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Negative monetary policy rates and systemic banks' risk-taking: evidence from the euro area securities register

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Abstract

We show that negative monetary policy rates induce systemic banks to reach-for-yield. For identification, we exploit the introduction of negative deposit rates by the European Central Bank in June 2014 and a novel securities register for the 26 largest euro area banking groups. Banks with more customer deposits are negatively affected by negative rates, as they do not pass negative rates to retail customers, in turn investing more in securities, especially in those yielding higher returns. Effects are stronger for less capitalized banks, private sector (financial and non-financial) securities and dollar-denominated securities. Affected banks also take higher risk in loans.

Keywords: Negative rates, non-standard monetary policy, reach-for-yield, securities, banks.

JEL Codes: E43, E52, E58, G01, G21.

Non-technical Summary

In June 2014 the Governing Council of the ECB lowered the rate of the deposit facility into negative territory for the first time. The deposit facility rate (DFR) applies to the excess reserve balances of euro area banks at the central bank (in October 2019 a two-tier reserve system was introduced). Money market rates adjusted accordingly as their levels track the DFR in the current environment. Wholesale funding of banks obtained via money markets therefore incorporates the negative rates. At the same time, euro area banks have been somewhat reluctant to pass on negative deposit rates, especially to their retail depositors. Retail deposits are typically smaller in size and usually offered in conjunction with other banking services. Banks analysed in this study typically fund between 20 and 60 percent of their total assets using retail deposits.

In this paper we analyze the impact of negative monetary policy rates on reach-for-yield behaviour by banks. We use a securities register that covers the 26 largest banking groups in the euro area. The identification of the effects of negative rates rely indeed on the observation that banks with more retail deposits – measured using the ratio of deposits over total assets (deposit ratio) – are more affected by negative rates, as they do not pass on negative rates to their customers. We analyze the data in a panel comparing the period before and after the introduction of negative policy rates in June 2014. In the database we can observe all the different securities with different yields and maturities held by each bank in a certain quarter, even within the same issuer of a security (like a firm or a sovereign).

We show that, after the introduction of negative rates, banks with more retail deposits invest relatively more in securities, especially in those securities yielding higher returns. Since we can observe all other securities characteristics, we argue that differences in risk can explain differences in the yield of otherwise similar securities. Overall, the economic effects are significant. A bank with a 10pp greater deposit ratio would increase its holdings of a security by around 2% in response to a 1pp higher yield. Reach-for-yield effects are stronger for less capitalized banks.

We also study how more affected banks take higher risks analysing the portfolio allocation by asset class and currencies. Our analysis shows that the reach-for-yield effects result from holdings of debt securities issued by private firms, both financial and non-financial corporations. Effects are not economically and statistically significant for sovereign debt. As regards to currency, the more affected banks reshuffle their portfolios towards riskier securities denominated in US dollar in addition to euro currency.

1 Introduction

Central banks have implemented a series of unconventional monetary policies during the last decade. An important difference in the implementation of monetary policy between the euro area and the US has been the use of negative policy rates. The Federal Reserve in particular (and also the Bank of England) has been somewhat critical of the use of negative rates (see Bernanke, 2016). In the euro area, however, negative policy rates were introduced by the European Central Bank (ECB) in June 2014, when the deposit rate for banks with an account at the central bank was lowered to −10 basis points. Negative rates have also been introduced by central banks in several other countries (Japan, Denmark, Sweden and Switzerland), and the value of securities (bonds) yielding negative rates reached around 15 trillion US dollars as of July 2019.[1] Therefore, negative rates currently represent an important policy tool, which going forward may be considered part of the standard toolkit, especially given the secular low levels of rates around the world. Thus, a key question is what are the effects of negative policy rates for banks?

In this paper we analyze the impact of negative monetary policy rates on reach-for-yield behaviour by banks. For identification, we exploit the introduction of negative deposit rates by the ECB in June 2014 and a novel securities register for the 26 largest euro area banking groups. Banks with more customer deposits tend to be more negatively affected by negative rates, as it is more difficult to pass negative rates to their retail customers.[2] In sum, our results show that, after the introduction of negative rates, banks with higher (as compared to lower) ex-ante customer deposits invest relatively more in securities, especially in those securities yielding higher returns. Reach-for-yield effects through this deposit channel are stronger for less capitalized banks. Moreover, we find that more affected banks also take higher risk in loans.

The transmission of monetary policy at the "zero lower bound" and below has become a topic of particular interest for researchers and policy makers since several central banks have chosen this path in the last few years (Brunnermeier and Koby, 2018; Eisenschmidt and Smets, 2018). A very recent literature is assessing how negative policy rates (NPR) are transmitted through the banking sector and how they affect credit supply to the economy and the equity valuations of banks (see for example Ampudia and Van den Heuvel, 2018; Basten and Mariathasan, 2018; Bottero et al., 2019; Heider et al., 2019; Eggertsson et al., 2019). However, to the best of our knowledge, ours is the first paper to analyze how negative policy rates affect investment choices in the securities portfolios of banks.

Analyzing banks' reach-for-yield in securities is important for several reasons. First, securities holdings represent an important share of the assets held by banks around the world: For example, in Europe they account for around 20% of total banking assets. In part because of lack of detailed micro data, banks' securities portfolios have not been analyzed as much as credit. While credit register data are available for several countries (in Europe, Asia, the Americas and

[1] See e.g. https://www.bloomberg.com/news/articles/2019-08-06/negative-yielding-debt-hits-record-15-trillion-on-trade-woes.

[2] In this paper we refer to customer deposits or retail deposits (or simply deposits) as the same concept. See Section 2.

even Africa), the new dataset at our disposal, which provides detailed information on securities holdings at the bank and security (ISIN) level is not generally available for other regions in the world. For each security we have information on yield, issuer, ratings, price and remaining maturity. In particular we observe, even within the same issuer (like a sovereign), all the different securities with different yields and maturities *held by each bank* in a certain quarter. The overall nominal holdings in our database are valued at around 3 trillion euros.

Second, banks take risk through their securities holdings in addition to their lending portfolios. In Europe, for example, during the sovereign debt crisis, the soundness of banks in some countries was severely affected by the decrease in prices of sovereign bonds held in their portfolios, which represented a strong link between the stability of the banking sector and of the sovereigns issuing the securities – the so-called sovereign-bank nexus (Acharya and Steffen, 2015; Brunnermeier et al., 2016). As banks may take significant risk via securities holdings, policy makers have discussed how to regulate the investment of banks in securities, which is at the centre of an important policy debate. In Europe the Liikanen and the Vickers Reports addressed these issues and in the US the Volcker Rule in the Dodd-Frank Act. Finally, securities are more liquid than loans and bank risk can be more easily reallocated by changing the positions in liquid assets (Myers and Rajan, 1998).[3]

How are negative rates transmitted through the banking sector and affect bank risk-taking? A reduction in the policy rate transmits to short-term rates first. Since banks tend to have long-term assets and shorter-term liabilities on their balance sheets, a rate cut should result in an increase in bank net worth via banks passing-through the rate cut on their liability side. However, the pass-through of negative rates is somewhat different: banks do not generally pass on negative rates to their retail depositors, differently from their wholesale deposits. As we discuss below, these funding structures tend to be persistent and high retail deposit banks have less wholesale deposits than low deposits banks, which implies that they are overall less able to pass the negative rates to their liabilities. Evidence from our sample of banks, and in related work (see Altavilla et al., 2019), also suggest that these high retail deposit banks are not increasing fees more than other banks on average.

When interest rates are positive, the impact of a cut in policy rates on bank risk-taking is theoretically ambiguous (see Dell'Ariccia, Laeven, and Marquez, 2014; Dell'Ariccia, Laeven, and Suarez, 2017). There are at least two different forces at work. First, a *portfolio reallocation* effect – safe assets become less attractive, which induces banks to take more risk. Second, a *risk-shifting* effect – lower interest rates increase franchise value, which would induce less risk-taking. The net effects of these two factors depend on banks' ability to pass-through rates to customers and to change their capital structure. Negative rates induce a differential shock across banks with different retail deposit ratios (see also Eggertsson et al., 2019; Brunnermeier and Koby,

[3] Myers and Rajan (1998) allude to the concept of transformation risk. They argue that "greater asset liquidity reduces the firm's ability to commit to a specific course of action" and hence "managers could substitute risky assets for safe ones" – or the other way around. Some recent evidence provided by (Timmer, 2018) shows indeed that banks react strongly to past returns in the securities holdings and adjust their holdings accordingly, leading to pro-cyclicality in investment dynamics.

2018). For these banks (as compared to banks with higher funding from the wholesale market) negative rates represent a financial burden, *decreasing* their franchise value and hence inducing overall more risk-taking.

To test this theoretical prediction, we use a difference-in-differences specification where we analyze how the holdings of a particular security change in response to the introduction of negative policy rates, differentiating between high (retail) deposit ratio and low deposit ratio banks. As argued above, banks with different retail deposit ratios are affected differently when policy rates reach negative territory and this provides a way to identify the effects of negative policy rates on reach-for-yield in securities from other forces that shape both monetary policy and the investment behavior of large euro area banks.

We exploit the data on securities holdings in Q4 2013–Q1 2014 for the pre-NPR period and Q2 2014–Q4 2014 for the post-NPR period. We end our analysis in Q4 2014, excluding the following period when the ECB announced and then implemented the expanded Asset Purchase Programme (APP), i.e. the euro area QE. We analyze the data at the *security-bank-quarter* level. This allows us to: (1) test whether the change in securities induced by the introduction of negative policy rates differs with certain (observed) bank characteristics controlling for unobserved bank heterogeneity; (2) control for unobserved security characteristics (e.g. the issuance of a particular security) via security (or other related) fixed effects; and (3) identify reach-for-yield, in particular whether banks with different characteristics (deposit ratio) change their holdings of securities with different yields. We analyze the data in a panel comparing the period before and after the introduction of negative policy rates. Additionally, we analyze the results quarter by quarter to check the parallel trend assumption.

We find robust evidence that negative policy rates lead to reach-for-yield behavior in the securities holdings of more exposed banks. Comparing the period before and after the introduction of negative rates, we show that banks more reliant ex-ante on customer deposits (compared to the other banks) relatively increase their holdings of securities, with stronger effects for those securities yielding higher returns.[4] Results are robust to controlling for security risk characteristics, like maturity and ratings, which are the main determinants of capital regulation, security fixed effects, or unobserved bank heterogeneity via bank fixed effects. Effects are also similar if we estimate weighted regressions (by weighting each security by the overall holding amount) or if we control for the covariance between a security and the current bank portfolio. We find no evidence of a similar relationship in the period before the introduction of negative rates. Before the introduction of negative rates, the response of banks' holdings to changes in yields of securities does not differ for banks with different levels of deposit ratio. Overall the economic effects are significant: after the introduction of negative rates, a difference in the deposit ratio of 10 percentage points (approximately one standard deviation) would imply an around 2 percentage

[4] We do not find evidence that more affected banks increase or decrease overall lending, but they increase their securities holdings. There are also somewhat higher deposit inflows to these more affected banks after the introduction of negative rates (see discussion at the end of Section 3.1).

points increase in the sensitivity of holdings of a particular security in response to a 1 percentage points change in the adjusted current yield.[5]

We then analyze *how* more affected banks take higher risk. The analysis within different asset classes shows that the reach-for-yield effects are confined to holdings of debt securities issued by private firms, both financial and non-financial corporations. Effects are not economically and statistically significant for public debt (for ABS, estimated effects are large, though the standard errors increase substantially for this asset class). As regards to currency, the more affected banks reshuffle their portfolios towards riskier securities denominated in US dollar in addition to euro currency – this is relevant when considering international spillovers of euro area monetary policy.[6] Moreover, in terms of duration risk, we show that more affected banks reshuffle their portfolios more towards longer-term higher-yielding securities. Importantly, the reach-for-yield effects by high-deposit banks are stronger for weakly capitalized banks, consistent with risk-shifting. Finally, our results suggest that more affected banks also increase their risk in loans. Therefore, we overall provide evidence that negative rates induce large, systemic banks to take on higher risk in both securities and loans.[7]

1.1 Contribution and Related Literature

Our main contribution is to the growing literature on the impact of non-standard monetary policy measures.[8] Despite a substantial number of empirical studies addressing the impact of quantitative easing, lending policies by central banks (such as the LTROs and TLTROs implemented by the ECB) and forward guidance, there is less evidence on negative rates, which is a more unique and special policy. To the best of our knowledge, this is the first paper to show how negative policy rates affect the securities holdings of banks for a large set of multinational, systemic banks.

