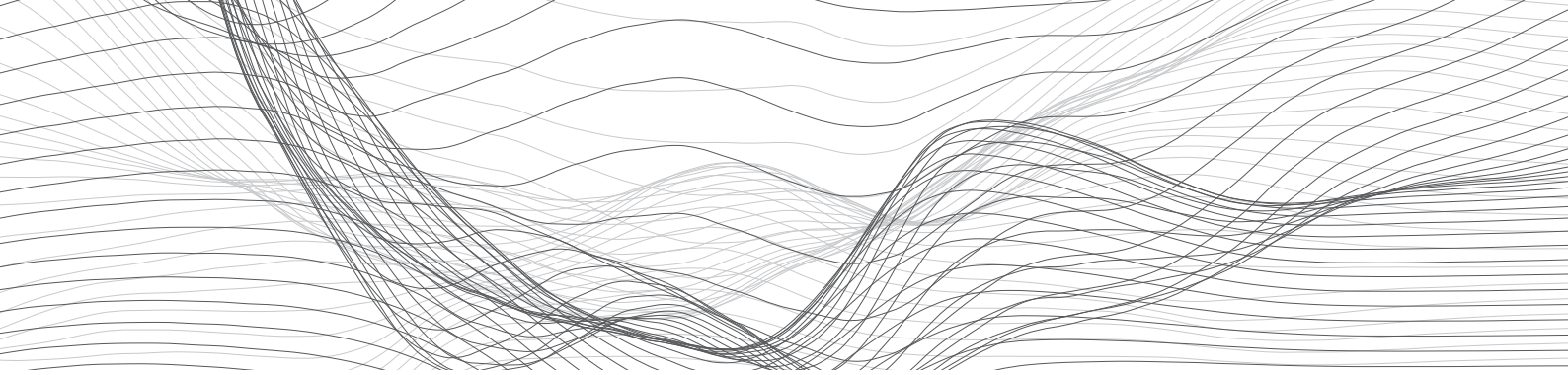

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# Tiers of Joy? Reserve Tiering and Bank Behavior in a Negative-Rate Environment*

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**Abstract**

As negative interest rates exert pressure on bank profitability, several central banks have introduced reserve tiering systems to lessen the burden. Reserve tiering means that banks are only charged the negative policy rate above a certain threshold of reserves. Altering the threshold affects bank profits and therefore has potential effects on the macroeconomy and financial stability. However, assessing these effects is challenging, because the introduction or modification of reserve tiers has usually been accompanied by other monetary policy actions, such as rate changes or quantitative easing measures. We are able to circumvent these issues by exploiting an unexpected decision by the Swiss National Bank in September 2019 to change the threshold calculation without taking any other policy actions. This change led to a large increase in overall exemptions, but with variation across banks. Using a difference-in-differences approach, we find that banks that experience a larger increase in their exemption threshold tend to raise their SNB sight deposit holdings, funded through more interbank borrowing and more customer deposits. The interbank market is important for the funding choice: banks with low collateral holdings (a proxy for market access) use less interbank borrowing and instead grow their customer deposits; they also pass on negative rates on a smaller share of their deposits. Effects on bank lending behavior are moderate; if anything, banks that benefit from a larger increase in the exemption threshold tend to charge higher spreads and take less risk.

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# 1 Introduction

In recent years, a number of major central banks have introduced negative policy rates to achieve their macroeconomic objectives. A possible concern, however, is that negative policy rates may lower bank profitability and have further knock-on effects on bank behavior, including reduced lending capacity (Brunnermeier and Koby, 2018; Eggertsson et al., 2019; Ulate, 2021) and higher risk taking (Dell'Ariccia et al., 2014, 2017).

To lessen the burden that negative interest rates imply for banks, several central banks have adopted tiered reserve systems.[1] In such a system, a portion of the bank reserves held at the central bank is exempted from negative rates, while ensuring that the *marginal* unit of reserves across all banks is still subject to the negative rate. The exemption amounts and how they are distributed across banks can therefore affect bank behavior, with potential consequences for the macroeconomy and financial stability. However, little is known about the effects of reserve tiering. An important challenge lies in the fact that the introduction or modification of reserve tiering systems has usually been accompanied by other monetary policy actions, such as policy rate changes or quantitative easing (QE) measures, which makes it difficult to disentangle the various effects.

In this paper, we analyze the effects of reserve tiering on bank behavior by exploiting a unique policy-event in Switzerland, where the Swiss National Bank (SNB) altered banks' exemption amounts unexpectedly and substantially without any other changes to monetary policy.[2] In aggregate, the SNB's decision increased exemptions by over 40%, corresponding to a potential decrease in negative interest payments from banks (at a rate of -0.75%) of about CHF 875 mn per year.[3] Importantly, there was substantial heterogeneity across banks, with some banks benefitting from large increases to their exemptions while others saw no increases or even decreases. We exploit this cross-sectional heterogeneity with a difference-in-differences approach and analyze how changes in the exemption threshold affected bank behavior, using confidential data about banks' balance

[1] As of end-2020, the ECB as well as the central banks of Japan, Switzerland and, de facto, Denmark and Sweden have adopted reserve tiering systems (see Deutsche Bundesbank, 2021 for an overview). Central banks cited broadly similar reasons for the introduction of such systems. The ECB stated that the two-tier system "aims to support bank-based transmission of monetary policy" (ECB press release, September 2019). The Bank of Japan explained that their system should ensure that "financial institutions' functions as financial intermediaries would not be impaired due to undue decreases in financial institutions' earnings." (BoJ press release, January 2016). The SNB expressed that it does not "burden the banking system any more than necessary" (SNB press conference, December 2019).

[2] The new exemption amounts were announced on 19 September 2019 (see SNB press release) and came into effect on 1 November 2019. The main adjustments were two-fold: first, the SNB introduced a calculation method that let the exemption threshold reflect developments in banks' balance sheets over time. Second, the SNB raised the aggregate amount of exempt SNB sight deposits by a significant amount. See Section 2 for details.

[3] As noted in the SNB Annual Report 2019, p. 58, total exemptions at the end of 2019 stood at CHF 409 bn, versus CHF 291 bn one year earlier (SNB Annual Report 2018, p. 55).

sheets, profitability, and liquidity situation, information on their deposit pricing and composition, as well as loan-level data on corporate lending. We end the sample period in February 2020, in order to avoid confounding effects from the onset of the COVID-19 pandemic and associated policy actions.

We find that banks that experience a larger raise in their exemption threshold tend to increase their SNB sight deposits (reserves), with only limited substitution from other assets; thus, these banks grow their balance sheets relative to their peers. The larger balance sheet is funded through an increase in interbank borrowing and customer deposits. Banks whose exemptions increased by more also display higher profitability and improve their liquidity situation.

However, banks display heterogeneous responses to an increase in exemptions of a given size, and we document an important role for the interbank market. This market allows banks to trade excess supply and demand in SNB sight deposits quickly and efficiently. As trading is usually collateralized, we use collateral holdings as a proxy for access to the interbank market. We show that banks with less collateral prior to the announcement of the policy change use less interbank borrowing and instead grow their customer deposits following an increase in exemptions. Observed effects on the pricing of deposits are consistent with our results on deposit volumes: banks with larger increases in exemptions tend to charge negative interest rates on a smaller share of their deposits, especially if they have little collateral.[4] Finally, banks with less collateral experience smaller increases in their profitability for a given change in the exemption threshold.

Effects on bank lending behavior appear limited. Based on balance sheet data, banks with larger increases in exempt reserves do not display differential growth in the stock of customer loans. However, given the short time frame of our study, an analysis using data on outstanding loan aggregates may have limited power. Therefore, we complement the balance sheet regressions with an analysis of loan-level data on new corporate loan agreements. These granular data also allow us to control for potentially heterogeneous demand effects, similar to Khwaja and Mian (2008). We find that banks with higher increases in exemption thresholds tend to charge higher spreads and take less risk (issuing shorter-maturity loans and fewer fixed-rate loans). These results indicate that the "bank capital channel," where banks with a higher net worth should expand their lending, may be dominated by the risk-taking channel, where more profitable banks are less

[4]Banks will make little direct profit from attracting more customer deposits and investing them in interest-free SNB deposits, given that banks are generally reluctant to charge negative interest rates on deposits, especially in the retail customer business. That banks with higher exemption amounts still grow their deposits, at least in relative terms, may indicate that they aim to increase their franchise value through a larger customer base (e.g., Hanson et al., 2015).

inclined to take risks and feel less pressured to expand lending. Consistent with this notion, we find that banks with more collateral (and therefore larger profitability gains) tend to increase their lending spreads relative to their peers in response to a given increase in the exemption threshold. Quantitatively, however, the effects of changes in the exemption threshold on lending spreads are rather small; a 10 percentage point increase in exemptions relative to total assets is predicted to raise lending spreads by less than 5 basis points.

Overall, exempting a part of the banks' SNB sight deposits from negative interest rates seems to have beneficial effects for financial stability. We find a reduction in bank risk taking, higher profitability, and a better liquidity situation. Furthermore, depositors benefit as banks with larger exemptions become less likely to transmit negative rates to deposits. Borrowers, on the other hand, are not offered better rates from banks with larger exemptions.

As discussed, the strength of these effects depends partly on a bank's ability to participate in the interbank market. This factor is important for policy makers to bear in mind when designing reserve tiering systems. One caveat to our analysis is that the sample period is relatively short, as noted above. Furthermore, our finding that a boost to profitability does not automatically stimulate lending might be specific to the benign economic conditions in which the adjustment took place and the overall healthy capital positions the banks were in.[5] Conceivably, in a crisis situation, raising exemptions and thereby helping profitability would bolster bank lending. Nevertheless, our results should inform policy makers that are considering the use of, or changes in, reserve tiering to help stimulate the economy or strengthen bank health.

Our work relates to the growing literature analyzing the transmission of negative interest rates; Brandao-Marques et al. (2021), Brown (2020), Heider et al. (2020) and Tenreyro (2021) provide surveys of recent studies.[6] The overall conclusion appears to be that the reversal rate (Brunnermeier and Koby, 2018) has not been reached and that negative interest rates can lead to higher risk taking, especially for banks that rely heavily on deposit funding. However, the effects of reserve tiering systems, which we focus on, have received far less attention. Fuhrer et al. (2020a) study the effects of the Swiss reserve tiering system on volumes and prices in the interbank market, but they do not consider the broader effects on bank behavior. Basten and Mariathasan (2020), Demiralp

[5] According to the SNB Financial Stability Report 2020 (p. 37), domestically focused Swiss banks held large capital buffers at end-2019. Their capital ratios were typically 7.5-12.5 percentage points above the 8% risk-weighted minimum and 3-6 percentage points above the 3% leverage ratio minimum.

[6] See, e.g., Claessens et al. (2018); Lopez et al. (2020); Coleman and Stebunovs (2019); Molyneux et al. (2019) for empirical evidence on profitability and Baeriswyl et al. (2021); Bittner et al. (2021); Bottero et al. (2019); Demiralp et al. (2019); Heider et al. (2019); Hong and Kandrac (2020); Schelling and Towbin (2020); Tan (2019) on lending behavior and risk taking. Altavilla et al. (2019) study the pass-through of negative rates to (corporate) depositors.

et al. (2019) and Schelling and Towbin (2020) analyze how negatively charged reserves affect bank behavior, exploiting differences in charged reserves across banks. However, in the events these papers study, the policy rate was lowered simultaneously. Our event, in contrast, exclusively consists of a change in reserve tiers. This allows us to cleanly isolate its effects on bank behavior. Given that we examine adjustments across the whole balance sheet, an isolated change in the reserve tiering structure is particularly valuable; for many balance sheet positions, the granular data needed to control for heterogeneous demand effects induced by interest rate changes is lacking.

Turning to more conceptual analyses of reserve tiering, Balloch and Koby (2020) complement their empirical analysis of the effects of negative rates in Japan with a counterfactual model-based analysis of reserve tiering in that context, while Berentsen et al. (2020) theoretically examine the effects of reserve tiering systems on welfare. To our knowledge, ours is the first empirical study to exclusively focus on the effects of (a change in) reserve tiering on bank behavior.

Our lending analysis is related to a large literature studying the effects of shocks to banks' net worth on their lending (e.g., Peek and Rosengren, 1997; Ivashina and Scharfstein, 2010; Puri et al., 2011; Chodorow-Reich, 2014; Bidder et al., 2021). This work primarily studies the effects of negative shocks on banks, usually during crises, while we exploit a positive profitability shock coming from the larger exemptions during normal times. Also related is work examining how capitalization affects banks' lending or their reactions to changes in interest rates or other shocks (e.g. Van den Heuvel, 2002; Gambacorta and Mistrulli, 2004; Jiménez et al., 2012; Gambacorta and Shin, 2018). In our setting, although banks with larger increases in exemptions might be able to lend more, it appears that the reduction in risk-taking incentives outweighs this "bank capital channel," at least over the initial few months after the policy change. Our finding of a strong risk-taking channel is in line with, among others, Jimenéz et al. (2014), Ioannidou et al. (2015) and Paligorova and Santos (2017), or, in the context of negative rates,Heider et al. (2019), Bottero et al. (2019) and Schelling and Towbin (2020).

Finally, we relate to recent work studying the effects that increased central bank reserves resulting from policies such as quantitative easing and foreign exchange interventions have on bank lending and risk taking. For instance, Kandrac and Schlusche (2021) and Kandrac et al. (2021) study the effects of QE-induced increases in bank reserves in the US, while Fuhrer et al. (2020b) use data on Swiss banks over the 2006-2016 period. These papers find that expansions in reserves lead to increased lending and risk taking, and more strongly so the lower the return on these reserves. In our setting, the increase in exemptions is equivalent to a higher return on reserves; our

finding that this leads to higher loan spreads and less risk taking is consistent with these other recent papers.

The remainder of the paper is structured as follows: the next section provides an overview of negative interest rates and reserve tiering in Switzerland and shows some aggregate patterns. Section 3 describes our data sources, bank samples, and how we measure individual exposure to the policy change. Sections 4 through 7 then contain the heart of our analysis, examining cross-sectional differences in banks' balance sheets, lending behavior, deposit pricing and composition, and liquidity and profitability metrics. Section 8 discusses the results and presents the conclusions.

## 2 Background on reserve tiering in Switzerland

On 18 December 2014, the SNB announced that it would impose negative interest rates on sight deposit balances at the SNB, with an initial interest rate at -0.25%, which was soon after decreased to -0.75%.[7] With this policy move, the SNB intended to take its reference rate at the time, the three-month Libor, into negative territory. To limit the banks' interest burden, the SNB concurrently introduced a reserve tiering system. Under such a system, negative interest is only charged on the tier of sight deposit account balances that exceed a certain pre-defined threshold. The tier of deposits below this threshold is usually exempted from negative interest, i.e., remunerated with zero percent.[8] To ensure that the negative policy rate is still transmitted to short-term money markets, the threshold is calibrated such that the marginal unit of reserves in the system is subject to the negative policy rate.

When introduced in December 2014, exemption thresholds were essentially fixed in nominal terms, calculated as 20 times the bank-specific minimum reserve requirement for the period of 20 October to 19 November 2014.[9] Reserve requirements in Switzerland are determined by the short-term liability structure of a bank's balance sheet.[10]

[7] See SNB press release, 18 December 2014. The interest rate of -0.25% announced on 18 December was to be charged starting 22 January 2015, but was lowered further to -0.75% on 15 January 2015, when the SNB also discontinued the minimum exchange rate of CHF 1.20 per euro.

