Mixing QE and Interest Rate Policies at the Effective Lower Bound: Micro Evidence from the Euro Area*

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Abstract

We study jointly expansionary rate-based monetary policy and quantitative easing, despite their concurrent implementation around the world, by exploiting the introduction of negative monetary-policy rates in a fragmented euro area, alongside cross-sectional heterogeneity in banks' balance sheets. Banks more exposed to quantitative easing increase their credit supply less when they incur higher funding costs due to a zero lower bound (ZLB) on deposit rates. Using administrative data from Germany, we also uncover that German banks rebalance their interbank lending from safe to risky countries, and that the ZLB on deposit rates compromised the effectiveness of quantitative easing.

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1 Introduction

The policy space for conventional, rate-based monetary stimulus has become increasingly limited in the post-crisis era. Central banks around the world have since employed unconventional monetary policies to fulfill their mandates.[1] Most prominently, they have implemented large-scale asset purchases, or quantitative easing (QE), to inject liquidity into the economy. As asset-purchase programs predominantly take place in low-rate environments, when the limit of conventional monetary stimulus has been reached, quantitative easing and rate-setting monetary policy seem inextricably linked at the effective lower bound. This renders it unclear how lower rates and quantitative easing interact, and whether they substitute or complement each other (Abadi, Brunnermeier, and Koby, 2022).

In this paper, we approach this question through the lens of a bank-based transmission channel of monetary policy. We do so by focusing on the euro area where monetary-policy rates broke through what was believed to be the zero lower bound (ZLB) in 2014—a clear expression of nearing the limits of conventional monetary stimulus—prior to the implementation of quantitative easing. While rate pass-through is an important determinant of the effectiveness of QE (Beraja, Fuster, Hurst, and Vavra, 2018; Di Maggio, Kermani, and Palmer, 2019), it may be impaired for some asset classes in a low-rate environment. We provide empirical evidence that banks that see only a weak pass-through of monetary policy to their funding costs and that are at the same time strongly exposed to QE increase their credit supply to the real economy less.

How do conventional monetary policy and QE interact, and what changes under negative monetary-policy rates? Under QE, the European Central Bank (ECB) expands its balance sheet by accumulating securities on the asset side, which are funded by reserves on the liability side. Since reserves can only be held by euro area banks, QE mechanically increases their reserves. Conventional monetary policy affects the rate on these same reserves. Cutting interest rates below zero effectively taxes newly created reserves at the central bank. In a frictionless world, banks would pass through these negative rates on their assets to their liability side, lowering their funding costs and thereby enhancing their ability to lend out newly created reserves. Such a scenario resembles the transmission of lower but still positive monetary-policy rates during QE. However, banks have been shown to be reluctant, or unable, to pass on negative rates to their depositors (Heider, Saidi, and Schepens, 2019; Eggertsson, Juelsrud, Summers, and Wold, 2019).

[1] See Bernanke (2020) for a synthesis of the new tools of monetary policy and their effectiveness since 2008.

This gives rise to cross-sectional heterogeneity in the pass-through of lower, negative monetary-policy rates.

Under negative monetary-policy rates, high-deposit banks incur higher funding costs in comparison to banks whose cost of funding is more aligned with the monetary-policy rate. When quantitative easing is implemented, pass-through of lower monetary-policy rates to banks' asset side remains strong, or becomes even stronger, as long-term assets are replaced with central-bank reserves. The net worth of low-deposit banks is relatively shielded because they continue to see a pass-through of lower, even negative, monetary-policy rates to their funding costs. This, in turn, enables them to lend out (some of) the newly created reserves so as to reduce their exposure to negative rates. In contrast, high-deposit banks incur relatively higher funding costs, which inhibits their ability to lend out funds, such as the newly created reserves, to the non-financial sector.[2]

We disentangle the effect of banks' exposure to asset purchases from the transmission of monetary policy by exploiting variation in the pass-through of negative monetary-policy rates to banks' funding costs across countries and banks. First, since the European sovereign debt crisis, banks' funding costs vary significantly across euro area countries, especially so for local deposit markets.[3] When the respective rates are closer to the ZLB in a given country, the pass-through of monetary-policy rates to banks' funding costs is more likely to be impaired. Second, when banks' funding costs are already close to the ZLB, the pass-through of even lower, negative monetary-policy rates is impaired primarily for retail deposits rather than other types of funding, such as wholesale market funding. This allows us to define banks' exposure to negative monetary-policy rates as a function of their funding structure, as the ZLB on retail deposit rates implies that deposit-funded banks incur relatively higher funding costs than do otherwise-funded banks.

To test how banks' exposure to negative monetary-policy rates and QE affects their credit supply, we use granular data on syndicated lending by euro area banks. These data allow us to compare the lending behavior of differentially treated banks to the same borrower. Moreover, the cross-country dimension enables us to compare banks with each other that are located in different countries where retail deposit rates may be either far away or closer to the ZLB. While syndicated loans account for a sizable portion of total bank lending, they do not necessarily capture overall bank lending behavior in the euro area. Therefore, in addition to using syndicated-loan data, we

[2]This is consistent with the rationale laid out by Repullo (2020), in that banks' funding costs determine their response to counteract what would otherwise constitute an adverse shock to their profitability.

[3]See, for instance, Bittner, Bonfim, Heider, Saidi, Schepens, and Soares (2022).

conduct further analyses using microdata from Germany where many banks do not benefit from lower funding costs due to a binding ZLB on retail deposit rates.

To capture banks' exposure to negative monetary-policy rates, we use information on their funding structure, in particular their customer deposit share (Heider, Saidi, and Schepens, 2019). This reflects the rationale that high-deposit banks, in comparison to low-deposit banks, incur higher funding costs during the negative interest-rate period. To measure banks' exposure to QE during that period, we use the ex-ante relative prevalence of securities on their balance sheets (Rodnyansky and Darmouni, 2017). Finally, we interact the resulting distinction between high- vs. low-deposit and high- vs. low-security banks with time variation in the ECB's asset purchases.

Irrespective of how we define the ECB's asset purchases to spill over to euro area banks' balance sheets, we find that banks whose asset portfolios are more exposed to QE reduce their credit supply relatively more when they rely more on deposit funding. Our identification strategy may be subject to reverse causality, in that QE and negative monetary-policy rates are implemented due to worsening macroeconomic conditions in the euro area. To mitigate this concern, we exploit the portion of variation in ECB asset purchases that cannot be explained by time-varying country-level characteristics, such as GDP growth and inflation, and our findings remain robust.