Ampudia and Van den Heuvel (2018) look at the effects of ECB monetary policy announcements on bank equity including periods of low and negative interest rates. They find that when interest rates are positive, an unexpected decrease in policy rates raises bank equity – as in English, Van den Heuvel, and Zakrajšek (2018). However, when policy rates are zero or negative, the impact can be reversed – in particular for banks that rely more on deposit funding – and further rate cuts lower bank equity, a result consistent in spirit with the notion of a reversal rate as in Brunnermeier and Koby (2018). Altavilla, Boucinha, and Peydró (2018) analyze the impact of standard and non-standard monetary policy on bank profitability. They find that a monetary policy easing (a decrease in short-term interest rates and/or a flattening of the yield

[5] This statement is based on the third column of Table 4.

[6] See e.g. Obstfeld (2019); Morais et al. (2019), or Rajan's 2014 complain on US QE as RBI governor in an interview with Bloomberg (https://www.bloomberg.com/news/articles/2014-01-31/india-vs-dot-the-u-dot-s-dot-when-central-bankers-collide).

[7] Note, however, that banks with higher ex-ante retail deposits only increase overall securities holdings, not overall credit, after the introduction of NPR, see in particular Table A.11.

[8] We also contribute to the literature on the risk-taking channel of monetary policy, see e.g. Maddaloni and Peydró (2011) and the references therein.

curve) is not associated with lower bank profits when controlling for the endogeneity of the policy measures to expected macroeconomic and financial conditions, though accommodative monetary conditions asymmetrically affect the main components of bank profitability. Differently to these papers, we analyze security-level data.

Our results are complementary to the results found by Heider, Saidi, and Schepens (2019). We broadly share their identification strategy, based on the banks' reliance on customer deposits. They analyze the risk profile of the syndicated loan portfolios of banks during the period of the introduction of negative interest rates. They find that banks with more deposits tend to lend less overall but more to riskier borrowers. Using a similar strategy with Swiss data, Schelling and Towbin (2018) find that banks with a lot of deposits offer more generous lending terms in order to capture market shares. We provide complementary evidence to these studies based on the analysis of the securities holdings of banks. In the last part of the paper, we also run a robustness analysis using syndicated lending data for the banks in our sample, and we find evidence of reach for yield in both securities and loans for the largest euro banks, which are the most systemically relevant.

Other studies on the impact of negative rates have relied on banks' excess reserves at the central bank. Demiralp, Eisenschmidt, and Vlassopoulos (2017) assess the impact of negative policy rates on lending volumes and holdings of government bonds. Their identification strategy is based on banks' excess liquidity deposited at the ECB. They find that more exposed banks increase their overall holdings of non-domestic government bonds. Their dataset does not have the granularity to control for risk or issuance at the security level nor the exhaustive analysis of heterogeneous effects across different securities with different yield levels (i.e., we exploit a securities register). In our sample, where we can distinguish different securities (with different yields and maturities) issued by the same sovereign, we do not find evidence of reach-for-yield within sovereign bonds. Using a similar identification strategy — central bank reserves at the Swiss National Bank – Basten and Mariathasan (2018) show in a bank-level analysis that, in aggregate, more affected banks are lending more and invest more in financial assets. Our channel of identification and also data are different.

Our paper is also related to Peydró, Polo, and Sette (2017). Using the Italian securities register during the recent crisis period, but before the introduction of negative rates, they show that bank risk-taking in response to a monetary policy loosening is proportional to a particular bank's risk-bearing capacity (i.e. bank capital) – a result inconsistent with the risk-shifting hypothesis which would apply to banks with low levels of capital (gambling for resurrection). We show that in our sample this result also holds: after NPR introduction, banks with higher capital reach for higher yield. However, among the most affected banks (i.e., banks with high deposit ratios), those with higher equity take less risk after NPR introduction. In the most recent period, Bottero, Minoiu, Peydró, Polo, Presbitero, and Sette (2019), exploiting administrative data from Italy, find that negative rates have expansionary effects on credit supply (and the real economy) through a portfolio rebalancing channel, rather than a deposit channel.

Few papers have analyzed risk-taking in response to negative rates for the overall investment portfolio of banks, analyzing risks stemming from securities, loans and all other assets on banks' balance sheets. These papers use the risk weighted asset measures (RWA) that are calculated by banks in order to determine capital requirements. Evidence is not unequivocal. Looking at these less granular measures that extend beyond the securities portfolio Arce et al. (2018) as well as Boungou (2020) and Reghezza et al. (2019) find a decrease in overall risk (measured as risk weighted assets or the z-score) after the introduction of negative rates. Basten and Mariathasan (2018) find an increase in risk weighted assets for the Swiss banks most affected by the negative interest rates policy. Using a risk measure derived from banks' equity valuations Nucera, Lucas, Schaumburg, and Schwaab (2017) find that the risk impact of negative rates depends on banks' business models: large and more diversified banks are perceived as less risky, while smaller and more traditional banks are perceived as more risky.

Differently from all the papers mentioned above, we analyse the securities portfolios of the largest (more systemic) euro area banks and assess the impact of the introduction of negative policy rates. Focusing on the securities portfolios of German banks, Abbassi, Iyer, Peydró, and Tous (2016) find evidence of reach-for-yield behavior in response to the global financial shock associated to the bankruptcy of Lehman Brothers. Banks with higher trading expertise increased their investments in securities with higher fire sales, especially in low-rated and long-term securities. At the same time, these banks reduced their credit supply, suggesting a substitution from loans to securities yielding higher returns. Our results complement these findings, since we find evidence of changes in euro area banks' securities holdings due to changes in monetary policy, as opposed to the financial crisis. Our work is close in spirit also to the analysis of Koijen, Koulischer, Nguyen, and Yogo (2018) which use a security-level dataset on holdings for euro area sectors (e.g. the holdings at the banking sector level as well as other financial sectors). We use the holdings of a limited sample of euro area banks (albeit covering a large majority of the assets of the euro area banking sector), but we can disentangle the holdings at the level of a single banking group.

There is also evidence on how low levels of interest rates affect investment of non-bank financial intermediaries. Di Maggio and Kacperczyk (2017) find that in response to policies that maintain low interest rates, money market funds change their product offerings by investing in riskier asset classes. Choi and Kronlund (2017) analyze the investment behavior of corporate bond mutual funds. They argue that incentives for reaching-for-yield strengthen when interest rates are low. Their study shows that funds generate higher returns when they reach for yield, in particular in periods of low interest rates. More recently, Ozdagli and Wang (2019) show that life insurance companies, the largest institutional holders of corporate bonds, tilt their portfolios towards higher-yield bonds when interest rates decline. They argue, however, that this is mainly due to active duration adjustment of their portfolios in response to lower policy surrenders and lapses when interest rates decline.

2 The Impact of Negative Policy Rates: Hypotheses, Identification and Data

There is a large literature addressing the impact of monetary policy rates on banks' balance sheets. Lower policy rates decrease the cost of funding for the banks and this generally translates in higher bank net worth, because of the maturity transformation operated by banks (see for example Dell'Ariccia et al., 2014; Freixas and Rochet, 2008). However, negative policy rates add an additional dimension to the monetary analysis as their transmission through the banking sector is different. We analyze these issues in detail in the next section.

2.1 The Transmission of Low (Negative) Policy Rates

A reduction in policy rates is immediately transmitted to the general level of short-term interest rates. Since the balance sheet of banks usually is composed by longer-term assets and shorter-term liabilities, a rate cut would generally result in increased bank net worth. This is based on the assumption that banks can immediately pass-through the rate cut to their liabilities. Therefore banks can fund themselves at lower rates while the asset side remains largely unaffected, leading to an increase in the value difference between assets and liabilities, and hence in the net worth of banks. This in turn would relax financial constraints and increase banks' capacity to lend and invest in securities.

With positive rates, the effect of a rate cut on bank risk-taking is theoretically ambiguous (see Dell'Ariccia, Laeven, and Marquez, 2014; Dell'Ariccia, Laeven, and Suarez, 2017).[9] On the one hand, banks' risk-taking will depend on *portfolio reallocation* effects. A decrease in the yield of safe assets will make them less attractive and generally increase banks' demand for risky assets. On the other hand, lower short-term rates increase the franchise value of banks, reducing the incentives to take more risk – *risk-shifting* effects.

The overall effect of these countervailing factors will depend on the ability to pass-through lower rates to customers (e.g. retail customer versus wholesale funding) and the ability to change the capital structure (e.g. some banks have business models with higher retail funding, which tend to be persistent over time). Overall, negative rates induce a *differential shock* between high- and low-(retail) deposit banks (see also Eggertsson et al., 2019; Brunnermeier and Koby, 2018). While the effects of portfolio reallocation are similar (safe assets generally become less attractive), negative rates are a financial burden for high-deposit banks, as they reduce their franchise value, thereby inducing more risk-taking.

Indeed, the pass-through of negative rates is somewhat different. Banks do not generally pass-through negative rates to their retail depositors but only to their wholesale depositors (see Figure 1). High-deposit banks have less wholesale deposits than low-deposit banks,[10] and, as it can be inferred also from Figure 2, these funding structures are quite persistent. Banks that

[9] We thank Skander van den Heuvel for suggesting these arguments.

[10] In our sample we found a negative correlation between deposit ratios and wholesale deposits (regression coefficient of -0.07, p-value: 0.01), see also Figure A.8 in the Annex.

fund more through the wholesale market pass on negative rates to their depositors. For example, the average overnight interbank market rate in the euro area (EONIA) became negative already in the second half of 2014, shortly after the introduction of negative policy rates. Banks with more retail deposits have less wholesale funding, which implies that they are overall less able to pass the negative rates to their liabilities.

Banks may be reluctant to charge negative rates to retail depositors for several reasons, at least over short time horizons. They may not want to jeopardize long-term customer relationships, and depositors could just decide to hold currency and/or move deposits to another bank that does not charge negative rates. This may apply especially to customer deposits that are typically smaller in size. There may also be legal constraints in charging negative deposit rates, due to the institutional setting of some deposit-taking corporations (like cooperative banks for example).[11]

Banks may compensate for the effects of negative rates by increasing customer fees for their services. Reliable data on fees are hard to obtain and we do not have it for our sample of banks during the time period that we are considering. As a proxy, we have looked at the values of *non-interest income*. As shown in the last column of Table A.11 in the Annex, non-interest income does not change significantly more for high-deposit banks compared to low-deposit banks after the introduction of negative interest rates. This is consistent with evidence shown in Altavilla et al. (2019), where they find no evidence of a substitution of rates by fees within a sample of more than 200 large euro area banks. They show that "banks with a large proportion of deposits always charge lower fees and do not change their behavior after the implementation of the NIRP."[12]

All in all, based on the theoretical literature and on institutional practices in the banking sector, the testable predictions (hypotheses) from the introduction of negative rates imply that more affected banks are the ones with higher ex-ante retail deposits, and these banks will respond to NPR by taking more risk. The *intensity of the treatment* induced by the introduction of negative policy rates therefore varies across banks with the degree to which they are funded by customer deposits. This enables us to identify the effect of negative interest rates on the securities holdings of banks.

[11] Altavilla et al. (2019) provide some recent evidence based on euro area banks. They show that as of end-2018 negative interest rates applied only to around 5% of total euro area deposits. However, there is considerable heterogeneity across countries and sectors: about 50% of German corporate deposits are placed with banks that report average deposit rates at levels below zero. At the same time, the average interest rate applied to this type of deposits across the whole German banking sector has never fallen below −0.03%. We refer to the series "Overnight deposits, Total original maturity, New business coverage, Non-Financial corporations (S.11) sector, denominated in Euro" in the publicly available MFI Interest Rate Statistics (SDW: 124.MIR.M.DE.B.L21.A.R.A.2240.EUR.N). See also Figure 1 for a time series of the euro area aggregate.

[12] They show that the deposit ratio has a negative correlation with the dependent variable *Fees and commissions* and that the coefficient of the interaction Deposit Ratio*Post is not statistically significant.

2.2 Identification Approach

Policy rates in the euro area moved into negative territory in June 2014, when the ECB lowered the deposit facility rate to −0.10%. Three further reductions in the policy rate brought the rate on the deposit facility to −0.40% by March 2016 (see Figure 1 for the evolution of the policy rates in the euro area).

In the current economic and institutional environment, central bank liquidity is allocated on a full allotment basis and a series of non-standard monetary policy measures are in place. In aggregate, euro area commercial banks hold a substantial amount of excess liquidity at the central bank, i.e. more liquidity than they need to fulfil reserve requirements. While *required reserves* are remunerated at an interest rate that equal to the main refinancing operations rate (MRO),[13] *excess reserves* held by euro area banks are charged a negative deposit facility rate (DFR) since June 2014.[14]

Our main identification argument is based on the limited pass-through of negative policy rates to the rates paid on retail deposits. Eisenschmidt and Smets (2018) show that by the end of 2016, in some core European countries, banks started to charge negative deposit rates but only to corporations (e.g. −0.03% on average in Germany as of April 2019), while rates for households deposits remained positive. This suggests that eventually the pass-through of negative rates may take place, but it is more sluggish than with positive rates and it may affect only certain types of customers (see also Heider et al., 2019; Eggertsson et al., 2019).