[8] This is the case in Switzerland. In principle, it is possible to have more than one additional tier, with different interest rates; for instance, the Bank of Japan's system features three tiers, with rates of -0.1%, 0%, and 0.1% (as of March 2021).

[9] In addition to the static component described above, there was a dynamic component that was quantitatively much less important. The dynamic component reflected changes in cash holdings: any increase (decrease) was deducted from (added to) the threshold. This component served as a disincentive for the banks to move into cash.

[10] Specifically, the reserve requirement equals 2.5% of relevant short-term liabilities, which are calculated as the sum of short-term liabilities in Swiss francs (up to 90 days) plus 20% of liabilities towards customers in the form of savings and investments.

Five years later, on 19 September 2019, the SNB announced that it would adjust the exemption thresholds, effective November 1.[11] The main adjustments were two-fold: first, the SNB introduced a calculation method that allowed the exemption threshold to reflect developments in banks' balance sheets over time. Under the new method, the exemption threshold is calculated as a multiple of the moving average of the minimum reserve requirements over the preceding 36 months, or reference periods.[12] With the revised calculation method for exemption thresholds, banks are able to directly affect their exemption thresholds over time by increasing their reserve requirements, i.e., their relevant short-term liabilities.[13] Second, the SNB effectively raised the total amount of exempt SNB sight deposits by a significant amount, as the multiple was increased from 20 to 25. The increase in the multiple reflected that the total amount of SNB sight deposits had expanded significantly since the introduction of negative interest rates and the SNB's intent to bring the interest burden placed on the banking system to the minimum needed for the implementation of monetary policy (Maechler and Moser, 2020).[14]

Three points are worth highlighting with regards to our study. First, when the SNB announced and implemented the change in its reserve tiering system, it kept the policy rate constant, which means that we do not have to deal with possible confounding effects due to concurrent changes in interest rates. This setting contrasts with other cases where reserve tiers were introduced or modified, which featured simultaneous policy actions such as changes to the policy rate or quantitative easing. A possible concern might be that the announcement contained a signal about future monetary policy, which therefore could affect banks via changes in the term structure of interest rates or changes in the exchange rate. However, there were no large movements in short- or long-term interest rates or the exchange rate against the Euro following the policy announcement on 19 September 2019 (see Appendix Figure A.1).

Second, there is no indication that the change in the exemption threshold had been anticipated by banks or other market participants. For example, there was no mention in the media of the exemption threshold from the beginning of 2019 up until the day before the announcement. For

[11] See SNB press release, 19 September 2019.

[12] The last reference period starts on the 20th calendar day three months before the beginning of the respective interest period. For example, the last reference period for the November interest period is 20 August - 19 September. Under the new regime, the method to account for cash holdings (see footnote 9) was also adjusted, again with quantitatively minor implications; see the press release for details.

[13] We show in Appendix B that there is some evidence of banks reallocating their deposits to categories that count more toward the minimum reserve requirement after the September 2019 announcement, specifically from savings deposits toward sight deposits.

[14] The multiple was later increased to 30 (announced on 19 March 2020, effective 1 April 2020) as part of the policy response to the Coronavirus pandemic. This period is not part of our analysis sample.

the rest of the year, we found over 50 mentions in articles from numerous news outlets.[15] This provides an ideal setting to identify the effects of this policy change on bank behavior, as we can exactly pinpoint the time of the intervention and argue, with reasonably certainty, that there were no anticipation effects.

Third, the policy change had a significant aggregate impact on the amount of SNB sight deposits that were exempt from negative interest rates and, thus, on bank profitability. Figure 1 shows the evolution of total sight deposits by banks at the SNB, along with the total exemption amounts and two measures of the amount of deposits that were subject to the negative rate of -0.75%. The lower blue line indicates the aggregate amount of excess reserves, i.e., the difference between total sight deposits (black line) and total exemptions (green line). The figure shows that excess reserves started out just below CHF 100 bn in January 2015 and then essentially doubled by 2017. When the exemptions increased in November 2019 (after the announcement from September), the total amount of sight deposits subject to negative rates was roughly cut in half, back to approximately CHF 100 bn. Thus, in aggregate, the increase in the exemption threshold in late 2019 reduced the interest burden back to, approximately, the level when negative rates were introduced in January 2015. The increase in total exemptions of approximately CHF 117 bn corresponds to negative interest rate payments of approximately CHF 875 mn per year (at the prevailing rate of -0.75%). This change is nontrivial relative to consolidated Swiss banking sector profits, which ranged from CHF 8 to 15 bn in the previous 5 years. More importantly, as we show below, there was sizable variation across banks.

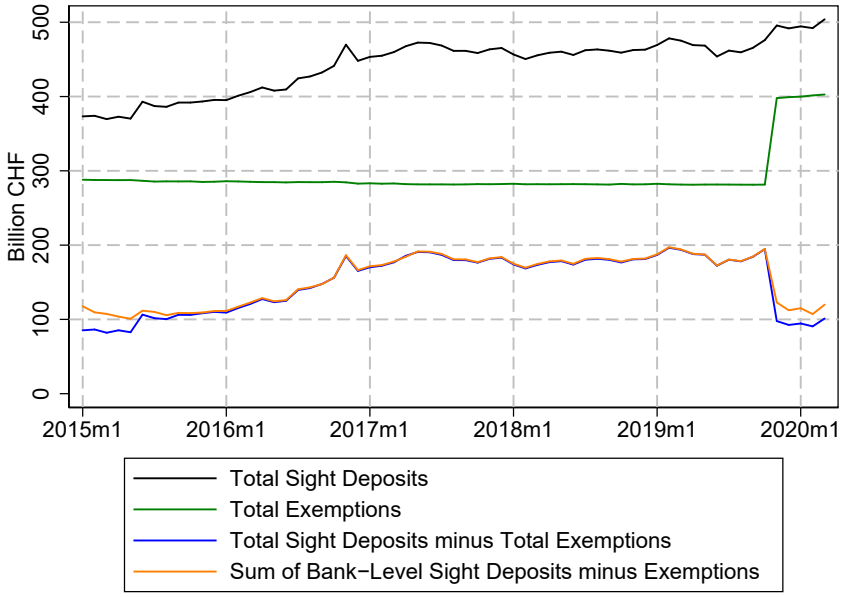
The orange line just above the blue line shows the actual amount of SNB sight deposits subject to negative rates, i.e., the sum across banks $j$ of $max(SightDeposits_j - Exemption_j, 0)$. Thus, the fact that the orange line is above the blue line indicates that some banks did not fully take advantage of the reserve exemptions that they were granted by the SNB. The figure shows that in 2015, it took a few months for banks to complete "arbitrage" and eliminate the gap; in 2019/2020, similarly, the gap did not disappear immediately.

Figure 2 shows that total borrowing and lending in the interbank market increased following the September 2019 announcement. Total interbank borrowing in CHF increased from approximately CHF 80 bn prior to the announcement to approximately CHF 120 bn by November 2019, when the new exemptions came into effect.[16] Interbank borrowing in other currencies also in-

[15] We searched for the official German term used by the SNB for exemption threshold ("Freibetrag") in the online media database "swissdox," which covers a large portion of the Swiss media landscape.

[16] We again note that there is no evidence for anticipation effects prior to September.

**Figure 1:** SNB sight deposits and exemptions in aggregate




Note: The figure shows the total SNB sight deposits (black), the total amount of SNB sight deposits exempt from negative interest rates (green) and two measures of SNB sight deposits subject to negative interest rates. The blue line equals the difference between total sight deposits (black line) and total exemptions (green line). The red line takes into account that some banks did not take full advantage of the exemption granted by the SNB. The line is constructed by summing up $max(SightDeposits - Exemption, 0)$ across all banks. The data is sourced from the SNB survey of balance sheet positions subject to minimum reserve requirements.

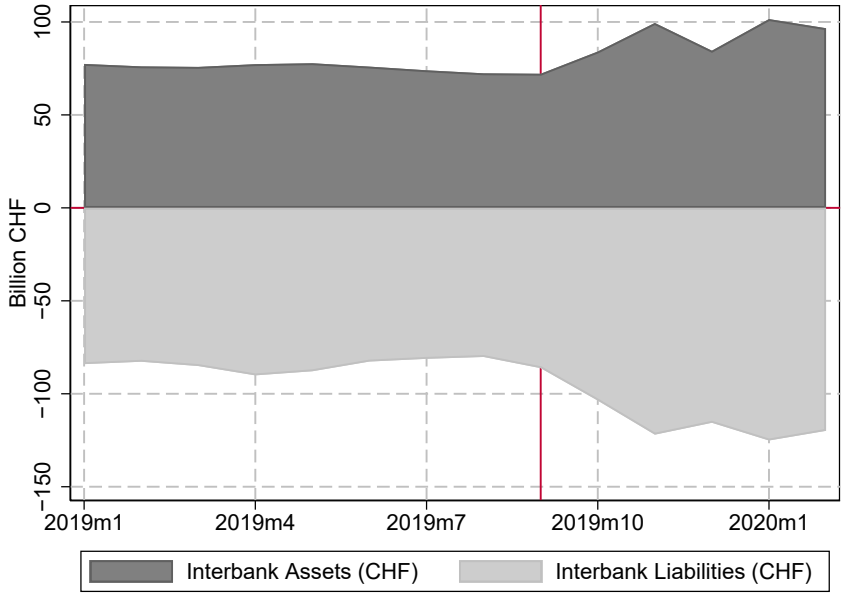
creased by an additional CHF 5-10 bn. However, as shown in Figure 1, approximately CHF 20 bn of the overall increase in exemptions remained unused over the period from November 2019 to February 2020. Thus, although the interbank market is an important tool for banks to even out differences in excess SNB sight deposits, there appear to be some frictions that prevent at least some of the banks from completely using their available exemptions. We return to these issues when discussing the cross-sectional patterns in Section 4.

## 3 Data, sample, and exposure to policy change

For our main analysis, we combine bank-level data from various confidential reports that are required from essentially all banks active in Switzerland. We use monthly balance sheet data, semi-annual income and profit statements from supervisory reports, annual data on deposit interest rate bands, monthly liquidity reports, and loan-level data of newly granted corporate loans.[17]

[17]For details on the monthly balance sheet data, see https://emi.snb.ch/en/emi/MONAX; for details on semi-annual income and profit statements, see https://emi.snb.ch/en/emi/AURX; for details on annual data on deposit interest rate bands, see https://emi.snb.ch/de/emi/jahrx/JAHR_U/1.8/UEA; for details on liquidity reporting, see https://emi.snb.ch/en/emi/LCR and https://emi.snb.ch/en/emi/LMT; and for details on the corporate loan data, see https:

**Figure 2:** Total interbank assets and liabilities (CHF) of banks in the analysis sample




Note: Interbank assets and liabilities are from the SNB monthly balance sheet statistic. They are denominated in Swiss Francs and comprise all maturities. The bank sample comprises 143 banks, as described in Section 3. The vertical line indicates the month when the policy change was announced.

We remove the following entity types from the full sample of banks: branches of foreign banks; banks based in Liechtenstein; small banks whose reporting requirement ended in December 2019[18]; and banks which do not have individual deposit accounts at the SNB.[19] Finally, we drop one bank with a large jump in total assets in October 2019. This leaves us with a sample of 143 banks for the main analysis of the monthly balance sheet data.[20]

In much of our analysis, we separately study two subsamples of banks. We classify as "retail" those banks that have more than 50% of their assets in mortgages as of August 2019, plus a few cantonal banks whose ratio falls just below this threshold (but they nevertheless play an important role in their local deposit and credit market). This yields a sample of 55 banks. We refer to the remaining 88 banks as "wealth management" banks, since that is generally their main focus, although there is some heterogeneity.[21]

//emi.snb.ch/en/emi/KREDZ.

[18]Since January 2020, only banks whose balance sheet total and fiduciary transactions combined exceed CHF 500 mn are subject to monthly balance sheet reporting requirements (previously: banks whose balance sheet total and fiduciary transactions combined exceeded CHF 150 mn and whose balance sheet total amounted to at least CHF 100 mn)—see https://data.snb.ch/en/topics/banken#!/doc/changerev_banken#rev_2020.

[19]This is the case for a number of relatively small banks that are part of the "Entris" group.

[20]We generally use non-consolidated data; for the Raiffeisen Group, we only observe the combined balance sheet of the over 200 individual local banks.

[21]Credit Suisse and UBS each enter the sample with two separate units—their Swiss units in the retail sample, and

We define our main explanatory variable, a bank's exposure to the change in the exemption threshold announced on 19 September 2019 and coming into effect on 1 November 2019, as follows:

$$\Delta ET_i = \frac{ET_{i,Nov2019} - ET_{i,Aug2019}}{Assets_{i,Aug2019}}. \quad (1)$$

The numerator of the expression indicates the increase in a bank's exemption threshold. If the bank holds sight deposits at the SNB that exceed $ET_{i,Nov2019}$ throughout the period, then the numerator directly captures the amount on which the bank saves the interest payment of 0.75% p.a. from November 2019 onward. However, even if a bank's sight deposits are initially below the new threshold, it can potentially benefit from the increase by borrowing on the interbank market (from banks whose sight deposits are above their exemption threshold) at a rate close to -0.75% and depositing the money at the SNB at a rate of 0%. Thus, for any bank in the sample, the change in the exemption threshold represents the amount on which it could potentially earn 0.75% more interest (or pay less interest) relative to before the policy change. To make this amount comparable across banks, we normalize it by bank assets before the announcement of the change in the exemption threshold.

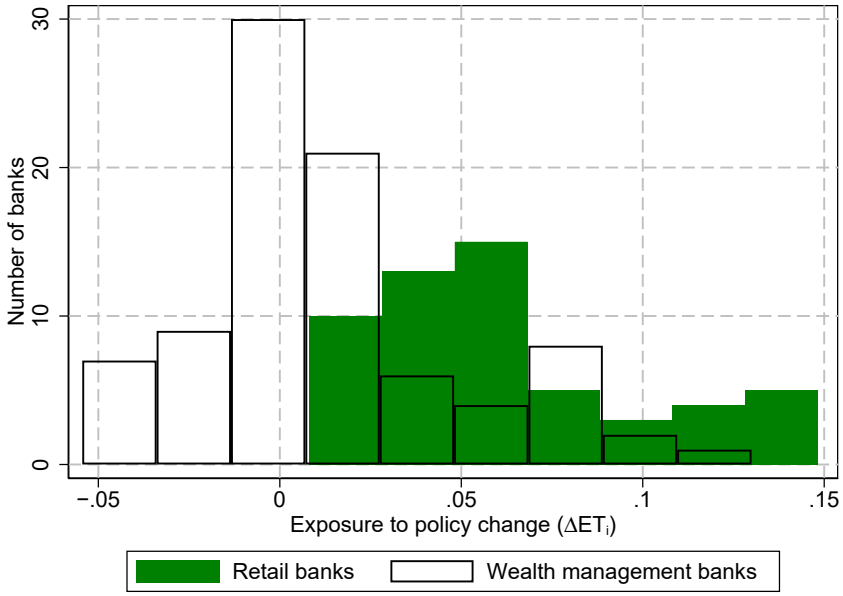
Figure 3 shows the distribution of $\Delta ET_i$ across the two bank types described above. There is substantial heterogeneity; for some banks, the amount newly exempted from negative rates represents up to 15% of their total assets, while for others, the exemption *decreased* by 5% of their assets. The figure also illustrates that retail banks all had positive exposure to the policy change, while wealth management (or WM) banks were distributed more closely around 0. One important reason for the difference across these bank types is that retail banks tend to have higher minimum reserve requirements (relative to total assets) than the WM banks, because a much larger share of their deposit funding is in Swiss francs. Since the multiplier on reserve requirements increased from 20 to 25 with the policy change, this led to larger increases for banks with relatively higher reserve requirements.

