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INTEREST RATE PASS-THROUGH AND BANK RISK-TAKING UNDER NEGATIVE-RATE POLICIES WITH TIERED REMUNERATION OF CENTRAL BANK RESERVES

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Abstract

We identify the effects of negative rates on bank behavior using difference-in-differences identification. First, we find that going negative can interrupt not only the pass-through from policy to deposit but also to mortgage rates. To preserve their deposit franchise, banks finance negative deposit with increased mortgage spreads, the more the bigger their market power. Second, negative rates on reserves induce banks to cut some reserves without replacement and replace others with riskier assets. With increased mortgage spreads, balance sheet restructuring preserves profits but increases risk-taking. Third, pass-through interruption and risk-taking can be reduced through tiered remuneration.

Keywords:

negative interest rate policy, monetary policy transmission, interest pass-through, credit risk, interest rate risk, tiered remuneration

JEL Codes:
E43, E44, E52, E58, G20, G21

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1. Introduction

In the past decade, central banks in the Euro area, Denmark, Switzerland, and Japan, have for the first time implemented "Negative Interest Rate Policies" (NIRP).[1] The European Central Bank (ECB) did so to stimulate bank lending and thereby economic growth and inflation[2], while Danmarks Nationalbank and the Swiss National Bank (SNB) followed the ECB into negative territory to limit upward pressure on their currencies. By and large it appears that negative interbank rates have indeed increased banks' incentives to replace central bank reserves with loans or foreign-currency assets. Yet, much remains to be understood about the efficacy of different NIRP designs, their effects on banks, Balloch, Koby, and Ulate (2022), and their role in the monetary policy toolbox (Nakamura and Steinsson, 2021). A consistent finding in existing research, for instance, is banks' hesitance to pass negative rates through to depositors, which implies negative deposit margins and pressure on banks' profitability. This raises two questions. First, under which circumstances can negative rate policy interrupt not only the pass-through from policy to deposit but also to lending rates, and thereby hinder the transmission of monetary policy to the real economy?[3] Second, to what extent does it incentivize banks to take more risk and thus possibly impair financial stability?

We address both questions in the context of Switzerland's NIRP, show explicitly how pass-through and risk-taking responses differ between positive and negative rate policies, and discuss how policy can mitigate unwanted effects. Specifically, we first show that the pass-through from policy to lending rates can indeed be interrupted under NIRP, for banks seek to offset, where possible, the squeeze of their deposit margins by expanding asset margins. Market power facilitates this asset margin expansion. Second, we show that beyond changing their rate setting, banks adjust also their balance sheets. On the one hand, they cut some central bank reserves without replacement and replace others with higher return alternatives to preserve profitability. On the other hand, they reduce bond financing, which increases the relative importance of deposit funding. Jointly, we find these adjustments to increase market, liquidity, interest rate, and credit

[1] With safe central bank reserves unremunerated, banks with excess liquidity might prefer lending to the central bank at 0% over lending to other banks at negative rates, causing interbank rates to increase at least to zero. See e.g. Bech and Malkhozov (2016).

[2] https://www.ecb.europa.eu/explainers/tell-me-more/html/why-negative-interest-rate.en.html

[3] In the following, we use the term *pass-through* to denote the effect of policy rate cuts on other *rates*, whereas "transmission" refers to the effects on loan *volumes* and the *real* economy.

risk to a degree that is not matched by better capitalization. Hence losses become more likely to exceed capital buffers. Further analyses show risk increases to be more pronounced among larger and more weakly capitalized banks, which raises additional concerns about financial stability. Importantly, the interruption of rate pass-through and risk increases both differ from the effects of an earlier rate cut within positive territory. Finally, we exploit that the SNB was the first central bank to implement negative policy rates via "tiered remuneration" and discuss to what extent interrupted pass-through and risk-taking can be mitigated if central banks impose negative rates on only a fraction of all central bank reserves.

Our work contributes to existing work on negative policy rates along several dimensions. First, we capture affectedness by NIRP directly through the fraction of each bank's central bank reserves on which negative interest rates were actually charged.[4] This is different from and complementary to most of the existing literature that identifies affectedness indirectly via the ratio of deposits to total assets (e.g., Heider, Saidi, and Schepens, 2019).[5] Although both exposure measures capture pressure on banks' profitability, our analysis allows us to show, on the one hand, that more directly exposed banks were indeed hesitant to lose depositors, which supports the use of the deposit ratio for identification. On the other hand, our results also emphasize that banks' responses are partly driven by the change in returns to central bank reserves relative to those on other assets. We further explore the difference in banks' response depending on the exposure measure as a robustness check and show that the two measures are related but can yield different results, e.g., for lending rates. Second, we study banks that are heavily invested in the mortgage market and contribute to the few studies (Eggertsson et al., forthc.; Amzallag et al., 2019; Schelling and Towbin, 2022) that provide evidence on how NIRP affects mortgage rates. Different from existing papers, we combine the analysis of lending rate effects with an analysis of bank balance sheets and supervisory risk measures. Especially the evidence on liability restructuring and risk beyond credit risk is new and allows us to investigate broader implications for financial stability. To our knowledge, our paper is also the first to link lending rate increases under NIRP to market power. Third, we study a case of NIRP outside of the Euro area, which - in addition to enabling our identification strategy - has

[4] An earlier paper of ours scaled Exposed Reserves instead by Total Assets, beyond using a smaller sample. We now scale them by total reserves to facilitate interpretation, but our Online Appendix shows that results are robust to how we scale.
[5] In the Euro area, our identification would not have been possible until October 2019, since the ECB initially only exempted minimum reserve requirements (MRR) from negative reserve rates.

several advantages: It allows us to study the effect of NIRP on banks that were generally well-capitalized and profitable, and that operated in an economy exposed to negative rates only due to exchange rate considerations. We further observe essentially the entire Swiss banking system and supervisory measures of all major dimensions of bank risk-taking. We can also compare key effects of the policy rate cut into negative territory with effects of an earlier rate cut within positive territory. Finally, studying Switzerland allows us to quantify how tiered remuneration can moderate the negative side effects of NIRP.

Our identification of the effect of the Swiss NIRP on banks' pricing, balance sheet structure, income statements, and risk-taking relies on a difference-in-differences (DiD) strategy. We compare inter-temporal changes in the outcomes of interest at banks that had different fractions of their reserves affected by negative reserve rates. This is possible because the original Swiss policy imposed negative rates only on central bank reserves that exceeded the twenty-fold of each bank's minimum reserve requirement (MRR). The entire banking system started with reserves of about 22 times the aggregate MRR, implying that two times MRR was charged. At the same time, the fraction of exposed reserves varied widely across individual banks. We control for both bank and time fixed effects and placebo tests support our identifying assumption of parallel trends in the outcome variables of interest. The fixed effects imply that our estimates could be biased only by factors that vary over time and across banks *and* are correlated with our measure of treatment intensity. One potential source of such correlation could be the appreciation of the domestic currency. The SNB removed a peg to the Euro simultaneously with introducing negative rates, implying biased estimates if banks more affected by NIRP were also more exposed to the appreciation of the Swiss Franc (CHF). In our main analysis, we address this potential confounding first by dropping foreign-owned banks, which could be particularly exposed to the currency shock. Second, in additional robustness checks, we also control (i) for the currency mismatch in the share of banks' assets and liabilities, (ii) banks' proximity to the currency area border, and (iii) the size of banks' corporate loan portfolio (which may be subject to steeper foreign competition after the currency appreciation), and find no confounding from the currency shock. In an additional robustness check, we follow Varian (2014) in using Google Trends data as proxies for economic developments to show that our results are robust to controlling for mortgage demand. Our results are further robust to measuring treatment as exposed reserves over total assets, or as deposits over total assets, as well as to distinguishing between different bank business models.[6]

Tiered remuneration enables our identification strategy by allowing us to compare banks that are (more adversely or more beneficially) affected by NIRP to unaffected banks.[7] At the same time, the simultaneous presence of more adversely and more beneficially affected banks complicates inference about aggregate consequences of NIRP. Yet, we can draw some conclusions by considering the distribution of affectedness to NIRP across banks. The pass-through from interbank to lending rates, for instance, is interrupted more by larger banks, consistent with our market power results, and thus likely relevant for the average mortgage borrower. Risk-taking also increases more for larger banks, which tend to be less well capitalized. These observations suggest that our findings are relevant for financial stability. Presumably in line with the SNB's considerations, however, pass-through interruptions and risk increases, at least at the bank-level, are significantly moderated by tiered remuneration.

Contributions to the Literature:

We contribute first to the literature on the transmission of monetary policy through the banking system under NIRP. From a theory angle, Abadi, Brunnermeier, and Koby (forthc.) and Ulate (2021) first introduced mechanisms under which low policy rates can erode bank equity and so reduce their lending capacity. While plausible in some contexts, their considerations are less likely to apply in the case of Switzerland where banks were generally profitable and well-capitalized and where we find that banks avoided reductions in their profitability and equity, albeit at the cost of increased risk-taking. Interestingly, however, we observe interrupted pass-through from policy to lending rates even without equity constraints becoming binding. As in periods of positive but low rates (Claessens, Coleman, and Donnelly, 2018), banks strive to compensate negative deposit spreads by widening selected lending spreads rather than just absorbing more deposit business losses with equity. With the corresponding mortgage volumes increasing as a share of total assets (TA) but not in absolute terms, however, monetary policy transmission is interrupted. Our findings

[6] In an earlier, more extensive version we have amongst others also shown robustness to correcting p values for potential "multiple inference" problems, as well as to the potential problem of "negative weights" as raised by Chaisemartin and D'Haultfœuille (2020), for details see Basten and Mariathasan (2020).

[7] We do not actually observe banks that are entirely unaffected by NIRP, but there are banks in our sample for which total reserves are very close to the 20-fold of their MRR.

are thus more in line with the evidence in Eggertsson et al. (forthc.) or Baeriswyl et al. (2021), although specifically the mechanism in Eggertsson et al. (forthc.) relies on declining deposit margins, and neither paper links expansions in asset margins to market power.

Linking our work to the traditional literature on bank-based monetary policy transmission, the interruption of pass-through to loan rates suggests an impaired bank lending channel (Bernanke and Gertler, 1995; Kashyap and Stein, 2000; Jiménez et al., 2012) and thus more moderate credit volume responses to policy rate changes. At the same time, negative rates also change the functioning of the deposits channel (Drechsler, Savov, and Schnabl, 2017): Therein banks normally respond to policy rate cuts by lowering their deposit margins, resulting in greater deposit volumes and therefore more capacity to lend. In the context of negative policy rates, instead, deposit margins become negative as banks seek to retain depositors for later business, so that deposits remain at least as attractive for bank clients as before the rate cut.[8] The expansion of lending that we would therefore expect under positive rates is thus interrupted when banks simultaneously expand loan margins to cross-subsidize their now loss-making deposit business. Our results on market power are then in line with Wang et al. (2020) who find a similar loan margin response to policy rate changes in positive interest rate environments in the US and who show that this response is more pronounced the greater a bank's mortgage market power. Lastly, the risk-taking channel (Borio and Zhu, 2012; Jiménez et al., 2014; Bonfim and Soares, 2018) may be strengthened under negative rates as banks that wish to retain loss-causing depositors may engage in more risk-taking to temporarily cross-subsidize their deposit business.