[Insert Figure 1 about here.]

There is ample cross-sectional variation in terms of retail deposit ratios across our sample. Figure 2 shows that the large euro area banks in our sample fund between 20% and 60% of their balance sheet via customer deposits. Over time, deposit ratios are rather sticky, as it is shown in Figure 2. In terms of volume, we note that after the introduction of negative rates there was an increase in deposits for high deposit banks compared to low deposit banks.[15]

[Insert Figure 2 about here.]

We use a difference-in-differences specification to analyze how the holdings of a particular security change in response to the introduction of negative policy rates, differentiating between high-(retail) deposit ratio banks and low-deposit ratio banks. As argued above, banks with different deposit ratios are affected differentially when policy rates reach negative territory and this provides a way to identify the effects of negative policy rates on bank risk-taking in securities

[13] See also Article 8 of Regulation (EC) No 1745/2003 of the European Central Bank of 12 September 2003 on the application of minimum reserves (ECB/2003/9).

[14] Only in October 2019 a two-tier system for for remunerating excess reserve holdings was introduced by the ECB.

[15] See Figure A.6 in the Annex.

(i.e. *reach-for-yield*) and isolate them from other forces that shape both monetary policy and the investment behavior of large euro area banks.

We investigate if banks with a larger retail depositor base invest in higher-yielding securities after NPR. We analyze the data at the security-bank-quarter level. This allows us to test whether the reaction to the introduction of NPR differs with certain (observed) bank characteristics (deposit ratio) for high vs. low yielding securities (reach-for-yield), controlling for unobserved bank and security heterogeneity (e.g. bank risk and issuance of some securities).

The analysis is based on a difference-in-differences estimation where we capture the effect of monetary policy through a dummy variable that equals 1 when policy rates are below zero. The ECB deposit facility rate was set to −0.10% effective from June 11th 2014. We classify the period Q4 2013 – Q1 2014 as the pre-NPR period and Q2 2014 – Q4 2014 as the post-NPR period. We stop our analysis at the end of 2014 so that we can interpret our findings as resulting from the introduction of negative policy rates, excluding the following period when the ECB announced and then implemented the expanded Asset Purchase Programme (APP), i.e. the euro area QE.[16] We choose to stop our analysis at the end of 2014 because extending the time period further would overlap with the period in which central bank asset purchases were carried out. Obviously this policy action has a direct impact on the securities holdings of banks and may have affected banks differently, depending on their ex-ante securities allocation, possibly confounding our results.

Our dependent variable is the holdings of the security by a certain banking group in a certain quarter. The main coefficient of interest is the interaction term Deposit Ratio*Post*Yield. Identification relies on the Deposit Ratio, the ratio of customer deposits over total assets. Post is a dummy variable equal to one for the period June 2014 onwards. The variable Yield is a risk measure based on the adjusted current yield of a security (please refer to Section 2.3 for details on how we compute Yield). We include the total assets and the ratio of equity over total assets (i.e. the equity ratio of the bank) as controls. We also include fixed effects, e.g. bank or security fixed effects. In all our specifications we double cluster standard errors at the security and bank-time level.

We employ fixed effects to control for the factors that can explain banks' investment in certain securities, such as regulatory pressures, or issuance of particular securities (the supply of securities), e.g. the need to raise funding. A major development in the regulatory landscape during the period that we analyze was the implementation of the Single Supervisory Mechanism (SSM) in the euro area and the transfer of the direct supervision of large euro area banks from the national supervisory authorities to the ECB. All the banks in our sample were affected by this

[16] During the period that we consider there were other measures of non-conventional monetary policy that were undertaken. In June 2014 the ECB announced the two targeted longer-term refinancing operations (TLTRO) with allotments taking place in September 2014 and December 2014. It is not clear ex-ante, why the TLTRO take-up would differ across large banks with different deposit ratios and therefore affect the results of our analysis. Bottero et al. (2019) construct a bank-level measure of borrowing capacity and show that it does not affect changes in loan supply immediately after the introduction of negative rates. Heider et al. (2019) perform their analysis until the end of 2015 and run robustness checks for the sub-period of 2014. Moreover, our results are significant even before the TLTRO implementation (see Figure 3).

change and their direct supervision was transferred from the national competent (supervisory) authorities to the SSM. The SSM became operational in November 2014, and Figure 3 shows that our results are significant before November 2014, though preparatory work was undergoing during the period that we analyze. Similarly, other regulatory measures were being implemented, in particular the Liquidity Coverage Ratio (LCR), that came into effect in October 2015. Our results would be affected by these developments if changes in regulation would have a differential impact across banks with low and high deposit ratios during our estimation window in the years 2013-2014. Related to the implementation of the LCR, it can be argued that the LCR is likely to have created incentives to invest in liquid assets, yielding lower returns, as opposed to riskier and higher-yielding securities (see also the related discussion in Heider et al., 2019).

2.3 Data

Securities holdings are an important fraction of bank balance sheets. On average they account for around 20% of total banking assets in the euro area. The main database used in the analysis is the new Securities Holdings Statistics by Group (SHSG) database of the Eurosystem. The database contains at the level of each banking group security-level information on the securities holdings for 26 reporting banking groups legally incorporated in the euro area (see Table A.9). It covers the large majority of the euro area banking sector in terms of financial assets. Data are collected on a quarterly basis since Q4 2013. The SHSG database provides information on holdings at the security level as identified by the International Securities Identification Number (ISIN). For the purpose of the analysis in this paper, we focus on the holdings of debt securities (both short-term and long-term) and enrich the database with security level information — like rating, coupon rates, prices and maturity – from the Eurosystem Centralised Securities Database (CSDB).[17] Data on banks' balance sheets are from SNL Financials.

Using information on the issuer of the debt securities, we classify the assets in four broad categories. Securities are classified as Public Debt if they are issued by the sectors "General Government" and "Central Bank" as well as by certain supranational institutions such as the European Investment Bank (EIB) or the European Stability Mechanism (ESM). Securities from private issuers are grouped into three distinct categories. Securities issued by "Deposit-taking corporations except the central bank" are classified as "Private debt issued by banks". "Asset backed securities (ABS)" includes different types of securitized debt: covered bonds, MBS, Pfandbrief, CDOs and other ABS. The asset class "Private debt (other)" is a residual category and includes debt issued by financial corporations other than banks and by the non-financial corporate sector.

Table 1 shows the average total nominal holdings (and the holdings share) for the four asset classes considered, both before and after the introduction of negative policy rates. Overall, there was a broad disinvestment from debt securities issued by euro area banks and other private

[17] On average the percentage of the securities portfolio invested in equities is below 5% for the banking groups in our sample.

issuers, while there was some increase in the percentage of the portfolio invested in public debt and in ABS securities.

[Insert Table 1 about here.]

To compare investment in financial assets with different yield patterns (reach-for-yield), we use the adjusted current yield (ACY) measure as in Abbassi et al. (2016). Differences in risk can explain differences in the yield of otherwise similar securities. In the SHSG database the banking groups report the value of their holdings both in nominal terms and valued at market prices along with the number of securities held at the end of the quarter. To obtain prices for all securities in our database we rely on this information as opposed to using external sources. We compute the prices by dividing the reported market value of the holdings of a certain ISIN by the number of securities that the bank holds. We obtain the information on coupon rates and residual maturities from the CSDB of the Eurosystem.[18]

We compute the adjusted current yield (ACY) of a security as:

$$\text{Yield} = 100 \cdot \frac{\text{Coupon}[\%\text{ ann.}]}{\text{Price}} + \frac{100 - \text{Price}}{\text{Residual Maturity}/365}$$

We include in the sample all securities with a nominal holding amount that at some point exceeded 0.5 million euro, summing up the holdings of the 26 reporting banking groups. Furthermore, we trim our data according to the variable adjusted current yield and include all securities with an adjusted current yield between the 5th and the 95th percentile of the overall distribution.[19] Table 2 shows summary statistics of our sample, in particular a large variation across securities yields, as well as bank retail deposit ratios.

[Insert Table 2 about here.]

3 Results

In this section we show our main results, in particular the reach-for-yield associated to the introduction of negative policy rates. Moreover, we analyze how the effects of negative interest rates evolve over time and test the parallel-trends assumption. In addition, we look at the heterogeneity of effects across distinct asset classes and currencies, and how these effects vary with the maturity of securities, as well as with banks' equity ratios. Finally, we analyze lending.

[18] See also Table 2 in "Who holds what – new information on securities holdings" (ECB Economic Bulletin, Issue 2/2015, p. 75).

[19] Over the time frame considered in our analysis, the cross-sectional distribution of the adjusted current yield shifts to the left, partly as a result of lower policy rates. Therefore at the end of 2014 a large fraction of the securities portfolio of the largest euro area banks was yielding a negative return. Figure A.4 in the Appendix shows how the overall distribution of the adjusted current yield (weighted by the nominal holding amount) for the securities holdings in our sample changed between Q4 2013 (the beginning of our sample) and Q4 2014 (the end of our sample period). Note that the adjusted current yield values securities at current market prices. Banks do not necessarily incur losses on their holdings at negative values of the adjusted current yield, e.g. since securities may have been bought earlier at different prices.

3.1 Negative Monetary Policy Rates and Reach for Yield

The dependent variable is the (log-transformed) holdings of a security by each bank in a certain quarter. Before our benchmark results in Table 4, the results in Table 3 show that, overall, securities holdings decreased during the implementation of negative policy rates (see negative coefficient of Post) in columns (1) to (3). The fourth column additionally controls for the risk of a security via the adjusted current yield. Not surprisingly, given the reduction in policy rates, deleveraging was stronger for riskier securities with a higher yield, see the negative coefficient of Post*Yield. This holds across different specifications with bank and security fixed effects (columns 4 to 9 in Table 3).

[Insert Table 3 about here.]

To identify the link between negative policy rates and reach-for-yield behavior, we estimate a difference-in-differences specification where identification is provided by banks' reliance on customer deposits. We compare banks that were more affected by the introduction of negative interest rates to a control group that was less affected. Thereby we can disentangle the effects that are due to changes in the supply of securities, or driven by other economic developments, from those effects that we can attribute to the introduction of negative interest rates by the ECB.

[Insert Table 4 about here.]

Results are reported in Table 4 with different sets of fixed effects on the bank- and security-level. Our dependent variable is the (log-transformed) holdings of a security by each bank in a certain quarter. First, we find that the coefficient of Deposit Ratio*Post is positive, thereby implying higher security holdings for banks with higher retail deposits after the introduction of NPR. Second, the estimated coefficient of the interaction Deposit Ratio*Post*Yield shows that the impact of an increase in the adjusted current yield in the post-NPR (negative policy rate) period was significantly different for banks with a higher retail deposit ratio. This can be interpreted as evidence of (relative) reach-for-yield behavior induced by the introduction of negative policy rates. Based on the coefficient of Deposit Ratio*Post*Yield in the third column of Table 4 we find that after the introduction of negative policy rates, a difference in the deposit ratio of 10 percentage points (approximately one standard deviation) would imply an around 2 percentage points increase in the sensitivity of the holdings of a particular security in response to a change in the adjusted current yield by one percentage point.[20] The coefficient of the

[20] Both the adjusted current yield (cf. Figure A.4 in the Annex) and the deposit ratio (cf. Figure 2) are measured in percentage points, while the dependent variable of nominal holdings has been log-transformed.

triple interaction Deposit Ratio*Post*Yield is positive and significant both between banks (or securities) and within, exploiting within-security variation and within-bank variation.[21]

Overall, the post-NPR portfolio of high-deposit ratio banks becomes riskier compared to low-deposit ratio banks, suggesting reach-for-yield in securities holdings caused by the introduction of negative interest rates. This (ex-post) result is consistent with our (ex-ante) hypothesis. Banks that are more reliant on customer deposits are more affected by negative rates and increase risk-taking by reaching for higher yields (cf. Section 2.1).

