls for time-varying firm type-fixed effects (Firm Type*Time FE) and for specific bank-firm relationships (Bank*Firm Type FE).

Table 4: Other Loan Terms

	(1) log(loan size)	(2) fixed rate	(3) commission	(4) maturity	(5) collateralized
Deposit Ratio*After Rate Cut	0.50***	0.24***	-0.21***	0.26	-0.02
	(0.07)	(0.04)	(0.02)	(0.49)	(0.02)
Charged Reserve Ratio*After Rate Cut	0.59	0.94***	-0.37**	8.40***	0.08
	(0.38)	(0.26)	(0.14)	(1.88)	(0.16)
Capital Ratio*After Rate Cut	-0.28	-0.58	-0.24	-18.11	-0.27
	(1.43)	(1.04)	(0.41)	(10.68)	(0.68)
log(Total Assets)*After Rate Cut	0.05***	0.01	-0.01***	-0.27**	-0.00
	(0.01)	(0.01)	(0.00)	(0.10)	(0.01)
Firm Type*Time FE	Yes	Yes	Yes	Yes	Yes
Bank*Firm Type FE	Yes	Yes	Yes	Yes	Yes
Observations	70794	70794	70794	48715	70794
R^2	0.544	0.422	0.400	0.465	0.501
Number of Banks	20	20	20	20	20

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Standard errors in parentheses.
* p < 0.10, ** p < 0.05, *** p < 0.01

Notes: The table reports the estimated coefficients and bank-clustered robust standard errors (in parentheses) of our baseline difference-in-differences model (see equation 2 in section 4.4) using least squares. We look at several lending terms as dependent variables: The log of the loan size (column 1), whether the loans has a fixed interest rate (column 2), whether a commission was charged on top of the interest rate (column 3), the maturity of the loan expressed in number of days divided by 360 (column 4), and whether the loan was collateralized (column 5, see section 4.1). We interact it with a dummy variable which takes the value of 1 after the interest rate change. Our main continuous differencing variable is the deposit ratio (Swiss Franc savings and sight deposits divided by total assets). In addition, we control for the following bank characteristics: The ratio of reserves at the Swiss National Bank subject to negative interest rates, normalized by total assets (Charged Reserve Ratio), the overall capital position normalized by total assets (Capital Ratio) and the log of total assets as a measure of bank size (log(Total Assets)). We control for time-varying firm type-fixed effects (Firm Type*Time) and for specific bank-firm relationships (Bank*Firm Type).

5.2 Lending volume – intensive and extensive margin

In addition to loosening lending terms, high banks also lend more than other banks when rates are negative. This is true both at the intensive and the extensive margin.

Intensive margin: Table 5 column (1) shows that, at the intensive margin, higher reliance on deposits leads to a higher volume of new loans to a given firm type in response to the rate cut. According to the estimate of 1.82, a one standard deviation increase in the deposit ratio raises the response of the (flow) volume of new loans to the rate cut by 27 percent.

To see how the rise in lending volumes relates to the decrease in the lending spread described in Section 5.1, we also compute the lending spread in the pre- and post rate cut period by taking the volume-weighted average of individual lending spreads. For direct comparability with volumes we take the log. As seen by column (2), the estimated coefficient of -0.72 implies that a one standard deviation increase in the deposit ratio lowers spreads by 10 percent in a negative rate environment.

Note that the estimated coefficients in columns (1) and (2) are directly comparable: The rise in volume (27 percent) exceeds the decrease in spreads (10 percent). The net effect is an increase in net revenue from credit intermediation, which we define as volume times spread. Concretely, a one standard deviation increase in the deposit ratio increases the rise in net revenues after the rate cute by 17 percent (column 3).