We obtain these results controlling for time-invariant unobserved heterogeneity at the bank level, time-varying unobserved heterogeneity at the level of the countries in which these banks are incorporated, and also for time-varying unobserved heterogeneity at the firm level by including firm-time fixed effects. This within-firm estimator controls sufficiently well for overall credit demand and can rule out negative credit demand shocks as a driver of our results (Khwaja and Mian, 2008; Jiménez, Ongena, Peydró, and Saurina, 2014). In this manner, we find that the average bank lends up to 9.38% less than a bank with a both one-standard-deviation lower security and deposit ratio in response to a one-standard-deviation increase in asset purchases.

How do large-scale asset purchases exert an influence on banks' proclivity to lend when the central bank also pursues rate-setting monetary policy? One line of argumentation is centered on a positive effect on banks' net worth, which sets in when asset purchases positively impact security prices as the newly injected reserves may reduce term premia (Christensen and Krogstrup, 2019). This price effect, in turn, increases the marked-to-market value of banks' security holdings and, thus, raises banks' net worth—a mechanism also known as "stealth recapitalization" (Brunnermeier and Sannikov, 2014).

However, in the presence of negative monetary-policy rates, any such price-driven effect on bank net worth is confounded by a negative force on bank earnings. The QE purchases by the ECB mechanically increase central-bank reserves on banks' balance sheets, so that the amount of reserves in the system is controlled by the ECB. The negative interest rates on reserve balances therefore must be paid by banks in the euro area, and are associated with a reduction in net worth if banks cannot readily lend out those newly created reserves because their funding costs do not drop accordingly. This is the case when retail deposit rates are close to the ZLB and banks rely heavily on this funding source.[4] We confirm that the asset purchases lead to relatively lower net worth and less credit supply in low-rate environments such as the core of the euro area, while this does not apply in other countries of the euro area where sovereign yields (and deposit rates) are higher (Bittner, Bonfim, Heider, Saidi, Schepens, and Soares, 2022).

For the largest economy in the euro area, Germany, we can zoom in on this mechanism. Besides rich administrative data from the Bundesbank, focusing on Germany also holds the advantage of mitigating the potential reverse-causality concern surrounding the concurrent implementation of QE and negative monetary-policy rates in the euro area.[5] Using quarterly balance-sheet data, we first establish that the newly created reserves are disproportionately held by banks that have both high security and high deposit ratios. Among high-security banks that sell their securities to the ECB, which are in turn swapped for reserves on their balance sheet, those with high deposit ratios are constrained in their ability to lend out these reserves, but also to reduce their balance sheet, due to costly and sticky customer deposits at the zero lower bound. Therefore, more negative interest-rate bearing reserves remain on the balance sheets of banks with high security and high deposit ratios, imposing a tax on the proceeds from the QE security sales.

Using credit-registry data, we then corroborate our headline finding that banks with higher security and deposit ratios reduce their credit supply to firms relatively more when QE is implemented. This confirms that the negative credit-supply effects are not limited to syndicated loans, but also extend to private credit attained by a wider and more representative range of firms. Economically, we find comparable but larger effects for Germany than for the whole panel of euro area banks, consistent with the idea that German deposit rates are constrained by the ZLB.

[4]Acharya and Rajan (2022) show theoretically that the creation of commercial-bank liabilities following QE can be contractionary for lending growth if banks see a convenience yield to liquid reserves during times of stress. This would be a separate mechanism for why central bank balance-sheet expansions might not always stimulate the real economy.

[5]Figure A1 in the Online Appendix shows that GDP growth in Germany was back to $> 2\%$ already prior to QE, while in contrast to, for instance, Italy, the non-performing loan share in the banking system is low. Therefore, it is unlikely that QE was targeted for Germany.

Combining the German credit-registry data with more detailed balance-sheet data than are available for the panel of euro area banks allows us to differentiate between household deposits, the rates on which face a hard ZLB, and corporate deposits, which see a stronger pass-through of negative monetary-policy rates (Heider, Saidi, and Schepens, 2019; Altavilla, Burlon, Giannetti, and Holton, 2022). This enables us to compare banks with similar deposit ratios that differ only in the source of their deposits. In this manner, we find that banks with higher security and deposit ratios reduce their credit supply only if they are funded by household deposits, reaffirming the importance of the ZLB on retail deposit rates.

Second, we use data on German banks' security holdings to examine their trading of securities around the large-scale asset purchases. We show that banks with ex-ante more securities sell more of them during the QE period, but their purchases are not significantly different from banks with fewer security holdings. Using the net sales of securities as an alternative measure of banks' exposure to QE, we corroborate our findings that banks that are more exposed to QE and have a higher deposit ratio reduce their credit supply by more. This also addresses the potential concern that the pre-existing security ratio does not proxy well for banks' exposure to QE and, as such, may be driven by other bank-specific factors unrelated to the asset purchases.

We conclude our analysis of banks' credit-supply response by analyzing the transmission of affected banks' credit contraction to firms' real outcomes. First, we confirm that around the implementation of QE, German firms' total borrowing across all banks declined relatively more for those in lending relationships with banks that have high security and high deposit ratios, indicating that these firms were unable to fully substitute the reduction in credit supply due to the negative interaction between QE and negative rates across lenders.

We then turn to the consequences for the real economy, and show that German firms borrowing from banks that have high security and high deposit ratios see relatively weaker employment growth than their counterparts. A simple back-of-the-envelope calculation suggests that the adverse interaction of QE and negative monetary-policy rates in the presence of a ZLB on deposit rates eradicates any positive employment effects stemming from QE, such as those documented for the U.S. (Foley-Fisher, Ramcharan, and Yu, 2016; Luck and Zimmermann, 2020). Therefore, our results provide a rationale for why QE has been potentially more successful in spurring employment in the U.S. than in the euro area.

Having shown that affected banks reduce their lending, with repercussions for the real sector, we consider the possibility that they rebalance their asset side by, instead, increasing their portion of liquid assets. Unlike corporate loans, interbank loans help to transfer and redistribute reserves, but do not lead to the creation of costly deposits elsewhere in the system. To evaluate this, we scrutinize German banks' interbank positions and find that high-deposit banks that are more exposed to QE increase their interbank lending, with possible implications for the distribution of interbank liquidity in the euro area. Using bilateral country-level banking flows, we present suggestive evidence that lends support to the idea that financial dependence of periphery banks from the core may have increased during the ECB's large-scale asset purchases.