We now explore the potential drivers of higher securities holdings for high-deposit banks after NPR. Figure 2 shows the evolution of the deposit ratio across the banks in our sample. We have split the sample in two groups of banks, below and above the median for the deposit ratio. There were limited changes in the deposit ratios of the two groups of banks after the introduction of negative policy rates. Consistently, the overall amount of customer deposits of high-deposit banks indeed increased somewhat after the introduction of negative policy rates (see Figure A.6 in the Annex). This suggests that there were indeed more deposit inflows towards high-deposit banks compared to low-deposit banks.[22]

Table A.11 in the Annex shows the results of bank level panel regressions, controlling for unobserved bank heterogeneity via bank fixed effects, which provide further evidence based on the banks in our sample. The first column shows indeed that deposits were flowing relatively more to high deposit banks after the introduction of negative rates. At the same time, the second column shows that the volume of loans did not change similarly and that high deposit banks did not increase loans relative to low deposit ratio banks. We can infer from this evidence that high deposit banks preferred to invest the additional deposit inflows in (liquid) securities holdings that are easier to readjust than (illiquid) loans (as these new deposits could unexpectedly reverse themselves).

3.2 The Parallel-Trends Assumption

Our identification strategy relies on the assumption that, in the period before the introduction of negative policy rates, risk taking behavior did not differ systematically across banks with low and high deposit ratios (parallel-trends assumption). To investigate further on this, we estimate a specification that includes dummies for the lags and leads of the policy change, as in Autor (2003). Instead of the interaction with Post, we include interactions with a dummy variable

[21] The sign of the triple interaction is also robust across subsamples restricted to the bottom quartile, the two mid quartiles and top quartile of the adjusted current yield. Very small holdings (below 0.5 million on aggregate) are typically just held by a single bank and therefore excluded in our baseline estimations. However our results are robust to including all reported securities holdings including reported zero holdings as well as to a weighted estimation of our benchmark regression, with weights based on the overall holdings of each security (see first four columns of Table A.10). Moreover, if we control for the correlations between a security and the portfolio of securities by a bank (e.g. different shares in sovereign debt, private securities and foreign securities), results are virtually the same (see the last two columns of Table A.10).

[22] High deposit banks have a business model that is catered more to retail customers. They may offer better deposit rates, but also better services, more branches etc. Also, for the banks in our sample, we can show that high-deposit banks tend to have higher levels of equity and less wholesale funding, hence they are probably perceived to be safer banks, and hence preferred by depositors (see Figure A.7 in the Annex).

for each quarter. These dummy variables take a value of 1 in the respective quarter and a value of 0 for all other quarters. Figure 3 shows all estimated coefficients of the interactions of deposit ratio, adjusted current yield and dummy variables for each quarter with 90% confidence bands. Without a systematic difference before and after the policy change, we would expect the pre-treatment interaction of a quarter dummy with the deposit ratio and the yield to be close to zero (not statistically significant). Our data is available from the fourth quarter of 2013 onwards and we use the quarter before the introduction of negative policy rates (Q1 2014) as our reference period. Before the policy change, the estimated coefficient of the triple interaction of Deposit Ratio, Yield and the dummy variable for Q4 2013 is not statistically (and economically) significant. Based on this evidence, we do not reject the *parallel trend* assumption during the pre-NPR period.

[Insert Figure 3 about here.]

Figure 3 also illustrates the effects of negative interest rates over time: the strongest effect is already visible at the end of the second quarter (negative policy rates were first implemented on June 11 2014), while the subsequent reduction in remuneration of the ECB's deposit facility on 10 September to -0.2% had a more limited impact. The results of this test also provide a rationale to define the time frame of our analysis and to pin down the effects of the policy change in the second quarter of 2014. Indeed, if we included this quarter in our pre-NPR period, we would violate the parallel trends assumption, which would prevent us from identifying a causal effect. On the other hand, as we end our sample before the announcement of the ECB asset purchases in January 2015, the time window of our analysis includes the two quarters before and the three quarters after the introduction of negative policy rates. For robustness, we have carried out a similar analysis in a specification with just two periods.[23] We can also extend the post-NPR period by up to three quarters in 2015 and our findings still hold. We cannot run a similar exercise for the pre-NPR period, because the SHSG database starts in Q4 2013.

3.3 Asset Class and Currency Denomination

We have shown a reach-for-yield channel after the introduction of negative policy rates. Using the granular database at our disposal, we now explore in which types of securities banks increase and decrease holdings in the process of facilitating this reach-for-yield channel. We answer the following question: is the evidence of reach-for-yield behavior by high deposit ratio banks prevalent for certain asset classes? We perform the same estimations as in Table 4 restricting our sample across different asset classes. In this specification we include fixed effects for securities

[23] We find similar results if we summarize the holdings Q4 2013-Q1 2014 and Q2 2014-Q4 2014 and estimate a simple two-period specification.

in the same rating category, and with similar residual maturity. The rationale for these fixed effects is to group securities that need a similar amount of regulatory capital.[24]

[Insert Table 5 about here.]

The left panel of Table 5 reports the results of each separately estimated regression. The positive relationship captured by the coefficient of Deposit Ratio*Post*Yield is confirmed for all asset classes, albeit at different levels of statistical and economic significance. Evidence for reach-for-yield behavior of high deposit ratio banks is strongest and statistically significant for private debt securities issued by financial and non-financial corporations. Relative differences in behavior between affected banks and less affected banks are particularly pronounced within this asset class. More affected banks direct their investment more towards riskier debt in the class of private debt securities compared to the relative shifts within other asset classes. Effects are not significant for sovereign debt, and are large but not statistically significant for ABS (the estimated coefficient is large but the standard errors are much larger than in the other columns).

The investment of banks in securities denominated in currencies other than the euro is important because it tackles the international spillovers of monetary policy.[25] In particular, it represents a channel through which euro area (accommodative) monetary policy leaks to other economic areas and currencies. Therefore, we also consider portfolio shifts across different currencies. We estimate our relationship separately across different currencies in the right panel of Table 5. The differential response by high deposit ratio banks is particularly pronounced for securities denominated in US dollar (USD). Sensitivities in this category are estimated to be almost twice the size of those for securities denominated in euro (see columns 5 and 6 of Table 5). Interestingly, we observe a counteracting effect for securities issued in Swiss Franc (CHF), British Pound (GBP) and other currencies. However, investment in these currencies represents a very small fraction of the total portfolios of the banks in our sample, therefore the economic significance of these effects is rather limited. Nevertheless, these findings of reach-for-yield behavior in US dollars are evidence of a "leakage" effect of euro area monetary policy in securities markets outside the euro area.

3.4 Bank Capital and Risk-Shifting

Peydró et al. (2017) provide evidence that bank risk-taking in response to a monetary policy loosening during a crisis period can be explained by banks' risk-bearing capacity (i.e. bank equity). Their analysis is based on granular data on loans and securities holdings of Italian

[24] We construct these fixed effects as follows: First, we group securities by maturity. We use multiples of 100 days (i.e. the first group contains all securities maturing between 0-99 days, the second group those with 100-199 remaining days of maturity etc.). Based on this we compute a common fixed effect for securities within the same maturity group, holding the same rating during a certain quarter.

[25] See for example Obstfeld (2019), Morais et al. (2019) or Rajan's 2014 complain on US QE as RBI governor in an interview with Bloomberg (https://www.bloomberg.com/news/articles/2014-01-31/india-vs-dot-the-u-dot-s-dot-when-central-bankers-collide).

banks. We also investigate how differences in bank equity affect securities holdings in the context of negative rates. Hence, we interact our coefficient of interest with the equity ratio (equity divided by total assets) of each bank.[26] The results are displayed in Table 6.

[Insert Table 6 about here.]

First, we observe that the coefficient of Deposit Ratio*Post*Yield remains positive and significant for all the different specifications. To evaluate how the deposit ratio and bank capital interact, we look at the coefficient of the quadruple interaction Equity Ratio*Deposit Ratio*Post*Yield. The coefficient of the interaction is always negative and significant for some specifications. After the introduction of NPR, among the most affected banks (with higher retail deposits), banks with a higher level of equity took less risk. Banks with a weaker capital position take on more risk associated to the retail deposit channel of negative rates. Therefore, our results suggest risk-shifting via the retail deposit channel as outlined in Section 2.1. At the same time, the positive coefficient of Equity Ratio*Post*Yield confirms the findings of Peydró et al. (2017) during the sovereign debt crisis in the euro area.[27]

3.5 Duration Risk

Duration risk is an additional dimension through which banks' securities portfolios can become riskier. We measure duration risk via maturity.[28] To explore how duration risk interacts with risk taking behavior after the introduction of negative policy rates, we estimate our benchmark specification from section 3.1 and include maturity as an additional measure of risk (see Table 7). In particular we are interested how maturity interacts with our main coefficient of interest Deposit Ratio*Post*Yield. We also confirm that the estimated coefficient Deposit Ratio*Post*Yield remains positive and significant, i.e. robust to the addition of maturity as a control.

[Insert Table 7 about here.]

Additionally the positive and significant coefficient of the quadruple interaction Maturity*Deposit Ratio*Post*Yield suggests that reach-for-yield behavior is stronger for longer-term securities. This suggests that, after the introduction of negative rates, high-deposit banks invested more in higher-yielding securities with longer maturities compared to low deposit ratio banks. This is evidence of an additional channel of bank-risk taking that is consistent with

[26] In general, there is no mechanical relationship between the deposit ratio and the equity ratio since more equity funding does not necessarily decrease the ratio of deposits over total assets. Rather, we find a slightly positive relationship between the retail deposit ratio and the equity ratio for the banks in our sample (see also Figure A.7 in the Annex).

[27] This leads to a counteracting effect that quantitatively dominates the overall relationship.

[28] Figure A.5 in the Annex shows the maturity structure of the securities holdings in our sample before and after the introduction of negative policy rates. There were no significant aggregate shifts in the maturity structure during our sample period.

our theoretical predictions in section 2.1. Banks that are more affected by the introduction of negative policy rates take higher risks also by increasing the maturity of those securities in their portfolio that trade at higher yields.

3.6 The Lending Portfolio

In the previous sections we have analyzed the impact of negative policy rates on the securities holdings of large European banks. While securities are liquid assets and easier to rebalance in response to changes in policy rates, loans represent a larger fraction of banks' assets. We now provide some complementary evidence on the impact of negative rates on large banks' assets by using data on syndicated lending.

Other studies that have addressed the impact of low or negative rates on banks' portfolios have mainly analyzed the loans' portfolios (see also discussion in Section 1.1). High-deposit banks lend less, and to riskier firms in the euro area syndicated loan market (Heider et al., 2019). The negative effect on bank credit supply is however less pronounced when high-deposit banks also hold more excess reserves (Demiralp et al., 2017). Using credit register data for Italian banks, Bottero et al. (2019) find that affected banks rebalance their portfolios from liquid assets to lending, granting loans especially to ex-ante riskier and smaller firms, without however higher ex-post delinquencies – overall non-performing loans do not change over the period.

Ideally, we would need detailed loan-level data for the banks in the sample (i.e. a credit register) in order to properly account for borrower risk. These data are not available at this level of granularity for banks headquartered in different countries and for the time period we are considering, while similar analysis can be carried out by using data of one country at the time (see for example Bottero et al., 2019). We use syndicated loans transactions from Dealogic and include in the analysis only loans for which at least one of the banks in our sample was involved in the deal.

We run difference-in-differences regressions around the introduction of negative policy rates both at the bank-month level and at the bank-borrower level. For the first analysis we construct the database as follows: We aggregate the volumes of all deals within a month at the level of a bank holding company, and include only banks with the role of "Mandated Arrangers". Because mandated arrangers "tend to hold on to their loan share throughout its life" (Heider et al., 2019), in this way we exclude possible effects arising from loan securitization. However, this selection significantly limits the size of our sample. Indeed, this specification includes just 60 bank-month observations for 15 banks in our sample for which the loan amount is reported (results from this subsample are reported in the first column of Table 8, under the heading "Aggregate Loans"). We also report the results of the analysis for a specification with *allocated* loan amounts (see column 2, "Aggregate Allocated Loans"). We divide the overall loan amount reported in Dealogic equally among all banks in the loan syndicate. This enables us to increase the sample size to 183 bank-month observations for 22 banks. For the analysis at the bank-borrower level, we include

in the database single loans, considering banks in all roles, but including each bank only once. In this case, our sample consists of 568 bank-borrower observations for 22 banks.

[Insert Table 8 about here.]