Our evidence on risk-taking further contributes to the literature showing NIRP to increase bank risk, especially in the corporate loan portfolio. Specifically for large banks in their syndicated lending, evidence of increased risk-taking was first documented by Heider et al. (2019).[9] Our results are in line with increases in credit risk, primarily with respect to mortgages, but also show

[8] Using granular Norwegian data, Basten and Juelsrud (forthc.) indeed show that the values of banks' deposit and mortgage franchises are positively correlated, as depositors are more likely to borrow from the same bank at which they have their deposits. Their results corroborate the hypothesis that banks are reluctant to actively cut deposit funding.

[9] Altavilla et al. (2021) show that banks may feel more leeway to set negative deposit rates for corporate clients. Yet as not all deposit clients are corporates, also a zero lower bound on (even if only part of) household deposits alone will depress a bank's *average* deposit margin. Notice also that fees are not equivalent to negative deposit rates, as they are typically not charged in proportion to deposit volumes.

that banks' riskiness increases along multiple dimensions and extends, for example, to market and interest rate risk.

Finally, the case of Switzerland also lends itself to studying the role of tiered remuneration in the design of NIRPs. From a theory angle, Balloch and Koby (2020) and Berentsen, van Buggenum, and Ruprecht (2020) show how imposing negative rates on only part of central bank reserves can mitigate the pressures on bank profitability, which may reduce lending and risk-taking. Furthermore, Boutros and Witmer (2020) show how the tiering threshold needs to be linked to any substitution of reserves with cash to allow the central bank to achieve its desired interbank rate. We discuss how tiered remuneration can moderate both interruptions in monetary policy transmission and reduce incentives to increase bank risk-taking. Furthermore, we are the first to estimate the magnitudes of these effects.[10]

In the following, Section 2 describes the introduction of NIRP in Switzerland and Section 3 introduces our data and empirical strategy. Section 4 presents our main results and Section 5 discusses several robustness checks. Section 6 concludes.

2. Negative Interest Rate Policy in Switzerland

2.1. Background

Until December 2014, monetary policy in Switzerland was conducted by communicating a (positive) target, as well as upper and lower bounds for the 3-month CHF Libor and by using open market operations to achieve this target.[11] Central bank reserves were unremunerated and hence earned a return below that in the interbank market, and the Libor target was typically below Euro area interbank rates to mitigate upward pressure on the Franc. This framework came under pressure when the ECB announced negative policy rates in the summer of 2014. Because the SNB had guaranteed a lower bound of 1.20 CHF per euro since 2011, exchange rate pressure from the ECB's rate cut substantially increased the amount of foreign currency denominated assets the SNB had

[10] More recently, Fuster, Schelling, and Towbin (2021) analyzed also a change in exemption computations in 2019. They confirm our findings that more adverse NIRP exposure leads banks to replace central bank reserves with other assets or to reduce the size of their balance sheets, as well as that absolute loan volumes fail to expand following rate cuts.

[11] Since June 2019, the SNB's monetary policy target has been specified for the Swiss Average Rate Overnight (SARON) instead of the CHF 3-month Libor, see https://www.snb.ch/en/mmr/reference/pre_20190613/source/pre_20190613.en.pdf

to acquire. These asset purchases lead to concerns that the SNB's balance sheet was becoming too large and would, at some point, cause losses that could hurt its reputation.

Against this background the SNB announced on 15 January 2015 that it would stop guaranteeing the minimum exchange rate from February onwards and, to prevent a sustained appreciation of the CHF, lowered the target for the 3-month CHF Libor to -75 basis points (bps). To avoid that banks could simply replace interbank assets with central bank reserves, it further announced that reserves would also be remunerated at -75 bps.[12] While this constituted the biggest rate cut into negative territory across all currency areas, the SNB limited the cost of its policy for banks by exposing only marginal reserves to negative interest.[13] Inframarginal exemptions were determined via a static and a dynamic component and were based on individual banks' MRRs for the period from 20 October to 19 November 2014. Until 2019 and therefore throughout our sample period, the static component was generally computed as 20 times each bank's MRR. Since MRR requirements are computed as 2.5% of relevant liabilities, which most importantly include deposits, each extra CHF of deposits increases the exemption by up to (CHF 2.5% * 20 =) CHF 0.5.[14] Deposits therefore carry a significantly lower negative rate burden than without an MRR-dependent exemption.[15] In addition to that static component, a dynamic component implied that exemptions would be reduced 1:1 for each CHF of additional cash holdings. The static component primarily limited the strain on the banking system whereas the dynamic component helped to steer the overnight rate away from the return on cash (Boutros and Witmer, 2020).[16] The initial amount of MRR-eligible assets across all banks was equal to CHF 322,699 million, compared to a sum of MRRs equal to CHF 14,604 million. Total MRR-eligible assets thus amounted to 22.1 times the aggregate MRR.[17,18,19] Over

[12] To operationally prepare banks for negative rates, it had announced negative rates of only -25 bps for the same end-of-January effectiveness date already in December 2014, but had still committed to keep the minimum exchange rate, which financial markets had believed. See https://www.snb.ch/en/mmr/reference/pre_20141218/source/pre_20141218.en.pdf

[13] www.snb.ch/en/mmr/reference/pre_20141218/source/pre_20141218.en.pdf

[14] Relevant liabilities include different types of customer deposits. Deposits without withdrawal restrictions are counted in full, while those that are cancellable within a notice period carry a 20% weight. The largest deposit category for most banks in our sample has no withdrawal restrictions, so that every additional CHF increases the MRR by CHF 1 * 2.5% = CHF 0.025 and the exemption from negative rates by CHF 0.025 * 20 = CHF 0.5. An additional CHF of a 20%-weighted deposit, instead, would increase the exemption by CHF 0.5 * 20% = CHF 0.1.

[15] Note that the original NIRP of the ECB, analyzed for example in Heider et al. (2019), did not feature any exemption, so that the negative rate burden of additional deposits was higher. Even when the ECB introduced tiered remuneration, exemptions per EUR of deposits increased by less than under the Swiss policy.

[16] This measure was particularly necessary in Switzerland, where the space required to hold any number of CHF 1,000 banknotes is smaller than the space required to hold the same value in any other currency, and given the availability of many safes.

[17] See https://data.snb.ch/

[18] For some banks, the fraction of liquid assets exposed is larger if we add net interbank loans, to which the rate cut was passed through directly, but for the system these cancel out. Estimates are robust to including net interbank assets.

[19] Some additional liquidity was held by foreign banks and non-banks also eligible for SNB accounts but without MRR. These institutions were granted fixed exemptions not based on MRR, but they do not change our results.

time, the policy reduced up to 90% of the entire system's *exposed reserves* (reserves that exceeded 20 times the aggregate MRR) and achieved full pass-through to the interbank market.[20]

Tiered remuneration of reserves, adopted by the ECB only in 2019, makes the Swiss NIRP interesting to study. First, it allows for an identification strategy that at the time would not have been possible for other currency areas. The initial fraction of individual banks' exposed reserves (reserves that exceed 20 times each bank's MRR, formally defined in Equation (1) in Section 3) is an attractive measure of treatment intensity as it varied widely across banks, was difficult to anticipate, and, because it relies on November 2014 values, could not easily be manipulated to influence the original affectedness by NIRP. Second, it allows to understand how the adverse consequences of negative rates can be moderated through tiered remuneration. We show, for instance, that a design with exemptions improves the pass-through to loan rates rather than reducing it, while at the same time reducing risk-taking. A challenge of the Swiss setting, instead, is the simultaneously announced end of the minimum exchange rate guarantee, which triggered a temporary but sharp appreciation of the domestic currency. In Section 5 we explain in detail how we ensure that our findings are not materially affected by this exchange rate movement.

2.2. Aggregate Developments

Figure 1 plots the 3-month CHF Libor, for which the central bank communicated its target, as well as rates for 5- and 10-year swaps which proxy refinancing costs for mortgages when interest rate risk is fully hedged. The figure shows that the 3-month CHF Libor went almost immediately to the central bank's new policy target of -75 bps and then remained there. Public data for the Swiss Average Rate Overnight (SARON) for collateralized interbank lending, as well as for short-term government or covered bonds, similarly show immediate pass-through. These data demonstrate that tiered remuneration did not impair the desired pass-through to interbank rates.[21] The figure also shows a clear dip for 5- and 10-year swap rates, which is mirrored in public data on the interest rates for CHF bonds issued by the Swiss Confederation or cantons. It further

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[20] The burden may have been reduced less for some foreign institutions also eligible for SNB accounts (https://www.snb.ch/de/mmr/reference/sicgiro_access/source/sicgiro_access.de.pdf) but not subject to MRR: https://www.snb.ch/de/mmr/reference/repo_mb28/source/repo_mb28.de.pdf. They received fixed exemptions of at least CHF 10 million. Further, after Nov. 2014, aggregate reserves kept increasing while exemptions were fixed until Sept. 2019, so Exposed Reserves increased.

[21] In fact, ***Appendix Figure AF1*** shows that the Euribor, the reference interbank rate of the Eurozone when the central bank introduced negative rates without tiered remuneration, took much longer to go negative.

illustrates how markets gradually reached the equilibrium view that rates would remain negative for a while.

In positive territory, deposit rates would typically drop following a cut in interbank rates, albeit possibly with a delay and only partially depending on banks' deposit market power (Drechsler et al., 2017). In negative territory, deposit rates tend to remain non-negative (e.g., Balloch et al., 2022) and ***Figure 2*** confirms that this applies to Swiss banks too. In combination with the negative SARON, non-negative deposit rates further imply a negative "liability margin" (the difference between rates earned on the interbank market and rates paid on deposits) which points to a potentially negative effect on profitability for deposit-dependent banks.[22] ***Figure 3*** shows the analogous margin for short-term mortgage lending and its components. We specifically plot average adjustable rates for Libor mortgages, which banks compute every three months as the 3-month Libor rate plus a spread specified in their mortgage contracts. Fortunately for the banks under analysis, their contracts for Libor mortgages typically already contained a clause preventing negative mortgage rates so that the corresponding margins actually *increased* when interbank rates went negative. Finally, ***Figure 4*** plots the margin, and its components, for 10-year fixed-rate mortgages, the most common loan tenor in the Swiss mortgage market during our sample period. Ten-year swap rates declined with the SNB announcement and, after a very brief recovery in the spring of 2015, continued to fall as interbank markets expected negative rates to last. Unchanged margins would thus have implied an analogous fall for fixed-rate mortgages, but the red, dash-dotted line shows an interrupted pass-through to mortgage rates. Average rates for 10-year fixed rate mortgages actually increased, suggesting that part of the drop in deposit margins was offset by wider mortgage margins.

Plots of aggregate data are suggestive but allow only for an intertemporal comparison, which could be distorted by other intertemporal changes, e.g., in the exchange rate. For our empirical analysis, we observe monthly rates for different products *at the bank level* and can therefore compare intertemporal changes across banks that are differently affected by NIRP. This allows us to conduct

[22] Over the following years, many banks gradually introduced exceptions to this rule for deposits exceeding large thresholds, often CHF 1 million, when they deemed that they could communicate it to those selected clients. With these partial exceptions a bank's average deposit margin may have been less negative than the 75 bps plus its deposit rate, but negative nonetheless. Possible variation in the extent to which banks could push through exceptions to their zero lower bound (ZLB) is something we cannot observe. But in the period studied this affects at best a small portion of overall deposits, inter alia because a limited number of deposit accounts contained volumes above CHF 1 million.

a Difference-in-Differences analysis and to tease out the effect of NIRP exposure on banks' rate-setting. Next, we explain our data and empirical strategy in more detail.