Related literature. Our paper contributes to various strands of the literature. First, we contribute to the literature on the effects of low or negative monetary-policy rates in general and their bank-based transmission in particular. Abadi, Brunnermeier, and Koby (2022) show theoretically that when interest rates drop below a "reversal rate," a decline in interest rates can be contractionary. Ulate (2021) studies the effects of negative rates in a DSGE model where banks intermediate the transmission of monetary policy.[6] Heider, Saidi, and Schepens (2019) show that banks with higher deposit ratios reduce their syndicated lending by more in response to the introduction of negative monetary-policy rates in the euro area. Eggertsson, Juelsrud, Summers, and Wold (2019) confirm that retail household deposit rates in Sweden are subject to a lower bound, and show that once this bound is reached, the pass-through to lending rates and credit volumes is substantially lower, and bank equity values decline in response to further policy-rate cuts. Our findings suggest that quantitative easing substantially contributed to the contractionary effects of negative interest rates.

More concretely regarding the transmission of negative monetary-policy rates, Bottero, Minoiu, Peydró, Polo, Presbitero, and Sette (2022) show that negative interest-rate policies can still have expansionary effects on bank credit supply and firm-level outcomes through a portfolio rebalancing channel. Bubeck, Maddaloni, and Peydró (2020) show that banks with higher deposit ratios invest more in higher-yielding securities in response to the introduction of negative monetary-policy rates. In line with our evidence, Ampudia and Van den Heuvel (2018) uncover that during the period of negative interest rates in the euro area, stock prices of banks declined in response to accommodative monetary-policy announcements, and even more so for banks with a greater reliance on deposit funding.

[6] A separate strand of the literature studies the medium- to long-term effects of interest rate changes on banks' lending behavior and the economy more broadly (Bernanke and Blinder, 1988; Christiano and Eichenbaum, 1992; Stein, 2012; Gomez, Landier, Sraer, and Thesmar, 2021).

In comparison to this literature on the transmission of negative monetary-policy rates,[7] we explore its interaction with large-scale asset purchases, or QE. Krishnamurthy and Vissing-Jørgensen (2011) study the effect of QE on interest rates in the United States. Koijen, Koulischer, Nguyen, and Yogo (2021) show that banks sold purchase-eligible government bonds during QE. Using bank-level data, Paludkiewicz (2021) finds that German banks that see a stronger yield decline on their securities portfolio induced by QE are more likely to sell (eligible) bonds and increase their lending to the real sector. Rodnyansky and Darmouni (2017) define banks' exposure to QE by measuring the relative prevalence of mortgage-backed securities on their books, and show that U.S. banks that were strongly exposed to QE increased their lending. Di Maggio, Kermani, and Palmer (2019) find that after the first round of QE in the U.S., the origination of mortgages qualifying for inclusion in eligible securities for Fed purchases increased significantly more than did those of non-qualifying mortgages. On the other hand, Chakraborty, Goldstein, and MacKinlay (2020) document that more exposed banks increased mortgage lending at the expense of their commercial lending. Luck and Zimmermann (2020) study the employment effects of the transmission of QE to bank lending in the U.S. Other papers have adopted similar approaches to investigate the effects of unconventional monetary policies in Europe (see, for instance, Acharya, Eisert, Eufinger, and Hirsch, 2019; Grosse-Rueschkamp, Steffen, and Streitz, 2019; Crosignani, Faria-e Castro, and Fonseca, 2020; Benetton and Fantino, 2021; Carpinelli and Crosignani, 2021; Peydró, Polo, and Sette, 2021).

Recent theoretical work examines the relationship between unconventional monetary policy and the real economy. Acharya and Rajan (2022) analyze the consequences of central bank balance-sheet expansions, and argue that the offsetting liabilities that are created following an influx of reserves at commercial banks dampen the potential stimulative effects on lending growth, especially during a crisis. De Fiore, Hoerova, and Uhlig (2018) and Corradin, Eisenschmidt, Hoerova, Linzert, Schepens, and Sigaux (2020) show that asset purchases give rise to a scarcity effect, which induces money market frictions and can have adverse effects on lending. Bianchi and Bigio (2022) argue that purchases of liquid assets (the ones we study) can be ineffective, whereas purchases of more illiquid assets (such as loans) can be more effective. Diamond, Jiang, and Ma (2021) show that the central-bank reserve creation through QE crowds out bank lending, consistent with our findings. In contrast to most papers in this literature, we specifically study whether the credit-supply response of banks to QE varies with the extent to which banks are exposed to

[7] See Heider, Saidi, and Schepens (2021) for an overview of this literature.

the transmission of monetary-policy rates. Furthermore, while most of the QE literature focuses on the announcement effects of QE, we study its implementation during its run-time.

One of the few exceptions in the literature that studies the interaction between negative interest rates and QE is Abadi, Brunnermeier, and Koby (2022), who posit that QE should be employed only after the room for lowering rates is exhausted. When the central bank reduces interest rates, capital gains on banks' securities increase, and banks with large security holdings benefit disproportionately from these capital gains. Abadi, Brunnermeier, and Koby (2022) argue that as QE mechanically reduces securities on banks' balance sheets, the gains from cutting interest rates decrease after QE is conducted, as banks benefit less from higher security prices. Empirically, we find that high-security banks gain less when they also rely heavily on deposit funding that sees no monetary-policy pass-through prior to QE due to the ZLB on retail deposit rates. This adverse interaction suggests that the potential complementarities between QE and policy-rate adjustments at the ZLB are limited at best (as previously conjectured by Sims and Wu, 2020, 2021).

2 Data

2.1 Bank Lending and Balance-Sheet Data

In the first part of the paper, we analyze credit supply by euro area banks using data on syndicated-loan transactions from DealScan. For a syndicated loan, different banks form a syndicate and then lend to firms. The lead arranger in a syndicate is usually responsible for monitoring the loan and various other tasks associated with risk management (Ivashina and Scharfstein, 2010). Lead arrangers tend to hold on to their loan shares, while other syndicate members (participants) can and do sell their shares in the secondary market. In the DealScan data, one only sees the facility amount, the banks that participate in the syndicate, and whether they act as lead arrangers or other participants. However, banks' individual contributions are not properly recorded most of the time. We therefore follow the literature, and split two-thirds vs. one-third of the total loan amount equally among all lead arrangers and other participants, respectively.[8]

We then merge the syndicated-loan data with balance-sheet characteristics of euro area banks from Moody's Analytics BankFocus. In particular, we use data on banks' total security holdings, their customer deposits, as well as various other control variables.[9] Finally, we use bank stock-

[8]See, for example, Chodorow-Reich (2014). The results are robust to other choices.