Extensive margin: Deposit funding also encourages an expansion at the extensive margin in a negative interest rate environment. After the rate cut, a high deposit bank is more likely to grant a loan to a new firm type and less likely to let all outstanding loans to a firm type expire. As described in Section 4.3.1, we use as dependent variables the dummy variables entry (set to one if a bank grants a loan to a new firm type) and exit (set to one if a loan expires after the rate cut). A one standard deviation increase in the deposit ratio makes it 1.7 percentage points more likely that a loan a bank grants is granted to a new firm type (7.3 percent of all bank/firm type relationships in the post rate cut sample are new relationships). An equally sized increase in the deposit ratio also makes it 0.6 percentage points less likely for a bank to let all loans to a firm type expire without replacement (2.7% of all bank/firm type relationships expire after the rate cut). Since we also find an expansionary effect at the extensive margin, the increase in net revenues calculated above for the intensive margin is a lower bound estimate for the increase in net revenues.

In sum, high deposit banks gain market share from their low deposit peers. They attract additional borrowers by offering looser lending terms. In the process they earn higher net revenues.

5.3 Robustness and extensions

Table 6 reports various modifications to our baseline specification for lending spreads as described in equation 2, with regards to window size, sample composition, and changes to the econometric specifications.

Window size: Column (1) to (3) report estimations for alternative window sizes, ranging from a narrow two-sided 45 days window to a wide two-sided 720 days window. The narrow window is attractive from an identification perspective, as it is unlikely that our estimates are contaminated by other shocks that are correlated with

Table 5: Lending Volume - Intensive and Extensive margin

	(1) log(vol)	(2) log(lending spread)	(3) log(net rev)	(4) new firm-type	(5) exit firm-type
Deposit Ratio *After Rate Cut	1.82***	-0.72***	1.10***	0.12***	-0.04***
	(0.31)	(0.06)	(0.34)	(0.03)	(0.01)
Charged Reserve Ratio *After Rate Cut	-1.57	-0.45	-2.02*	-0.11	0.10
	(0.97)	(0.41)	(1.14)	(0.16)	(0.07)
Capital Ratio *After Rate Cut	0.82	0.11	0.93	0.23	0.28
	(2.60)	(1.03)	(2.56)	(0.41)	(0.22)
log(Total Assets)*After Rate Cut	0.21***	-0.05***	0.16***	0.00	-0.01***
	(0.04)	(0.01)	(0.04)	(0.00)	(0.00)
Bank*Firm Type FE	Yes	Yes	Yes	No	No
Firm Type *Time FE	Yes	Yes	Yes	No	No
Firm Type FE	No	No	No	Yes	Yes
Observations	7050	7050	7050	5555	11592
R^2	0.925	0.886	0.917	0.378	0.306
Number of Banks	20	20	20	20	20

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Standard errors in parentheses.
* p < 0.10, ** p < 0.05, *** p < 0.01

Notes: The table reports the estimated coefficients and bank-clustered robust standard errors (in parentheses) of our difference-in-differences model using least squares. Column (1)-(3) show estimates at the intensive margin. The dependent variables are the log of loan volumes granted to firm types (column 1), the log of the lending spread (column 2) and the log of net revenues (column 3, defined as lending spread*volume). Columns (4) and (5) show estimates at the extensive margin. In column (4) the dependent variable indicates whether a loan granted constitutes a new bank/firm type relationship. In column (5) it indicates whether an existing bank/firm type relationship has expired (see section 4.3.1). Our main continuous differencing variable is the deposit ratio (Swiss Franc savings and sight deposits divided by total assets). In addition, we control for the following bank characteristics: The ratio of reserves at the Swiss National Bank subject to negative interest rates, normalized by total assets (Charged Reserve Ratio), the overall capital position normalized by total assets (Capital Ratio) and the log of total assets as a measure of bank size (log(Total Assets)). In column (1) to (3) we control for time-varying firm type-fixed effects (Firm Type*Time) and for specific bank-firm relationships (Bank*Firm Type). In columns (4) and (5), we drop the time interaction from our fixed effects, since after taking first differences we have a pure cross section.

the deposit ratio or influenced by management action. The wide window is attractive from an economic perspective, as it tells us if the effects are persistent. The negative effect of deposit funding on lending spreads is present for all window sizes. For wider windows, the effect is about three times smaller, but remains economically and statistically significant. Thus, a different funding profile before the rate cut has persistent effects on loan pricing after the rate cut. These differences in funding are not arbitraged away. A possible explanation is the franchise value of deposits, i.e. banks do not want lose depositors, which are key to their business model.