3. Data and Empirical Strategy

3.1. Data

Our panel comprises symmetric pre- and post-treatment periods, starting 18 months before and finishing 18 months after the introduction of negative rates in January 2015. We use monthly information on bank rates and balance sheet positions, semi-annual information from earnings reports, and quarterly information from risk and capitalization reports from the supervisory authority FINMA. We include both commercial banks and wealth management (WM) banks. Commercial banks are defined by FINMA as earning at least 55% of income through loan fees and net interest income on average over the last three years. WM banks are defined as earning at least 55% of income through advisory fees. Among the commercial banks, we include also the two big universal banks, UBS, and Credit Suisse (CS). They are significant players in wealth management, investment banking, and commercial banking. At the time covered by the study, the two big banks' domestic activities were not yet organized as separate entities, so we must use data on the entire banking groups including their investment banking entities.[23]

We drop a small number of trading banks as well as 18 foreign-owned banks, as the relationships with their owners may have exposed them to the simultaneous exchange rate shock. In addition, we cannot include individual cooperative banks, as they hold their reserves with their own clearing bank, which in turn has an account at the SNB. Overall, this selection leaves 52 commercial and 46 wealth management banks, providing a total of 98 banks on most variables, and fewer for mortgage rates which are reported only by the banks most active in mortgage lending. The resulting 98 banks cover close to 80% of the total assets (TA) of all Swiss banks when counting all currencies and counting foreign as well as domestic assets.

Table 1 provides pooled summary statistics***.*** ***Panel A*** shows key bank characteristics measured for our analyses in November 2014, the last month before the SNB announced its intention to introduce negative rates. ***Panels B–E*** show four sets of variables of interest on bank rates, balance

[23] Earlier regressions without the "Big Two" as well as earlier regressions focusing only on commercial banks yield essentially the same results.

sheets, income components, and risk-taking, respectively. The most important variable in ***Panel A*** is our baseline treatment measure, *Exposed Reserves* (ER), which we define for each bank *i* as the fraction of its total central bank reserves subject to negative interest:

$$ER_i = \frac{(Total\ Reserves_i - Exempted\ Reserves_i)}{Total\ Reserves_i} \qquad (1)$$

ER_i varies by bank but is for each bank measured only once just before the SNB's NIRP announcement. It is, by definition, bounded by one above for a hypothetical bank with no exempted reserves. ***Table 1*** shows that this upper bound is not binding in our sample, where the maximum value is 0.91. Its negative bound is defined by a bank that holds just enough reserves to satisfy its MRR, implying a theoretical treatment intensity of (MRR-20*MRR)/MRR or -19. De facto the minimum in our sample is -1.92. While close to half of the banks in our sample have a positive exposure, the mean is -0.34 due to a few extreme left outliers.[24] Further, the average bank in our sample was 72% funded with deposits, 47% of banks were focused on wealth management rather than commercial banking, about a third was headquartered in a canton (state) bordering the euro area, and, on average, 11% (but up to 60%) of TA were invested in loans as of November 2014. Further, those banks with mortgages faced an average Herfindahl-Hirschmann Index (HHI) of cantonal mortgage market concentration of 0.18, with a range between 0.1 and 0.35. ***Panel B*** shows that the combined deposit and mortgage margin[25] ranged between 14 and 191 bps points and averaged 89 bps. This was achieved with deposit rates of, on average, 23 bps, but -importantly for our analysis- never lower than zero. Rates on adjustable-rate mortgages averaged 119 bps; and rates on 10-year FRM averaged 215 bps. Of the latter, an average of 152 bps was accounted for by the spread, the remainder by the 10-year interest swap rate, i.e. by the refinancing cost when interest rate risk was fully hedged. ***Panel C*** reveals that the average bank held close to 19% of total assets as central bank reserves, about 11% as loans, and approximately 40% as mortgages. Slightly over 5% of banks' liquid assets were held in foreign currency, experiencing year-on-year growth

[24] When we scale Exposed Reserves by TA, an alternative treatment measure for which we report results in Table AT4 of our Online Appendix, the measure varies between -0.15 and (due to some wealth management banks with small balance sheets but much liquidity) 0.69, with an average of about 0.07. Notice that we report treatment measures in decimals, but outcome variables in Panels B-E in percentages. This is to allow an interpretation of our point estimates as the (ceteris paribus) difference in the change of the outcome variable, in percentage points, between a bank with no and a bank with full exemption.

[25] We compute deposit margins as interbank minus deposit rates, mortgage margins as mortgage minus maturity-congruent interest swap rates.

of total assets between -32% and +40% and on average +3.6%. On the liability side, the average sample bank was 71% funded by deposits, indicating stability of the deposit ratio relative to its November 2014 value, and close to 8% of funding was obtained by issuing bonds. Focusing mostly on TA-scaled variables in our analyses of balance sheet adjustments below has the advantage of better reflecting riskiness than raw volumes of different assets or liabilities. It also allows us to more easily compare banks of different sizes. In ***Panel D***, we see that net interest income amounted to on average 0.79% of total assets, ranging between -0.48% in the worst and +2.06% in the best case. This was achieved by the average bank by earning interest of 1.12% of total assets and paying interest of about 0.33% of total assets. Finally, all fee income scaled by total assets amounted to 0.14% on average. Last, ***Panel E*** looks at regulatory risk-taking measures. It shows that the average bank had an average risk-weight of slightly over 35%. This corresponds to the risk-weight assigned to mortgages with loan-to-value ratios of up to two-thirds in the Swiss standardized approach (see Basten, 2020). It goes as low as 2.34% for some wealth management banks with a significant part of their assets held as central bank reserves, and as high as 121.14% for banks with significant off-balance sheet activities. The average bank in our sample would have lost about 6% of its equity following a 100-basis-point increase of all interest rates, although a few banks would even have benefited. FX mismatch, defined as the difference between the foreign-currency share of assets and that of liabilities, amounted to 0.27% of TA at the average bank in our sample but went as high as 11.69% at some wealth management banks. Finally, the average bank in our sample had an unweighted Common Equity Tier 1 capital ratio of about 8% and a risk-weighted one of close to 20%, with the highest values typically accounted for by wealth management banks.

To conclude our data description, we acknowledge that we do not have access to loan level data which would allow for within-borrower analyses when borrowers receive funding from multiple lenders. Since most households borrow from only one bank, however, the advantage of matched loan-level information would anyways accrue primarily to the analysis of corporate loans, which -unlike mortgages- are not the dominating asset class for the banks in our sample. At the same time, our data covers all relevant types of banks and their entire balance sheets and risk reports. The latter feature, in particular, allows us to understand to what extent evidence of risk-taking generalizes beyond specific asset classes and thus to assess the size of the threats that NIRP can pose to financial stability. For credit risk, we use as summary measure risk-weighted over total assets. Here it is important to note that, with the exception of the Big Two (who do not materially affect our results), all banks in our sample operate under the Swiss version of the Basel Standardized Approach. Therein, risk-weights of different assets are tied to the type of asset but do neither significantly vary across time, nor can they be computed by banks themselves through internal ratings-based approaches. Furthermore, we acknowledge that banks can of course increase risk-taking even within each risk-weight category, so that any risk-taking triggered by NIRP may be even larger than those reflected in our estimates.

Finally, part of the increases in average risk-weights come about because banks reduce their TA. Importantly, this does not make the risk increases "automatic" or misleading. It simply implies that banks choose to reduce TA by over-proportionally reducing safer assets. The result is still higher credit risk relative to banks' size. Next, we explain our empirical strategy.

3.2. Empirical Strategy

Our basic identification strategy is a DiD analysis, comparing changes in our outcomes of interest from before to after the start of the Swiss NIRP, across banks that are differentially affected by negative interest on their central bank reserves. In our baseline specification, we measure exposure to NIRP through the fraction of central bank reserves on which banks actually have to pay negative rates as defined in Equation (1) above. Each coefficient on the interaction of a Post dummy, equal to one from January 2015 and equal to zero before, and that fraction can then be interpreted as the effect of NIRP on a hypothetical bank for which all central bank reserves are subject to negative interest, relative to a (hypothetical) bank that would be fully exempted. With a sample standard deviation of 0.93 for ER (see ***Table 1***), the coefficient on the interaction term can also be read approximately as the effect of increasing ER by one SD.

We measure treatment intensity in November 2014, the last point before the SNB first announced its intention to introduce negative rates and the reference date based on which the SNB determined individual banks' exemptions.[26] Baseline regressions control for both bank fixed effects and time

[26] Measuring exposure as the fraction of *average* exposed reserves over the 18 months of our pre-treatment period yields similar results.

fixed effects so that treatment intensity and the Post dummy are redundant.[27] In robustness tests, we also analyze whether the effect of interest differs for banks with greater foreign currency (FX) exposure by studying the triple interaction of the Post dummy, our measure of treatment intensity, and a measure of FX exposure. Following these considerations, our benchmark model estimates for bank *i* and month (or semester for profit, and quarter for risk) *t*:

$$Y_{i,t} = \alpha + \beta(ER_i \cdot Post_t) + \mu_i + \tau_t + \varepsilon_{i,t} \tag{2}$$

Here ER_i measures the treatment intensity (exposed over total reserves) recorded for each bank in November 2014. $Post_t$ takes value zero from July 2013 until December 2014, and value one from January 2015 until June 2016; μ_i are bank fixed effects and τ_t are time fixed effects. Following Bertrand, Duflo, and Mullainathan (2004), we cluster standard errors by the cross-sectional variable bank.

The validity of identification through DiD methodology hinges on parallel counterfactual trends, the plausibility of which for binary treatment intensity is typically assessed by comparing pre-trends between treated and untreated units. In our case of a continuous treatment, an approach closer to our actual estimations is to estimate a dynamic DiD model, i.e. to interact our measure of treatment intensity with a separate dummy for each period rather than with a single "Post" dummy:

$$Y_{i,t} = \alpha' + \beta'_t \cdot (ER_i \times \tau_t) + \mu_i + \tau_t + e_{i,t}. \tag{3}$$

We estimate model (3) for all balance sheet outcomes, which we observe at monthly frequency and where pre-trends can hence be observed in sufficient granularity to test for effects at placebo dates with sufficient statistical power. In particular, we use the first month of our sample, July 2013, as baseline and then estimate coefficients on the interactions of treatment intensity with dummies for each of the 35 subsequent months. In Section 4.5 we discuss the corresponding

[27] Given the bank fixed effects, our baseline estimates do not include further bank level controls such as total assets, its composition, or capitalization. Including those makes little difference as they capture only within-bank variation. At the same time, since we document that NIRP actually affects most such candidate controls, including them would introduce endogeneity concerns. Considering that the parallel trends assumptions appear plausible, even without additional bank controls, we therefore prefer the more parsimonious empirical setup.

monthly effects which can serve as a test of our parallel trends assumption, but also provide a sense of the evolution of the treatment effects over time.[28,29]

4. Results

In this section, we first present our results on how banks adjust their mortgage rates and balance sheets in response to NIRP (***Table 2***). We then document the implications for profitability and risk-taking (***Table 3***), before discussing how key effects differ from those of an earlier rate cut within positive territory (***Table 4***) and implications for system-wide financial stability.