[9]Descriptive statistics for the DealScan sample can be found in Table A1.

price data from the same database.

2.2 German Microdata

We complement our analysis of syndicated lending in the euro area with administrative credit-registry data (BAKIS-M) from Germany (Schmieder, 2006). Banks domiciled in Germany are required to report all loans exceeding €1 million.[10] The dataset contains the loan amount outstanding to the respective borrower on a quarterly basis.

In addition, we use the Securities Holdings Statistics, SHS-Base plus,[11] formerly known as WpInvest (Blaschke, Sachs, and Yalcin, 2020). The database covers all securities held by German banks on their own behalf (full census). Banks report the holdings amount on a security-by-security basis.[12] We enrich this dataset with security master data from the Centralised Securities Database (CSDB)[13] (Bade, Flory, Gomolka, and Schnellbach, 2018). The purpose of the CSDB is to cover all securities likely to be held or transacted by euro area residents. With its high-quality coverage of more than ten million securities per time stamp, we incur almost no loss of observations from merging our datasets.

Furthermore, we use the monthly balance-sheet statistics (BISTA)[14] with coverage of banks' asset and liability positions (Gomolka, Schäfer, and Stahl, 2020). This allows us, in particular, to construct banks' deposit ratios (deposits over total assets) and security ratios (securities over total assets).

Finally, we merge the Bundesbank data with firm-level balance-sheet data from BvD Orbis.

3 Evidence from Syndicated Lending

3.1 Empirical Setup

In this section, we analyze syndicated lending by banks in the euro area. In particular, we study the lending behavior of banks that are differentially exposed to the negative interest-rate policy

[10] In January 2015 the reporting threshold was reduced from formerly €1.5 million. Note that this reporting requirement applies to all borrowers, including those with less credit exposure, as long as the total loan amount of a given borrower's parent and all affiliated units is equal to or exceeds the threshold at any point in time during the reporting period.

[11] Data ID: 10.12757/Bbk.SHSBaseplus.05122006

[12] See also Timmer (2018).

[13] Data ID: 10.12757/BBk.CSDB.200903-201912.01.01

[14] Data ID: 10.12757/BBk.BISTA.99Q1-19Q4.01.01

and asset-purchase programs.

When the ECB initiated its asset-purchase programs in 2015, banks' security holdings declined substantially (Figure 1). In 2013 and 2014 security holdings of banks were relatively stable, but once the ECB started purchasing assets at a large scale, security holdings of banks declined significantly, while at the same time the ECB's security holdings increased sharply. The ECB's security holdings increased by around €1,400 billion, and security holdings of euro area banks accounted for almost one-fifth of the sales, based on approximately €250 billion sold.

As can be seen in Figure 2, banks that had more securities in 2013 were more exposed to QE and sold more securities in the course of the QE implementation, leading to a stronger reduction in security holdings. We label such banks with higher pre-determined security ratios as "treated" more heavily by the ECB's asset-purchase programs.[15] These high-security banks are more likely to benefit from asset-price appreciation than banks with lower security ratios (Brunnermeier and Sannikov, 2016). Under QE, they sell their securities to the central bank and swap them for central-bank reserves, which in turn yield negative rates. Banks can then "avoid" paying this tax on their capital gains by lending out the newly created reserves. Their ability to do so is, however, compromised if banks experience weaker pass-through of negative monetary-policy rates to their funding costs. In that case, greater exposure to asset-purchase programs can reduce bank profitability and, thus, lead to a reduction in credit supply.

As pointed out by, among others, Abadi, Brunnermeier, and Koby (2022), Heider, Saidi, and Schepens (2019), and Eggertsson, Juelsrud, Summers, and Wold (2019), banks tend to face a zero lower bound on retail deposit rates. They are either reluctant, or it is impossible for them, to lower deposit rates to below zero in spite of the monetary-policy rate having crossed that threshold. If banks set a rate below a "reversal rate" (such as zero), customers may withdraw their deposits. As this friction is not present for wholesale funding sources, banks that rely more on retail deposit funding incur relatively higher funding costs following the introduction of negative monetary-policy rates. To capture this, we follow Heider, Saidi, and Schepens (2019) and differentiate banks by their deposits-to-assets ratio.

Figure 3 plots euro area banks' security ratios on the y-axis against their deposit ratios on the x-axis. The size of the dots reflects the total assets of each bank in 2013. The average security ratio is just above 20%, as indicated by the dotted line on the y-axis. The average deposit

[15] In Section 5, we provide more direct evidence for German banks, and thereby confirm, that pre-existing security holdings predict well the sales of securities when QE is implemented.

ratio is significantly higher, at around 50%, as indicated by the dotted line on the x-axis. The correlation coefficient between the security ratio and the deposit ratio is only -0.03 and statistically insignificant, suggesting that banks with higher deposit ratios, which are more exposed to negative monetary-policy rates, are not necessarily more exposed to asset purchases and vice versa. The scatter plot also illustrates that there exists notable variation within each size category. While, on average, larger banks have lower deposit ratios, both large and small banks exhibit similar variation in terms of their exposure to asset purchases.

To test whether banks that are more exposed to both QE and negative monetary-policy rates react differently in terms of their credit supply, we estimate the following regression specification at the transaction level using our syndicated-loan data:

$$\begin{aligned} \ln(Lending_{i(l),j(l),t(l)}) = {} & \beta_1 QE \times Security\ Ratio_i + \beta_2 QE \times Deposit\ Ratio_i \\ & + \beta_3 QE \times Security\ Ratio_i \times Deposit\ Ratio_i \\ & + \mu_i + \theta_{j,m(t)} + \phi_{c(i),m(t)} + \epsilon_{i,j,t}, \end{aligned} \tag{1}$$

where *Lending*$_{i(l),j(l),t(l)}$ is the amount lent by bank i (incorporated in country c) to borrower j at date t in loan package l. *QE* is a time-varying measure of the ECB's asset purchases, which we standardize to have a 0 mean and a standard deviation of 1 throughout (unless indicated otherwise). *Security Ratio*$_i$ is the share of securities over assets of bank i in 2012, and *Deposit Ratio*$_i$ is the share of deposits over assets of bank i in 2012. The sample spans the time period from the introduction of negative monetary-policy rates in 2014 to 2020. Standard errors are clustered at the bank level.