Of course, another important determinant for the change from the old exemption amounts is how a bank's characteristics changed over the five years between end-2014 (when the previous exemptions were determined) and end-2019. One might be concerned that $\Delta ET_i$ could be determined by a bank's recent growth, which in turn would potentially lead to pre-trends and might generate spurious difference-in-differences results. One aspect of the revised formula that guards

the parent company in the wealth management sample. Removing these observations from the analysis does not qualitatively alter our findings.

against this is that it is based on the 3-year moving average of reserve requirements, meaning that very recent developments do not have a dominant weight. Furthermore, we show in Appendix Figure A.2 that, even though changes in bank characteristics over time do matter as a determinant of $\Delta ET_i$, the changes that are most important in determining cross-sectional differences happened in 2016 and 2017, well before the start of our sample period. Finally, we directly assess pre-trends in our analysis below and generally find little reason for concern.

**Figure 3:** Distribution of exposures to the policy change, by bank type




Notes: The exposures to the policy change are defined as the difference between the new exemption threshold (November 2019) and the old exemption threshold (August 2019), normalized by total assets before the change (August 2019, see equation 1). The exposures are winsorized at the top and bottom 5 values. "Retail banks" have a mortgage to assets ratio of over 50% as of August 2019 or are backed by the local government (cantons). The rest are labeled "wealth management banks".

These changes in exemptions are of substantial size relative to the typical profits of Swiss banks in recent years. For example, if a bank experiences an increase in its exemption corresponding to 10% of its total assets, then this bank should experience an increase in its annual income of 0.075% of total assets, ceteris paribus.[22] For comparison, the average annual return on assets of our sample banks over the 2016-2018 period was 0.38%, with an interquartile range, or IQR, of also 0.38% (from 0.22% to 0.60%). For retail banks only, the average was slightly lower (0.34%) and dispersion was much smaller (with an IQR of 0.22%).[23] Thus, the increase in exemptions had an expected

[22]This calculation assumes that the bank holds SNB sight deposits above the new exemption threshold. If the bank's sight deposits are below the new exemption and it borrows in the interbank market to take advantage of the spare exemptions, the increase in annual income would be slightly smaller.

[23]For net interest income divided by assets, the variation is even smaller for retail banks, i.e., the IQR was 0.15%,

nontrivial effect on profitability compared with both the average profitability and its dispersion across banks; furthermore, this effect was not a one-time windfall but a persistent increase when compared to a counterfactual where exemptions had remained fixed.

Access to interbank funding may play an important role in how banks respond to reserve tiering. Banks whose SNB sight deposits are below the exemption threshold need to attract funds to take full advantage of the exemption. A bank has several options for attracting funds, the quickest and most efficient being borrowing from the interbank money market. Since post-crisis money market transactions are collateralized, the amount of collateral that a bank has available is a deciding factor in whether it can participate in this market (Fuhrer et al., 2020a). We measure a bank's collateral availability using the regulatory Liquidity Coverage Ratio (LCR) reporting for August 2019 (before the policy change). As collateral, we count all reported High Quality Liquid Asset (HQLA) securities of categories 1 and 2a. This corresponds to the collateral that the SNB accepts in its repo transactions.[24]

The descriptive statistics as of August 2019 are shown in Table 1. On average, the 55 retail banks in our sample are larger (in terms of total assets) than the 88 wealth management banks, though within both groups, there is substantial variation in terms of size. Retail banks hold most of their assets in mortgages (73% on average), while WM banks have larger shares in SNB sight deposits, interbank claims, other loans, and securities. Both types of banks are approximately 60% deposit funded on average but with substantial heterogeneity. Regarding other liabilities, retail banks primarily rely on covered bonds, while WM banks are more active in borrowing in the interbank market. The final four rows show our two main independent variables in the regressions that follow: $\Delta ET$ and Collateral. For both of these, there are some outliers, so for the analysis, we winsorize them at the top/bottom 5 values (corresponding to 4%). The table illustrates that this reduces the standard deviation of these variables primarily within the WM banks.

For most of our regressions below, we will report the results separately for retail and WM banks (in addition to the full sample). The advantage of the sample split is that it should allow the effect within an otherwise more homogeneous group of banks to be studied (especially in the retail sample; in the WM sample, there remains more heterogeneity).

relative to a mean of 1.00%.

[24] See https://www.snb.ch/en/mmr/reference/repo_mb26/source/repo_mb26.en.pdf. We subtract all securities that a bank has pre-positioned at the SNB's liquidity-shortage financing facility since these are not available for market transactions.

# 4 Effects on balance sheet components

Next, we study whether various components of the balance sheet evolved differentially for banks that benefitted more from the increase in available exemptions. To do so, we estimate difference-in-differences (DiD) regressions of the following form:

$$y_{it} = \alpha_i + \gamma_t + \beta_{post}(\Delta ET_i \times \underbrace{I(t \geq Oct2019)}_{\text{"Post"}}) + \beta_{sept}(\Delta ET_i \times \underbrace{I(t = Sept2019)}_{\text{"Sept"}}) + \varepsilon_{it}. \quad (2)$$

In this equation, $y_{it}$ is an outcome of interest, usually a balance sheet component (measured as of month-end) normalized by total assets as of August 2019. Normalizing with a fixed denominator ensures that the variation across banks is fully driven by the numerator and prevents spurious results coming from changes in the denominator (Welch, 2020).

Our main coefficient of interest is $\beta_{post}$, which measures the differential effect of being exposed to a change in the exemption threshold ($\Delta ET_i$) in the post-announcement period. We define the main treatment period to start in October 2019 and separately "dummy out" the month of September. This allows for the possibility that after the policy change was announced on 19 September, banks started adjusting prior to the actual implementation in November, at least partially. Including the September dummy also provides us with a simple diagnostic for pre-trends—if an effect is already large in September (as estimated by $\beta_{sept}$), this suggests that it may not have been driven by the change in exemptions. $\alpha_i$ and $\gamma_t$ are bank and month fixed effects to control for time-invariant bank characteristics and common shocks, respectively. Finally, the sample period is April 2019 through February 2020, meaning that we have five months in both the pre- and post-treatment periods (plus September in between). Throughout, we cluster standard errors at the bank level.

In Appendix Figures A.3 and A.4, we show the results graphically from specifications where we replace the "Post" dummy above with indicators for each month in the sample (omitting August 2019, the month prior to the announcement). This technique allows tracing out monthly effects of $\Delta ET_i$ and directly assessing whether there is evidence for pre-trends. Overall, such pre-trends are absent for the main outcomes of interest we emphasize in the discussion below.

We note that for some of the outcomes we study, notably SNB sight deposit holdings and interbank borrowing/lending, the standard DiD assumption of no spillovers from the treatment assigned to a bank $i$ on the outcomes of bank $j$ does not hold, by the nature of the outcome. The aggregate amount of SNB sight deposits is determined by the size of the SNB balance sheet, so if

a bank $i$ increases its sight deposits at a point in time, some other bank(s) $j$ must decrease theirs. Similarly, additional interbank borrowing by a bank $i$ corresponds to interbank lending by another bank $j$ (though this bank could be outside of our sample). Thus, the estimated treatment effects should be interpreted relative to other banks in the sample; our approach does not allow estimating aggregate effects. Also note, however, that in case we do not find a significant treatment effect, this would imply that there cannot be an aggregate effect either (unless it stems from general-equilibrium forces, which DiD analyses cannot directly address).

### 4.1 Assets

The results for the asset side are shown in Table 2. As expected, sight deposits at the SNB grow more for those banks with larger ET increases as they try to exploit their exemptions (columns 1-3). Note that the coefficients are lower than one, which can be explained by either some banks being above the threshold before the policy change or their inability to fully take advantage of their ET increase. We return to the latter case in Section 4.3. To assess the magnitude, we can multiply the coefficient by 0.1, as this corresponds roughly to the difference between the bank at the 10th and 90th percentile of $\Delta ET$ (see Figure 3); in this case, this corresponds to an effect on SNB sight deposits relative to total assets of 7 percentage points for the full sample in column 1.

Next, we find a decrease in (gross) interbank claims, which is statistically significant for retail banks but not in the full sample (columns 4-6). A reduction in interbank claims makes sense for the banks that have spare exemptions after the increase and move their money from interbank claims into SNB sight deposits. The size of this effect is much smaller than that for SNB sight deposits. In contrast, we do not observe any effect on the sum of outstanding mortgages and other customer loans (columns 7-9).[25] This result may not be overly surprising—as the loan figures are monthly stocks, any effect should materialize only slowly, which makes it difficult to detect over our relatively short sample window. In Section 5, we use a loan-level data set of newly granted corporate loans, where we find that banks experiencing a higher increase in ET take less risk by tightening lending terms. Finally, we do not find significant effects on securities holdings (columns 10-12), although directionally, the effect is negative in the full sample and for WM banks (while retail banks in our sample tend to only have small securities holdings anyway).

The strong positive effect of exemption increases on SNB sight deposits is reflected in the

[25] This remains true if we study the two categories separately, or if we use monthly changes instead of levels in the numerator of the dependent variable.

growth of total assets (columns 13-15). The coefficients are slightly smaller than those for SNB sight deposits alone, reflecting some of the asset substitution we observed (reductions in interbank claims and securities, even though those are not necessarily statistically significant). Nevertheless, the primary adjustment mechanism is the size of the balance sheet—those banks with higher increases in exemptions ended up with relatively larger balance sheets.[26] The next subsection will analyze how the growth in total assets was funded.

### 4.2 Liabilities

The results for the liability side are shown in Table 3. For interbank liabilities, we separately study gross liabilities and net borrowing (i.e., liabilities minus claims).[27]

Interbank borrowing increases for those banks with larger increases in ET, but while the effect is strongly significant in the overall sample, it is not significant for retail banks. In the overall sample and for wealth management banks, a 10 percentage point higher $\Delta ET$ leads to net interbank borrowing that is 4-4.5 percentage points higher (columns 4 and 6).

For deposits, in contrast, there is an insignificant effect overall, but a highly significant positive effect within the retail sample (columns 7-9). Thus, retail banks with larger increases in ET experienced relatively stronger deposit growth over the period from October 2019 to February 2020. As we will show below, this result appears to be driven by banks with limited ability or willingness to participate in the interbank market and is also reflected in interest rates on deposits.

There is also a positive effect on residual funding through covered bonds and other bonds (columns 10-12). Since essentially only retail banks use this funding source, and those banks, on average, have a larger increase in ET, this effectively reflects an overall increase in covered bond funding after October 2019. Within retail banks, the correlation with the ET increase is also positive, but not quite statistically significant.

[26] The effects of exemptions on SNB sight deposit holdings and total assets are qualitatively in line with those found by Basten and Mariathasan (2020) when looking across banks with different levels of charged reserves after the introduction of negative rates in January 2015. For mortgages and other loans, Basten and Mariathasan find that banks with higher charged reserves grew the balance sheet share of these items. However, they note that if they normalized using a fixed denominator, as we do throughout this paper, there would not be differential growth in mortgages, in line with our results.

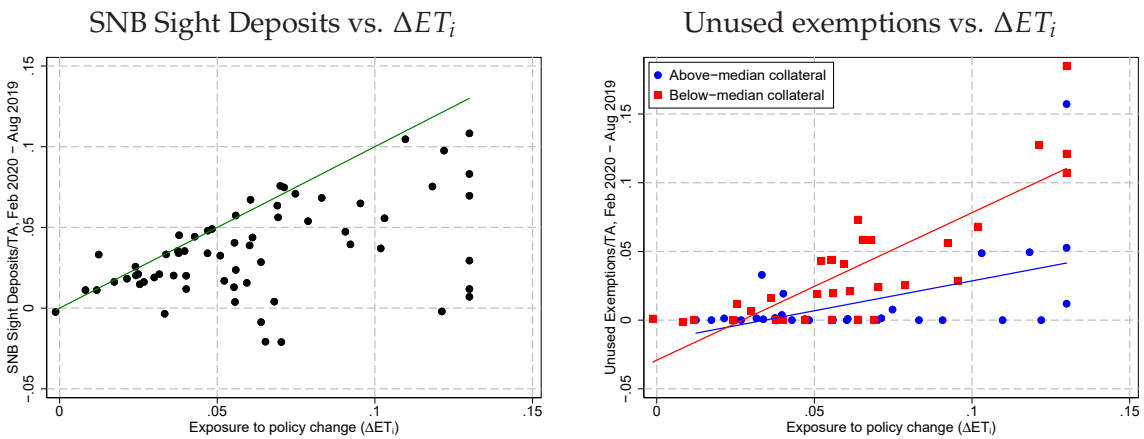
[27] For interbank liabilities and client deposits, we focus on the overall positions (all countries, all currencies); however, if we instead restrict our focus to values for banks and clients located in Switzerland and positions denominated in Swiss francs, we obtain similar results.

### 4.3 The importance of access to the interbank market

Qualitatively, the results in the previous two subsections are in line with what we would expect: banks that benefited from larger increases in exemptions increased their SNB sight deposits by more and they funded this increase through additional interbank borrowing and deposits.

However, the magnitude of the effects on SNB sight deposits is surprisingly small, especially within retail banks (which, as a group, benefitted from substantial increases in exemptions). This result is illustrated in Figure 4. The left panel shows the change in a bank's exemption threshold $\Delta ET_i$ on the horizontal axis and the change in sight deposit holdings on the vertical axis. The changes are calculated over the entire post-treatment period from August 2019 to February 2020 and are again normalized by total assets as of August 2019. We focus on those banks whose SNB sight deposits as of August 2019 were below the new exemption threshold—meaning they had an incentive to increase their sight deposits. Most observations lie below the 45 degree line, reflecting the fact that banks did not fully use their new exemption amounts.

**Figure 4:** Increase in SNB sight deposits and unused exemptions plotted against $\Delta ET_i$




Note: The left panel shows the scatter plot of a bank's change in SNB sight deposits (divided by total assets as of August 2019) between August 2019 and February 2020 against its $\Delta ET_i$. The right panel plots a bank's change in unused exemptions (normalized by total assets as of August 2019) against $\Delta ET_i$, separating banks into two groups based on their holdings of repo-eligible collateral (relative to total assets) as of August 2019.

A likely explanation for this lack of "utilization" of the increased exemptions is that some banks were unwilling or unable to borrow money on the secured interbank (repo) market, which is the quickest way to obtain funds that could then be deposited at the SNB. A bank may be unable to borrow (enough), in particular, if it does not have sufficient collateral available that could be pledged in a repo transaction. To gain a sense for whether this explanation is likely to have merit,

the right panel of Figure 4 plots the change in unused exemptions (normalized by total assets as of August 2019) against the change in a bank's exemption threshold $\Delta ET_i$. We separate the banks in two groups, depending on whether their collateral holdings (measured as described in Section 3) were above or below the median in this sample in August 2019. A clear pattern is visible: for those banks with below-median collateral, there is a strong positive relation between $\Delta ET_i$ and unused exemptions, suggesting that these banks could not attract enough funding to fully use their larger exemptions. For banks with above-median collateral, the relationship between $\Delta ET_i$ and the increase in unused exemptions is much weaker, indicating that they were better able to take advantage of the higher exemptions via funding in the interbank market.