4.1. Banks' Pass-Through and Balance Sheet Responses to NIRP

Table 2 shows the results of estimating Equation (2), with a focus on banks' mortgage rate and balance sheet responses. Column 1 shows the effect of NIRP exposure on the rates of banks' most common loan category, 10-year fixed rate mortgages. We find a one standard deviation increase in the fraction of ER (0.93 according to ***Table 1***) to raise mortgage rates by (3 bps * 0.93 =) 2.79 bps.[30] The result is found after bank fixed effects control for unobserved bank-specific factors and year*month fixed effects control for unobserved inter-temporal changes (including changes in the term premium of refinancing costs). Our results suggest that the lack of pass-through to mortgage rates in the aggregate (Section 2) is indeed a consequence of NIRP and driven by banks with larger exposure to negative interest on their central bank reserves. Our evidence therefore implies that the pass-through from policy to mortgage rates in negative territory is fundamentally different from the pass-through under positive rates, where we would expect decreasing mortgage rates. It also appears to be different from existing evidence on corporate loan rates under NIRP, which we do not observe, but which have been shown to decrease in Italy (Bottero et al., 2022) and Switzerland (Schelling and Towbin, 2022). It is consistent, however, with the few existing papers that provide evidence on mortgage rates under NIRP for Italy (Amzallag et al., 2019) and Sweden

[28] We acknowledge that more formal tests of parallel pre-trends exist and have performed tests for negative weights, following Chaisemartin and D'Haultfoeuille (2020), in previous working paper versions. Given that we do not observe "untreated" banks, however, and need to define them somewhat arbitrarily for treatment values around zero, we no longer report these tests and acknowledge that we may not be able to fully rule out diverging pre-trends. Yet, especially the dynamic DiD estimates we discuss in Section 4.5 give us confidence in the causal interpretation of our estimates.

[29] Although we operate with a continuous treatment variable, Table AT8 provides summary statistics for artificial binary treatment groups with above- and below-median treatment. It shows that wealth management banks were on average more adversely treated than commercial banks. Our main results also hold, however, if we conduct our analyses separately for commercial and wealth management banks.

[30] Notice that our dependent variable are mortgage *rates*, but that we can interpret the outcomes as mortgage *spreads*, since our time fixed effects control for refinancing costs.

(Eggertsson et al., forthc.). The literature thus suggests that the pass-through to lending rates under NIRP can indeed work differently for mortgage and corporate loan rates.

In related work on Switzerland, Schelling and Towbin (2022) further report a negative effect on mortgage rates when they measure exposure to NIRP via the deposit ratio, but -like us- a positive effect when they measure it via ER. We make a similar observation for the average bank, but additional analysis suggests that the negative effect is driven by low-market power banks and -independent of the treatment measure- turns positive for banks with higher market power. Because the deposit ratio also affects the exemption from negative reserve rates (see Section 2.1), however, we believe that ER are a less noisy measure of NIRP exposure in Switzerland. We nonetheless view the results based on the two different treatment measures as complementary and as an indication that ER and the deposit ratio may not capture entirely identical dimensions of NIRP exposure. Next, we thus discuss the driving forces behind the effect on mortgage rates, and specifically explore the role of market power in the mortgage market.

Column 2 tests whether banks with more market power increase their lending spreads more. Analyzing the role of market power in the context of mortgage rates is particularly interesting since banks are typically not pure price takers on this market and -to some extent- steer volumes via prices. This is similar on the deposit market, for which we have already established (in Section 2) that banks did not break through the zero lower bound (ZLB), independent of market power, but different for central bank reserves or bond financing, where banks typically take prices as given and primarily choose volumes. To measure market power on the mortgage market, we first compute the Herfindahl-Hirschmann Index (HHI) as the sum of squared mortgage market shares in November 2014 (i.e., before treatment) separately for each of the 26 cantons, which can be considered as largely separate markets (e.g., Basten and Ongena, 2020) . Then we map the HHI to each bank based on how its existing mortgage portfolio is distributed across cantons. We find that a hypothetical bank facing perfect competition on all markets (HHI = 0), would have lowered its 10-year FRM rate by 9 bps. In practice, the weighted average HHI faced by the banks in our sample ranges from about 10% to 35%, implying that banks facing most competition lowered their FRM rates by (9 - 10%*42 =) 4.8 bps, while banks with the most market power raised their rates by (-9 + 35%*42 =) 5.7 bps, after controlling for bank and time fixed effects. Our results therefore suggest that there is pass-through to mortgage rates by banks in particularly competitive markets, but that pass-through to bank rates is interrupted under NIRP for banks with market power.[31] We see this pass-through interruption as a second key difference in comparison with the pass-through to bank-based rates under positive interest rate policies (PIRPs).

To explore further through which channels NIRP affects banks, we proceed next to analyzing the effects on the balance sheet.[32] Throughout, we scale volumes by total assets to make effects comparable across differently-sized banks. To meaningfully discuss the resulting effects, we thus need to first determine to which extent NIRP has affected the overall size of banks' balance sheets, which we do in column 3. We find that a one standard deviation increase in ER reduces total assets by about 3%, implying that any ratio scaled by TA would grow by roughly 3% *even if the nominator remained constant*. When we then see, in column 4, that the ratio of central bank reserves over total assets is reduced by about (5.62 * 0.93 =) 5.23 percentage points (pp) for each standard deviation increase in ER, we need to take into account that this underestimates the effect on total reserves by almost 0.6 pp for the average bank (the sample average of Reserves/TA is 18.75%, which would grow by almost 0.6 pp due to the 3% drop in TA alone).

Next, we examine the extent to which reserves have been replaced with loans and mortgages. For the average bank the respective shares of these asset categories over total assets amount to 11% and 40%, so that we would expect the 3% drop in TA for each SD increase in treatment exposure to increase the corresponding ratio by 0.33 pp and 1.2 pp. When we actually find an increase of 1.42 pp for loans, this therefore means that corporate lending has in fact been expanded actively, which is in line with more adversely NIRP affected banks cutting the rates of their non-mortgage loans more strongly (Schelling and Towbin, 2022). An effect of 0.93 pp for mortgages by contrast implies no expansionary and potentially even a slightly contractionary effect on mortgage volumes, in line with our evidence on the interrupted pass-through to mortgage rates. Importantly, this does not change the fact that higher NIRP exposure implies portfolio rebalancing from reserves to mortgages, which should ceteris paribus increase credit risk. It does mean, however,

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[31] In the Online Appendix, we also report results for a specification that uses the deposit ratio as treatment measure. While most results are comparable, we find a negative effect for mortgage rates for the average bank. While this suggests that the treatment-measure-dependent change in the sign in Schelling and Towbin (2022) is not accidental and may reflect differences in the exposure to NIRP that is captured by ER and Dep/TA, further investigation reveals the interaction term with mortgage market power is -like in Table 2- positive (albeit insignificant).

[32] Table 2 shows that more banks report balance sheet outcomes than mortgage rates. This is, because mortgage rates are only reported by those banks most active in mortgage lending. We rely on the larger sample, whenever possible, but Table AT7 in the Online Appendix corroborates that balance sheet results hold for all business models.

that, due to the interrupted pass-through from policy to mortgage rates, the policy rate cut has failed to expand mortgage lending.

Last, we discuss the quantitatively most relevant liability categories in our sample. Most importantly, we find no statistically significant evidence that more adversely treated banks reduce deposit funding. This may appear surprising, seeing that non-negative deposit rates turn deposits into a relatively more expensive funding source. Then again, the finding is consistent with the consensus in the NIRP literature that banks keep interest rates non-negative precisely because they want to retain depositors. Using granular data from Norway, Basten and Juelsrud (forthc.), indeed show that depositors are more likely to borrow from the bank at which they have their deposits. If deposits are not reduced, however, while total assets and liabilities are, then some other liability category must be cut. Our regressions show this to primarily be bonds, including covered bonds. Since bonds could be issued at negative rates during our sample period, increasing the fraction of bond financing while maintaining a relatively higher deposit ratio, means that more adversely affected banks increase their average funding costs relative to less adversely affected ones. Because of a positive correlation between mortgage and deposit franchise, this seems to be a price banks are willing to pay for maintaining their depositors.

4.2. Profit and Risk-Taking Implications

In ***Table 3*** we analyze the implications of interrupted pass-through and balance sheet adjustments for banks' profits and risk-taking. Column 1 shows that a more adverse policy exposure is not associated with a fall in net interest income. We even find that net interest income scaled by TA increases by about 0.03% for a one standard deviation increase in ER, although this is primarily driven by the decreasing denominator.[33] Nonetheless, columns 2 and 3 further document that interest earned increases by at least as much as interest paid, which reflects how banks actively offset the cost of negative rates on their central bank reserves with higher mortgage spreads. Column 4 adds that banks may also have managed to increase their fee income although the effect is not significant when we do not simultaneously control for exposure to the exchange rate

[33] The pooled sample average NII/TA is 0.79 (Table 1). The drop in TA following a SD increase in the fraction of exposed reserved would thus already account for an increase of about 2 bps in NII/TA for the average bank.

movement.[34] With a view to the significant effects we estimate with FX exposure controls, it is worth considering that banks were possibly less concerned about permanently losing customers by increasing fees for selected services than by setting negative deposit rates, as the latter are arguably more salient. But importantly, the raising of fee income is fundamentally different from a pass-through of negative policy to deposit rates. For, in contrast to deposit rates, fees typically are not proportional to the deposit amounts clients hold with a bank. Either way, our main conclusion with respect to bank profitability is that banks by and large managed to preserve it, despite a binding zero lower bound on deposit rates.

The evidence on interest rates, market power, and profitability jointly point towards "reaching for yield" (Balloch et al., 2022) as an important bank-based transmission channel for NIRP in Switzerland. Deposit margins are squeezed due to the zero lower bound, and banks respond with widening mortgage margins, likely enabled by increasing demand and market power. That lending rates increase more among more adversely affected banks further suggests that the "opportunity cost of lending" channel is less dominant as it would require falling lending rates. Considering that all banks in our sample were generally well-capitalized and healthy, and that NIRP was introduced for reasons largely exogenous to the Swiss economy, it is also unlikely that the "risk bearing" and "balance sheet constraint" channels played important roles. The "funding rate channel" could in principle be responsible for an interrupted pass-through to lending rates but would require that more adversely affected banks' funding cost is determined more strongly by the deposit rate than that of less adversely affected banks. Finally, the "deposit channel" may also contribute to our findings, since the ZLB on deposit rates means that deposits become even more attractive to depositors than in positive rate environments.

If the reaching for yield channel is indeed dominant, this raises the question whether NIRP exposure incentivizes banks to take additional risks to preserve their profitability. The most important outcome to examine in this context is banks' risk-weight density, i.e., the ratio of risk-weighted over total assets. Risk-weighted assets are explicitly designed by lawmakers and the

[34] In particular for wealth management banks, an alternative to scaling fee income by total assets would be to scale by business volume, i.e., to add assets under management. Sign and significance of the effect on that outcome are the same, so we display fee income scaled by total assets to facilitate the comparison with the other columns. In the appendix, we show that Fee Income/TA significantly increases by about 2% of TA when we control for exchange rate exposure. The pooled sample average Fee Income/TA is 0.14%, so that the drop in TA, due to a SD increase in the fraction of exposed reserves would account for an increase in Fee Income/TA of only 0.4 bps.

Basel Committee on Banking Supervision (BCBS) to capture bank risk, so that the risk-weight density provides a strong proxy for the average riskiness of banks' assets.[35] Column 5 shows that a one standard deviation (SD) increase in the fraction of ER increases the average bank's risk-weight density by around 1.7 pp (= 1.81 pp * 0.93) or around 5% of the sample average. This increase reflects mostly increases in credit risk, resulting from the balance sheet restructuring described above and the mortgage spread expansion discussed in Section 4.1. To start with, safe and zero risk-weight central bank reserves are replaced with riskier mortgages, loans, and other assets carrying higher risk-weights.[36] In addition, higher mortgage spreads likely reflect the issuance of riskier mortgages with higher LTV ratios, either because banks actively pursue riskier borrower profiles to earn more interest or because higher market-power-enabled mortgage rates make borrowing riskier for given borrower profiles.