Importantly, besides bank fixed effects, μ_i, we include borrower by month-year fixed effects, $\theta_{j,m(t)}$, and (banks') country by month-year fixed effects, $\phi_{c(i),m(t)}$, to control for firm-level determinants of credit demand and time-varying unobserved heterogeneity at the level of the country c in which a given bank i is incorporated.

3.2 Baseline Results

Table 1 shows the results from estimating (3). All specifications yield a negative estimate of β_3, indicating that banks that are more exposed to both QE and negative monetary-policy rates lend less in response to asset-purchase programs than their less exposed counterparts. Also, in line with the idea that banks with higher security ratios benefit from QE, the coefficient on the respective interaction is positive. Hereafter, whenever applicable, all tables display only the coefficient on the triple interaction, β_3, because the double-interaction terms cannot be interpreted independently from the triple interaction as both exposure variables—banks' security and deposit ratios—are defined to be non-zero for all banks.

In columns 1 and 2, we define $QE_{c(i),m(t)}$ as the amount of government bond purchases of country c, where bank i is incorporated, by the ECB in a given month-year $m(t)$, divided by the respective country's banks' total security holdings in 2012. This can be seen as a measure of the absorption of securities relative to a pre-existing stock. This "flow" measure of QE constitutes our baseline measure.[16]

Our estimate of β_3 is robust across the first two columns, where we additionally vary the set of fixed effects. In column 1, we control for bank and borrower by month-year fixed effects. The latter are included so as to capture time-varying unobserved heterogeneity at the borrower level, including but not limited to loan demand (Jiménez, Ongena, Peydró, and Saurina, 2014; Khwaja and Mian, 2008). Effectively, we identify our effect using firms that borrow from different banks in the same month. Thus, to the extent that credit demand does not vary across banks as a function of their exposure to negative monetary-policy rates and QE, any difference in lending can be attributed to credit supply rather than demand. To estimate β_3 in the presence of such borrower-time fixed effects, we implicitly restrict our sample to firms that borrow from at least two banks at the same time. However, as we focus on syndicated loans, which by definition are made by a syndicate of banks, this restriction is innocuous. In column 2 and all remaining columns, we also include bank i's country by month-year fixed effects, which control for time-varying unobserved heterogeneity associated with a given bank's country c.

One potential concern with our identification strategy could be reverse causality, i.e., QE and negative monetary-policy rates are implemented concurrently because of deteriorating macroeconomic conditions in the euro area. To address this concern, we exploit variation in QE that is not explained by time-varying country-level characteristics.

First, to identify potentially unanticipated variations in asset purchases by the ECB, in column 3 we replace $QE_{c(i),m(t)}$, defined as in columns 1 and 2, with the residual of a regression in which this measure is regressed on the two-year lags of GDP growth and inflation of country c. This controls for potential interactions between the latter two variables of aggregate economic activity and banks' security and deposit ratios, in addition to controlling for country by month-year fixed

[16] D'Amico and King (2013) show that there are both flow and stock effects of QE.

effects. Our coefficient of interest, β_3, remains robust.

Next, we follow Koijen, Koulischer, Nguyen, and Yogo (2021) and exploit the unique institutional feature that the Eurosystem's government bond purchases are proportional to each country's capital key, which in turn is based on a calculation that reflects the respective country's share in the total population and GDP of the European Monetary Union, giving rise to arguably exogenous cross-sectional variation in the size of the Eurosystem's purchases. Our estimate of β_3 does not vary markedly in column 4 when we predict $QE_{c(i),m(t)}$, defined as in columns 1 and 2, with the interaction between the ECB capital share of country c and the natural logarithm of one plus the total amount of securities purchased by the ECB.

Our findings in columns 2 to 4 are robust to redefining $QE_{c(i),m(t)}$ as the natural logarithm of one plus the monthly purchases in country c instead of the scaled monthly purchases (see columns 5 to 7). In this manner, we simultaneously drop all observations with negative asset purchases. Across all specifications, our coefficient ranges from -1.34 to -0.64. In terms of economic magnitude, a bank with a 20% security and a 50% deposit ratio (corresponding to the average bank in Figure 3) relative to a bank with a 10% security and a 30% deposit ratio (approximately one standard deviation below) lends between $((0.1-0.03)\times 1.34=)$ 9.38% and $((0.1-0.03)\times 0.64=)$ 4.48% less in response to a one-standard-deviation increase in asset purchases. To measure an average effect on credit supply, we define $QE_{m(t)}$ in column 8 to be an indicator variable that equals 1 during the quantitative-easing period. The respective coefficient on the triple interaction implies $((0.1-0.03)\times 2.0=)$ 14% less lending.

One concern regarding the identification of these estimates could be that banks that are strongly exposed to both QE and negative rates are also different in terms of other characteristics that may govern bank lending over time. To investigate this, in Table A2 of the Online Appendix, we regress bank characteristics in 2012 on the interaction between the security ratio and the deposit ratio in the cross-section of euro area banks. Affected banks, i.e., those with high security and high deposit ratios, do not differ substantially in terms of other important bank characteristics, such as total assets, capitalization, or profitability. As such, it does not come as a surprise that our estimates in Table 1 are robust to including interaction terms of (all variants of) our *QE* measure with the above-mentioned control variables (see Table A3 in the Online Appendix).

Figure 4 plots the coefficient on the interaction of $\textit{Security Ratio}_i$ and $\textit{Deposit Ratio}_i$ annually between 2010 and 2020. Before the introduction of negative monetary-policy rates, there is no discernible difference in credit supply as a function of banks' exposure to negative monetary-policy rates and QE. This absence of a pre-trend, combined with a strong decline in the coefficient once negative monetary-policy rates (red vertical line) and QE (purple dashed line) are introduced, lends support to our identifying assumption that banks more exposed to QE and negative rates would not have been on different trajectories absent the introduction of these policies.

In Table 2, we re-estimate our baseline specification for a longer time period (starting in 2010, as in Figure 4) and replace the *QE* treatment variable with an indicator variable, $Post_t$, that equals 1 starting with the introduction of negative monetary-policy rates in the euro area (June 11, 2014). Given that the QE and negative interest-rate periods roughly coincide, we effectively replace our QE treatment-intensity variable with a dummy variable for non-zero asset purchases by the ECB, similarly to column 8 of Table 1. In spite of incorporating a significantly longer pre-period, comprising the reduction of the deposit facility rate to zero in July 2012, the results remain similar: banks that are more exposed through their balance sheet (higher deposit and security ratios) to both negative interest rates and QE lend less during the negative interest-rate period than before compared to less exposed banks. This holds also after including our most restrictive set of control variables, including borrower by month-year and country by month-year fixed effects.