We study the importance of collateral for SNB sight deposit holdings, interbank borrowing, and funding through customer deposits more formally in Table 4. There, we report regressions where our explanatory variables of interest are further interacted with a measure of the collateral that a bank had available prior to the announcement of the policy. This collateral measure is standardized within each sample to have a mean of zero and a standard deviation of one to make the interaction coefficients easier to interpret. The coefficient of interest is the triple interaction Post $\times \Delta$ET$\times$ Coll.

Our first dependent variable is the difference between available exemptions and SNB sight deposits (normalized by total assets in August 2019), which measures the degree to which a bank leaves available exemptions unused (columns 1-3). Banks with more collateral tend to make better use of their increased exemption amounts. This is particularly true for retail banks, where we have previously observed that the effect of an increase in exemption amounts on SNB sight deposits was weaker. For a retail bank with average collateral, an increase in ET by one percent of total assets leads to an increase in unused exemptions of 0.82 percentage points over the period October 2019-February 2020. However, for a retail bank with collateral holdings that are one standard deviation above the group average, the increase in unused exemptions is only 0.5 percentage points (0.818-0.312). For wealth management banks, the magnitude of the coefficient of interest is much smaller and is not statistically significant. However, the group of wealth management banks tends to utilize its exemption amount better than retail banks, as many of them already had SNB sight deposits exceeding the new exemption amounts prior to the policy change.[28]

As noted above, we use the amount of available collateral as a proxy for a bank's ability or willingness to participate in the interbank market. Accordingly, banks with little collateral borrow

[28]Examining the period after the exemption increases, the 75th (90th) percentile of unused exemptions in the retail sample is 0.047 (0.097); for the wealth management banks, it is 0 (0.005).

less in the interbank market and are, thus, less able to utilize their exemption amounts (columns 4-6). Again, the role of collateral is primarily visible for retail banks. Retail banks with high collateral holdings increase their net interbank borrowing significantly more in response to an increase in exemptions, although the relation is clearly less than one to one. Given a one percentage point increase in $\Delta$ ET, a retail bank with collateral holdings that are one standard deviation above the average increased its net interbank borrowing by 0.27 percent ($= 0.066 + 0.206$) of total assets in August 2019.[29] These results on the use of exemptions and interbank borrowing as a function of available collateral are consistent with those of Fuhrer et al. (2020a), who document that over the period from January 2015 (the beginning of the negative interest rate period) to December 2019, banks with limited collateral were less able to use the interbank market to optimize their SNB sight deposit holdings relative to their exemptions.

The reduced effect on interbank borrowing for banks with less collateral is to some extent mitigated by stronger growth in customer deposits (columns 7-9). Retail banks with less collateral exhibit significantly larger increases in customer deposits in response to a given increase in exemptions. This indicates that banks with less collateral compensate for their limited access to interbank funding by attracting more deposits.

Given that rates on customer deposits are approximately zero due to the prevalent zero lower bound on deposit rates, banks likely derive little or no immediate monetary gain from increasing their deposits and "parking" them as SNB sight deposits (also at 0% up to the exemption threshold). However, franchise value considerations may explain why banks nonetheless choose to grow deposits; attracting new customers or maintaining existing relationships may generate profits from future business and allow banks to invest in more illiquid assets (e.g., Hanson et al., 2015; Egan et al., 2017; Drechsler et al., 2021). Increased exemption amounts make such "investments" in customer relationships less costly.

## 5 Effects on lending

We now complement the aggregate balance sheet regressions with an analysis of corporate lending decisions using granular loan level data. This will allow us to control for heterogeneous demand effects.

[29] In Appendix Table A.1, we directly split banks into those that, prior to the announcement, are likely to have an incentive to increase their SNB sight deposit holdings from November 2019 onward and those whose SNB sight deposits already exceeded the new exemption thresholds (so they have no incentive to increase their sight deposits). As expected, it is the former group that accounts for the results on net interbank borrowing.

Our data source is the SNB Lending Rate Statistic, which covers the twenty banks with the largest market share in the corporate loan segment.[30] These banks cover approximately 80% of corporate loans in Switzerland. They all belong to the group of retail banks. Banks report all new loan agreements with nonfinancial firms that exceed CHF 50,000. The data contain information on various lending terms and borrower characteristics and also cover off-balance-sheet loan commitments. For each loan agreement, we know the exact date when it is paid out.

Our regression specification is similar to that of Schelling and Towbin (2020):

$$y_i = \alpha_{j,f,l} + \gamma_{f,l,t} + \beta_{post}(\Delta ET_j \times I(t \geq 20Sept2019)) + \varepsilon_i, \tag{3}$$

where $i$ indexes an individual loan, granted by bank $j$ to a firm of type $f$ in month $t$, with $l$ indexing the loan type. $\alpha_{j,f,l}$ denotes bank $\times$ firm type $\times$ loan type fixed effects, which control for time-invariant unobserved bank heterogeneity by firm and loan type. $\gamma_{f,l,t}$ denotes firm type $\times$ loan type $\times$ month fixed effects, which control for time-varying demand effects. We construct firm types as in Schelling and Towbin (2020), combining information on a firm's sector (81 sectors), location (26 cantons, administrative divisions in Switzerland) and number of employees (4 categories).[31] We require every firm type in a given period to receive a loan from at least two distinct banks, à la Khwaja and Mian (2008). We distinguish between the following three loan types: loans with a defined maturity, loans with undefined maturity that are paid out in full, and credit commitments with undefined maturity. Given the daily frequency of the data, our treatment dummy takes a value of one after the announcement day on 19 September 2019. Our sample runs from 19 March 2019 to 19 February 2020.[32]

As the dependent variable $y$, we consider the following four loan terms: the lending spread, defined as the difference between the interest charged on a loan and the yield on a Swiss government bond with the same maturity, the size of the loan (in logs), whether the loan is issued at a fixed rate, and the maturity (in logs).[33]

The results shown in Table 5 suggest that the effects of the change in exemptions on lending behavior are modest. If anything, banks that benefit from a larger increase in the exemption threshold become more restrictive in their lending policies and take less risk. Banks with a high $\Delta$ET tend to

[30] Reporting forms are available at `https://emi.snb.ch/de/emi/KREDZ` (German and French only).

[31] See Auer and Ongena (2019) and Degryse et al. (2019) for similar approaches.

[32] For symmetry reasons, a "month" $t$ always runs from the 20th of a calendar month to the 19th of the following calendar month.

[33] The regressions with maturity as the dependent variable restrict the sample to observations with defined maturity.

increase their lending spreads for a given firm type and loan type by more than their peers (column 1), suggesting that they are tightening their loan supply. However, the size of the effect is relatively small; a 10 percentage point larger increase in ΔET increases loans spreads by only approximately 3 basis points, and the effect is only marginally statistically significant. The results for other loan terms also point towards less risk taking, as banks with high ΔET values become less likely to issue fixed-rate loans (column 5), thereby reducing interest rate risk, and shorten the maturity of their loans (column 7). We do not find any statistically significant effect on loan size (column 3).

These results do not support a bank capital or net worth channel, which would imply an increase in lending as banks' profitability is improved. They are instead consistent with a risk-taking channel, where banks with less profitability pressure do not need to take as much risk to reach their profit targets. Additional specifications in which we interact the treatment variable with our collateral measure confirm such an interpretation. For a given increase in the exemption threshold, banks with more collateral increase their lending spreads by more (column 2). A plausible explanation is that because these banks could increase their profitability by more (see Section 7.2), they become less subject to profitability pressures and therefore reduce their risk taking.

Our results are consistent with the findings of Schelling and Towbin (2020), who study the period around January 2015, when negative interest rates were introduced in Switzerland. As in the present study, banks with a lower amount of charged SNB sight deposits tended to increase lending spreads, were less likely to issues fixed rate loans, and shortened their maturity.[34] Similarly, looking at the same episode, Basten and Mariathasan (2020) find that banks with larger shares of charged reserves after January 2015 increase their risk taking, based on various summary metrics from regulatory reports.

## 6 Effects on deposit pricing

One rationale behind providing (higher) exemptions from negative rates to banks is that these exemptions may reduce the propensity of banks to pass on the negative rates to their depositors (e.g., Lenz and Schlegel, 2020). In this section, we test this rationale. Our results on the deposit volumes above showed that those banks with larger increases in exemptions (i.e., higher ΔET) increase their customer deposits relative to other banks. We predict that they attract these deposits

[34] Schelling and Towbin find that these effects are present in the short term and disappear over the medium term. Given the start of the Covid-19 pandemic in March 2020, we are not able to cleanly study medium run developments following the 2019 policy change.

by offering higher interest rates.[35] The effect should be stronger for banks that are less able to borrow in the interbank market, i.e., those banks with little collateral. In the Swiss context, where only a small share of deposits still earn positive interest, the most salient metric is how large the share of deposits is that a bank charges negative rates to (rather than 0%).

From the SNB's comprehensive year-end statistic, we observe at the end of each year the shares of a bank's deposits that lie in different interest rate bands (e.g., [-0.5,-0.25), [-0.25,0), [0,0.25), etc.). Thus, we can calculate the share of deposits on which a bank charged negative rates at the end of 2019 and compare it to the same bank's share at the end of 2018.[36]

First, we present some descriptive evidence. The left panel of Figure 5 shows the cumulative distributions of bank-level shares of total deposits with negative interest rates in 2018 and 2019.[37] These distributions do not appear to be very different; in both years, roughly one-third of banks did not have any deposits with negative rates, and the median share of negative-rate deposits was below 2%, suggesting that the typical Swiss bank was still reluctant to pass on negative rates to their customers almost five years after negative policy rates were introduced. However, there is substantial heterogeneity; in both years, approximately 10% of banks charge negative rates on 40% or more of their deposits.

The right panel of the figure shows that even though the overall distributions in the levels do not appear to be different, many banks are moving around in the distribution across the two years (meaning they have non-zero changes in negative-rate-deposits shares). The figure also shows that the increases in negative-rate shares from 2018 to 2019 were more pronounced for banks with below-median $\Delta$ET; among those banks, 20% increased the negative-rate share by five percentage points or more, while the same occurred for only 6% of banks with above-median $\Delta$ET. This is consistent with the premise that increases in exemptions reduced the propensity of banks to charge negative rates on larger shares of their deposits.[38]

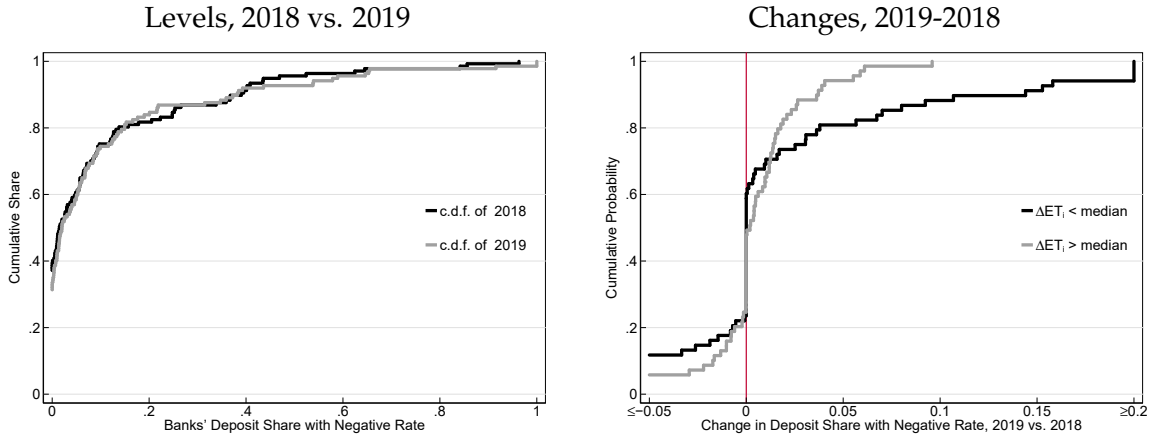
[35] Of course, it might also be possible for banks to attract additional deposits without offering better interest rates, for instance, through reducing account fees or offering additional services. Due to data limitations, we do not explore this dimension further.

[36] We do not observe the average rate a bank pays on its deposits. An alternative might be to examine banks' advertised deposit rates, but in recent years, these are unlikely to be very informative, as many banks have certain maximum deposit amounts up to which they do not charge negative rates (so the headline rate would still be 0%) and/or grant higher maximum amounts to depositors who also do other business with the bank.

[37] Total deposits are from domestic residents, are denominated in Swiss francs, and include a wide variety of deposit products, such as sight deposits, callable deposits and deposits with a fixed maturity. Pension provisions are excluded.

[38] The patterns in aggregate data are also consistent with this view: while from 2017 to 2018, the overall share of deposits with negative rates increased by 2.1 percentage points from 5.4% to 7.5% (so the relative increase was 37%), the increase from 2018 to 2019 was only 0.9 percentage points (or 12% in relative terms), to 8.4%. Data source: https://data.snb.ch/en/warehouse/BSTA#!/cube/BSTA@SNB.JAHR_UEA.BIL.PAS.VKE.KOV; series for "Banks in Switzerland excluding private bankers and excluding branches of foreign banks."

**Figure 5:** Bank-level share of deposits with negative interest rates




Note: The left panel shows the cumulative distribution of bank-level shares of deposits with interest rate $< 0$, separately for 2018 and 2019. The right panel shows the cumulative distribution of the change in this share between 2018 and 2019, winsorizing changes at -5 and +20 percentage points. Data source: banks' comprehensive year-end statistics ("JAHR"); we use total deposits excluding pension provisions.

We now study this more formally through cross-sectional regressions. In our baseline specification, we model the share of deposits with negative interest rates as of end-2019 of a bank $i$ as follows:

$$\mathbb{E}\left(s_{i,2019} \mid \Delta ET_i, s_{i,2018}\right) = \Phi\left(\alpha + \beta \Delta ET_i + \gamma s_{i,2018} + \kappa I(s_{i,2018} = 0)\right). \tag{4}$$

Thus, the share is modeled as depending on its lagged value (with a separate dummy for those banks that had no deposits at negative rates at the end of 2018), as well as on $\Delta ET_i$. Since $s$ is a share that can take values in [0,1], we use a fractional probit model (Papke and Wooldridge, 1996).[39] In a second specification, we then further interact $\Delta ET_i$ with a bank's repo-eligible collateral as of August 2019, as a proxy for its ability to be active in the interbank market. As noted above, we predict a negative coefficient on $\Delta ET$ and a positive coefficient on the interaction between $\Delta ET$ and collateral.