The results also hold when we remove the period around the rate cut (column 4). Specifically, we remove the 29 days before the 15 January rate cut to exclude the first policy announcement on 18 December 2014 (see 3.1). After the rate cut, we remove the first two weeks to ensure that our results are not driven by short term volatility.

Sample composition: Our results are not driven by firm characteristics or by banks that carry a large weight in our sample. Columns (5) to (7) show that we obtain similar results when excluding the industry sector with the most observations (real estate sector, 28% of all observations), the canton with most observations (ZH, 14% of all observations) and the bank with most observations (25% of all observations).

Changes to specification: A number of changes to the econometric specification do also not change our conclusion. In particular, the result continues to hold if we control for other loan characteristics as described in Section 4.3.1 (column 8), complement our standard balance sheet controls with other bank characteristics (SME loan to asset ratio, net long FX position over total assets, return on assets, liquidity coverage ratio, column 9), weight by loan size (column 10), and replace the lending spread with a simple interest rate (column 11). In a final check, we control for variations in the riskiness of borrowers within firm types. To this end, we interact firm type*time effects with a categorial rating variable. This rating variable represents a bank's subjective appraisal of the borrower's creditworthiness. Results continue to hold (column 12).

Table 6: Lending spread robustness checks

	(1) +- 45 days	(2) +- 360 days	(3) +- 720 days	(4) wo. cut per.	(5) wo. larg. sect.	(6) wo. larg. Cant.	(7) wo. larg. Bank	(8) Loan Char.	(9) oth. Bank Char.	(10) Weighted	(11) Int. rate	(12) Rating
Deposit Ratio*After Rate Cut	-1.21***	-0.29**	-0.32**	-0.70***	-0.95***	-0.88***	-0.96***	-0.58***	-0.73**	-0.57***	-0.88***	-0.82***
	(0.29)	(0.12)	(0.13)	(0.19)	(0.15)	(0.13)	(0.12)	(0.09)	(0.27)	(0.10)	(0.09)	(0.15)
Charged Reserve Ratio*After Rate Cut	-2.94**	-0.87	-0.14	-2.79***	-5.21***	-2.23**	-3.98***	-1.18*	-3.36**	-2.10***	-2.00***	-3.49***
	(1.16)	(0.52)	(0.77)	(0.67)	(1.23)	(1.03)	(0.66)	(0.58)	(1.44)	(0.37)	(0.61)	(0.35)
Capital Ratio*After Rate Cut	-1.10	1.95	3.32	0.13	-2.37	-2.03	-1.41	1.53	-1.00	-0.42	-2.64	-2.54
	(5.25)	(2.04)	(2.65)	(2.41)	(3.43)	(3.24)	(2.56)	(2.01)	(2.93)	(2.27)	(2.00)	(3.02)
log(Total Assets)*After Rate Cut	0.04	0.03*	0.04*	-0.00	-0.00	-0.02	0.01	0.01	0.11	0.00	-0.05**	-0.01
	(0.04)	(0.02)	(0.02)	(0.02)	(0.03)	(0.03)	(0.02)	(0.01)	(0.08)	(0.02)	(0.02)	(0.02)
log(loan size)								-0.10***				
								(0.01)				
maturity								-0.01**				
								(0.01)				
fixed rate								0.25***				
								(0.05)				
commission								1.73**				
								(0.66)				
collateralized								-0.69***				
								(0.14)				
LCR*After Rate Cut									0.08			
									(0.10)			
Net FX Pos./TA*After Rate Cut									0.29			
									(1.48)			
SME Loan Ratio*After Rate Cut									0.80*			
									(0.46)			
RoA*After Rate Cut									0.16			
									(0.47)			
Firm Type*Time FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No
Bank*Firm Type FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No
Firm Type*Rating*Time FE	No	No	No	No	No	No	No	No	No	No	No	Yes
Bank*Firm Type*Rating FE	No	No	No	No	No	No	No	No	No	No	No	Yes
Observations	16221	144551	289836	84597	45741	60181	51987	48715	70794	70794	70794	59731
R^2	0.588	0.558	0.548	0.581	0.511	0.560	0.593	0.698	0.574	0.671	0.538	0.672
Number of Banks	20	20	20	20	20	20	19	20	20	20	20	19