Results are shown in Table 8. In our analysis at the bank-borrower level we find some evidence that banks with a higher deposit ratio decrease the amounts of syndicated loans (see negative coefficient of Deposit Ratio*Post in column 3 of Table 8); however, this result is not robust across the different columns. Also, when we consider "Total Net Loans" in the bank-level analysis as reported in Table A.11 in the Annex we do not find a significant coefficient. Therefore, the evidence on overall lending is very weak. More related to the focus of our paper, to exploit differential risk-taking on the level of the borrower, we include issuer ratings,[29] in particular the interaction Deposit Ratio*Post*Rating. The coefficient of the triple interaction Deposit Ratio*Post*Rating is positive, thereby suggesting that banks more dependent on retail deposits increase their exposure to ex-ante riskier borrowers relative to low deposit ratio banks (the coding of the rating variable is such that a higher value corresponds to a riskier rating). We find statistically significant results when restricting the sample to the period November 2013 - December 2014 in order to exclude the announcement of the ECB's asset purchases.[30] These findings on loans and risk-taking are comparable to the positive triple interaction coefficient in our security-level regressions. While recognising the caveats of the analysis due to severe sample limitations, these results provide suggestive evidence that high-deposit banks take higher risks after NPR also in their syndicated loan portfolios. More analysis on this topic based on granular data that may become available to researchers in the future is needed to provide further support to this result.

4 Conclusions

The implementation of negative policy rates in several countries in the last few years constituted an important novelty for policy makers and researchers interested in the effects of monetary policy. We contribute to the ongoing literature on this topic addressing the impact that negative rates have on financial intermediaries, in particular banks. We exploit a new dataset covering the securities holdings of the 26 largest euro area banking groups and evaluate the impact of the introduction of negative policy rates on these portfolios. There was no previous evidence on the effects of negative policy rates on banks' risk-taking in securities despite the fact that securities holdings represent a large fraction of banks' assets and are important for policy-makers with respect to risk-taking.

[29] This restricts the analysis to loans where the rating of the borrower is specified, which further reduce the sample size. Ratings are coded with a numerical variable ranging from 1 for AAA to 16 for B-.

[30] The coefficients of interest lose statistical significance in regressions based on an extended sample covering syndicated loan transactions during the years 2013-2015.

Our identification relies on a differential shock induced by negative rates on high- and low-(retail) deposit banks. We find robust evidence that negative policy rates lead to reach-for-yield behaviour in the securities holdings of more exposed banks. Comparing the period after the introduction of negative rates and before, banks more reliant ex-ante on customer deposits (compared to the other banks) relatively increase their holdings of securities, with stronger effects for those securities yielding higher returns. Our analysis of portfolio choices within asset classes shows that the reach-for-yield effects are confined to holdings of debt securities issued by private firms, financial and non-financial. As regards to currency, the more affected banks reshuffle their holdings towards riskier securities denominated in US dollars, in addition to euro currency (this is relevant when considering international spillovers of euro area monetary policy). Moreover, we find that, after the introduction of NPR, the reach-for-yield effects for banks with higher customer deposits are stronger for weaker capitalized banks, thus consistent with risk-shifting behavior.

Our analysis complements the results obtained by other researchers which mainly focused on the impact of negative policy rates on the lending portfolio of banks. It remains to be investigated how the results of all these studies can be combined to assess the macroeconomic impact of negative policy rates and to evaluate the possible trade-offs between temporary distortions in some parts of the financial sector and the effects on the economy at large. Our results also have important implications for the assessment of non-standard monetary policy tools and how these tools can have a heterogeneous impact across financial intermediaries, that is not directly related to the primary objectives of policy makers.

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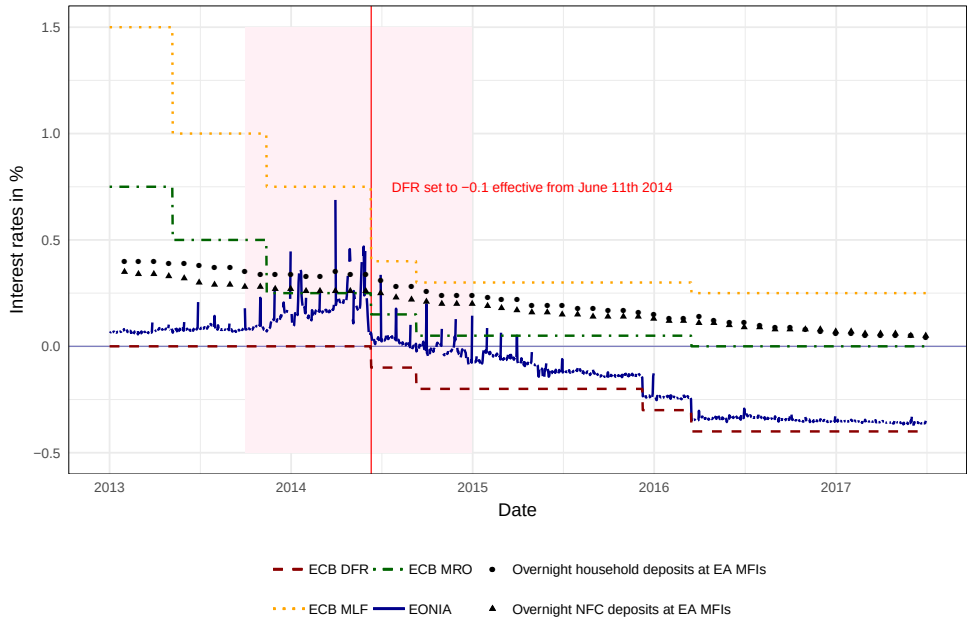
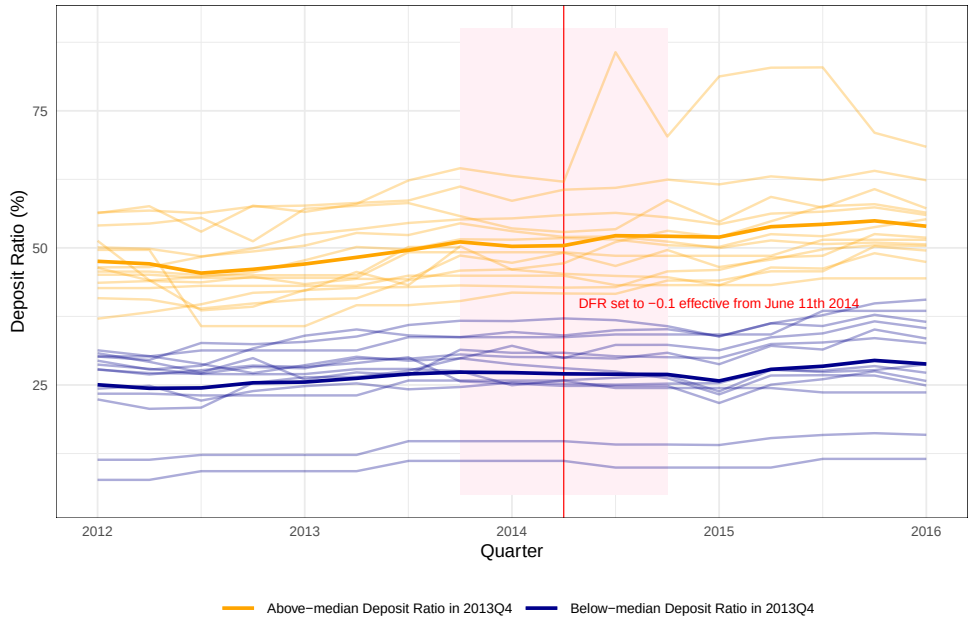
Figures

Figure 1: Policy Rates and Market Interest Rates in the Euro Area



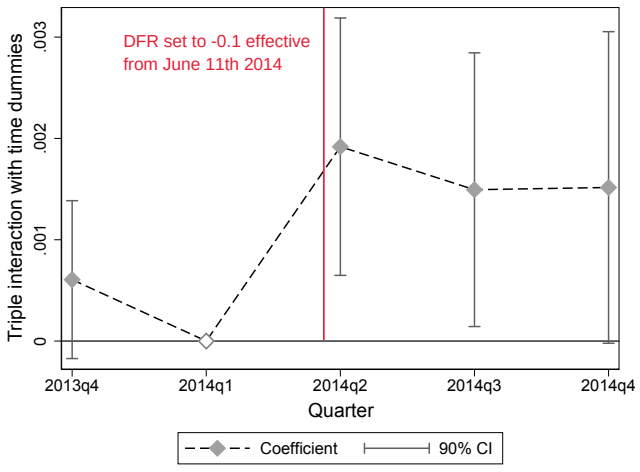
Notes: This figure shows a daily time series of the policy rates of the ECB and other important bank interest rates in the euro area between January 2013 and June 2017. The dashed line is the deposit facility rate (ECB DFR), the dash-dotted line is the rate on main refinancing operations (ECB MRO) the dotted line is the marginal lending facility (ECB MLF) obtained from ECB SDW. The blue line is a daily series of the EONIA interbank interest rate (Euro OverNight Index Average) obtained from ECB SDW. The dots and triangles show a monthly time series of the rates applied to "new business" overnight household and NFC deposits from the euro area MFI Interest Rate Statistics obtained from ECB SDW.

Figure 2: The Evolution of the Deposit Ratio over Time



Notes: This figure shows a quarterly time series of the Deposit Ratio (in %) between Q1 2012 and Q1 2016 obtained via SNL Financials for each bank in our sample. We compute the Deposit Ratio by dividing Customer Deposits in Euro by Total Assets in Euro. Banks are also classified into above-median Deposit Ratio banks and below-median Deposit Ratio banks according to their Deposit Ratio in Q4 2013. The yellow thick line shows a quarterly average for above-median Deposit Ratio banks, and the light yellow lines show the deposit ratio for each of these banks. The blue thick line shows a quarterly average for below-median Deposit Ratio banks, and the light blue lines show the deposit ratio for each of these banks.

Figure 3: Evidence on the Parallel Trends Assumption



Notes: This figure shows the triple interaction coefficient Deposit Ratio*(Pre/Post) Quarter*Yield in a regression with dummies for each quarter instead of the dummy variable and bank and security fixed effects. We plot each coefficient with a 90% confidence interval at the respective value of the variable quarter on the x-axis. Please note that the coefficient for Q1 2014 is 0 by construction (reference period, omitted from the regressions).

Tables

Table 1: Average Total Nominal Holdings by Asset Class and Region

	Q4 2013-Q1 2014		Q2 2014-Q4 2014	
	Euro billion	%	Euro billion	%
Asset Class				
ABS	524.8	17.8%	521.4	18.5%
Private debt (other)	485.5	16.5%	403.0	14.3%
Private debt issued by banks	830.8	28.2%	754.7	26.8%
Public debt	1100.7	37.4%	1141.9	40.5%
Currency				
CHF & GBP	46.5	1.6%	42.9	1.5%
EUR	2390.7	81.3%	2275.1	80.7%
Other	283.1	9.6%	283.0	10.0%
USD	221.4	7.5%	219.9	7.8%
Total	2941.7		2821.0	

Notes: This table displays the average total nominal holdings of securities by all 26 banks in the SHSG database both in period before the introduction of negative policy rates (Q4 2013-Q1 2014) and after the introduction of negative policy rates (Q2 2014-Q4 2014). The top panel splits all holdings by asset class (issuer and debt type). The lower panel splits securities by the currency of issuance.

Table 2: Summary Statistics

Security-level variables	N	mean	sd	min	max
Yield (ACY)	404,039	0.884	4.104	*	*
Rating	280,087	6.024	4.263	1	18
Ln(Holdings)	404,039	14.22	3.619	*	*
Holdings (Euro billion)	404,039	0.03	0.27	*	*
Post	404,039	0.617	0.486	0	1
Maturity (Years)	404,039	7.353	11.09	*	*
Bank-level variables	N	mean	sd	min	max
Total assets in Euro trillion (from SNL)	131	6.27	5.06	0.74	20.78
Log(Total Assets) (from SNL)	131	26.84	0.825	25.02	28.36
Equity/Total Assets in % (from SNL)	131	5.098	1.321	3.109	8.167
Customer deposits/Total Assets in % (from SNL)	131	39.26	14.25	9.943	85.68
Customer deposits in Euro billion (from SNL)	131	237.6	184	10.59	713.2
Non-Interest Income in Euro billion (from SNL)	75	1.029	1.252	-0.338	4.965
Total Net Loans in Euro trillion (from SNL)	100	2.881	1.959	0.9082	7.571
Loan-level variables	N	mean	sd	min	max
Loan amount in Euro million (Dealogic)	564	51.21	50.13	0	266.7
Rating (Dealogic)	128	9.398	2.131	5	15

Notes: This table shows summary statistics of the variables included in our regressions (Q4 2013-Q4 2014). All security-level variables are obtained from SHSG: The Yield (ACY) is the adjusted current yield computed with price information from the Centralized Securities Database (CSDB) of the Eurosystem, Rating is a numerical variable based on the most frequent rating of a security in the CSDB (AAA corresponds to 1), Maturity is top-coded at 100 years. All bank-level variables are obtained on the banking group level via SNL Financials. Loan-level variables are from Dealogic. Confidential data points from the securites register (SHSG data) were omitted.