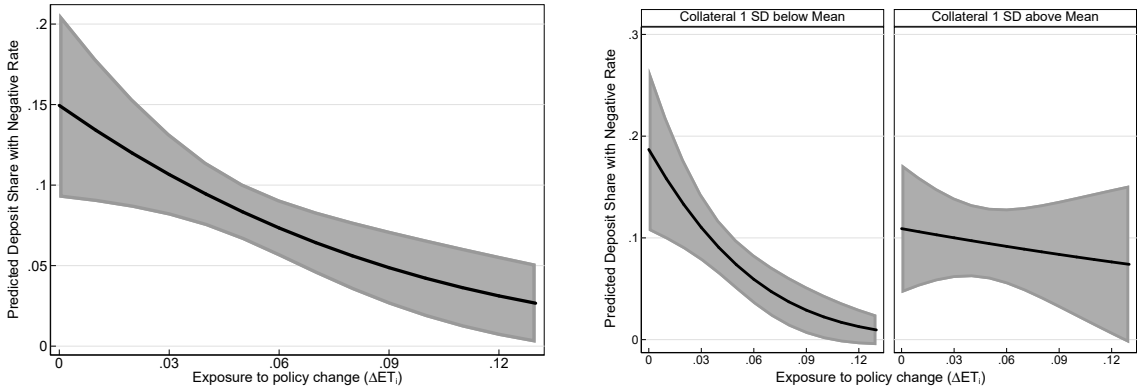
The results reported in Table 6 are in line with these predictions, both for the entire sample and for the two subsamples of retail and wealth management banks. Given that the model is non-linear, the regression coefficients do not have a straightforward interpretation. We therefore illustrate their implications in Figure 6.The left panel shows the predicted share of deposits with a negative rate as a function of $\Delta ET$, for a hypothetical bank with $s_{i,end2018}$ at the sample average. We see a clear decreasing pattern of substantial magnitude; the predicted negative-rate share falls

[39]The results are very similar with a fractional logit model, suggesting that the functional form assumption is not driving our results. We have further assessed quadratic or cubic functions of $s_{i,end2018}$ as controls, with similar results.

by approximately 10 percentage points as we move from $\Delta ET = 0$ (no change in exemptions) to $\Delta ET = 0.1$ (a 10% increase in exemptions relative to assets). The right panel repeats the same exercise separately for a hypothetical bank with collateral one standard deviation below or above the average. The decreasing pattern is even stronger for the low-collateral bank, while for the high-collateral bank, $\Delta ET$ plays much less of a role in affecting the share of deposits with negative rates.[40]

In summary, the evidence on differential changes in deposit rates (specifically, the share of deposits that is charged a negative rate) is in line with the evidence on deposit volumes presented earlier—banks with larger increases in exemptions are less likely to charge negative rates, especially when they do not have much collateral that can be used to borrow in the interbank market (a substitute for growing deposits).[41]

**Figure 6:** Predicted shares of deposits with negative rates as a function of $\Delta ET_i$, based on the fractional probit regressions.




Note: The predicted values and 95% confidence intervals from the fractional probit regression results shown in columns (1) and (2) of Table 6. In the right panel, the predictions are shown separately for banks with high vs. low collateral prior to the policy change.

# 7 Effects on liquidity and profitability

In this section, we study two additional outcomes of particular interest from a financial stability perspective, namely, banks' liquidity situation and profitability.

[40] Appendix Figure A.5 presents the same plot for retail banks, where the qualitative patterns are the same, while the magnitudes of the effects are somewhat smaller.

[41] In Appendix B, we study another aspect of bank optimization related to deposits, finding some evidence that after the September 2019 announcement, banks reallocate deposits toward categories that lead to higher minimum reserve requirements and, therefore, higher future exemptions.

### 7.1 Liquidity situation

Our results regarding balance sheet developments have shown that banks that benefit from a larger increase in the exemption threshold increase their SNB sight deposits by more. They primarily fund these additional assets either through an increase in interbank borrowing or through an increase in customer deposits.

In this section, we examine how these patterns affect the liquidity situation of a bank. The key regulatory metric is the Liquidity Coverage Ratio (LCR), which is the defined as the ratio of High Quality Liquid Assets (HQLA) divided by projected Net Cash Outflows (NCO) in a stress situation. We will separately examine the changes in the numerator and the denominator of this ratio, in both cases normalized by total assets as of August 2019. HQLA consist of central bank reserves, as well as highly rated and liquid securities. Net Outflows—defined as the difference between projected inflows and outflows—are calculated based on a regulatory defined scenario over thirty days, where outflow rates depend on the stability of the funding source.[42] In normal times, banks need to achieve an LCR of at least 100 percent, meaning that HQLA exceed NCO. We define a bank's HQLA surplus as the difference between HQLA and NCO, normalized by total assets as of August 2019.[43]

The results in Table 7 show that banks with large increases in the exemption threshold tend to improve their liquidity situation relative to peers, especially for retail banks. As expected, banks with a larger increase in exemptions increase their HQLA, in line with the observed increase in SNB sight deposits (columns 1-3). The effect is significant for all bank samples. However, since these additional assets need to be funded, we also observe larger NCO for these banks (columns 4-6). Overall, we observe a statistically significant increase in the HQLA surplus for retail banks, while the increase for wealth management banks is not statistically significant (columns 7-9).

### 7.2 Profitability

Our ability to directly examine the differential impacts of the policy change on bank profitability is limited, given that profitability data is reported only semi-annually and that we can only use one post-change observation per bank (2019:H2), since further changes to the exemption thresh-

[42] For example, retail deposits are subject to lower outflow rates than unsecured short-term whole sale funding. See Basel Committee on Banking Supervision (2013) for details.

[43] For our purposes, we prefer the HQLA surplus as a measure of the banks liquidity situation, since the LCR ($= HQLA/NCO$) is known to be quite volatile and outlier-prone, given that the denominator (NCO) is the difference between two potentially large quantities. Indeed, if we use the LCR as our dependent variable in the regressions in this section, the effects are not statistically significant.

olds along with a Covid-related refinancing facility were subsequently introduced in 2020:H1. In addition, even for 2019:H2, the changed exemption thresholds were only applied for two out of six months (November and December). Despite these data limitation, we find evidence that the impact of the change in thresholds directionally manifested itself in the profitability data as expected.

The variable we focus on is net interest income (NII), normalized by total assets.[44] We regress a bank's NII in the second half of 2019 on $\Delta$ET, controlling for NII from the two previous half-years. The results are shown in Table 8. Column (1) shows that over our full sample of banks, we obtain a positive and significant coefficient. This coefficient is somewhat larger (but not statistically significantly) than the theoretically predicted coefficient of 0.125 ($= 0.75\%/12 * 2$) if banks were able to fund additional SNB sight deposits at the short term market rate of $-0.75\%$. The following two columns indicate that when examining the subsamples, the coefficient is much smaller for retail banks. However, this again seems driven by heterogeneity in collateral; in column (4), we interact our previously discussed (standardized) collateral measure with $\Delta$ET and find a positive coefficient. This finding means that for retail banks with sufficient available collateral, an increase in ET did lead to larger net interest income in 2019.

## 8 Discussion and conclusion

We have used a unique policy event to study banks' responses to reserve tiering in a negative interest rate environment. In line with expectations, banks that benefit from larger increases in exemption amounts expand their sight deposit holdings at the SNB. There is also some evidence for asset substitution (reducing other assets to increase central bank reserves), but these effects are quantitatively small and often are not statistically significant. Therefore, banks with larger exemptions grow their balance sheets relative to their peers. How the larger balance sheet is funded depends importantly on a bank's collateral situation, a proxy for its access to interbank funding. Banks with large amounts of collateral tend to fund additional central bank reserves primarily with interbank borrowing, whereas those with little collateral instead tend to use customer deposits as a funding source. These differences are also reflected in the pricing of customer deposits; the latter group of banks is less likely to charge negative interest rates on customer deposits. The effects of reserve tiering on lending behavior are moderate; if anything, banks with larger exemption amounts take fewer risks and charge higher lending spreads.

[44] The reporting forms from which the data are drawn are available at https://emi.snb.ch/de/emi/AURX. We calculate NII as the difference between *Zins- und Diskontertrag* and *Zinsaufwand*.

Beyond shedding light on the effects of reserve tiering, our results more generally improve the understanding of bank behavior in a negative interest rate environment and the associated theoretical mechanisms. First, consistent with earlier studies, our results on lending behavior imply an important role for the risk-taking channel, where less profitable banks take more risk; in our setting, it appears to outweigh the bank capital channel, where less profitable banks are capital constrained and lend less. The flip side of the fact that the reversal rate (Brunnermeier and Koby, 2018) has not been reached and rate cuts in a negative rate environment still stimulate lending (Brandao-Marques et al., 2021; Tenreyro, 2021) is that boosts to bank profitability do not automatically stimulate lending. However, it is conceivable that the relative strength of the two theoretical channels will change in a crisis situation, for example, when banks are capital constrained. The policy change we study occurred during a calm period with no financial stress and with a robustly capitalized banking system. Furthermore, our sample period is relatively short, and it is possible that the effect of better profitability on lending only builds over time.

Second, our results indicate that the franchise value of a customer deposit base is an important factor in understanding bank behavior in a negative rate environment. Banks appear reluctant to charge negative interest on deposits, among other things, because lower deposits reduce the value of their franchise. However, opportunity costs still matter. Banks are more inclined to grow their customer deposits if they benefit from large amounts of central bank reserves exempted from negative interest rates, especially if interbank funding is less accessible.

Third, our study highlights that frictions in interbank markets affect the transmission of negative interest rates and the extent to which exemptions are utilized (see also Fuhrer et al., 2020a). It is likely that those frictions would become more important in a market stress situation. When frictions in the interbank market rise, it is plausible that customer deposits will become a more important source to fund additional central banks reserves and that in the aggregate, a larger share of exemptions remains unused.

In terms of policy implications, our results suggest that exempting a larger part of banks' central bank reserves from negative interest rates does not stimulate lending, at least in calm times. It does, however, seem to have beneficial effects for financial stability. For banks that enjoy higher exemptions, we find reductions in bank risk taking, higher profitability, and a better liquidity situation. All of these effects are to some extent mediated by a bank's ability to participate in the interbank market. Access to the interbank market and collateral availability are thus important factors for policy makers to bear in mind when designing reserve tiering systems.

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**Table 1:** Descriptive statistics as of August 2019

| | All | | Retail | | WM | |
|---|---|---|---|---|---|---|
| | mean | sd | mean | sd | mean | sd |
| Total Assets (CHF bn) | 22.88 | 76.49 | 28.96 | 61.93 | 19.09 | 84.44 |
| *Assets, as share of TA:* | | | | | | |
| SNB Sight Deposits | 0.20 | 0.16 | 0.11 | 0.04 | 0.26 | 0.18 |
| Interbank Claims | 0.12 | 0.12 | 0.03 | 0.03 | 0.18 | 0.12 |
| Mortgages | 0.31 | 0.34 | 0.73 | 0.10 | 0.06 | 0.10 |
| Other Loans | 0.21 | 0.18 | 0.07 | 0.04 | 0.29 | 0.18 |
| Securities | 0.08 | 0.10 | 0.04 | 0.02 | 0.10 | 0.12 |
| *Liabilities, as share of TA:* | | | | | | |
| Interbank Liabilities | 0.12 | 0.16 | 0.08 | 0.12 | 0.15 | 0.18 |
| Customer Deposits | 0.62 | 0.18 | 0.59 | 0.11 | 0.64 | 0.22 |
| Cov. Bonds+Other Debt | 0.06 | 0.09 | 0.15 | 0.07 | 0.01 | 0.04 |
| $\Delta$ ET | 0.03 | 0.08 | 0.06 | 0.04 | 0.00 | 0.08 |
| (wins.) | 0.03 | 0.04 | 0.06 | 0.04 | 0.01 | 0.04 |
| Collateral | 0.04 | 0.08 | 0.02 | 0.02 | 0.05 | 0.09 |
| (wins.) | 0.03 | 0.04 | 0.02 | 0.02 | 0.04 | 0.05 |

*Notes:* Assets and liabilities are sourced from the SNBs comprehensive monthly balance sheet statistic. $\Delta ET$ is the change in the bank-individual exemption threshold, which is defined as the difference between the new exemption threshold (November 2019) and the old exemption threshold (August 2019), normalized by total assets before the policy event (August 2019, see equation 1). Collateral is sourced from the Liquidity Coverage Ratio reporting and comprises high quality liquid assets (HQLA 1 and 2a securities) net of those pledged for the SNBs liquidity-shortage financing facility. $\Delta ET$ and collateral are winsorized at the top and bottom 5 values. Regarding the bank samples, "All" comprises the whole sample of banks ($N = 143$), "Retail banks" ($N = 55$) have a mortgage to assets ratio of over 50% as of August 2019 or are backed by the local government (cantons), and the rest are labeled "wealth management banks" (or "WM"; $N = 88$).

**Table 2:** DiD regression results: Asset side

| | SNB Sight Deposits | | | Interbank Claims | | | Mortgages&Other Loans | | | Securities | | | Total Assets | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) | (13) | (14) | (15) |
| Post $\times\Delta$ ET | 0.707*** | 0.316*** | 0.635** | -0.087 | -0.095** | -0.006 | 0.019 | -0.002 | -0.001 | -0.070 | -0.009 | -0.141 | 0.547*** | 0.189** | 0.422 |
| | (0.168) | (0.113) | (0.315) | (0.111) | (0.047) | (0.221) | (0.066) | (0.045) | (0.113) | (0.067) | (0.011) | (0.115) | (0.177) | (0.090) | (0.317) |
| Sept $\times\Delta$ ET | 0.056 | 0.073 | -0.050 | 0.087 | -0.003 | 0.192 | -0.004 | 0.003 | 0.014 | -0.022 | 0.000 | -0.046 | 0.100 | 0.071 | 0.078 |
| | (0.101) | (0.045) | (0.181) | (0.102) | (0.012) | (0.180) | (0.055) | (0.022) | (0.092) | (0.036) | (0.006) | (0.064) | (0.112) | (0.047) | (0.197) |
| Month FEs | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Bank FEs | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Sample | All | Retail | WM | All | Retail | WM | All | Retail | WM | All | Retail | WM | All | Retail | WM |
| Nr Banks | 143 | 55 | 88 | 143 | 55 | 88 | 143 | 55 | 88 | 143 | 55 | 88 | 143 | 55 | 88 |
| Mean Dep. Var. | 0.20 | 0.12 | 0.25 | 0.13 | 0.03 | 0.19 | 0.52 | 0.80 | 0.35 | 0.08 | 0.04 | 0.10 | 1.01 | 1.01 | 1.00 |
| SD Dep. Var. | 0.15 | 0.04 | 0.18 | 0.13 | 0.03 | 0.13 | 0.27 | 0.08 | 0.20 | 0.10 | 0.02 | 0.12 | 0.07 | 0.03 | 0.09 |
| R2 | 0.910 | 0.884 | 0.894 | 0.920 | 0.929 | 0.876 | 0.990 | 0.989 | 0.971 | 0.985 | 0.993 | 0.984 | 0.423 | 0.738 | 0.417 |
| R2 within | 0.094 | 0.132 | 0.041 | 0.004 | 0.036 | 0.002 | 0.000 | 0.000 | 0.000 | 0.014 | 0.006 | 0.025 | 0.040 | 0.043 | 0.012 |
| Obs. | 1570 | 605 | 965 | 1570 | 605 | 965 | 1570 | 605 | 965 | 1570 | 605 | 965 | 1570 | 605 | 965 |

Standard errors (clustered by bank) in parentheses. * p<0.1, ** p<0.05, *** p<0.01.

*Notes: Post* is a dummy equal to 1 from October 2019 onward; *Sept* is a dummy equal to 1 for September 2019. $\Delta ET$ denotes the exposure to the change in the bank-individual exemption threshold. This change is defined as the difference between the new exemption threshold (November 2019) and the old exemption threshold (August 2019, see equation 1). $\Delta ET$ and the dependent variables are normalized by total assets before the policy event (August 2019). Regarding the bank samples, "All" comprises the whole sample of banks, "Retail banks" have a mortgage to assets ratio of over 50% as of August 2019 or are backed by local government (cantons) and the rest are labeled "wealth management banks" (WM). Data source: SNB comprehensive monthly balance sheet statistic.