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Standard errors in parentheses.
* p < 0.10, ** p < 0.05, *** p < 0.01

Notes: The table reports the estimated coefficients and bank-clustered robust standard errors (in parentheses) of our robustness checks. Column (1) shortens the estimation window from +-180 days to +-45 days around the rate cut. Column (2) and (3) increase it to +-360 days and +-720 days, respectively. Column (4) removes from the estimation the period between the rate cut on 15 January 2015 and the policy announcement on 18 December 2014 and the two weeks following the rate cut. Column (5) to (7) excludes firm characteristics and banks that carry a large weight: Column (5) excludes real estate sector, column (6) excludes the canton of Zurich, and column (7) excludes the biggest banks in terms of corporate lending. Column (8) controls for additional individual loan characteristics. Column (9) adds further bank controls to our baseline specification: Liquidity coverage ratio (LCR), the net long position in foreign currency divided by total assets (Net FX Pos./TA), loans and loan commitments to small and medium enterprises normalized by total loans (SME Loan Ratio), and profits normalized by total assets (RoA). Column (10) we weight observations by loan size. Column (11) replaces the dependent variable lending spread with lending rate rate. Column (12) interacts firm type * time fixed effects and bank * firm type fixed effects with a categorical bank-internal rating variable (5 categories). Deposit Ratio, Charged Reserve Ratio, Capital Ratio and log(Total Assets) are defined in Table 3.

Placebo tests: We run the regressions for 11 previous rate cuts in positive territory that our sample covers (2006m06 to 2014m12).[16] The rate change dummy takes a value of one if there was a rate cut and a value of minus one if there was a rate hike. Absent a lower bound on deposit rates, we would not expect to find a similar effect of deposit funding on lending terms. Our results confirm the hypothesis. All of the coefficients are insignificant, except for one case, where the coefficients is positive, i.e. the opposite of what was found for negative rates. It also provides support that the parallel trend assumption holds, because the dependent variable moves in parallel for different deposit ratios when there is no actual "treatment" in positive territory.

[16]These rate cuts cannot be considered as unanticipated and exogenous. For example, they include responses to the financial crisis.

Table 7: Estimates for rate cuts in positive territory

	9/14/06	12/14/06	3/15/07	6/14/07	9/13/07	10/8/08	11/6/08	11/20/08	12/11/08	3/12/09	8/3/11
Deposit Ratio*After Rate Cut	-0.4	-0.3	-0.23	0.04	-0.36	-0.78	-1.39	-1.62	-1.68	0.34	1.41***
	0.69	0.36	0.26	0.31	0.29	0.8	1.05	1.07	1.21	0.85	0.44
Observations	30,240	45,077	54,594	49,301	50,090	68,212	69,790	70,659	73,491	82,891	73,604
R2	0.6	0.59	0.59	0.53	0.53	0.56	0.54	0.54	0.54	0.53	0.56
Number of banks	20	20	20	20	20	20	20	20	20	20	20

Standard errors in parentheses.

* p < 0.10, ** p < 0.05, *** p < 0.01

Notes: The table reports the estimated coefficients and bank-clustered robust standard errors (in parentheses) for all monetary policy rate changes since September 2006. The underlying baseline difference-in-differences model is described in equation 2 in section 4.4. The rate change dummy takes a value of one if there was a rate cut and a value of minus one if there was a rate hike. Our main continuous differencing variable is the deposit ratio (Swiss Franc savings and sight deposits divided by total assets). We further control for bank characteristics, firm types and specific bank-firm relationships, as described in the baseline model (not reported in the table).