Table 3: Overall Evolution of Securities Holdings

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Dependent variable: Securities Holdings								
Post	-0.801*	-0.765*	-0.406**	-0.748*	-0.719*	-0.375**	-0.538**	-0.285**	-0.167**
	(0.420)	(0.394)	(0.190)	(0.394)	(0.373)	(0.182)	(0.239)	(0.138)	(0.0807)
Deposit Ratio	0.0365**	0.0155	0.0129	0.0362**	0.0154	0.0133	0.0176*	0.0104	0.00237
	(0.0162)	(0.0108)	(0.0162)	(0.0159)	(0.0106)	(0.0162)	(0.0105)	(0.0129)	(0.00733)
Yield				-0.0181***	-0.0161***	-0.00930	0.0117	-0.00145	-0.00325
				(0.00513)	(0.00562)	(0.00675)	(0.0100)	(0.00891)	(0.00364)
Post*Yield				-0.0640**	-0.0592**	-0.0398***	-0.0343**	-0.0174**	-0.00803
				(0.0270)	(0.0242)	(0.0144)	(0.0137)	(0.00721)	(0.00550)
Observations	402,649	402,649	402,649	402,649	402,649	402,649	386,551	386,551	353,771
R-squared	0.030	0.050	0.218	0.035	0.055	0.220	0.470	0.580	0.861
Bank Controls	No	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes
Bank	No	No	Yes	No	No	Yes	No	Yes	–
Security	No	No	No	No	No	No	Yes	Yes	–
Security*Bank	No	No	No	No	No	No	No	No	Yes
*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$									

Notes: This table shows regressions on the security-level (ISIN) for quarterly observations between Q4 2013 and Q4 2014. The dependent variable Ln(Holdings) is calculated on nominal amounts and is determined by the holdings of security i by bank j at the end of quarter t. Post is the coefficient of a dummy variable that equals 1 from Q2 2014 onwards (negative policy rates were announced in June 2014). Deposit Ratio is calculated as Customer Deposits over Total Assets (in %). The Yield is the adjusted current yield (in %) of a security. Standard errors are double clustered on the security and bank-time level. Bank controls include the equity ratio (Equity/Total Assets) and log(Total Assets). The different sets of fixed effects are marked with "Yes" if they are included in the regressions, absorbed fixed effects are marked with "–".

Table 4: Benchmark Model (incl. Deposit Ratio Interaction)

	(1)	(2)	(3)	(4)	(5)	(6)
	Dependent variable: Securities Holdings					
Post	-2.140*	-2.245*	-1.558**	-1.704**	-1.204**	-0.655**
	(1.192)	(1.138)	(0.648)	(0.738)	(0.494)	(0.307)
Deposit Ratio (DR)	0.00911	-0.0149	-0.0403*	-0.00588	-0.0308**	-0.0181*
	(0.00712)	(0.0115)	(0.0204)	(0.00704)	(0.0155)	(0.00941)
Yield	-0.0255	-0.0164	0.0188	-0.0142	0.00133	0.0103
	(0.0158)	(0.0167)	(0.0203)	(0.0167)	(0.0133)	(0.0111)
Post*Yield	-0.164**	-0.155**	-0.116***	-0.0914***	-0.0655***	-0.0377**
	(0.0755)	(0.0698)	(0.0439)	(0.0334)	(0.0206)	(0.0187)
DR*Post	0.0388	0.0426*	0.0323**	0.0322**	0.0251**	0.0132**
	(0.0240)	(0.0234)	(0.0136)	(0.0150)	(0.0104)	(0.00639)
DR*Yield	0.000246	3.80e-05	-0.000795*	0.000756	-4.75e-05	-0.000364
	(0.000400)	(0.000404)	(0.000426)	(0.000526)	(0.000335)	(0.000306)
DR*Post*Yield	0.00294*	0.00282*	0.00224**	0.00163**	0.00136**	0.000835*
	(0.00165)	(0.00154)	(0.00100)	(0.000760)	(0.000533)	(0.000442)
Observations	402,649	402,649	402,649	386,551	386,551	353,771
R-squared	0.042	0.062	0.223	0.473	0.582	0.862
Bank Controls	No	Yes	Yes	Yes	Yes	Yes
Bank	No	No	Yes	No	Yes	–
Security	No	No	No	Yes	Yes	–
Security*Bank	No	No	No	No	No	Yes
*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$						

Notes: This table shows regressions on the security-level (ISIN) for quarterly observations between Q4 2013 and Q4 2014. The dependent variable Ln(Holdings) is calculated on nominal amounts and is determined by the holdings of security i by bank j at the end of quarter t. Post is the coefficient of a dummy variable that equals 1 from Q2 2014 onwards (negative policy rates were announced in June 2014). Deposit Ratio is calculated as Customer Deposits over Total Assets (in %). The Yield is the adjusted current yield (in %) of a security. Standard errors are double clustered on the security and bank-time level. Bank controls include the Equity Ratio (computed as Equity/Total Assets) and log(Total Assets). The different sets of fixed effects are marked with "Yes" if they are included in the regressions and "No" otherwise, additionally absorbed fixed effects are marked with "–".

Table 5: Benchmark Model across Asset Classes and Currencies

	Asset Class				**Currency**			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Public debt	Private debt issued by banks	Private debt (other)	ABS	EUR	USD	CHF & GBP	Other
	Dependent variable: Securities Holdings				Dependent variable: Securities Holdings			
Deposit Ratio	-0.0309**	-0.0487**	-0.0736**	-0.00699	-0.0400**	-0.0330	-0.119**	-0.0181
	(0.0141)	(0.0214)	(0.0328)	(0.0110)	(0.0199)	(0.0353)	(0.0582)	(0.0124)
Yield	0.00401	0.0755***	0.0258	0.224***	0.0928***	-0.0120	-0.320***	-0.114***
	(0.0260)	(0.0210)	(0.0248)	(0.0563)	(0.0134)	(0.0324)	(0.0948)	(0.0350)
Post*Yield	-0.0346	-0.0579*	-0.152***	-0.132	-0.0890***	-0.173**	0.331***	0.0494
	(0.0415)	(0.0333)	(0.0422)	(0.0842)	(0.0335)	(0.0809)	(0.113)	(0.0442)
Deposit Ratio*Post	0.0229**	0.0337**	0.0556***	0.00290	0.0307**	0.0335**	0.0823***	0.0134**
	(0.00963)	(0.0147)	(0.0191)	(0.00640)	(0.0138)	(0.0150)	(0.0238)	(0.00595)
Deposit Ratio*Yield	-0.000130	-0.00100**	-0.00105	-0.00517***	-0.000756**	-0.00153	0.00673***	0.00234***
	(0.000654)	(0.000471)	(0.000675)	(0.00112)	(0.000329)	(0.00101)	(0.00248)	(0.000769)
Deposit Ratio*Post*Yield	0.000718	0.00158*	0.00408***	0.00256	0.00257***	0.00461**	-0.00621**	-0.00144
	(0.000985)	(0.000873)	(0.00117)	(0.00157)	(0.000961)	(0.00189)	(0.00276)	(0.000977)
Observations	78,431	82,488	87,115	25,173	170,928	64,181	9,529	28,526
R-squared	0.262	0.347	0.447	0.473	0.317	0.430	0.780	0.329
Bank Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Bank FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Maturity*Rating*Time FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$								

Notes: This table shows regressions on the security-level (ISIN) for quarterly observations between Q4 2013 and Q4 2014. Each column restricts the sample to a certain asset class or currency as specified in the header of the table. The estimation equation can be found in Section 2.2. The dependent variable Ln(Holdings) is calculated on nominal amounts and is determined by the holdings of security i by bank j at the end of quarter t. Post is the coefficient of a dummy variable that equals 1 from Q2 2014 onwards (negative policy rates were announced in June 2014). Deposit Ratio is calculated as Customer Deposits over Total Assets (in %). The Yield is the adjusted current yield (in %) of a security. Standard errors are double clustered on the security and bank-time level. Bank controls include the Equity Ratio (computed as Equity/Total Assets) and log(Total Assets). We include Bank and Maturity*Rating*Time fixed effects.

Table 6: Benchmark Model with Additional Bank Equity Ratio Interaction

	(1)	(2)	(3)	(4)	(5)	(6)
	Dependent variable: Securities Holdings					
Post	-4.954	-4.801	-5.886***	-3.998	-4.699***	-2.175**
	(4.038)	(3.989)	(2.056)	(2.501)	(1.572)	(0.992)
Deposit Ratio (DR)	-0.0322	-0.0259	-0.548***	-0.0417	-0.437***	-0.243***
	(0.0337)	(0.0408)	(0.167)	(0.0302)	(0.131)	(0.0829)
Yield	0.0224	0.0879	0.165*	-0.0572	-0.00898	0.194***
	(0.0790)	(0.0954)	(0.0920)	(0.0776)	(0.0733)	(0.0690)
Post*Yield	-0.580**	-0.594**	-0.457***	-0.311***	-0.198**	-0.178***
	(0.267)	(0.266)	(0.163)	(0.115)	(0.0849)	(0.0652)
DR*Post	0.0771	0.0792	0.116***	0.0645	0.0930***	0.0426**
	(0.0804)	(0.0831)	(0.0406)	(0.0504)	(0.0318)	(0.0200)
DR*Yield	-0.00165	-0.00306*	-0.00390**	0.000748	-0.000659	-0.00390***
	(0.00151)	(0.00184)	(0.00172)	(0.00182)	(0.00152)	(0.00142)
DR*Post*Yield	0.00895	0.00947*	0.00721**	0.00485*	0.00315*	0.00298**
	(0.00543)	(0.00538)	(0.00332)	(0.00252)	(0.00185)	(0.00134)
Equity Ratio (ER)	-0.145	-0.0445	-5.407***	-0.313	-4.337***	-2.401***
	(0.308)	(0.363)	(1.601)	(0.295)	(1.266)	(0.803)
ER*Yield	-0.00843	-0.0222	-0.0350*	0.0117	0.00380	-0.0430***
	(0.0175)	(0.0210)	(0.0194)	(0.0165)	(0.0155)	(0.0155)
ER*DR	0.00702	0.00392	0.108***	0.00923	0.0862***	0.0474***
	(0.00716)	(0.00892)	(0.0326)	(0.00663)	(0.0257)	(0.0163)
ER*DR*Yield	0.000331	0.000631	0.000742**	-7.13e-05	7.55e-05	0.000827***
	(0.000339)	(0.000412)	(0.000371)	(0.000343)	(0.000318)	(0.000302)
ER*DR*Post	-0.0102	-0.0102	-0.0197**	-0.00902	-0.0160***	-0.00696*
	(0.0157)	(0.0168)	(0.00757)	(0.0101)	(0.00587)	(0.00363)
ER*Post*Yield	0.102*	0.107**	0.0862**	0.0532**	0.0338*	0.0358**
	(0.0527)	(0.0529)	(0.0336)	(0.0248)	(0.0193)	(0.0139)
ER*DR*Post	-0.0102	-0.0102	-0.0197**	-0.00902	-0.0160***	-0.00696*
	(0.0157)	(0.0168)	(0.00757)	(0.0101)	(0.00587)	(0.00363)
ER*DR*Post*Yield	-0.00162	-0.00175	-0.00141**	-0.000855*	-0.000536	-0.000604**
	(0.00107)	(0.00106)	(0.000670)	(0.000512)	(0.000408)	(0.000269)
Observations	402,649	402,649	402,649	386,551	386,551	353,771
R-squared	0.052	0.064	0.234	0.475	0.588	0.864
Bank Controls	No	Yes	Yes	Yes	Yes	Yes
Bank	No	No	Yes	No	Yes	–
Security	No	No	No	Yes	Yes	–
Security*Bank	No	No	No	No	No	Yes
*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$						

Notes: This table shows regressions on the security-level (ISIN) for quarterly observations between Q4 2013 and Q4 2014. Compared to our benchmark specification these results are estimated by additionally interacting all coefficients with the Equity Ratio (in %) of a bank. The dependent variable Ln(Holdings) is calculated on nominal amounts and is determined by the holdings of security i by bank j at the end of quarter t. Post is the coefficient of a dummy variable that equals 1 from Q4 2014 onwards (negative policy rates were announced in June 2014). Deposit Ratio is calculated as Customer Deposits over Total Assets (in %). The Yield is the adjusted current yield (in %) of a security. Standard errors are double clustered on the security and bank-time level. The Equity Ratio is computed as Equity divided by Total Assets (in %). Bank controls include log(Total Assets). The different sets of fixed effects are marked with "Yes" if they are included in the regressions and "No" otherwise, additionally absorbed fixed effects are marked with "–".