**Table 3:** DiD regression results: Liability side

| | Interbank Liabilities | | | | | | Customer Deposits | | | Covered Bonds & Other Debt | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Gross | | | Net | | | | | | | | |
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) |
| Post ×Δ ET | 0.309*** | 0.014 | 0.444** | 0.397*** | 0.109 | 0.450* | 0.206 | 0.148*** | 0.006 | 0.050*** | 0.039 | -0.002 |
| | (0.108) | (0.075) | (0.177) | (0.131) | (0.090) | (0.251) | (0.130) | (0.052) | (0.234) | (0.018) | (0.026) | (0.017) |
| Sept ×Δ ET | 0.101* | 0.047 | 0.145 | 0.014 | 0.051 | -0.047 | 0.041 | 0.017 | -0.012 | 0.011 | 0.014 | -0.003 |
| | (0.057) | (0.044) | (0.088) | (0.094) | (0.042) | (0.161) | (0.092) | (0.031) | (0.169) | (0.012) | (0.015) | (0.011) |
| Month FEs | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Bank FEs | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Sample | All | Retail | WM | All | Retail | WM | All | Retail | WM | All | Retail | WM |
| Nr Banks | 143 | 55 | 88 | 143 | 55 | 88 | 143 | 55 | 88 | 143 | 55 | 88 |
| Mean Dep. Var. | 0.13 | 0.09 | 0.15 | -0.00 | 0.06 | -0.04 | 0.62 | 0.59 | 0.64 | 0.06 | 0.15 | 0.01 |
| SD Dep. Var. | 0.17 | 0.13 | 0.18 | 0.20 | 0.12 | 0.22 | 0.19 | 0.10 | 0.22 | 0.09 | 0.07 | 0.04 |
| R2 | 0.961 | 0.991 | 0.950 | 0.947 | 0.987 | 0.938 | 0.954 | 0.987 | 0.950 | 0.994 | 0.995 | 0.966 |
| R2 within | 0.036 | 0.002 | 0.036 | 0.034 | 0.019 | 0.022 | 0.011 | 0.044 | 0.000 | 0.022 | 0.019 | 0.000 |
| Obs. | 1570 | 605 | 965 | 1570 | 605 | 965 | 1570 | 605 | 965 | 1570 | 605 | 965 |

Standard errors (clustered by bank) in parentheses. * p<.1, ** p<.05, *** p<.01

*Notes:* Net interbank liabilities are the difference between interbank liabilities and interbank assets. *Post* is a dummy equal to 1 from October 2019 onward; *Sept* is a dummy equal to 1 for September 2019. $\Delta ET$ denotes the exposure to the change in the bank-individual exemption threshold. This change is defined as the difference between the new exemption threshold (November 2019) and the old exemption threshold (August 2019, see equation 1). $\Delta ET$ and the dependent variables are normalized by total assets before the policy event (August 2019). Regarding the bank samples, "All" comprises the whole sample of banks, "Retail banks" have a mortgage to assets ratio of over 50% as of August 2019 or are backed by the local government (cantons), and the rest are labeled "wealth management banks" (WM). Data source: SNB comprehensive monthly balance sheet statistic.

**Table 4:** Triple-differences regression results: The importance of collateral

| | Unused Exemptions | | | Net Interbank Liabilities | | | Customer Deposits | | |
|---|---|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) |
| Post ×Δ ET | 0.342*** | 0.818*** | 0.100 | 0.410*** | 0.066 | 0.450* | 0.200 | 0.172*** | -0.021 |
| | (0.067) | (0.105) | (0.068) | (0.131) | (0.075) | (0.251) | (0.127) | (0.055) | (0.230) |
| Post × Coll. | 0.001 | 0.007 | -0.001 | 0.001 | -0.005 | 0.003 | 0.011 | 0.007** | 0.014 |
| | (0.001) | (0.004) | (0.001) | (0.009) | (0.004) | (0.012) | (0.008) | (0.003) | (0.010) |
| Post ×ΔET× Coll. | -0.179*** | -0.312*** | -0.064 | 0.134 | 0.206*** | 0.118 | -0.246 | -0.175*** | -0.210 |
| | (0.058) | (0.095) | (0.064) | (0.156) | (0.059) | (0.223) | (0.152) | (0.058) | (0.209) |
| Sept ×Δ ET | -0.022 | -0.001 | -0.019 | 0.019 | 0.042 | -0.047 | 0.031 | 0.027 | -0.032 |
| | (0.031) | (0.024) | (0.059) | (0.095) | (0.037) | (0.165) | (0.091) | (0.030) | (0.165) |
| Sept × Coll. | -0.002 | -0.001 | -0.002 | 0.001 | -0.000 | 0.001 | 0.007 | 0.002 | 0.009 |
| | (0.001) | (0.001) | (0.002) | (0.007) | (0.002) | (0.009) | (0.006) | (0.002) | (0.008) |
| Sept ×ΔET× Coll. | 0.031 | 0.020 | 0.034 | 0.039 | 0.032 | 0.067 | -0.220* | -0.064*** | -0.267 |
| | (0.035) | (0.015) | (0.058) | (0.118) | (0.047) | (0.156) | (0.130) | (0.023) | (0.176) |
| Month FEs | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Bank FEs | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Sample | All | Retail | WM | All | Retail | WM | All | Retail | WM |
| Nr Banks | 143 | 55 | 88 | 143 | 55 | 88 | 143 | 55 | 88 |
| Mean Dep. Var. | 0.01 | 0.01 | 0.00 | -0.00 | 0.06 | -0.04 | 0.62 | 0.59 | 0.64 |
| SD Dep. Var. | 0.02 | 0.03 | 0.01 | 0.20 | 0.12 | 0.22 | 0.19 | 0.10 | 0.22 |
| R2 | 0.618 | 0.762 | 0.551 | 0.947 | 0.989 | 0.938 | 0.955 | 0.987 | 0.951 |
| R2 within | 0.269 | 0.490 | 0.063 | 0.038 | 0.117 | 0.025 | 0.027 | 0.097 | 0.017 |
| Obs. | 1570 | 605 | 965 | 1570 | 605 | 965 | 1570 | 605 | 965 |

Standard errors (clustered by bank) in parentheses. * p<.1, ** p<.05, *** p<.01

*Notes:* Unused exemptions are defined as $max$(ET−SNB Sight Deposits, 0). Net Interbank Liabilities are the difference between interbank liabilities and interbank assets. *Post* is a dummy equal to 1 from October 2019 onward; *Sept* is a dummy equal to 1 for September 2019. $\Delta ET$ denotes the exposure to the change in the bank-individual exemption threshold. This change is defined as the difference between the new exemption threshold (November 2019) and the old exemption threshold (August 2019, see equation 1). *Coll.* is a measure of a bank's freely available collateral as of August 2019 and comprises high quality liquid assets (HQLA 1 and 2a securities) net of those pledged for the SNBs liquidity-shortage financing facility. $\Delta ET$, *Coll.*, and the dependent variables are normalized by total assets before the policy event (August 2019). *Coll.* is then standardized so that the mean equals zero and the standard deviation equals 1. Regarding the bank samples, "All" comprises the whole sample of banks, "Retail banks" have a mortgage to assets ratio of over 50% as of August 2019 or are backed by the local government (cantons), and the rest are labeled "wealth management banks" (WM).

**Table 5:** Loan level regression: Lending terms

| | Lending spread (%) | | Log(loan size) | | Fixed rate (0/1) | | Log(maturity) | |
|---|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| Post $\times\Delta$ ET | 0.322* | 0.285 | -0.133 | -0.062 | -0.349*** | -0.349*** | -1.169*** | -1.391*** |
| | (0.180) | (0.180) | (0.304) | (0.292) | (0.082) | (0.072) | (0.407) | (0.270) |
| Post $\times\Delta$ ET $\times$ Coll. | | 0.351** | | 0.168 | | -0.341 | | 0.335 |
| | | (0.161) | | (0.578) | | (0.212) | | (0.352) |
| Post $\times$ Coll. | | -0.009 | | -0.018 | | 0.015 | | 0.018 |
| | | (0.007) | | (0.022) | | (0.010) | | (0.033) |
| Loan-type $\times$ Firm-type $\times$ Month FEs | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Loan-type $\times$ Firm-type $\times$ Bank FEs | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Nr Banks | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 |
| Mean Dep. Var. | 2.45 | 2.45 | 6.26 | 6.26 | 0.70 | 0.70 | 5.55 | 5.55 |
| SD Dep. Var. | 1.32 | 1.32 | 1.39 | 1.39 | 0.46 | 0.46 | 1.63 | 1.63 |
| R2 | 0.859 | 0.859 | 0.558 | 0.558 | 0.758 | 0.758 | 0.568 | 0.568 |
| R2 within | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 | 0.000 | 0.000 |
| Obs. | 67393 | 67393 | 67393 | 67393 | 67393 | 67393 | 53363 | 53363 |

Standard errors (clustered by bank) in parentheses. * p<0.1, ** p<0.05, *** p<0.01.

*Notes:* Lending spread is defined as the individual loan interest rate minus the maturity-matched Swiss government bond yield, calculated based on a Nelson and Siegel (1987) term structure model. Loan size is the individual loan volume. Fixed rate is a dummy indicating whether the loan has a fixed interest rate (as opposed to a variable rate). Maturity is the maturity of an individual loan in days at the time it was granted. Loans are included if they were registered between March 20, 2019, and February 19, 2020. *Post* is a dummy equal to 1 if a loan was registered after September 19, 2019. $\Delta ET$ denotes the exposure to the change in the bank-individual exemption threshold. This change is defined as the difference between the new exemption threshold (November 2019) and the old exemption threshold (August 2019, see equation 1). *Coll.* is a measure of a bank's freely available collateral as of August 2019 and comprises high quality liquid assets (HQLA 1 and 2a securities) net of those pledged for the SNBs liquidity-shortage financing facility. $\Delta ET$ and *Coll.* are normalized by total assets before the policy event (August 2019). *Coll.* is standardized so that the mean equals zero and the standard deviation equals 1. Firm types are based on interactions of a firms sector (81 sectors), location (26 cantons, administrative divisions in Switzerland) and number of employees (4 categories). The loan types are defined as follows: loans with a defined maturity, loans with open maturity that are paid out in full, and credit commitments with an open maturity. Time FE are the indicators for the month runs from the 20th of the preceding calendar month to the 19th of the current calendar month. Data sources: SNB lending rate statistic (KREDZ), SNB comprehensive monthly balance sheet statistic, and Liquidity Coverage Ratio reporting. The lending rate statistic is reported by banks whose loans to domestic non-financial firms exceed CHF 2 bn.

**Table 6:** Share of deposits with negative interest rates at the end of 2019

| | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| Δ ET | -6.873*** | -6.423*** | -0.783 | -2.544** | -7.992*** | -6.857*** |
| | (2.353) | (2.113) | (1.293) | (1.242) | (2.995) | (2.622) |
| ΔET× Coll. | | 4.767** | | 2.638** | | 4.833* |
| | | (2.304) | | (1.029) | | (2.884) |
| Coll. | | -0.171 | | -0.048 | | -0.229* |
| | | (0.112) | | (0.068) | | (0.135) |
| Share2018 | 1.829*** | 1.892*** | 5.654*** | 5.875*** | 1.534** | 1.552** |
| | (0.608) | (0.646) | (0.643) | (0.508) | (0.665) | (0.690) |
| I(Share2018=0) | -0.587* | -0.578* | -0.618*** | -0.467*** | -0.667* | -0.691* |
| | (0.342) | (0.335) | (0.143) | (0.148) | (0.399) | (0.378) |
| Constant | -1.228*** | -1.256*** | -1.905*** | -1.873*** | -1.117*** | -1.156*** |
| | (0.169) | (0.167) | (0.099) | (0.087) | (0.208) | (0.208) |
| Sample | All | All | Retail | Retail | WM | WM |
| Mean Dep. Var. | 0.11 | 0.11 | 0.06 | 0.06 | 0.14 | 0.14 |
| SD Dep. Var. | 0.20 | 0.20 | 0.08 | 0.08 | 0.25 | 0.25 |
| Obs. | 137 | 137 | 55 | 55 | 82 | 82 |

Robust standard errors in parentheses. * p<0.1, ** p<0.05, *** p<0.01.

*Notes:* Fractional probit regressions. Dependent variable: share of a bank's deposits (excluding pension provisions) with interest rate $< 0$ at the end of 2019, as reported in the comprehensive year-end statistics. $\Delta ET$ denotes the exposure to the change in the bank-individual exemption threshold. This change is defined as the difference between the new exemption threshold (November 2019) and the old exemption threshold (August 2019, see equation 1). *Coll.* is a measure of a bank's freely available collateral as of August 2019 and comprises high quality liquid assets (HQLA 1 and 2a securities) net of those pledged for the SNB's liquidity-shortage financing facility. $\Delta ET$, *Coll.*, and the dependent variables are normalized by total assets before the policy event (August 2019). *Coll.* is then standardized so that the mean equals zero and the standard deviation equals 1. *Share*2018 is the share of a bank's deposits with interest rate $< 0$ at the end of 2018, and $I(Share2018 = 0)$ is a dummy equal to one if this share was exactly zero. Regarding the bank samples, "All" comprises the whole sample of banks, "Retail banks" have a mortgage to assets ratio of over 50% as of August 2019 or are backed by the local government (cantons), and the rest are labeled "wealth management banks" (WM).

**Table 7:** DiD regression results: LCR components

| | HQLA/TA | | | NCO/TA | | | (HQLA surplus)/TA | | |
|---|---|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) |
| Post $\times\Delta$ ET | 0.571*** | 0.277*** | 0.496* | 0.338*** | 0.110** | 0.422*** | 0.233* | 0.167*** | 0.075 |
| | (0.164) | (0.092) | (0.289) | (0.092) | (0.048) | (0.154) | (0.133) | (0.060) | (0.237) |
| Sept $\times\Delta$ ET | 0.045 | 0.092** | -0.085 | 0.135* | 0.039 | 0.142 | -0.090 | 0.053 | -0.227 |
| | (0.107) | (0.042) | (0.191) | (0.075) | (0.026) | (0.133) | (0.100) | (0.035) | (0.178) |
| Month FEs | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Bank FEs | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Sample | All | Retail | WM | All | Retail | WM | All | Retail | WM |
| Nr Banks | 143 | 55 | 88 | 143 | 55 | 88 | 143 | 55 | 88 |
| Mean Dep. Var. | 0.24 | 0.13 | 0.30 | 0.12 | 0.09 | 0.14 | 0.12 | 0.04 | 0.17 |
| SD Dep. Var. | 0.17 | 0.05 | 0.19 | 0.08 | 0.04 | 0.10 | 0.13 | 0.02 | 0.14 |
| R2 | 0.924 | 0.932 | 0.900 | 0.877 | 0.945 | 0.863 | 0.930 | 0.770 | 0.912 |
| R2 within | 0.062 | 0.128 | 0.025 | 0.053 | 0.038 | 0.040 | 0.025 | 0.073 | 0.005 |
| Obs. | 1570 | 604 | 966 | 1570 | 604 | 966 | 1570 | 604 | 966 |

Standard errors in parentheses

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

*Notes:* HQLA are the regulatory High Quality Liquid Assets. NCO are Net cash outflows, defined as the difference between projected cash outflows and cash inflows in a in a stress situation according to the LCR regulation. HQLA surplus is defined as the difference between HQLA and net cash outflows. *Post* is a dummy equal to 1 from October 2019 onward; *Sept* is a dummy equal to 1 for September 2019. $\Delta ET$ denotes the exposure to the change in the bank-individual exemption threshold. This change is defined as the difference between the new exemption threshold (November 2019) and the old exemption threshold (August 2019, see equation 1). Data sources: SNB comprehensive monthly balance sheet statistic and Liquidity Coverage Ratio reporting.