Table 8: Dep. Variable: Lending Spreads on Residential Mortgages

	(1) all mat (+-6m)	(2) mat <=5y (+-6m)	(3) mat >5y (+-6m)	(4) mat>5y (+-2m)	(5) mat>5y (+-18m)
Deposit Ratio*After Rate Cut	-0.11	-0.11	-0.19**	-0.22**	-0.17**
	(0.08)	(0.08)	(0.09)	(0.10)	(0.08)
Charged Reserve Ratio*After Rate Cut	0.26	0.26	0.44	0.34	-0.15
	(0.29)	(0.29)	(0.32)	(0.40)	(0.31)
log(Total Assets)*After Rate Cut	0.02**	0.02**	0.03***	0.03***	0.01
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Capital Ratio*After Rate Cut	0.75	0.75	0.91	1.41	-0.24
	(1.06)	(1.06)	(1.30)	(1.42)	(0.94)
Bank FE	Yes	Yes	Yes	Yes	Yes
Time*Maturity FE	Yes	Yes	Yes	Yes	Yes
Observations	4840	4840	2539	854	7571
R^2	0.937	0.937	0.928	0.903	0.938
Number of Banks	45	45	44	44	44

Standard errors in parentheses.
* p < 0.10, ** p < 0.05, *** p < 0.01
Notes: The table reports the estimated coefficients and bank-clustered robust standard errors (in parentheses) of a difference-in-differences model applied to a residential mortgage loan data set using least squares. In the first column, we look at all mortgage loans in a in a one year window around the January 15 2015 rate cut (similar to our baseline specification). In column (2), we restrict the data to all mortgages with a maturity of less than 5 years. In column (3), we restrict the data to all mortgages with a maturity of more than 5 years. In the last two columns, we focus on mortgages with a maturity of more than 5 years and vary the window size. We use a window of +-2 months (column 4) and a window of +-18 months (column 5) around the rate cut. Our main continuous differencing variable is the deposit ratio (Swiss Franc savings and sight deposits divided by total assets). In addition, we control for the following bank characteristics: The ratio of reserves at the Swiss National Bank subject to negative interest rates, normalized by total assets (Charged Reserve Ratio), the overall capital position normalized by total assets (Capital Ratio) and the log of total assets as a measure of bank size (log(Total Assets)). We control for bank-fixed effects (Bank FE) and for time-varying maturity fixed effects (Time*Maturity FE).

Residential mortgages: Our results extend beyond the corporate loan market. To check whether our results hold for other credit markets, we apply a similar analysis to the residential mortgage market, where we have more banks, but less granular data (see section 4.1 for a description). We use lending spreads on fixed rate mortgages with a maturity between on and ten years. We use a two sided window of six months around the rate cut as baseline. Results are shown in Table 8. Standard errors are again clustered at the bank level. We find a similar effect as in our baseline, but for long maturities only (more than five years, column 3). Deposit funding has no effect in a specification with only short (five years or less, column 2) or all maturities (columns 1). It appears that high deposit ratio banks primarily aim to expand their lending in a maturity bucket where yields are structurally higher. The coefficient (-0.19) is about five times smaller than for corporate loans in absolute terms, but compared to the sample standard deviation of lending spreads for residential mortgages (about six times smaller, 25 basis points) this is a similar magnitude. We also find a statistically significant effect for a short two-sided 2 months window, indicating a quick response, and a long two-sided 18 months window (column 5), indicating that the effect is persistent.

5.4 Charged reserves as separate transmission channel

In addition to deposit funding, we also analyze the role of reserves that are charged negative interest rates. Two recent studies (Basten and Mariathasan, 2018; Bottero et al., 2018) have investigated the role of charged reserves or close equivalents as a separate bank characteristic that may affect transmission through a portfolio rebalancing

mechanism. In our baseline specification with a two sided window of 180 days, we do find evidence that banks with more charged reserves ask for lower spreads in response to the rate cut (see Table 3). A one standard deviation increase in the charged reserve ratio lowers lending spread by about 13 basis point in response to the cut, a similar magnitude as for corporate loans. This is consistent with portfolio unbalancing, where high deposits attempt to expand lending.