Instead of comparing a (long) pre-negative-rates period ($Post_t = 0$) with a post-negative-rates period ($Post_t = 1$), one can also estimate the effect of each (additional) rate cut into negative territory. For this purpose, we replace the indicator variable $Post_t$ with the actual deposit facility rate, $Deposit\ Facility_t$. As the latter was actually zero in 2012, we start the sample period then.[17] The results are in Table A4 of the Online Appendix. In line with our estimates in Table 2, the coefficient on the triple interaction is positive, implying that lower, negative deposit facility rates are associated with less lending by banks that are more exposed to both negative interest rates and QE.

These results raise the question whether negative monetary-policy rates would have led to reduced credit supply by banks with high deposit and security ratios even absent QE. To test this, we explore further heterogeneity in terms of the response to negative interest-rate cuts before and after QE was introduced, by estimating a staggered difference-in-differences specification. For this purpose, we split our sample into four periods: (1) a pre-period starting in 2010, (2) an $NIRP\ CUT\ BEFORE\ QE_t$ period, (3) a QE_t period, and (4) an $NIRP\ CUT\ AFTER\ QE_t$ period comprising further rate cuts by the ECB (with the first one after the announcement of QE taking place on

[17] Our results are robust to including the deposit facility rates from 2010 and 2011, which were positive and both increased and decreased during that time period.

December 9, 2015 and the last one on September 18, 2019). The estimates in Table 3 show that banks that are more exposed to QE and negative monetary-policy rates do not lend less than their counterparts after the first cut into negative territory without QE implemented at the same time. When in addition to negative rates QE is implemented, treated banks lend less than their counterparts, and the effect remains statistically significant when the ECB cuts the deposit facility rate further into negative territory, i.e., after both negative monetary-policy rates and QE have already been introduced.

4 Equity Returns

In this section, we estimate the reaction of bank stock returns in response to asset purchases. As equity returns measure expected future discounted bank profits, their variation can be indicative of profitability (English, Van den Heuvel, and Zakrajšek, 2018). To study the changes in equity returns of high-deposit and high-security banks relative to other banks in response to asset purchases during a period of low interest rates, we estimate the following regression model:

$$\begin{aligned} Return_{i,m} =& \beta_1 QE_{c(i),m} \times Security\ Ratio_i + \beta_2 QE_{c(i),m} \times Deposit\ Ratio_i \\ &+ \beta_3 QE_{c(i),m} \times Security\ Ratio_i \times Deposit\ Ratio_i + \mu_i + \delta_m + \epsilon_{i,m}, \end{aligned} \tag{2}$$

where $Return_{i,m}$ is the percent change in the equity prices of bank i between month-year m and $m-1$. $QE_{c(i),m}$ is the amount of government bond purchases (by the ECB in month-year m) of country c that bank i is incorporated in, divided by the respective country's banks' total security holdings in 2012, which we standardize to have a 0 mean and a standard deviation of 1. *Security Ratio*$_i$ is the share of securities over assets of bank i in 2012, and *Deposit Ratio*$_i$ is the share of deposits over assets of bank i in 2012. μ_i and δ_m denote bank and month-year fixed effects, respectively. The sample period runs from 2010 to 2020. Standard errors are clustered at the bank level.

Table 4 shows the results from estimating (2). Banks with higher security and deposit ratios exhibit lower stock returns during QE. Estimating (2) without fixed effects allows us to predict stock returns of banks with varying degrees of deposit and security ratios in response to a one-standard-deviation increase in QE ($QE_{c(i),m} = 1$). Figure 5 plots these predicted stock returns. For example, the most exposed bank in our sample with a deposit ratio of 89% and a security ratio of 54% is estimated to have a stock return of -11.53% in response to a one-standard-deviation increase in asset purchases. In contrast, the stock return of the least exposed bank with a security ratio of 2% and a deposit ratio of 7% is virtually insensitive to variations stemming from QE.

In Figure 6, we visualize predicted stock returns of two hypothetical banks over time: one that has a high security and a high deposit ratio (both at the 75th percentile) relative to a bank that has a low security and a low deposit ratio (both at the 25th percentile). The time variation is given by QE_m, which is the average of $QE_{c(i),m}$ (as defined in (2)) across countries in a given month-year. By construction, prior to QE stock returns of banks with differential exposure to the unconventional monetary-policy tools implemented by the ECB move in parallel. However, once the national central banks in the euro area start buying government bonds, stocks of banks with a high exposure underperform significantly. Banks that are highly exposed to QE and negative monetary-policy rates have persistently lower returns of less than -4% during the active QE and negative interest-rates period, while less exposed banks, as they have a larger wholesale funding base and fewer securities on their balance sheet, have stable returns hovering between -1% and -2%.

Negative monetary-policy rates are not passed through to banks' funding costs to the same extent across countries in the euro area, as despite a common nominal interest rate on interbank funds, customer deposit rates vary widely (Heider, Saidi, and Schepens, 2021; Bittner, Bonfim, Heider, Saidi, Schepens, and Soares, 2022). This becomes evident when comparing the evolution of household deposit rates in Germany as opposed to Italy (see Figure A2 in the Online Appendix). In countries, such as Italy, where government bond yields are perceived as relatively risky, the overall level of interest rates (including on customer deposits) is also higher, as government bonds and bank deposits can be seen as substitutes (Krishnamurthy and Vissing-Jørgensen, 2015; Li, Ma, and Zhao, 2021). Consequently, we would expect the adverse effect of negative monetary-policy rates on the funding costs of deposit-reliant banks to be more emphasized in countries where the zero lower bound on deposit rates is binding.