Relying on a regulatory measure for interest rate risk, column 6 further shows that a SD increase in ER also corresponds to an increase in predicted losses during an interest rate stress scenario by about 0.38% (= 0.41% * 0.93) of average bank equity.[37] This is consistent with the simultaneous increase in the average maturity of assets and decrease in the average maturity of liabilities.[38] Some banks undoubtedly hedge this increase in interest rate risk through swaps, but will then have to incur the corresponding cost. Others, particularly smaller banks, report never to use swaps in their supervisory filings.

Given the context of the Swiss NIRP, we are also interested in foreign currency mismatch as a measure of each bank's exchange rate risk. An increase in the foreign-currency share of bank assets may be considered part of the intended channel for negative rates to affect the exchange rate but if the foreign-currency share of liabilities does not increase in tandem, the bank will ceteris paribus

[35] They are also the basis for the BCBS "Pillar I" bank capital requirements, see, e.g., FINMA (2016).

[36] In unreported regressions, we find that safe reserves were also replaced, to a smaller extent, with financial assets, thus increasing banks' market risk.

[37] To compute each bank's interest rate risk, supervisors require banks to report the amounts of different types of assets and liabilities falling into different maturity bands at quarterly frequency. Then numbers are then used to estimate the losses the bank would make if interest rates in the interbank market suddenly increased by 100 bps, scaled by the bank's available equity. For deposit liabilities, effective maturities are often thought to be longer than contractual maturities, as not all depositors would immediately re-optimize their deposit volume held at a specific bank in response to better rates elsewhere. For this reason, FINMA computes its interest rate risk measure in three ways: First following each bank's own assumptions on effective maturities, second with the average (bank-invariant) assumption per quarter, and third with an assumption fixed across both banks and periods. Here, we focus on the average assumption, as common intertemporal changes are absorbed by our date fixed effects. Furthermore, we are interested in tracing out whether more adversely affected banks experienced an increase in their true maturity mismatch, undisturbed by possible differential changes in their assumptions.

[38] In line with this strategy and our results that banks reduce total assets but retain depositors, Demiralp, Eisenschmidt, and Vlassopoulos (2021) find more affected banks to reduce wholesale funding.

(i.e., without more costly hedging,) become more exposed to future exchange rate changes. Column 7 indeed finds a statistically significant increase in this mismatch worth about seven percent of total assets for each SD increase in ER.

The effect on all three risks should matter to bank owners but need not matter to other stakeholders if it is accompanied by increases in bank equity. Column 8 of ***Table 3*** suggests that the reduced bond financing (Section 4.1) indeed implies a deleveraging, but that banks do not actually increase their equity capital. CET1 increases by about 0.23% of TA for every SD increase in ER, which is essentially accounted for by the drop in TA for the average bank. To meaningfully discuss the effect on banks' capital buffer, however, we should account for the increase in asset risk. Scaling CET1 by risk-weighted assets in column 9, we then actually observe that the seemingly better capitalization does not compensate for the riskier portfolio and that CET1 decreases by about 0.66% of risk-weighted assets or about 3.2% of the sample mean, for every SD of additional exposure to NIRP. Therefore, we conclude that banks ultimately became riskier.

4.3. Negative vs. Positive Interest Rate Policy

Having established that the pass-through to deposit and lending rates under NIRP is different from what we would expect under Positive Interest Rate Policy (PIRP) and having shown that banks' balance sheets become smaller but riskier in response to NIRP, we compare in ***Table 4*** explicitly differences with a rate cut in positive territory. We specifically compare the effects of the 2015 cut of policy rates into negative territory to those of a 2011 cut of policy rates (by 25 bps) within positive territory. As central bank reserves were still unremunerated in 2011 and to make results for the two episodes as comparable as possible, we measure treatment intensity in 2011 (Panel A) and in 2015 (Panel B) as the net interbank position over TA in the month before the policy announcement. The net interbank position has been used to identify the effect of NIRP in the literature in settings without bank-specific exemptions (e.g., Bottero et al., 2022) and we therefore expect Panel B to show qualitatively similar results to our benchmark specification. Instead, we cannot directly compare magnitudes so that Panel B primarily serves to verify the alternative treatment variable that allows us to estimate a comparable model for the cut in positive territory. To further improve comparability, we include in the sample for 2011 only those banks also present in our 2015 baseline sample.

To start with, we notice that results on the negative rate episode indeed correspond qualitatively to those relying on our preferred treatment measure in the main analysis. This allows us to meaningfully discuss the differences with the 2011 cut in positive territory for which the exposed reserve measure would not have been available. The first noteworthy difference is that policy rates are passed through to mortgage rates after the 2011 rate cut (albeit not statistically significant in this sample and specification). This supports the interpretation that the negative deposit margins forced banks to increase mortgage margins under NIRP. Second, while central bank reserves became relatively more attractive after the cut in positive territory, they became less attractive under NIRP (column 2). Relatedly, while bank balance sheets expanded in positive territory, they contracted following the 2015-cut below zero (column 5). Third, columns 7 and 8 confirm that profit-preserving balance sheet adjustments increased both credit and interest rate risk under NIRP, while interest rate risk had not changed significantly, and credit risk had decreased following the replacement of some net interbank loans with central bank reserves after the 2011-cut in positive territory.

4.4. Distribution of Effects

Our analysis to this point compared inter-temporal changes in outcomes of interest between banks that were relatively more adversely affected by negative rates and banks that were relatively less adversely affected. We showed first that more adversely affected banks interrupt their rate cut pass-through more, and second that they increased their risk-taking more. Some banks, however, had "beneficial exposure", in the sense that they had spare capacity and could place additional reserves at the central bank without being charged negative rates by the SNB. Such banks may have found it attractive, for example, to *grow* their balance sheet under NIRP by borrowing more (at negative wholesale funding rates) and lending to the central bank. This raises the question whether the *aggregate* effect of negative rates is hence more or less pass-through interruption, and more or less risk to financial stability.

The answers cannot be obtained by simply adding up positive and negative changes across all banks. Instead, they depend also on their distribution across different types of banks.

To provide some insight on aggregate effects, we predict mortgage spreads and risk-taking for the last pre- and the last post-treatment month[39] for each bank. Then we compute for each bank the difference and analyze how it relates to cross-sectional characteristics before treatment. If spread increases occurred predominantly at banks with small market shares, they might not have gone up for the average borrower. To investigate, ***Figure 5*** plots predicted increases in the spread on 10-year (left panel) and 5-year (right panel) Fixed Rate Mortgages (FRM) against national mortgage market shares in December 2014. We plot average spread changes for equally-sized (in terms of the number of banks) bins of mortgage market shares rather than for each single share to avoid revealing the behavior of individual banks. The key result is that pass-through was if anything interrupted more by banks with larger market shares. An important implication of this observation is that the spreads to be paid increased not only for the borrowers of more adversely affected banks, but also for the *average* mortgage borrower in the market. In particular, the market-share-weighted average change in FRM10 is 67 bps, which is indeed close to the 75 bps by which policy and interbank rates were cut and by which deposit margins would have been squeezed for banks starting with deposit rates of exactly zero.

In the six panels of ***Appendix Figure AF2***, we conduct the same cross-sectional inspection for the three measures of changes in respectively credit risk, interest rate risk, and exchange rate risk. We find risk-taking to increase in market shares, with the effect being driven by the largest banks, and to increase more for less well capitalized banks.

Figure 6 combines both analyses by plotting risk-taking changes against capitalization, and weighting both dot sizes and linear fits by total asset shares in December 2014. In particular, the three panels show that for each percentage point for which prior risk-weighted capitalization was lower the risk-weight density measure of credit risk increases by an extra 0.14 pp. Relatedly, interest rate risk (losses due to a 100 bps interest rate increase in percent of capital) increases by an extra 0.04 pp. And the foreign-currency share of liquid assets increases by an extra 11 pp. This suggests that risk increases happen not only at banks that are small or sufficiently well capitalized to bear losses anyway. Hence, we argue that the risk increases caused by negative rates are also

[39] So we compare spreads and risk in June 2016 with that in December 2014. This is to account also for any rate pass-through occurring only in the later months of the post-treatment period. Comparing the *average* post- to the *average* pre-treatment period yields similar results.

relevant for financial stability. At the same time, they appear moderated by the tiered remuneration, which significantly reduced the more adverse exposure and instead generated also more beneficial exposure for other banks, who hence reduced their risk-taking.

Finally, while all three risk increases are positively associated with size and negatively with capitalization for commercial banks, whose lending and payment systems would seem most relevant for financial stability, ***Appendix Figure AF3*** shows the opposite relationship for wealth management banks at least for credit risk and interest rate risk, albeit not for exchange rate risk. To put this into context, note that wealth management banks typically manage client money assets off their own balance sheet so that their average risk-weight amounts to merely 24%, compared to 46% at commercial banks. By contrast, given the international background of most their clients the foreign-currency share of their liquid assets amounts to on average 7%, compared to merely 3.8% at the average commercial bank. Relatedly total assets of the average wealth management bank are only about two-thirds as high as those of the average commercial bank. For these reasons we deem commercial banks more relevant for the first two risks and for financial stability but nonetheless note the difference.[40]

4.5 Dynamic Treatment Effects

Next, we discuss the dynamic DiD estimates from model (3). We plot the monthly coefficients for the two key outcome variables, reserves and mortgages, for all sample banks (***Figure 7***), and for the subsamples of commercial (***Appendix Figure AF4***) and wealth management banks (***Appendix Figure AF5***) only. ***Figure 7*** shows that neither balance sheet component shows a significant effect for any of the 17 pre-treatment dates. Afterwards, by contrast, effects are significant, which supports our parallel trends assumption. In addition, it is interesting to see how the reduction of the TA fraction invested at the central bank is reduced only gradually as suitable alternative assets like loans and mortgages must be identified over time. ***Appendix Figures AF4*** and ***AF5*** document

[40] To prevent misunderstandings, we note that the cross-sectional differences we emphasize here do not invalidate our DiD design, which does not assume differentially treated units to be identical cross-sectionally. Instead, it assumes parallel trends absent treatment, which we validate by reporting dynamic treatment effects in Section 4.5 below. Cross-sectional differences in bank size or capitalization would be problematic if they were associated with different time trends in the outcomes of interest also absent our treatment of interest. But interactions of neither characteristic with the 17 prior placebo treatment dates suggests differential time trends.

that these adjustments are clearer for commercial banks, while we obtain wider standard errors for the more diverse subsample of WM banks.

In addition, the four panels of ***Appendix Figure AF6*** plot monthly coefficients also for the effects on respectively net interbank assets over total assets, loans over total assets, TA growth, and deposits over total assets. All four panels focus on commercial banks. This is, because for commercial banks loan growth and their own balance sheet can generally be considered more active choices, compared to wealth management banks that may lend to a client predominantly because they also manage that client's wealth. In all four panels, coefficients in the Pre period are not significantly different from zero while those in the Post period are. This further supports the parallel trends assumption underlying our design.