Table 7: Benchmark Model with Additional Interaction with Maturity

	(1)	(2)	(3)	(4)	(5)	(6)
	Dependent variable: Securities Holdings					
Post	-2.163*	-2.279**	-1.586**	-1.752**	-1.252**	-0.692**
	(1.166)	(1.123)	(0.659)	(0.760)	(0.516)	(0.327)
Deposit Ratio (DR)	0.00566	-0.0186	-0.0417**	-0.00524	-0.0320**	-0.0166
	(0.00650)	(0.0115)	(0.0209)	(0.00698)	(0.0160)	(0.0106)
Yield	-0.0150	-0.00483	0.0170	-0.0318*	-0.0114	0.00482
	(0.0118)	(0.0128)	(0.0158)	(0.0170)	(0.0134)	(0.0114)
Post*Yield	-0.129**	-0.124**	-0.0939**	-0.0717**	-0.0556***	-0.0343*
	(0.0627)	(0.0584)	(0.0371)	(0.0298)	(0.0202)	(0.0181)
DR*Post	0.0401*	0.0441*	0.0334**	0.0331**	0.0259**	0.0140**
	(0.0234)	(0.0230)	(0.0139)	(0.0154)	(0.0108)	(0.00684)
DR*Yield	5.40e-06	-0.000227	-0.000718**	0.00112**	0.000259	-0.000238
	(0.000329)	(0.000349)	(0.000343)	(0.000547)	(0.000332)	(0.000315)
DR*Post*Yield	0.00225*	0.00222*	0.00180**	0.00120*	0.00111**	0.000741*
	(0.00135)	(0.00127)	(0.000828)	(0.000709)	(0.000513)	(0.000434)
Maturity (Years)	-0.00108	-0.00590	-0.00128	-0.0325**	-0.0473***	-0.0106
	(0.0114)	(0.0110)	(0.0108)	(0.0126)	(0.0136)	(0.0194)
Maturity*Yield	-0.00156	-0.00124	0.00105	0.00472***	0.00592***	0.00108
	(0.00235)	(0.00234)	(0.00226)	(0.00174)	(0.00149)	(0.00115)
Maturity*DR	0.000589**	0.000678**	0.000472*	3.43e-05	0.000344	-0.000250
	(0.000292)	(0.000286)	(0.000282)	(0.000184)	(0.000217)	(0.000400)
Mat.*DR*Yield	-3.98e-05	-4.48e-05	-9.13e-05	-7.86e-05**	-0.000116***	-2.02e-06
	(6.51e-05)	(6.38e-05)	(6.23e-05)	(3.88e-05)	(3.69e-05)	(2.68e-05)
Mat.*DR*Post	-0.000600	-0.000620	-0.000495	-0.000331	-0.000267	-0.000136
	(0.000432)	(0.000411)	(0.000359)	(0.000218)	(0.000215)	(0.000113)
Mat.*Post*Yield	-0.0103**	-0.00948**	-0.00711**	-0.00549**	-0.00325**	-0.00103
	(0.00426)	(0.00402)	(0.00326)	(0.00219)	(0.00137)	(0.000887)
Maturity*Post	0.0211	0.0214	0.0170	0.0137	0.0109	0.00534
	(0.0170)	(0.0161)	(0.0134)	(0.00913)	(0.00816)	(0.00530)
Mat.*DR*Post*Yield	0.000234**	0.000218**	0.000168*	0.000134**	8.80e-05**	3.13e-05
	(0.000113)	(0.000107)	(9.12e-05)	(5.27e-05)	(3.69e-05)	(2.02e-05)
Observations	402,649	402,649	402,649	386,551	386,551	353,771
R-squared	0.046	0.065	0.225	0.474	0.582	0.862
Bank Controls	No	Yes	Yes	Yes	Yes	Yes
Bank	No	No	Yes	No	Yes	–
Security	No	No	No	Yes	Yes	–
Security*Bank	No	No	No	No	No	Yes

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Notes: This table shows regressions on the security-level (ISIN) for quarterly observations between Q4 2013 and Q4 2014. Compared to our benchmark specification these results are estimated by additionally interacting all coefficients with maturity in years of a security. The dependent variable Ln(Holdings) is calculated on nominal amounts and is determined by the holdings of security i by bank j at the end of quarter t. Post is the coefficient of a dummy variable that equals 1 from Q2 2014 onwards (negative policy rates were announced in June 2014). Deposit Ratio is calculated as Customer Deposits over Total Assets (in %). The Yield is the adjusted current yield (in %) of a security. Maturity is computed as the remaining maturity of a security in years and top-coded at 100 years. Standard errors are double clustered on the security and bank-time level. Bank controls include the Equity Ratio (computed as Equity/Total Assets) and log(Total Assets). The different sets of fixed effects are marked with "Yes" if they are included in the regressions and "No" otherwise, additionally absorbed fixed effects are marked with "–".

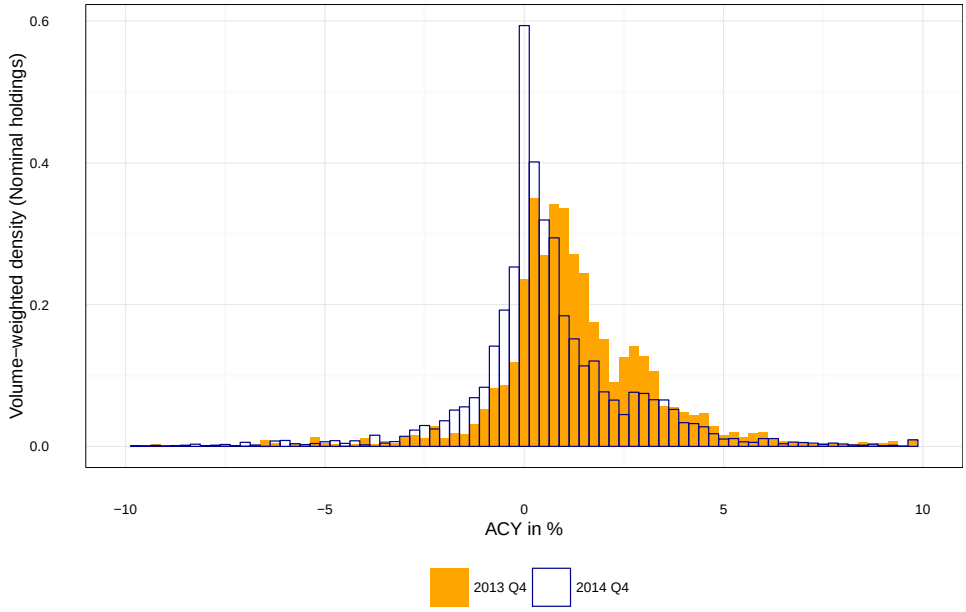
Table 8: Evolution of the Syndicated Loan Portfolio

	(1) Aggregate Loans	(2) Aggregate Allocated Loans	(3)	(4)	(5)	(6)
			Individual Loans			
Rating					-0.192*	
					(0.102)	
Post*Rating					-0.0366	
					(0.136)	
Deposit Ratio*Post	-0.0236	0.00602	-0.0152*	0.00270	-0.0684**	-0.0401*
	(0.0240)	(0.0125)	(0.00797)	(0.00381)	(0.0296)	(0.0213)
Deposit Ratio*Rating					-0.00149	-0.00203
					(0.00219)	(0.00169)
Deposit Ratio*Post*Rating					0.00619**	0.00406*
					(0.00304)	(0.00223)
Observations	60	183	568	530	125	123
R-squared	0.508	0.606	0.197	0.920	0.744	0.906
Lead Arrangers Only	Yes	Yes	No	No	No	No
Bank-Month Level	Yes	Yes	No	No	No	No
Bank-Borrower Level	No	No	Yes	Yes	Yes	Yes
Bank FE	Yes	Yes	Yes	Yes	Yes	Yes
Month FE	Yes	Yes	Yes	–	Yes	–
Borrower-Month FE	No	No	No	Yes	No	Yes
*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$						

Notes: This table shows regressions based on syndicated loan transactions obtained from Dealogic between between 1 November 2013 and 31 December 2014. The dependent variable are aggregate loan amounts on the bank-month level in the first two columns and reported individual loan amounts on the bank or bank-borrower level in columns 3-6. The first two columns on the bank-month level include only "Lead Arrangers", columns 3-6 include loan shares of banks in all roles. Allocated amounts split the overall loan amount equally among banks if individual loan amounts are not reported. Post is the coefficient of a dummy variable that equals 1 from June 2014 onwards. Deposit Ratio is calculated as Customer Deposits over Total Assets (in %) in Q4 2013. Rating is a numerical variable ranging from 1 (AAA) to 16 (B-) and refers to ratings reported in Dealogic. The different sets of fixed effects are marked with "Yes" if they are included in the regressions and "No" otherwise, additionally absorbed fixed effects are marked with "–".

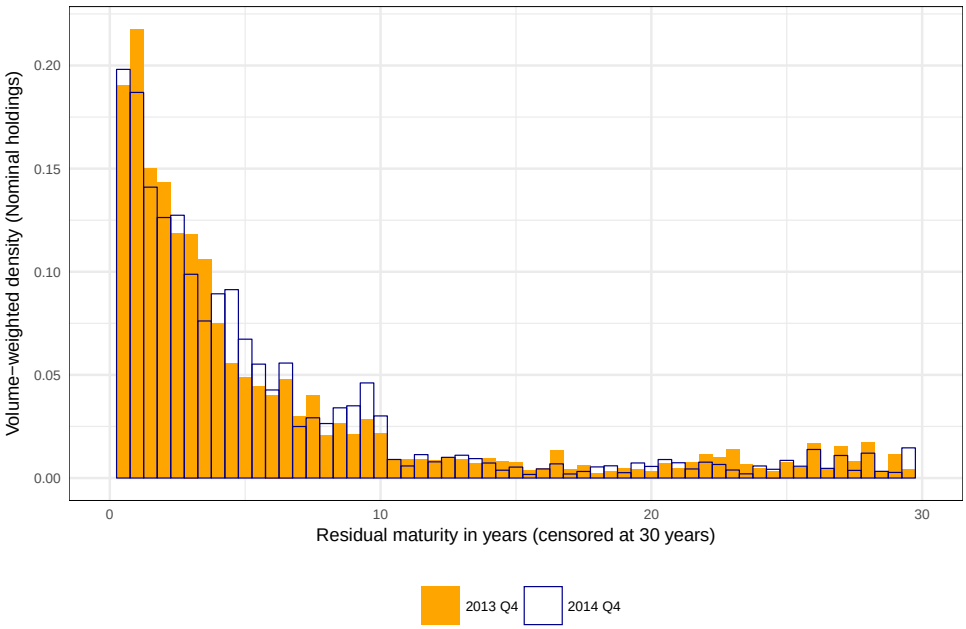
A Annex with Additional Figures and Tables

Figure A.4: Distribution of the Yield (ACY) Before and After Negative Policy Rates



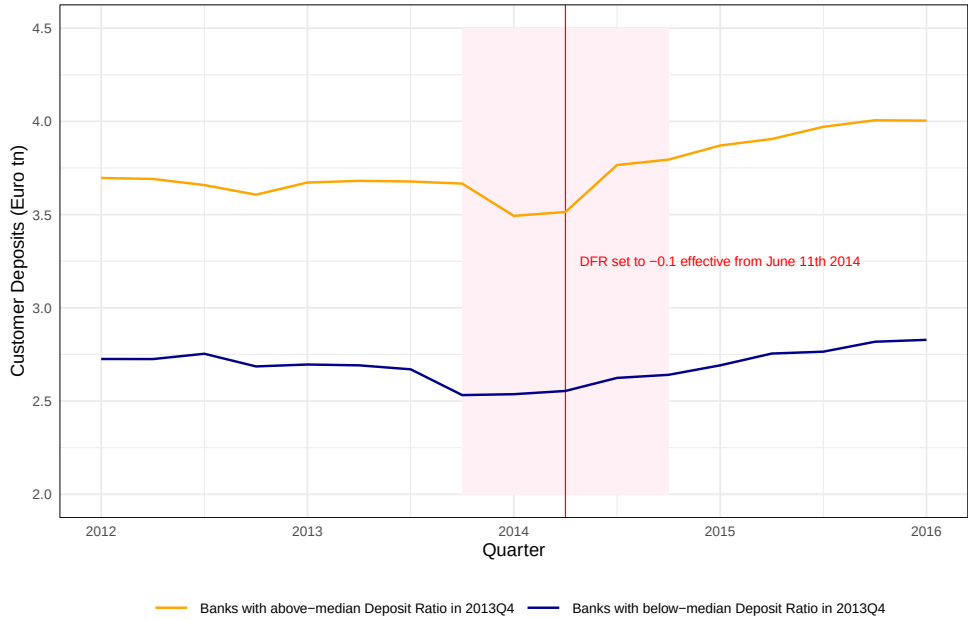
Notes: This figure shows a weighted histogram of the Yield (ACY, adjusted current yield) in % of all securities at the beginning of our sample (2013 Q4) and at the end of our sample (2014 Q4). We use the nominal holdings of each security in the SHSG to determine the weights.