In Table 5, we exploit heterogeneity in countries' distance to the ZLB on deposit rates. In column 1, we confirm that the adverse effect on banks' stock returns is stronger in Germany, a low-deposit-rate country, than in other countries in the euro area. That is, during QE high-security banks' reliance on deposits affects their funding costs and net worth under a negative interest-rate policy only when the ZLB on retail deposit rates is binding. Alternatively, when using an exposure index that we construct to be decreasing in the level of deposit rates prior to the introduction of negative monetary-policy rates, as in Bittner, Bonfim, Heider, Saidi, Schepens, and

Soares (2022), we see that banks with high security and high deposit ratios in countries that have a low index value see almost no negative reaction in stock returns (column 2). Such banks in GIIPS countries (Greece, Italy, Ireland, Portugal, and Spain), which tend to have higher deposit rates, also see a smaller decline in stock returns, but the effect is not statistically significant (column 3). In the last column, we show that the stock returns of banks with high security and high deposit ratios in countries that have higher ex-ante bond yields also suffer less. This suggests that the net-worth channel is less important for banks in these countries than for banks in countries that already have low deposit rates before and where an increase in bond prices does not recapitalize banks as much. Thus, QE is more likely to have expansionary effects when the transmission of monetary-policy rates is not impaired, which is the case for banks—regardless of their funding structure—in high-rate environments.

Next, we zoom in on Germany, where deposit rates are close to the ZLB and negative monetary-policy rates, thus, give rise to relatively higher funding costs for deposit-reliant banks.

5 Micro Evidence from Germany

5.1 Mechanism

The administrative data from the Bundesbank provide us with the possibility to observe not only credit relationships with different counterparties—firms and other banks—over time but also bank-level balance-sheet characteristics, decomposed to a greater level of detail, at the quarterly frequency.[18] In particular, this enables us to observe which countries' sovereign bonds are held by German banks, and to refine our baseline measure of QE accordingly by defining QE_q as the amount of German government bonds purchased by the ECB in quarter-year q divided by all German banks' total German sovereign bond holdings in 2012.

Using this refined measure of QE_q, we first show that our exposure variable for QE—i.e., banks' security ratio—is actually correlated with changes in security holdings as a function of the ECB's asset purchases. In Table 6, we use granular data on German banks' security holdings from the Securities Holdings Statistics database. In columns 1 and 2, we find a significant average effect on security holdings for all high-security banks, as we also visualize in Figure A4 of the Online Appendix. This validates our approach that relies on measuring banks' exposure to QE by means of

[18] We provide summary statistics in Table A5 of the Online Appendix.

their security ratio (as in Rodnyansky and Darmouni, 2017). However, in the remaining columns of Table 6, we see that among high-security banks, only large banks, which we define as banks with total assets exceeding €50 billion, with presumably better access to market makers, sell off securities from their balance sheets (columns 3 and 4).

To shed light on the mechanism, We start with graphical evidence of how the interaction of quantitative easing and the preceding introduction of negative monetary-policy rates in 2014 affected German banks' balance sheets. The top panel of Figure 7 shows that the relationship between banks' past security ratios and the change therein after QE—as is the case more broadly in the euro area (see Figure 2)—holds in general and regardless of banks' deposit reliance. Note that this relationship is unlikely to be driven by bank size, because large banks tend to have lower deposit ratios, as both high-deposit and low-deposit banks sell their securities to the ECB on average. Importantly, the bottom panel shows that a negative relationship between changes in security holdings and central-bank reserves holds only for banks that rely more on deposit funding. This implies that even among (high-security) banks more exposed to the ECB's asset purchases, only those with high deposit ratios experience an asset swap of securities for central-bank reserves.

When the ECB implements QE, it expands its balance sheet by increasing security positions on the asset side. The increase in security holdings must be matched by a corresponding increase in liabilities. The liability side of central banks consists mainly of bank reserves and currency in circulation. Holding currency in circulation fixed in response to QE, central-bank reserves of commercial banks must increase in aggregate. This implies that the size of the central bank's operation determines the amount of reserves in the system (Keister and McAndrews, 2009), imposing a tax on banks that hold these reserves when the deposit facility rate is negative.

After selling off securities to the ECB, an individual (high-security) bank may attempt to avoid paying negative rates on its newly created reserves, but this would require the ability to readily lend out the newly created reserves. However, banks have been either unwilling or unable to reduce the interest rate on (household) deposits to below zero (Heider, Saidi, and Schepens, 2021), preventing a drain in deposits and increasing funding costs for high-deposit banks. In contrast, otherwise-funded banks experience a stronger pass-through of lower, even negative, monetary-policy rates to their cost of funding.

In Table 7, we test this more formally at the bank by quarter-year level. Column 1 shows that, indeed, German banks that have both a high security and a high customer deposit ratio have more central-bank reserves when QE is conducted. The estimate implies that a bank with a 20% security and a 50% deposit ratio relative to a bank with a 10% security and a 30% deposit ratio sees an increase in its reserves-to-assets ratio of 0.21 percentage points ($= (0.1-0.03)\times 0.03$) following a one-standard-deviation increase in asset purchases, which is sizable given that reserves-to-assets ratios of German banks hover around 7%. This increase is not attenuated much by central-bank borrowing (column 2), so that the estimate in column 3 is similar to that in column 1. Moreover, banks with high security and high deposit ratios experience a smaller outflow of (deposit) funding, as deposit rates are close to, and eventually stuck at, the ZLB in Germany,[19] and, hence, see a relative increase in their ratio of liabilities over total assets compared to other banks (column 4). This is, for one, consistent with the idea that among high-security banks, those that are less reliant on deposit funding need not lend out all of the newly created reserves but can also flexibly reduce their balance sheet. In line with our evidence in Table 5, the positive coefficient in column 4 also hints at an adverse shock to the net worth (approximated by equity) of banks with high security and high deposit ratios, which stems from higher funding costs due to costly and sticky deposits, compromising their ability to lend out the newly created reserves subsequent to the ECB's asset purchases.

Why do high-deposit banks sell these securities if swapping the latter for reserves has a negative effect on their net worth? Taking into account that we analyze QE flows and banks' credit-supply response over a relatively long time period, a viable mechanism that explains our results should not depend centrally on announcement effects. In principle, asset purchases by central banks should not affect prices if the assets in question are valued only for their pecuniary returns (Wallace, 1981; Cúrdia and Woodford, 2011). However, the banking sector as a whole may have a preference to hold longer-term bonds, resulting in asset-price movements induced by QE due to a segmentation of the term structure (Vayanos and Vila, 2021). This implies that security prices of targeted assets would need to increase for the market to clear and the ECB to purchase the targeted amount of securities.