However, the effects fades out for longer estimation windows (see Table 6, column 2 and 3) and ist not statistically significant for for +- 360 days or +-720 days windows. This indicates that differences in charged reserves are primarily arbitraged away on the interbank market over the medium term: bank with reserves below the exemption threshold (negative charged reservers) probably accepted interbank loans from banks with a reserves above the threshold amount of charged reserves and used the interbank to increase their reserves at the SNB. In that regard, Basten and Mariathasan (2018) find that banks with more charged reserves reallocated liquidity by decreasing their central bank reserves and increasing their net interbank position relative to the balance sheet. Turning to lending, we find no evidence that charged reserves are associated with more lending, neither at the intensive nor the extensive margin (see Table 5). We also find no evidence for an effect on mortgage lending spreads (see Table 8). Overall, while charged reserves have affected corporate lending spreads in the short term, they appear overall of lesser importance for the transmission of negative interest rates.

6 Conclusion

After several central banks pushed their monetary policy rates into negative territory, banks generally proved reluctant to pass on negative interest rates to their retail customers. With market interest rates dropping below zero, banks more dependent on deposit funding face higher funding costs relative to other banks. In this paper, we investigate how such banks in Switzerland responded to negative interest rates.To this end, we focus on the Swiss National Bank's large and unexpected rate cut on 15 January 2015. Using a difference-in-differences approach, we analyze its impact with detailed micro data on corporate loans. Our results indicate that when market rates are negative, banks with a lot of deposits try to offset their relatively higher funding costs by offering more generous lending terms and thereby capturing market shares.

A number of studies has documented that with negative interest rates, the transmission from policy rates to lending rates declines or even breaks down (Bech and Malkhozov, 2016; Eggertsson et al., 2017). In Switzerland, lending spreads after the rate cut increased as well. Our results, however, do not support the notion that deposit funding could be the reason for a lack of transmission in Switzerland. To the contrary, the pass-through to lending rates for high deposit banks is stronger. Other factors must be the reason for the phenomenon. Future research may look at the following determinants of lending rate levels. On the demand side, there is evidence that the strong appreciation of the Swiss franc caused a worsening in borrower fundamentals (Efing et al., 2015) and an increase in uncertainty (Buchholz et al., 2018). It is possible that these factors masked looser lending terms by increasing credit risk. On the supply side, the rate cut may have served as an informal coordination device, i.e. there might have been an implicit understanding among banks not to adjust lending

rates and thereby maintain profitability.

References

Alessandri, Piergiorgio, and Andrew G Haldane (2009) 'Banking on the State.' https://www.bankofengland.co.uk/-/media/boe/files/paper/2009/banking-on-the-state.pdf

Altavilla, Carlo, Miguel Boucinha, and José-Luis Peydró (2017) 'Monetary policy and bank profitability in a low interest rate environment.' Working Paper Series 2105, European Central Bank, October

Arce, Oscar, Miguel Garcia-Posada, Sergio Mayordomo, and Steven Ongena (2018) 'Adapting lending policies when negative interest rates hit banks' profits.' mimeo

Auer, Raphael, and Steven Ongena (2016) 'The countercyclical capital buffer and the composition of bank lending.' BIS Working Papers 593, Bank for International Settlements

Auer, Simone, Christian Friedrich, Maja Ganarin, Teodora Paligorova, and Pascal Towbin (2018) 'International Monetary Policy Transmission through Banks in Small Open Economies.' *"Journal of International Money and Finance"*

Bank of Japan (2016) 'Introduction of "quantitative and qualitative monetary easing with a negative interest rate.' Press release. Available at url //www.boj.or.jp/en/announcements/release_2016/k160129a.pdf (accessed at 2 September 2018)

Basten, Christoph, and Mike Mariathasan (2018) 'How Banks Respond to Negative Interest Rates: Evidence from the Swiss Exemption Threshold.' CESifo Working Paper Series 6901, CESifo Group Munich