5. Robustness

5.1 Accounting for Exchange Rate Changes

Given our use of bank and time fixed effects, our estimates should be biased only by factors that vary across banks and over time, *and* that are correlated with our treatment. The most important candidate factor for this is bank-specific exposure to the exchange rate shock, which would cause our estimates to be biased if it was correlated with exposure to NIRP. This may be the case for several reasons: Unhedged exchange rate risk, for instance, may impair profitability and thus cause a similar response as exposure to negative rates. At the same time, banks focusing more on wealth management and less on commercial banking tend to both have more foreign clients and hold larger proportions of their assets invested in safe assets, including in reserves. They may thus be simultaneously exposed to both shocks. In addition, there is also evidence that the CHF appreciation hurt domestic firms' competitiveness (Auer, Burstein, and Lein, 2021) and that the stock prices of listed Swiss firms responded to the exchange rate shock (Efing et al., 2015), which could increase the credit risk for banks' lending to these firms.

These concerns are partly moderated by the fact that the effects on Swiss borrowers were relatively short-lived and had no material impact on GDP growth or unemployment.[41] Furthermore, it is not evident that exposure to firms that became temporarily riskier due to the exchange rate shock should be correlated with banks' exposure to negative reserve rates.

Yet, these considerations may not eliminate all concerns and we therefore consider the potential bias from FX exposure in several ways. We first note that our results are qualitatively unchanged in the subsample of commercial banks, which -unlike wealth management banks- have only an insignificant fraction of their income, costs, assets, and liabilities denominated in foreign currency. Next, ***Appendix Table AT1*** repeats our benchmark analysis while adding a bank- and time-varying control for exposure to the exchange rate movement. We specifically include $FX\ Exp_{it}$ as well as its interactions with all our variables of interest to the model, where $FX\ Exp_{it}$ is equal to the product of the difference between the foreign currency shares of assets and liabilities in November of 2014 and the monthly exchange rate between the CHF and the euro. Panel A reports the corresponding results on pass-through and balance sheet adjustments, Panel B those on profitability and risk-taking. We see, on the one hand, that exposure to the exchange rate shock affects bank behavior, as one would expect, but more importantly, that our benchmark results are not driven by these exchange rate-related choices. In addition, ***Appendix Table AT2*** repeats our main analysis but adds interactions of our effect of interest and the Post dummy with a dummy for whether the bank is headquartered in a canton bordering the euro area. Given that most banks in our sample focus their business on one or two cantons only, this accounts for the possibility that corporate borrowers of banks in border cantons face relatively more competition from foreign firms. Especially columns 7 and 8 on risk-taking, however, do not show border-canton banks to experience significantly different increases in risk-taking than banks that are headquartered further from the border. In ***Appendix Table AT3***, we interact our variables of interest with banks' loan intensity, which we define as loans over TA measured in November 2014. The idea behind this is that a bank that is more engaged in corporate lending may expect a larger increase in its credit risk exposure

[41] ***Appendix Figure AF7*** shows that the drop in GDP growth in 2015 was smaller than a drop in 2012, and much smaller than the slowdown associated with the financial crisis in 2009. This in in part because even relatively export-dependent firms in Switzerland often produce niche products that face a lower price elasticity of demand than less specific exports. ***Figure AF8*** shows that the moderate GDP slowdown did also not significantly affect the unemployment rate. This moderate employment effect is likely due to an increase in the use of "short-time work" or "furlough". Under this scheme, employees temporarily reduced the number of hours worked, but retained their jobs and did not experience significant salary cuts (salaries for the hours not worked were paid by the government).

– due to stronger foreign competition – than one focused more on other businesses. We find that, although initially more loan-focused banks become even more loan- (and mortgage-) focused, they also reduce their reserves and therefore their TA less. As a result, they actually see their credit and interest rate risk indicators increase less (columns 7 and 8).

Beyond these checks, it is worth considering which biases, if any, expected increases in credit risk would have on our estimates of interest, if none of our robustness checks fully accounts for the effects of the exchange rate shock. We think it is plausible to expect a bank anticipating an increase in its credit risk for exchange rate reasons to moderate its risk-taking in other dimensions. Yet, our benchmark results suggest an increase in average risk-weights that does not capture exchange-rate-related risk (risk-weights under the Swiss Standardized Approach to capital requirements depend on the type of loan and counterparty but do not vary with the exchange rate). If exposure to negative rates is indeed correlated with exposure to the exchange rate, and if the anticipation of heightened credit risk from increased foreign competition indeed motivates banks to moderate other risk-taking, our findings on average risk-weight increases therefore provide lower bounds for the effects of introducing negative rates under stable exchange rates. Similarly, if the exchange rate shock had an effect on credit demand, we would expect this demand to be lower for firms anticipating more foreign competition. This too would reduce the observed positive effects on loans over TA.

5.2 Controlling for Mortgage Demand

Mortgage lending constitutes the largest asset category on the balance sheets of most banks in our sample and one of our main results is the interrupted pass-through to mortgage rates. Yet, given that our analysis relies on bank-level data, one could wonder whether mortgage lending might vary not only because of changes in bank behavior but also due to changes in borrower behavior. In this case, the effects we observe would still be caused by negative rates but may not necessarily be driven by bank behavior. More specifically, it is conceivable that by reducing the returns on assets like bonds and by reducing at least some mortgage rates, negative rates motivate households to invest more in real estate and so increase mortgage demand. As an additional robustness check, we therefore control for mortgage demand using internet search data. Varian (2014) and references therein have shown that Google search behavior can predict concurrent economic behavior in the housing market, while Siliverstovs and Wochner (2018) provide evidence that Google searches have explanatory power specifically in Switzerland. ***Figure AF9*** in the Online Appendix plots aggregate Google searches for mortgages over time and indeed show a spike in January 2015, the month of the negative rate start.

Although it is not obvious how an increase in demand would be correlated with our treatment, we address potential concerns about such a correlation by constructing a bank- and time-varying control for mortgage demand based on Google searches and adding it to our benchmark specification. We start from search statistics for each canton and week from the Google Trends website, aggregate the data per month to match the frequency of our balance sheet information and scale it by the maximum value across all weeks for each canton.[42] To obtain a measure of the mortgage demand facing each specific bank, we then compute the weighted average across all 26 cantons for each month and bank, with weights given by the allocation of the bank's November 2014 mortgage portfolio to the 26 cantons. This weighting is motivated by the idea that increases in mortgage demand in a specific canton will benefit a bank in proportion to its presence in that canton. Local banks will typically have more branches and staff, better name recognition, and more local expertise. The resulting measure varies across months and banks. To ensure that our main effect of interest can be interpreted as the effect for a bank facing average mortgage demand, rather than a bank implausibly facing zero mortgage demand, we further standardize the variable by subtracting its sample mean and dividing by its sample standard deviation. We then add our mortgage demand control to our benchmark specification and interact it with our treatment effect.

The results in ***Appendix Table AT4*** show that our main findings, including especially the mortgage rate increases and the increases in the mortgage intensity of TA, remain robust to controlling for demand in this way. In addition, column 9 shows that a one standard deviation increase in the mortgage demand facing a specific bank in a specific month is indeed associated with an increase in its mortgage share of total assets by a full 20.67 pp. This last result corroborates the findings of Varian (2014) and others whereby Google searches are in general a useful proxy for actual

[42] We use the topic search term *Hypothek*, which is German for "mortgage." Topic searches automatically include relevant related search terms, which include identical search terms in English or one of the country's other languages.

economic behavior and shows that our search-based variable indeed captures bank-specific changes in mortgage demand.

5.3 Other Robustness Tests

Beyond the three sets of key robustness checks discussed above, our Online Appendix shows first that our results are qualitatively robust to measuring treatment as ER over TA rather than over total reserves (***Appendix Table AT5***).[43] Thereafter we show our key results are largely robust to measuring treatment as deposits over TA, the most common measure of affectedness to NIRP in the literature (***Appendix Table AT6***). As discussed above, we deem ER a less noisy and more direct measure of adverse treatment exposure in the Swiss context, as up to half of each increase in deposit dependence translates into an increase in NIRP exemptions in our setting. Yet, it is comforting to see that our key results do not depend on this choice. One potentially important difference, suggesting that the two measures may not capture entirely identical dimensions of affectedness is the result on mortgage rates. Using ER, we find a consistently positive effect, while we find a negative coefficient using the deposit ratio. This is in line with Schelling and Towbin (2022) who find negative effects on corporate and mortgage rates in Switzerland when they rely on the deposit ratio, but a positive effect when they rely on exposed reserves. However, further exploration reveals that, while mortgage rate responses of the average bank go in opposite directions depending on the treatment measure, the ability to raise rates is always related to market power. As when we use our preferred treatment measure in ***Table 2***, column 2 in ***Appendix Table AT6*** shows that, even using the deposit ratio to capture treatment, we find that banks with low or no market power tend to lower mortgage rates when NIRP is introduced, while banks with higher market power tend to raise them. Unfortunately mortgage rates are not reported by all banks in our sample, so that these results have limited statistical power, but our robustness check nonetheless corroborates that market power is important for banks' mortgage rate response. Accounting for market power may further help to explain the seemingly treatment-dependent mortgage rate response in our and Schelling and Towbin (2022)'s analysis of Swiss banks. Finally, we explore also how results differ between a commercial bank and a wealth management bank business model (***Appendix Table AT7***), and find no material differences.

[43] We used this as baseline measure in an earlier version of this paper but redefined the treatment measure for more convenient interpretability.

6. Conclusion

We have shown that at least for banks with sufficient market power negative policy rates and deposit margins can be associated with an interrupted pass-through of policy rate changes to mortgage rate changes. Banks seek to offset negative deposit margins at least partly by expanding some of their asset margins. The resulting expansion of mortgage spreads, more pronounced the larger a bank's market power, restricts the expansion of absolute mortgage volumes which a policy rate cut within positive territory would be expected to trigger.

In addition, banks adjust the composition and size of their balance sheets. They cut some reserves without replacement and replace others with higher yielding, but riskier assets. This replacement can support central bank objectives of stimulating the real economy or influencing the exchange rate but implies a worsening of risk-weighted capitalization. Distributional considerations suggest that this risk-taking has negative consequences for financial stability.

The effects we identify reflect banks' differential exposure to negative rates. Comparing differentially treated banks over time improves identification relative to pure inter-temporal comparisons but does not capture general equilibrium effects. We can therefore not easily discuss aggregate implications beyond the distributional considerations about where risk-taking is concentrated. Yet, effects from low-for-long rates, which lower the returns on assets equally for all banks, or from central bank policies that increase aggregate reserves, likely add additional incentives for risk-taking.

Importantly, the combination of negative rates with tiered remuneration of reserves has successfully reduced the interruption of rate pass-through, the shrinking of banks' balance sheets, and the increases in risk-taking. We conclude that if negative rates are deemed necessary, they may be best combined with tiered remuneration, to moderate adverse effects on financial stability.

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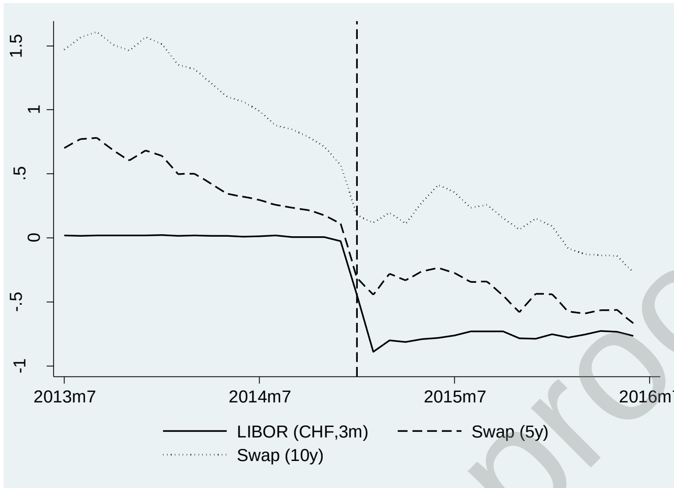
Figures

Figure 1. Pass-Through to Short- and Long-Term Interbank Market Rates



Notes: Figure 1 shows the pass-through to interbank market rates at time horizons of 3 months, 5 years, and 10 years, respectively. Source: Bloomberg.