**Table 8:** Cross-sectional regression: Net interest income (normalized by total assets in June 2019) in 2019:H2

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| $\Delta$ ET | 0.294** | 0.032 | 0.309 | 0.029 |
| | (0.124) | (0.058) | (0.202) | (0.057) |
| $\Delta$ ET $\times$ Coll. | | | | 0.120** |
| | | | | (0.047) |
| Collateral (Std.) | | | | -0.009*** |
| | | | | (0.003) |
| $NII_{2019:H1}$ | 1.021*** | 0.769*** | 1.016*** | 0.824*** |
| | (0.174) | (0.132) | (0.180) | (0.140) |
| $NII_{2018:H2}$ | -0.051 | 0.262* | -0.054 | 0.211 |
| | (0.169) | (0.144) | (0.174) | (0.149) |
| Constant | -0.001 | -0.009 | -0.002 | -0.011 |
| | (0.009) | (0.015) | (0.010) | (0.015) |
| Sample | All | Retail | WM | Retail |
| Mean Dep. Var. | 0.39 | 0.48 | 0.33 | 0.48 |
| SD Dep. Var. | 0.20 | 0.06 | 0.24 | 0.06 |
| R2 | 0.939 | 0.949 | 0.931 | 0.954 |
| Obs. | 143 | 55 | 88 | 55 |

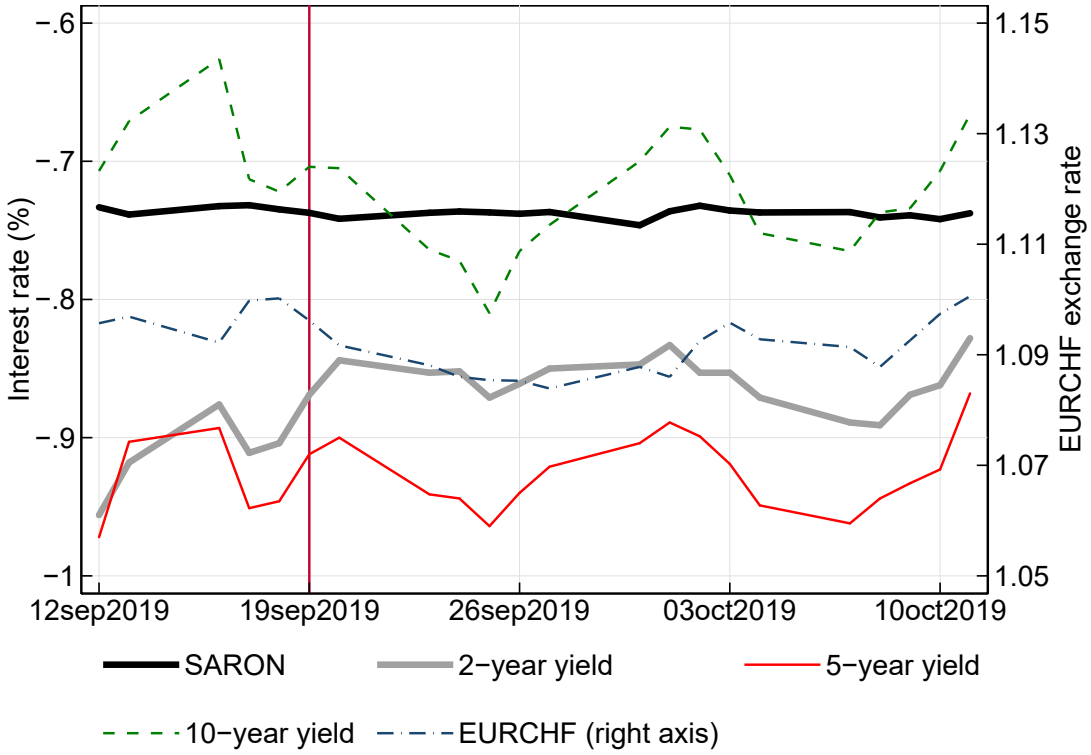
Robust standard errors in parentheses. * p<0.1, ** p<0.05, *** p<0.01.

*Notes:* Net interest income (NII) is defined as interest income less expenses, net of write-downs due to valuation adjustments and interest rate losses. $\Delta ET$ denotes the exposure to the change in the bank-individual exemption threshold. This change is defined as the difference between the new exemption threshold (November 2019) and the old exemption threshold (August 2019, see equation 1). *Coll.* is a measure of a bank's freely available collateral as of August 2019 and comprises high quality liquid assets (HQLA 1 and 2a securities) net of those pledged for the SNBs liquidity-shortage financing facility. $\Delta ET$ and *Coll.* are normalized by total assets before the policy event (August 2019); NII is normalized by total assets as of the end of 2019:Q2. *Coll.* is standardized so the mean equals zero and the standard deviation equals 1. Regarding the bank samples, "All" comprises the whole sample of banks, "Retail banks" have a mortgage to assets ratio of over 50% as of August 2019 or are backed by the local government (cantons) and the rest are labeled "wealth management banks" (WM). Data sources: SNB comprehensive monthly balance sheet statistic, Liquidity Coverage Ratio reporting, and FINMA Supervisory Reporting.

# Online Appendix for "Tiers of Joy? Reserve Tiering and Bank Behavior in a Negative-Rate Environment"

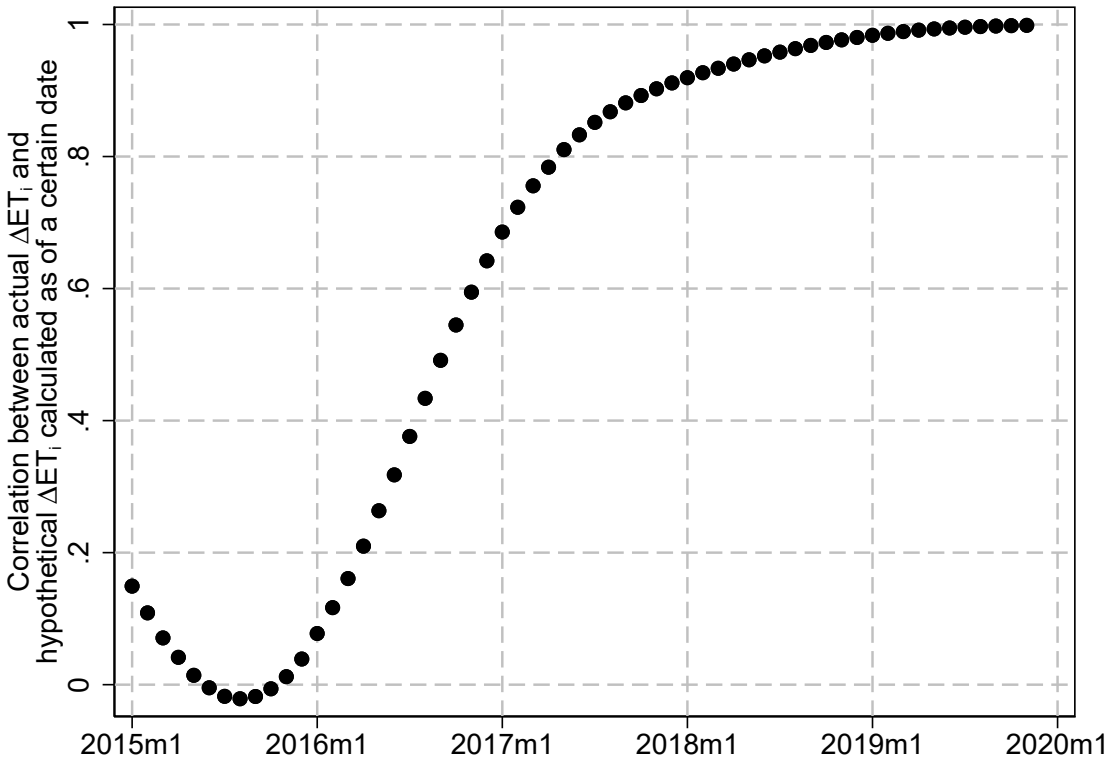
## A Additional figures and tables

**Figure A.1:** Swiss interest rates and the exchange rate against the Euro around the policy announcement on 19 September 2019




Note: The figure shows the evolution of Swiss interest rates and the Euro/CHF exchange rate around the SNB announcement of the change in exemption thresholds on 19 September 2019. The interest rates displayed are the Swiss Average Rate Overnight (SARON), which is the rate the SNB seeks to keep close to its policy rate (which is -0.75% over this period), and Swiss government bond yields for maturities 2, 5, and 10 years.

**Figure A.2:** Correlation between actual $\Delta ET$ and hypothetical $\Delta ET$ based on bank characteristics from earlier months over the 2015-2019 period.

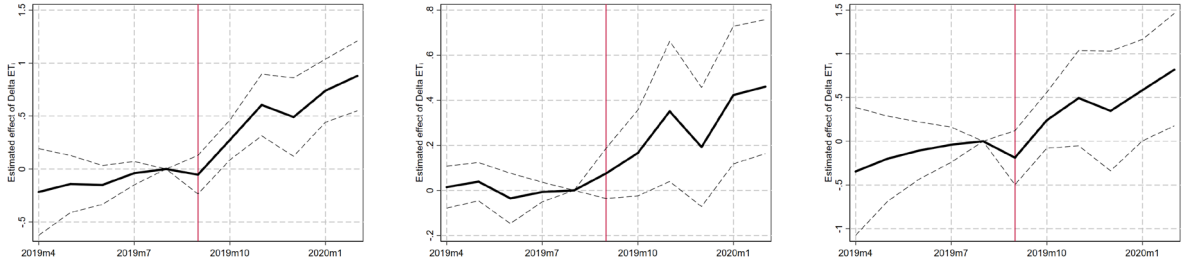



Note: The figure shows for all months $t$ between January 2015 and November 2019 the cross-sectional correlation between the actual $\Delta ET_i = \frac{ET_{i,Nov2019} - ET_{i,Aug2019}}{Assets_{i,Aug2019}}$ and a hypothetical $\widetilde{\Delta ET_i} = \frac{\widetilde{ET}_{i,t} - ET_{i,Aug2019}}{Assets_{i,Aug2019}}$, where $\widetilde{ET}_{i,t}$ is calculated based on the new formula announced on 19 September 2019 (explained in Section 3 or in the SNB press release) but using data as of month $t$. The evolution of the correlation illustrates to what extent changing bank characteristics (rather than the change in the formula) drive the actual $\Delta ET_i$ and when these changes in characteristics mostly occurred. For example, the chart indicates that if we calculated the "new" exemptions based on the bank characteristics as of January 2015, the correlation with the actual new exemptions that came into effect in November 2019 would only be +0.15. However, by January 2017, this correlation increased to +0.69, and by January 2018, to +0.92. This finding means that changes in bank characteristics over 2018 and 2019 were not important drivers of the cross-sectional dispersion in exposure to the policy change.

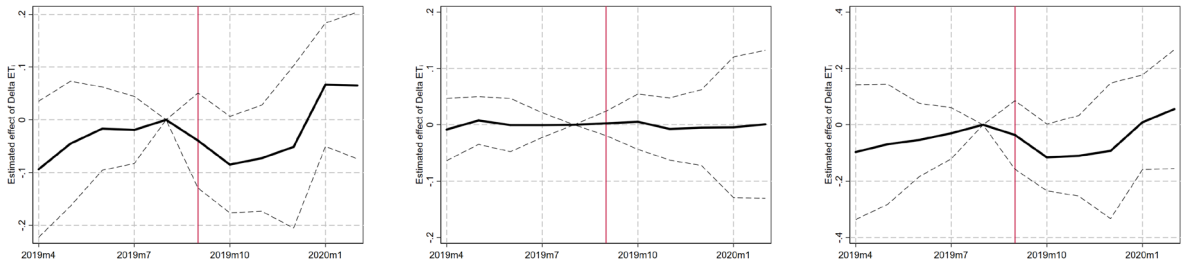
**Figure A.3:** Dynamic difference-in-differences plot, by bank type

**All banks** **Retail** **WM**

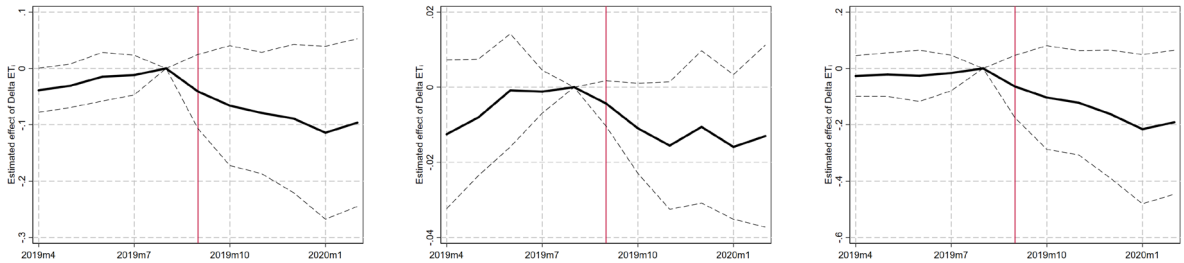
SNB Sight Deposits:



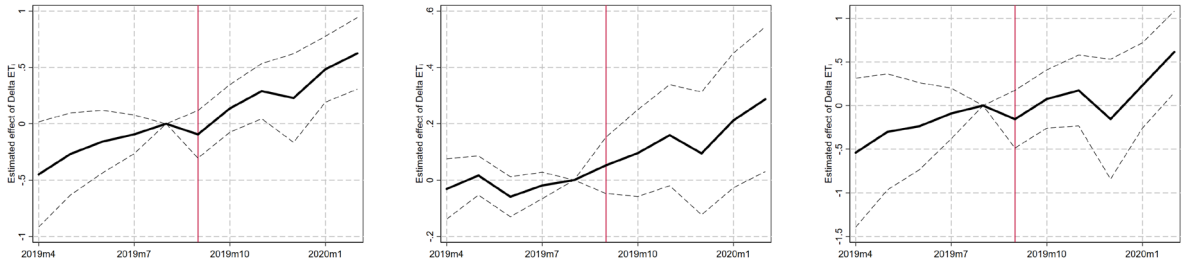

Mortgages & Other Loans:




Securities:

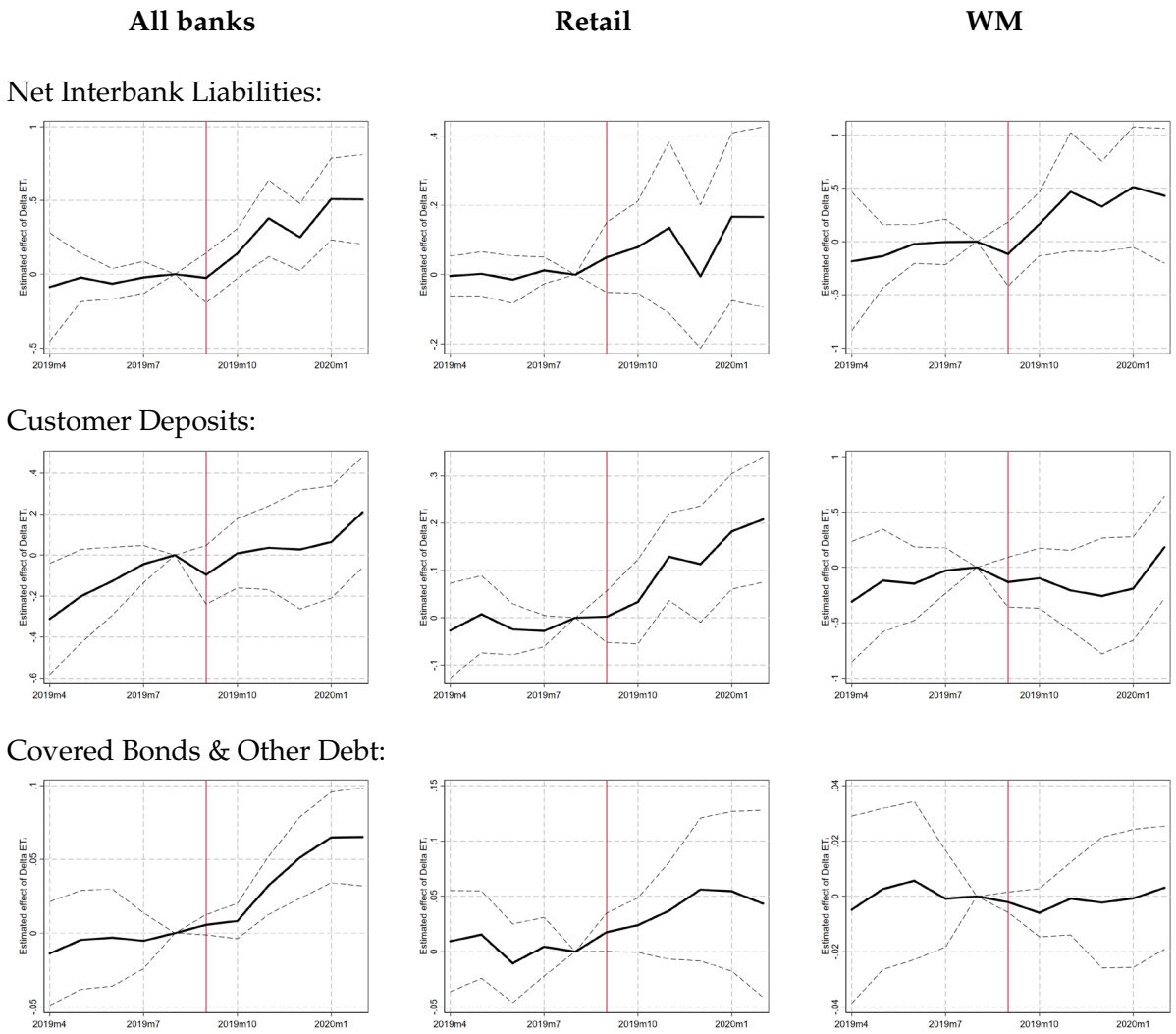



Total Assets (relative to Aug 2019):




Note: Estimated coefficients $\beta_t$ and 95% confidence intervals from regressions $y_{it} = \alpha_i + \gamma_t + \beta_t \Delta ET_i + \varepsilon_{it}$. Red line is September 2019.

**Figure A.4:** Dynamic difference-in-differences plot, by bank type




Note: Estimated coefficients $\beta_t$ and 95% confidence intervals from regressions $y_{it} = \alpha_i + \gamma_t + \beta_t \Delta ET_i + \varepsilon_{it}$. The red line is September 2019.

**Figure A.5:** Predicted shares of deposits with negative rates as a function of $\Delta ET_i$, based on the fractional probit regressions, for retail banks only

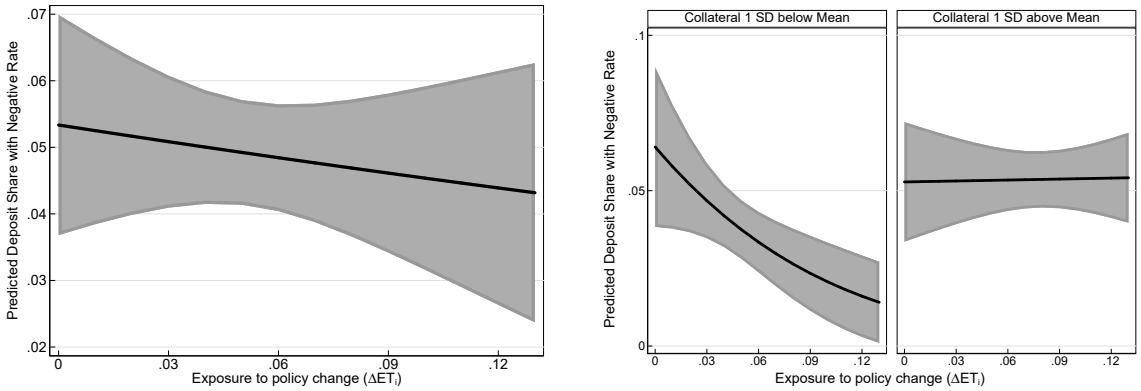


**Table A.1:** Triple-differences regression results, shown separately for banks whose SNB sight deposits in Aug 2019 were above vs. below their new exemption threshold

| | Unused Exemptions | | Net Interbank Liab. | | Customer Deposits | |
|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) |
| Post $\times\Delta$ ET | 0.015 | 0.701*** | 0.248 | 0.089 | -0.076 | 0.077 |
| | (0.036) | (0.109) | (0.380) | (0.070) | (0.275) | (0.100) |
| Post $\times\Delta$ET$\times$ Coll. | 0.041 | -0.337*** | 0.077 | 0.169** | -0.284 | -0.262* |
| | (0.049) | (0.101) | (0.483) | (0.078) | (0.345) | (0.151) |
| Post $\times$ Coll. | -0.000 | 0.012** | 0.003 | -0.003 | 0.013 | 0.015 |
| | (0.001) | (0.005) | (0.012) | (0.005) | (0.009) | (0.010) |
| Sept $\times\Delta$ ET | -0.066 | 0.029 | -0.131 | -0.068 | -0.007 | 0.008 |
| | (0.055) | (0.033) | (0.250) | (0.081) | (0.199) | (0.075) |
| Sept $\times$ Coll. | -0.002 | 0.001 | -0.002 | 0.034 | 0.008 | 0.007 |
| | (0.001) | (0.001) | (0.008) | (0.021) | (0.008) | (0.004) |
| Sept $\times\Delta$ET$\times$ Coll. | 0.120 | -0.022 | -0.101 | -0.342 | -0.207 | -0.188 |
| | (0.078) | (0.031) | (0.303) | (0.251) | (0.255) | (0.117) |
| Month FEs | Yes | Yes | Yes | Yes | Yes | Yes |
| Bank FEs | Yes | Yes | Yes | Yes | Yes | Yes |
| Sight dep. below new ET? | No | Yes | No | Yes | No | Yes |
| Nr Banks | 79 | 64 | 79 | 64 | 79 | 64 |
| Mean Dep. Var. | 0.00 | 0.01 | -0.02 | 0.02 | 0.62 | 0.62 |
| R2 within | 0.029 | 0.408 | 0.006 | 0.161 | 0.015 | 0.052 |
| Obs. | 866 | 704 | 866 | 704 | 866 | 704 |

Standard errors (clustered by bank) in parentheses. * p<.1, ** p<.05, *** p<.01

*Notes:* The same regressions as in Table 4 in the main text but the banks are divided into the following two subsamples: those whose SNB sight deposit holdings at the end of August 2019 were already above their new exemption threshold that started being applied in November 2019 (odd columns) and those whose SNB sight deposits at the end of August 2019 were below the new exemption threshold.

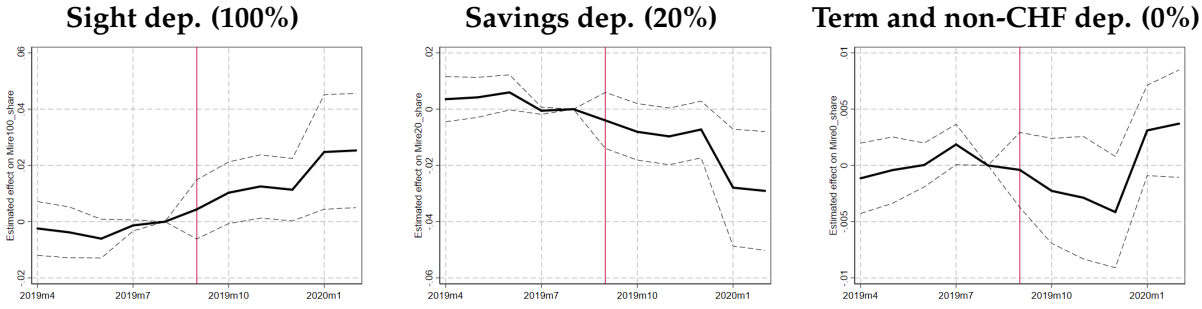
# B Reallocation within deposits

The SNB announcement in September 2019 not only had a one-time effect on each bank's exemption threshold but also made the thresholds "dynamic," as discussed in Section 2. As a consequence, banks have an incentive to favor some types of deposits over others. In particular, given that only 20% of savings account balances count toward minimum reserve requirements, while for sight deposits (and other deposits that potentially come due within three months), 100% count, banks have an incentive to increase their sight deposits relative to their savings deposits.[2]

We find evidence that banks responded to this incentive. We focus here on the subsample of retail banks, which, on average, had a substantial portion of their deposits classified as being subject to the 20% weight prior to the policy change (51% over April-August 2019, versus only 1% for wealth management banks). The dependent variables of interest are now the share of total deposits that count 100%, 20%, or 0% toward reserve requirements.

Figure A.6 shows how the average shares of the different deposit types evolved over time (relative to August 2019 and accounting for bank fixed effects). The share of savings deposits decreased after the announcement of the policy change in September 2019, and particularly strongly so after December 2019, plausibly because some banks changed the account status at year end. This is offset by an increase in sight deposits.

**Figure A.6:** Average conditional shares of different deposit types, retail banks




Note: Estimated coefficients $\gamma_t$ and 95% confidence intervals from regressions $y_{it} = \alpha_i + \gamma_t + \varepsilon_{it}$ where $y_{it}$ is the share (0-1) of a given deposit type in total deposits of a bank $i$ in month $t$, and August 2019 is omitted. The red line is September 2019.

In Table A.2, we present the regression version of these charts (with a simple "post" effect), and also check whether the reallocation was affected by how much a bank's exemption had increased. We find that the transition from savings deposits to sight deposits is stronger for banks that had

[2]Only CHF deposits count toward the minimum reserve requirements. Additionally, term deposits with more than three months of remaining maturity do not count.

benefitted less from the change in exemptions, suggesting that such banks feel a stronger need to "catch up" and benefit from an increase in exemptions in the future (thanks to the dynamic calculation).

**Table A.2:** Simple difference and DiD regression results: Deposit shares for retail banks

| | Share of Deposits with Weight for Min. Reserves of... | | | | | |
|---|---|---|---|---|---|---|
| | 100% | | 20% | | 0% | |
| | (1) | (2) | (3) | (4) | (5) | (6) |
| Post | 0.020*** | | -0.019*** | | -0.001 | |
| | (0.006) | | (0.006) | | (0.002) | |
| Sept | 0.007 | | -0.007 | | -0.000 | |
| | (0.006) | | (0.005) | | (0.002) | |
| Post $\times \Delta ET$ | | -0.434** | | 0.326 | | 0.108*** |
| | | (0.206) | | (0.214) | | (0.038) |
| Sept $\times \Delta ET$ | | -0.231 | | 0.172 | | 0.058** |
| | | (0.192) | | (0.190) | | (0.025) |
| Month FEs | No | Yes | No | Yes | No | Yes |
| Bank FEs | Yes | Yes | Yes | Yes | Yes | Yes |
| Month FE | No | Yes | No | Yes | No | Yes |
| Sample | Retail | Retail | Retail | Retail | Retail | Retail |
| Nr Banks | 55 | 55 | 55 | 55 | 55 | 55 |
| Mean Dep. Var. | 0.38 | 0.38 | 0.50 | 0.50 | 0.12 | 0.12 |
| SD Dep. Var. | 0.15 | 0.15 | 0.18 | 0.18 | 0.11 | 0.11 |
| R2 | 0.947 | 0.950 | 0.962 | 0.965 | 0.988 | 0.989 |
| R2 within | 0.069 | 0.046 | 0.066 | 0.027 | 0.001 | 0.026 |
| Obs. | 605 | 605 | 605 | 605 | 605 | 605 |

Standard errors (clustered by bank) in parentheses. * p<.1, ** p<.05, *** p<.01

*Notes:* The dependent variables are the shares (0-1) of deposits with different eligibility weights for the minimum reserve calculation, held by a given bank in a month. *Post* is a dummy equal to 1 from October 2019 onward; *Sept* is a dummy equal to 1 for September 2019. $\Delta ET$ denotes the exposure to the change in the bank-individual exemption threshold. This change is defined as the difference between the new exemption threshold (November 2019) and the old exemption threshold (August 2019, see equation 1). $\Delta ET$ and the dependent variables are normalized by total assets before the policy event (August 2019).

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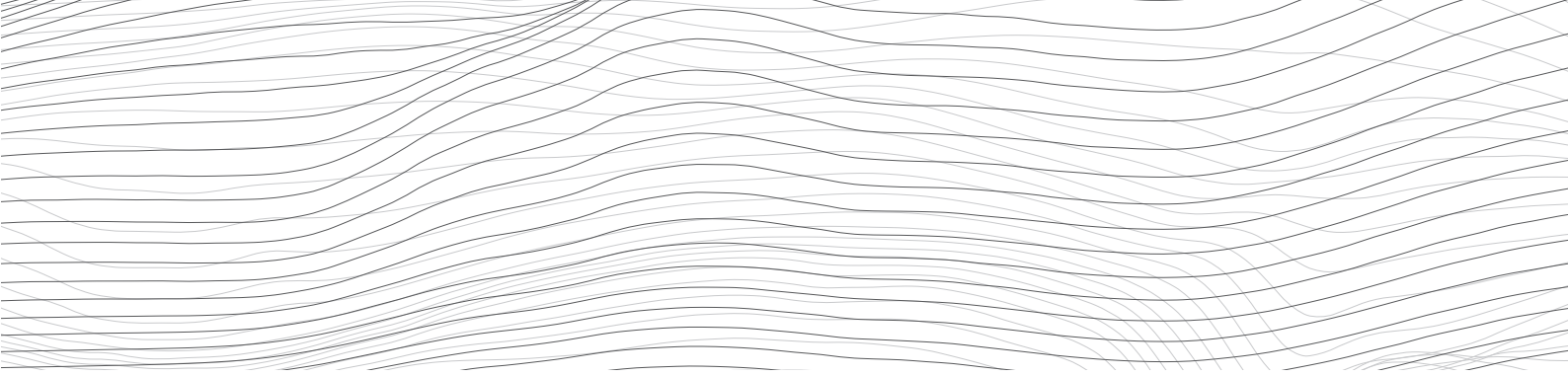

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