Bech, Morten, and Aytek Malkhozov (2016) 'How have central banks implemented negative policy rates?' *BIS Quarterly Review*

Beutler, Toni, Robert Bichsel, Adrian Bruhin, and Jayson Danton (2017) 'The Impact of Interest Rate Risk on Bank Lending.' SNB Working Paper 2017-04, Swiss National Bank

Boot, Arnoud (2000) 'Relationship banking: What do we know?' *Journal of Financial Intermediation* 9(1), 7–25

Bottero, Margherita, Camelio Minoiu, Jose Luis Peydró, Andrea Polo, Andrea Presbitero, and Enrico Sette (2018) 'Negative Policy Rates and Bank Asset Allocation: Evidence from the Italian Credit and Security Registers.' mimeo

Brewer, Mike, Thomas F. Crossley, and Robert Joyce (2018) 'Inference with Difference-in-Differences Revisited.' *Journal of Econometric Methods* 7(1), 1–16

Brunnermeier, Markus K., and Yann Koby (2018) 'The reversal interest rate.' Working Paper, Princeton Universtiy

Buchholz, Manuel, Gregor von Schweinitz, and Lena Tonzer (2018) 'Did the Swiss exchange rate shock shock the market?' IWH Discussion Papers 9/2018, Halle Institute for Economic Research (IWH)

Christensen, Jens H.E., and Signe Krogstrup (2018) 'Transmission of quantitative easing: The role of central bank reserves.' *The Economic Journal*

de Sola, Perea, and Kashama Kasongo (2017) 'The negative interest rate policy in the euro area and the supply of bank loans.' *Economic Review - National Bank of Belgium* pp. 43 – 61

Dell'Ariccia, Giovanni, Luc Laeven, and Gustavo A. Suarez (2017) 'Bank leverage and monetary policy's risk-taking channel: Evidence from the united states.' *Journal of Finance* 72(2), 613–654

Demiralp, S., Jens Eisenschmidt, and T. Vlassopoulos (2017) 'Negative interest rates, excess liquidity and bank business models: Banks' reaction to unconventional monetary policy in the euro area.' Koc University-TUSIAD Economic Research Forum Working Papers, Koc University-TUSIAD Economic Research Forum

Dietrich, Andreas, Reto Wernli, and Christoph Duss (2017) 'Studie zur Finanzierung der KMU in der Schweiz 2016.' State Secretariat for Economic Affairs SECO, Berne

Efing, Matthias, Rüdiger Fahlenbrach, Christoph Herpfer, and Philipp Krüger (2015) 'How Do Investors and Firms React to an Unexpected Currency Appreciation Shock?' Swiss Finance Institute Research Paper Series 15-65, Swiss Finance Institute, December

Eggertsson, Gauti B, Ragnar E Juelsrud, and Ella Getz Wold (2017) 'Are negative nominal interest rates expansionary?' Working Paper 24039, National Bureau of Economic Research, November

Eichengreen, Barry, and Ricardo Hausmann (1999) 'Exchange rates and financial fragility.' *Proceedings - Economic Policy Symposium - Jackson Hole* pp. 329–368

Eisenschmidt, Jens, and Frank Smets (2017) 'Negative interest rates: Lessons from the euro area.' mimeo

European Central Bank (2014) 'Introductory statement to the press conference (with q&a).' Available at url https://www.ecb.europa.eu/press/pressconf/2014/html/is140605.en.html (accessed at 2 September 2018)

Grisse, Christian, Signe Krogstrup, and Silvio Schumacher (2017) 'Lower-Bound Beliefs and Long-Term Interest Rates.' *International Journal of Central Banking* 13(3), 165–202

Heider, Florian, Farzad Saidi, and Glenn Schepens (2018) 'Life below zero: bank lending under negative policy rates.' Working Paper Series 2173, European Central Bank, August

Hong, Gee Hee, and John Kandrac (2018) 'Pushed Past the Limit? How Japanese Banks Reacted to Negative Interest Rates.' IMF Working Papers 18/131, International Monetary Fund, June