Figure A.5: Distribution of Residual Maturity in Years Before and After Negative Policy Rates



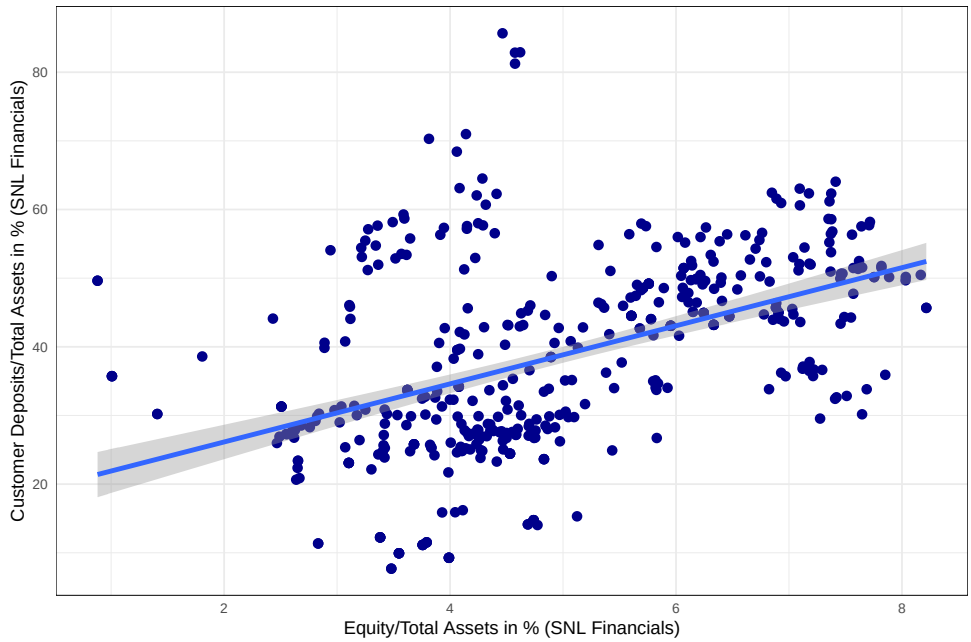
Notes: This figure shows a weighted histogram of the residual maturity in years of all securities at the beginning of our sample (2013 Q4) and at the end of our sample (2014 Q4). We use the nominal holdings of each security in our sample to determine the weights.

Figure A.6: Total Amount of Customer Deposits over Time



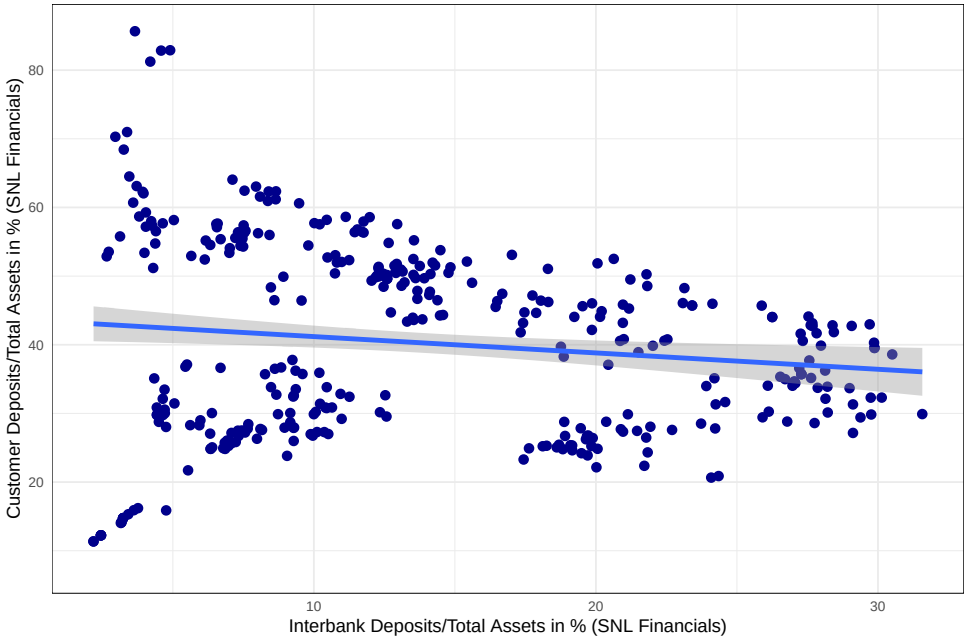
Notes: This figure shows a quarterly time series of Customer Deposits (in Euro trillion) between Q1 2012 and Q1 2016 obtained via SNL Financials. Banks are classified into above-median Deposit Ratio banks and below-median Deposit Ratio banks according to their Deposit Ratio in Q4 2013. The yellow line shows a quarterly total of Customer Deposits held at above-median Deposit Ratio banks. The blue line shows the quarterly total of Customer Deposits held at below-median Deposit Ratio banks.

Figure A.7: Equity Ratio and Deposit Ratio of the Banks in Our Sample



Notes: This figure shows on the x-axis the ratio Equity/Total Assets (in %) and on the y-axis the ratio of Customer Deposits/Total Assets (in %). The quarterly observations between Q1 2012 and Q1 2016 are obtained from SNL Financials. The blue line is a fitted regression line illustrating the positive correlation between the two variables.

Figure A.8: Interbank Deposits/TA and Deposit Ratio of the Banks in Our Sample



Notes: This figure shows on the x-axis the ratio of Interbank Deposits/Total Assets (in %) and on the y-axis the ratio of Customer Deposits/Total Assets (in %). Interbank deposits are a proxy for wholesale deposits. The quarterly observations between Q1 2012 and Q1 2016 are obtained from SNL Financials. The blue line is a fitted regression line illustrating the negative correlation between the two variables.

Table A.9: List of Reporting Banking Groups

	Country	Code	Short name	Full name
1	AT	AT20100	Erste	Erste Group Bank AG
2	BE	BE0403227515	KBC	KBC Group-KBC Groep NV/ KBC Groupe SA
3	BE	BE0403201185	Belfius	Belfius
4	DE	DE00001	DB	Deutsche Bank AG
5	DE	DE00003	COBA	Commerzbank AG
6	DE	DE00316	LBBW	Landesbank Baden-Wuerttemberg
7	DE	DE00317	BLB	Bayerische Landesbank
8	DE	DE00319	HELABA	Landesbank Hessen-Thüringen Girozentrale
9	DE	DE00320	NORDLB	Norddeutsche Landesbank Girozentrale NORD/LB
10	DE	DE01121	DZ	Deutsche Zentral-Genossenschaftsbank-DZ Bank AG
11	DE	DE03249	PBB	Deutsche Pfandbriefbank AG
12	ES	ES0049	BSCH	Banco Santander SA
13	ES	ES0182	BBVA	Banco Bilbao Vizcaya Argentaria SA
14	ES	ES7865	BFA	BFA Tenedora de Acciones SA (Bankia)
15	ES	ESHO486478	La Caixa	Criteria Caixa Holding SA
16	FR	FR10278	BFCM	Credit Mutuel CM5-CIC
17	FR	FR16188	BPCE	Group BPCE
18	FR	FR30003	SG	Société Générale
19	FR	FR30004	BNP	BNP Paribas
20	FR	FR30006	CA	Crédit Agricole Group-Crédit Agricole
21	IT	IT0000203426147	MPdS	Banca Monte dei Paschi di Siena
22	IT	IT0000102484824	UC	Unicredit SpA
23	IT	IT0000101262255	ISP	Intesa Sanpaolo
24	NL	NL149	ABN	ABN Amro Group NV
25	NL	NL163	ING	ING Groep NV
26	NL	NL600	Rabobank	Rabobank Group-Rabobank Nederland

Notes: This table shows all banks included in the Securities Holdings Statistics by Banking Groups (SHSG) during the sample period (Q4 2013-Q4 2014). The column code displays RIAD/MFI codes of all banks in our sample.

Table A.10: Robustness Checks of the Benchmark Regression

	Weighted Model		**Incl. Zero Holdings**		**Portfolio Controls**	
	(1)	(2)	(3)	(4)	(5)	(6)
	Securities	Holdings	Securities	Holdings	Securities	Holdings
Post	-1.218**	-0.678**	-0.615**	-0.209	-1.070**	-0.546**
	(0.501)	(0.312)	(0.291)	(0.163)	(0.452)	(0.264)
Deposit Ratio (DR)	-0.0316**	-0.0181*	-0.0250**	-0.0163**	-0.0257*	-0.0143*
	(0.0154)	(0.00943)	(0.0111)	(0.00695)	(0.0142)	(0.00833)
Yield	-0.00112	0.00861	0.0283**	0.0387**	0.00471	0.0194*
	(0.0142)	(0.0113)	(0.0120)	(0.0167)	(0.0142)	(0.0102)
Post*Yield	-0.0623***	-0.0335*	-0.0774***	-0.0539**	-0.0599***	-0.0382**
	(0.0207)	(0.0178)	(0.0257)	(0.0230)	(0.0191)	(0.0157)
DR*Post	0.0253**	0.0137**	0.0143**	0.00524	0.0217**	0.0106*
	(0.0105)	(0.00652)	(0.00637)	(0.00344)	(0.00955)	(0.00545)
DR*Yield	2.80e-06	-0.000324	-0.000143	-0.000704*	4.80e-05	-0.000513*
	(0.000346)	(0.000312)	(0.000293)	(0.000376)	(0.000352)	(0.000265)
DR*Post*Yield	0.00132**	0.000767*	0.00137**	0.000997*	0.00112**	0.000799**
	(0.000549)	(0.000426)	(0.000557)	(0.000520)	(0.000473)	(0.000358)
Observations	386,551	353,771	737,823	704,303	386,551	353,771
R-squared	0.580	0.882	0.795	0.930	0.586	0.863
Weighted Model	Yes	Yes	No	No	No	No
Incl. Zero Holdings	No	No	Yes	Yes	No	No
Bank Portfolio Controls	No	No	No	No	Yes	Yes
Bank Controls	Yes	Yes	Yes	Yes	Yes	Yes
Bank	Yes	–	Yes	–	Yes	–
Security	Yes	–	Yes	–	Yes	–
Security*Bank	No	Yes	No	Yes	No	Yes

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Notes: This table shows weighted regressions on the security-level (ISIN) for quarterly observations between Q4 2013 and Q4 2014. For the weighted model in columns 1 and 2 we aggregate holdings by ISIN across all banks and use this variable as the weight of each security-quarter-bank observation. In columns 3 and 4 we add zero holdings and also include all very small holdings (below 0.5 million overall nominal holdings across all banks). Columns 5 and 6 add two additional controls on the bank level: the fraction of public debt securities and the fraction of euro area securities in the securities portfolio of each bank . The specification is equivalent to our benchmark regression in Table 4. The dependent variable Ln(Holdings) is calculated on nominal amounts and is determined by the holdings of security i by bank j at the end of quarter t. Post is the coefficient of a dummy variable that equals 1 from Q2 2014 onwards (negative policy rates were announced in June 2014). Deposit Ratio is calculated as Customer Deposits over Total Assets (in %). The Yield is the adjusted current yield (in %) of a security. Standard errors are clustered on the security and bank-time level. Bank controls include the Equity Ratio (computed as Equity/Total Assets) and log(Total Assets). The different sets of fixed effects are marked with "Yes" if they are included in the regressions and "No" otherwise, additionally absorbed fixed effects are marked with "–".

Table A.11: Bank-level Regressions on Deposits, Loans and Non-Interest Income

	(1) Ln(Customer Deposits)	(2) Ln(Total Net Loans)	(3) Ln(Non-Interest Income)
Post	-0.0417*	-0.0444	-0.135
	(0.0249)	(0.0342)	(0.377)
Deposit Ratio	0.00470	0.00280	0.0111
	(0.00412)	(0.00440)	(0.0113)
Deposit Ratio*Post	0.00155**	0.00144	0.00300
	(0.000727)	(0.000926)	(0.00684)
Observations	130	100	73
R-squared	0.998	0.997	0.908
FE	Bank	Bank	Bank
*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$			

Notes: This table shows regressions at the bank-level for quarterly observations between Q4 2013 and Q4 2014. Post is the coefficient of a dummy variable that equals 1 from Q2 2014 onwards (negative policy rates were announced in June 2014). Deposit Ratio is calculated as Customer Deposits over Total Assets (in %). All Data is obtained from SNL Financials.

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