Figure 2. Liability Margin

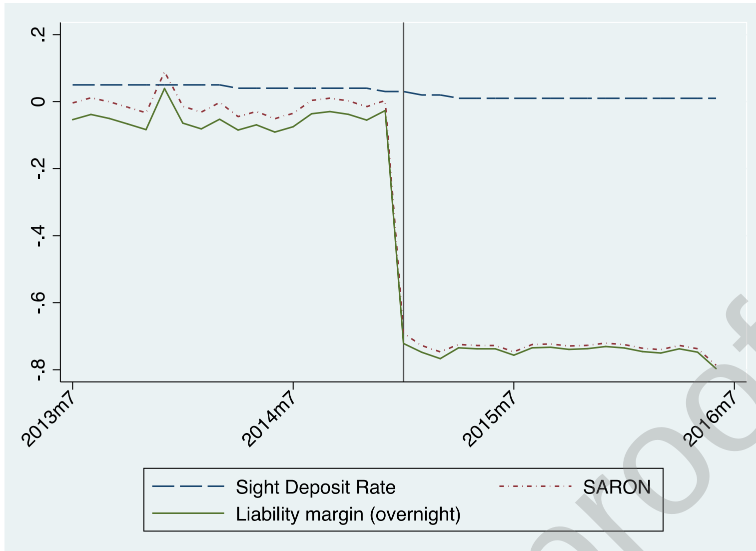
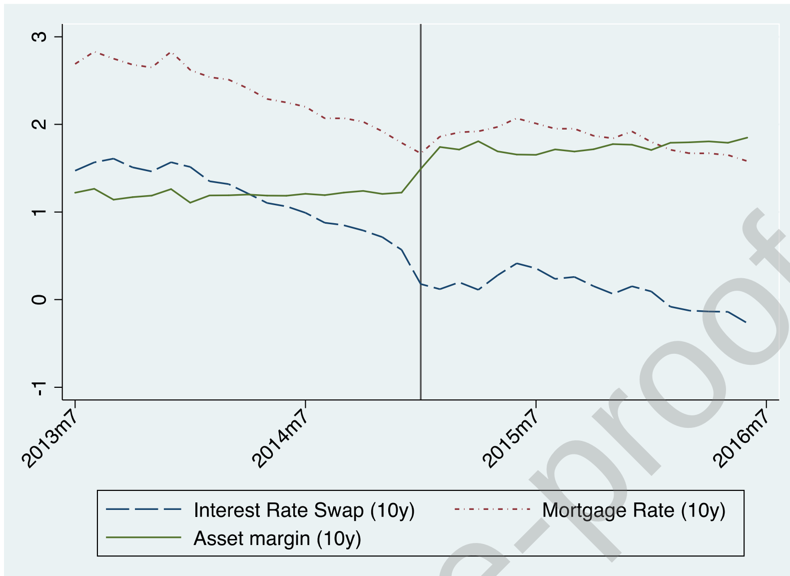


Figure 3. Short-Term Asset Margin

Notes: Figure 3 illustrates the evolution of banks' short-term asset margin between July 2013 and June 2016. *LIBOR (CHF, 3m)* is the three-month Libor rate; *Mortgage Rate (3y, LIBOR)* is the average adjustable mortgage rate, which is indexed to the *3-month* Libor rate and has a *contract duration of 3 years*. *Asset Margin (LIBOR)* is the difference between *Mortgage Rate (3y, LIBOR)* and *LIBOR (CHF, 3m)*. The vertical line identifies the beginning of the treatment period (01/2015). Source: SNB website.

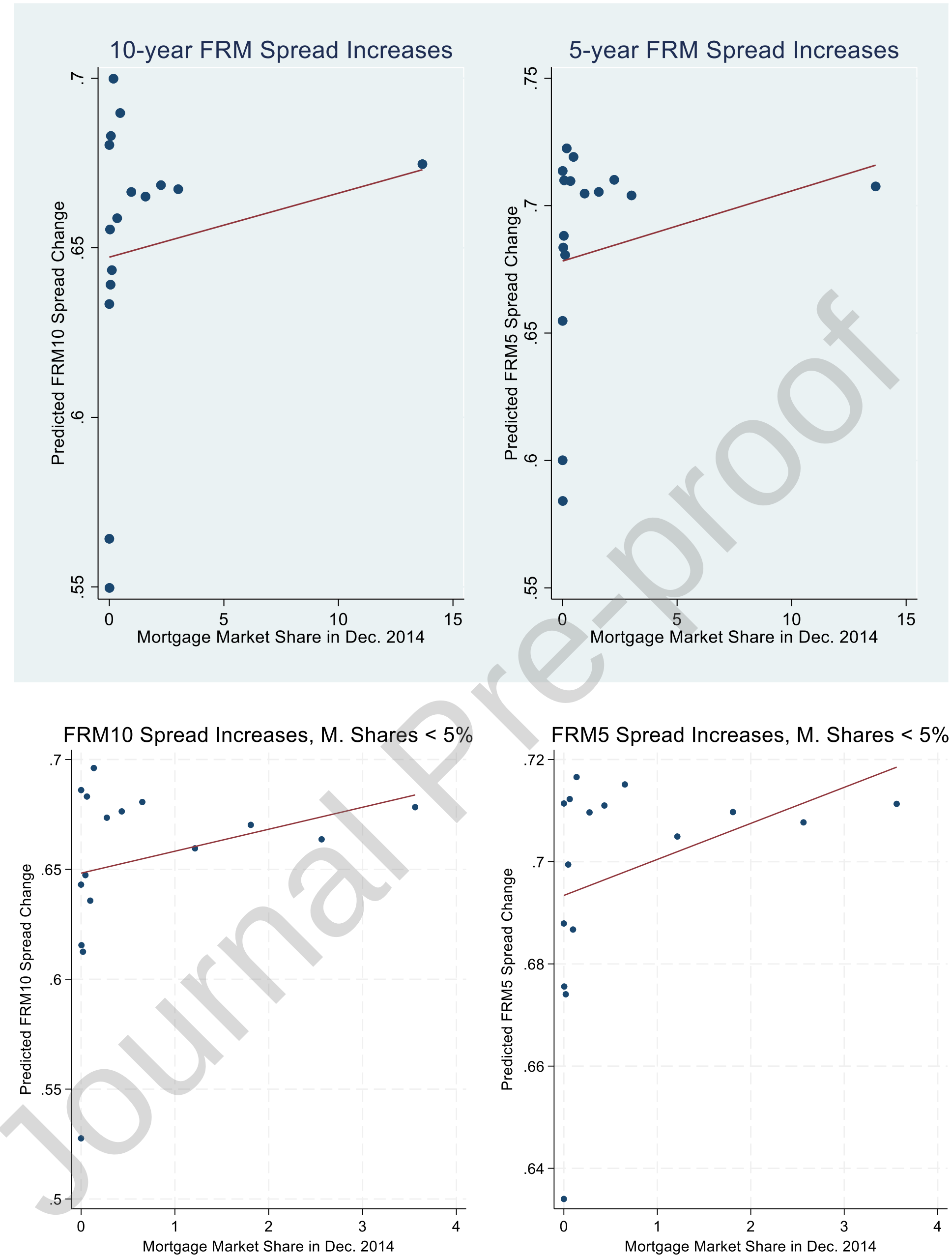
Notes: Figure 2 illustrates the evolution of banks' overnight liability margin between July 2013 and June 2016. *Sight Deposit Rate* is the average cost of deposit funding; *SARON* is the average Swiss overnight lending rate. *Liability Margin (overnight)* is the difference between *SARON* and *Sight Deposit Rate*. The vertical line identifies the beginning of the treatment period (01/2015). Source: SNB website.

<u>Figure 4. Long-Term</u> <u>Asset Margin</u>



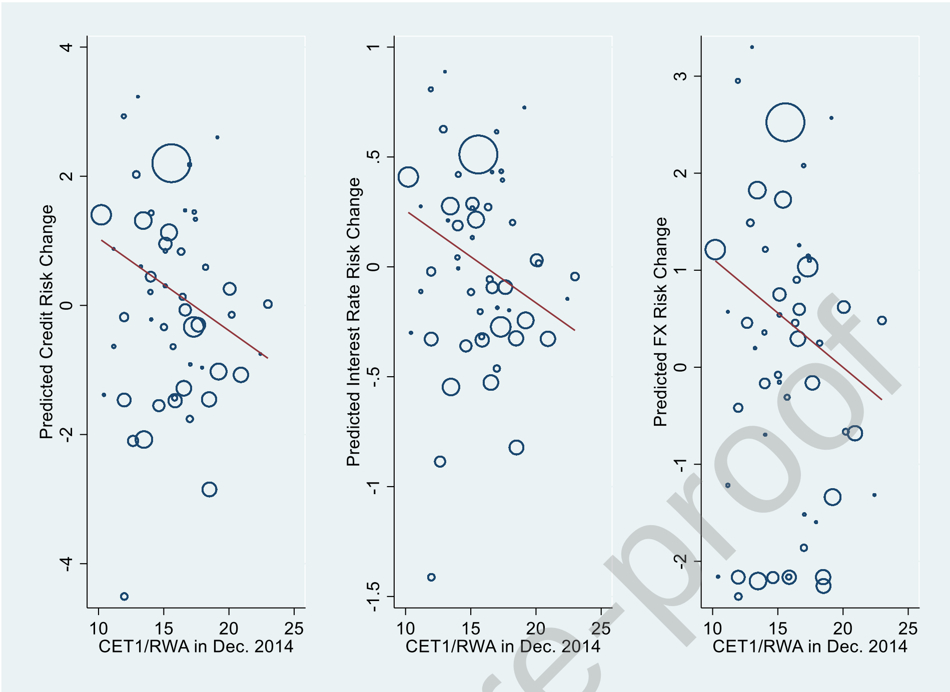
Notes: This figure illustrates the evolution of banks' long-term asset margin between July 2013 and June 2016. *Interest Rate Swap (10y)* is the swap rate on ten-year fixed-rate mortgages; *Mortgage Rate (10y)* is the average 10-year, fixed-rate mortgage rate. *Asset Margin (10y)* is the difference between *Mortgage Rate (10y)* and *Interest Rate Swap (10y)*. The vertical line identifies the beginning of the treatment period (01/2015). Source: SNB website and Bloomberg.