Ioannidou, Vasso, Steven Ongena, and Jose-Luis Peydro (2015) 'Monetary policy, risk-taking, and pricing: Evidence from a quasi-natural experiment.' *Review of Finance* 19(1), 95–144

Jiménez, Gabriel, Steven Ongena, José-Luis Peydró, and Jesús Saurina (2012) 'Credit supply and monetary policy: Identifying the bank balance-sheet channel with loan applications.' *American Economic Review* 102(5), 2301–26

Jimenéz, Gabriel, Steven Ongena, José Luis Peydró, and Jesús Saurina (2014) 'Hazardous Times for Monetary Policy: What Do Twenty Three Million Bank Loans Say About the Effects of Monetary Policy on Credit Risk Taking?' *Econometrica* 82(2), 463–505

Kandrac, John, and Bernd Schlusche (2017) 'Quantitative Easing and Bank Risk Taking: Evidence from Lending.' Finance and Economics Discussion Series 2017-125, Board of Governors of the Federal Reserve System (U.S.), October

Khwaja, Asim Ijaz, and Atif Mian (2008) 'Tracing the Impact of Bank Liquidity Shocks: Evidence from an Emerging Market.' *American Economic Review* 98(4), 1413–1442

Lepetit, Laetitia, Emmanuelle Nys, Philippe Rous, and Amine Tarazi (2008) 'The expansion of services in european banking: Implications for loan pricing and interest margins.' *Journal of Banking & Finance* 32(11), 2325 – 2335

Martinez-Miera, David, and Rafael Repullo (2017) 'Search for Yield.' *Econometrica* 85, 351–378

Nelson, Charles, and Andrew F Siegel (1987) 'Parsimonious modeling of yield curves.' *The Journal of Business* 60(4), 473–89

Nucera, Federico, André Lucas, Julia Schaumburg, and Bernd Schwaab (2017) 'Do negative interest rates make banks less safe?' *Economics Letters* 159(C), 112–115

Paligorova, Teodora, and Joao Santos (2017) 'Monetary policy and bank risk-taking: Evidence from the corporate loan market.' *Journal of Financial Intermediation* 30(C), 35–49

Pennacchi, George, and Joao A. C. Santos (2018) 'Why do banks target ROE?' Staff Reports 855, Federal Reserve Bank of New York, June

Rajan, Raghuram G. (2005) 'Has financial development made the world riskier?' *Proceedings - Economic Policy Symposium - Jackson Hole* (Aug), 313–369

Riksbank (2015) 'Riksbank cuts repo rate to minus 0.10 per cent, buys government bonds for sek 10 billion and is prepared to do more at short notice.' Press release. Available at url //http://archive.riksbank.se/en/Web-archive/Published/Press-Releases/2015/Riksbank-cuts-repo-rate-to-010-per-cent-buys-government-bonds-for-SEK-10-billion/index.html (accessed at 2 September 2018)

Stein, Jeremy, and Anil Kashyap (2000) 'What do a million observations on banks say about the transmission of monetary policy?' *American Economic Review* 90(3), 407–428

Swiss National Bank (2014) 'Swiss national bank introduces negative interest rates.' Press release. Available at url https://www.snb.ch/en/mmr/reference/pre_20141218/source/pre_20141218.en.pdf (accessed at 2 September 2018)

Swiss National Bank (2015) 'Swiss national bank discontinues minimum exchange rate and lowers interest rate to minus 0.75%.' Press release. Available at url https://www.snb.ch/en/mmr/reference/pre_20150115/source/pre_20150115.en.pdf (accessed at 2 September 2018)

Van den Heuvel, Skander (2006) 'The Bank Capital Channel of Monetary Policy.' 2006 Meeting Papers 512, Society for Economic Dynamics, December

Wu, Jing Cynthia, and Dora Xia (2018) 'The negative interest rate policy and the yield curve.' BIS Working Papers 703, Bank for International Settlements, February