Figure 5. Distribution of Predicted Rate Pass-Through Interruptions by Market Share



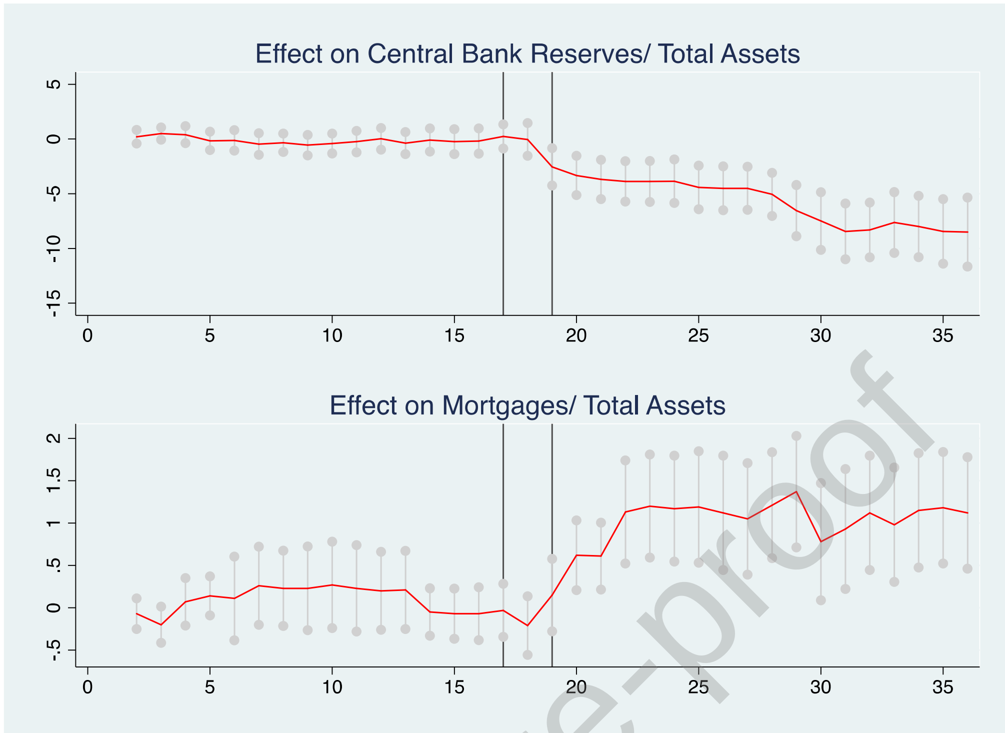
Notes: This figure plots, for all banks reporting mortgage rates, the change from December 2014 until June 2016 in spreads (mortgage rates less interest swap rates) on 10-year (left panel) and 5-year (right panel) Fixed Rate Mortgages (FRM) against December 2014 mortgage market shares. The top row reports observations for all banks, the bottom row focuses on the majority of banks with market shares (in terms of total assets) of less than 5%. We use bin scatter plots to avoid revealing behavior of individual banks.

Figure 6. Changes in Risk-Taking by Prior Capitalization



Notes: This figure plots in left, medium and right panel respectively changes from Dec. 2014 to June 2016 in each bank's predicted levels of credit risk (measured as risk-weight density or RWA/TA), interest rate risk, and FX risk (measured as share of liquid assets held in foreign currency) against risk-weighted capital ratios in December 2014. Observation diameter and fitted line are weighted by each bank's total assets in December 2014 to reflect that larger banks matter ceteris paribus more for financial stability than smaller ones. Comparing average predictions for post- with average predictions for pre-treatment period yields similar results. Online Appendix Figure AF2 2 relates risk changes to total assets and capitalization separately. While this figure and AF2 focus on commercial banks, AF3 repeats the same analyses also for wealth management banks.

Figure 7. Pre Trends and Dynamic Effects on the Asset Structure



Notes: This figure plots the coefficients from interacting a dummy for each month with treatment intensity as measured by the fraction of central bank reserves exposed to negative rates based on November 2014 balance sheets, here for our full sample.

Table 1: Summary Statistics **Notes:** Exposed Reserves are central bank reserves less the bank-specific exemption of twenty times the bank's minimum reserve requirements. Margins or spreads are computed as difference between bank rates and CHF 3-month Libor rates for deposits and adjustable rate mortgages (ARM), and between bank rates and CHF interest swap rates for the same maturity for fixed rate mortgages (FRM). Net interest income is the difference between interest earned and interest paid. The risk-weight density is defined as risk-weighted assets (RWA) over total assets (TA). FX mismatch is defined as the foreign-currency (i.e. non-CHF) share of assets minus that of liabilities. For capital we focus on the highest quality, Common Equity Tier 1 (CET1), scaled first by total assets and then by risk-weighted assets. Notice that we report treatment measures in decimals, but outcome variables in Panels B-E in percentages. This is to allow an interpretation of our point estimates as the (ceteris paribus) difference in the change of the outcome variable, in percentage points, between a bank with no and a bank with full exemption.

	N	Mean	SD	Min	Max
A. Characteristics Measured in Nov. 2014					
Exposed Reserves / Reserves	98	-0.34	0.93	-1.92	0.91
Exposed Reserves / Total Assets	98	0.07	0.17	-0.15	0.69
Deposits / Total Assets	98	0.72	0.11	0.46	0.91
Wealth Management Focused	98	0.47	0.5	0	1
Headquartered in a Border Canton	98	0.32	0.47	0	1
Loan Intensity	98	0.11	0.09	0	0.6
HHI in Mortgage Market	71	0.19	0.05	0.10	0.35
B. Rates and Margins (Prices)					
Margin = Deposit Margin + Mortgage Margin	1,238	0.89	0.3	0.14	1.91
Deposit Rate	1,446	0.23	0.16	0	0.75
Rate for Adjustable Rate Mortgage (ARM)	555	1.19	0.19	0.69	1.9
Rate for 10-year Fixed Rate Mortgage (FRM)	1,238	2.15	0.41	1.2	3.5
Spread for 10-year FRM	1,238	1.52	0.31	0.96	2.5
C. Balance Sheet Components (Volumes)					
Reserves / Total Assets	3,528	18.75	19.33	0	85.36
Loans / Total Assets	3,528	10.99	8.7	0	67.92
Mortgages / Total Assets	3,528	39.68	35.85	0	88.69
Year-on-Year Growth of Total Assets	3,528	3.59	12.88	-32.28	39.92
Deposits / Total Assets	3,528	71.43	11.29	50.59	92.16
Bonds / Total Assets	3,528	7.57	8	0	32.06
D. Profitability					
Net Interest Income / Total Assets	577	0.79	0.45	-0.48	2.06
Fee Income / Total Assets	574	0.14	0.18	0	0.97
E. Risk-taking					
Risk-Weight Density = RWA/TA	1,126	35.79	16.85	2.34	121.14
Interest Rate Risk	1,161	-1.18	5.9	-11.93	35.88
FX Mismatch	3,528	0.27	1.07	0	11.69
CET1 / TA	1,134	7.87	3.63	1.70	22.90
CET1 / RWA	1,141	20.24	11.03	9.29	77.34

Table 2: Banks' Pass-Through and Balance Sheet Responses to NIRP **Notes:** Affectedness is measured as Exposed Reserves (ER) over reserves (Res) in November 2014, the reference date for the first official exposure measures. "Post" is equal to 1 from January 2015 onward. HHI is the Herfindahl-Hirschmann Index, calculated for each bank as the mortgage portfolio weighted sum of the HHI for each of the 26 cantons. All columns control for both bank and either year*quarter or year*month fixed effects. Outcomes are the bank's rate for 10-year fixed-rate mortgages (FRM), total asset (TA) growth, the fractions of TA held as reserves, loans and mortgages, respectively, and the fractions of TA financed through deposits and bonds respectively. R2 rounded to 2 digits. Standard errors are clustered by bank and reported in parentheses. * p<0.1, ** p < 0.05, *** p<0.01.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	10y FRM Rate	10y FRM Rate	YoY Growth (TA)	Reserves/ TA	Loans/ TA	Mortgages/ TA	Deposits/ TA	Bonds/ TA

Post*(ER/Res)	0.03**	-0.09**	-3.13***	-5.62***	1.42***	0.93***	-0.11	-0.46***
	(0.01)	(0.04)	(1.05)	(0.92)	(0.35)	(0.32)	(0.65)	(0.12)
Post*(ER/Res) *HHI		0.42***						
		(0.15)						
Post*HHI		-0.27						
		(0.18)						
Bank FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Data Frequency	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly
N	1,238	1,238	3,528	3,528	3,528	3,528	3,528	3,528
Banks	39	39	98	98	98	98	98	98
R2	0.91	0.85	0.41	0.87	0.86	1.00	0.55	0.98

Table 3: Profitability and Risk-Taking Implications **Notes:** Affectedness is measured as Exposed Reserves (ER) over reserves (Res) in November 2014, the reference date for the first official exposure measures. "Post" is equal to 1 from January 2015 onward. All columns control for bank and time fixed effects (for semi-annual, quarterly, or monthly data respectively). Outcomes are net interest income (NII) over TA, its components interest earned over TA and interest paid over TA, and fee income over TA. Furthermore, we consider the effect on the risk-weight density, interest rate risk, and the TA-scaled difference between assets and liabilities denoted in foreign currency. Finally, we look at CET1 capital over TA and at CET1 capital over RWA. R2 rounded to 2 digits. Standard errors are clustered by bank and reported in parentheses. * p<0.1, ** p < 0.05, *** p<0.01.

	(1) NII /TA	(2) Interest Earned / TA	(3) Interest Paid / TA	(4) Fees / TA	(5) RWA / TA	(6) Interest Rate Risk	(7) (FXAss-FXLiab)/TA	(8) CET1 / TA	(9) CET1 / RWA
Post*(ER/Res)	0.03***	0.10***	0.07***	0.01	1.81***	0.41***	0.08***	0.25***	-0.71***
	(0.01)	(0.01)	(0.01)	(0.01)	(0.61)	(0.13)	(0.03)	(0.07)	(0.23)
Bank FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Data Frequency	Semi-annual	Semi-annual	Semi-annual	Semi-annual	Quarterly	Quarterly	Monthly	Monthly	Monthly
N	577	577	577	574	1,068	1,092	3,528	1,032	1,068
Banks	98	98	98	98	89	91	98	86	98
R2	0.97	0.98	0.94	0.86	0.74	0.89	0.73	0.92	0.90

Table 4: Positive vs. Negative Interest Rate Policy **Notes:** In this table, we compare effects between the policy rate cut within positive rate territory in 2011, and that into negative territory in 2015. To make the two episodes comparable, we measure exposure T in both Panels as central bank reserves over total assets, thus ignoring the exemption in 2015. R2 rounded to 2 digits. Standard errors are clustered by bank and reported in parentheses. * p<0.1, ** p < 0.05, *** p<0.01.

A. 2011 Rate Cut above Zero

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	10y FRM Rate	Reserves / TA	Loans / TA	Mortgages / TA	YoY Growth (TA)	NII / TA	RWA / TA	Interest Rate Risk
Post*(NetIB/TA)	-0.20	17.52***	0.64*	0.47***	26.87***	0.02	-0.11***	-0.01
	(0.19)	(0.95)	(0.37)	(0.17)	(1.81)	(0.03)	(0.02)	(0.00)
Bank FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Data Frequency	Monthly	Monthly	Monthly	Monthly	Monthly	Semi-annual	Quarterly	Quarterly
N	1,257	3,276	3,276	3,276	2,264	541	1,092	1,092
R2	0.90	0.32	0.04	0.04	0.26	0.24	0.04	0.02
Banks	38	91	91	91	91	91	91	91

B. 2015 Rate Cut below Zero

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Post*(NetIB/TA)	0.18	-21.57***	3.38***	2.67***	-10.83***	0.03	0.09***	0.02***
	(0.14)	(0.86)	(0.42)	(0.22)	(1.23)	(0.03)	(0.02)	(0.00)
Bank FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	1,238	3,528	3,528	3,528	3,479	577	1,126	1,161
Data Frequency	Monthly	Monthly	Monthly	Monthly	Monthly	Semi-annual	Quarterly	Quarterly
R2	0.90	0.18	0.04	0.09	0.07	0.07	0.04	0.07
Banks	39	98	98	98	98	98	98	98