This begs the question whether capital gains from selling securities to the ECB always outweigh the ex-post tax imposed by the negative deposit facility rate charged on central-bank reserves, which high-deposit banks are less likely to circumvent because they face higher funding costs and, as such, cannot readily lend out reserves due to security sales. Figure 8 shows that two-

[19]Commercial banks can also sell the securities of their customers, which would lead to an additional increase in deposits for them.

year (one- to three-year) German government bonds yield higher returns compared to the interest rate when holding deposits at the central bank prior to QE.[20] Under QE, the additional demand for government bonds by the central bank leads to lower returns on government bonds. The spread between government bond yields and the deposit facility rate becomes negative.[21] Even though government bonds and deposits at the central bank are both considered high-quality liquid assets (HQLA) under the liquidity coverage ratio (LCR), deposits at the central bank become relatively more attractive once QE is conducted. This, in turn incentivizes all banks—including those with high security and high deposit ratios that cannot readily lend out the newly created reserves—to sell, or not reinvest in, government bonds and increase their central-bank reserves instead. As a consequence, one does not require further quantification of the individual capital gains, which may vary between banks, to argue whether high-security banks participate in QE.

5.2 Credit Supply

Having established that large German banks with a higher security ratio and a higher deposit ratio are more prone to swapping their securities for central-bank reserves in the course of QE, we turn to estimating their differential credit-supply response. In Table 8, we use our credit-registry data at the bank-firm-quarter level (*i,j,q*), and estimate analogous regressions to those in our baseline Table 1. In this manner, we can test the effect on German banks' intensive margin of lending by estimating the following regression specification:

$$\begin{aligned}\ln(Lending_{i,j,q}) = {} & \beta_1 QE_q \times Security\ Ratio_i + \beta_2 QE_q \times Deposit\ Ratio_i \\ & + \beta_3 QE_q \times Security\ Ratio_i \times Deposit\ Ratio_i + \chi_{i,j} + \theta_{j,q} + \epsilon_{i,j,q},\end{aligned} \tag{3}$$

where $Lending_{i,j,q}$ is the euro amount outstanding between firm j and bank i in quarter-year q. QE_q is the amount of German government bonds purchased by the ECB in quarter-year q divided by all German banks' total German sovereign bond holdings in 2012, and is standardized to have a 0 mean and a standard deviation of 1. $Security\ Ratio_i$ is the share of securities over assets of bank i in 2012, and $Deposit\ Ratio_i$ is the share of deposits over assets of bank i in 2012. The sample period spans the first time negative monetary-policy rates are introduced (2014q3) up

[20] In order to improve comparability with the interest rate on the deposit facility at the central bank, we use German government bond indices of rather short maturity. The short maturity is less affected by term premia, and German government bonds are considered safe assets with low risk premia.

[21] Note that this pattern is not due to an inverted yield curve. Figure A3 in the Online Appendix shows positive term premia for the entire period and various maturity segments of German government bonds.

until 2018q4. Standard errors are clustered at the bank level.

The granularity of the data allows us to track a given bank i's loan exposure to firm j over time. As such, we can estimate the effect of banks' exposure to QE and negative rates, while controlling for both time-invariant unobserved heterogeneity at the bank-firm match level and time-varying unobserved heterogeneity at the firm level by including, respectively, bank-firm fixed effects, $\chi_{i,j}$, and firm by quarter-year fixed effects, $\theta_{j,q}$.

Despite the fact that the inclusion of firm-time fixed effects forces our identification to come from German firms in relationships with multiple banks, the estimated triple-interaction effect is comparable to, albeit larger than, that in column 2 of Table 1, where firm-time fixed effects rather capture the fact that multiple banks come together to provide a syndicated loan. This holds, however, only for the subset of large banks in column 1 of Table 8, but not for the remaining banks in column 2. In column 3, we use the pooled sample and find that the difference in the triple-interaction effect is significantly different (at the 1% level) for these two groups of banks. In columns 4-6, we estimate the same regressions, except that instead of by size, we distinguish banks by their access to the repo market. Banks with access to the repo market behave like large banks, in that they reduce their lending when they are exposed to both QE and negative rates through the securities on their asset side and their reliance on deposit funding. Large banks, in turn, make for the vast majority of banks participating in the syndicated-loan market, where we have documented similar credit contraction across the euro area in Section 3.

Our findings attest to the idea that banks' exposure to QE is contingent on their ability to sell off securities that are purchased by the ECB. This is the case primarily for large banks. We can leverage the German microdata to fine-tune the treatment variable and, hence, sharpen our identification. In particular, we can replace banks' exposure to QE_q as a function of their predetermined $\mathit{Security\ Ratio}_i$ by their actual change in security holdings over the course of one year, without having to limit our analysis to large banks in an attempt to proxy for banks' ability to sell off securities in general.

Doing so, we confirm in column 1 of Table 9 that high-deposit banks lend less following a drop in their security holdings during the ECB's asset purchases. In column 2, we use the granularity of the German microdata to distinguish between household deposits and deposits from non-financial corporations. This is motivated by the fact that the ZLB is more binding for households than for corporate deposits, not only in Germany (Figure A5 of the Online Appendix) but also in other euro area countries (see, among others, Heider, Saidi, and Schepens, 2019; Altavilla, Burlon, Giannetti, and Holton, 2022). In this manner, we can compare similarly deposit-reliant banks that source their deposits from different customers. Reflecting the hard ZLB on rates for household depositors, we find that the negative effect on credit supply is confined to banks relying on household deposits, rather than those of non-financial corporations. Finally, our results are broadly robust to replacing annual changes in banks' security holdings with quarterly changes (see columns 3 and 4).

In Table A6 of the Online Appendix, we estimate (almost) the same specifications as in the first two columns of Table 9, but limit the variable reflecting security changes to sales (columns 1 and 3) or purchases (columns 2 and 4). In line with high-deposit banks reducing their credit supply only when their securities are swapped for central-bank reserves, we find a statistically and economically significant coefficient on the relevant interaction term only for security sales and not for purchases.

5.3 Firm-level Real Effects

So far, we have established that banks that are more exposed to QE reduce credit supply by relatively more when they face higher funding costs due to the ZLB on retail deposit rates despite negative monetary-policy rates. Ultimately, the potency of monetary policy hinges on whether the relative reduction in credit supply is also transmitted to the real economy. In this subsection, we analyze the real effects of combining negative monetary-policy rates with quantitative easing. We exploit cross-sectional variation in firms' pre-existing relationships with banks that are differentially exposed to these unconventional monetary policies. In particular, we test whether firms that are more dependent on banks that reduced their credit supply compared to their counterparts in response to QE and negative monetary-policy rates differ in terms of their capital investment and employment decisions.

To this end, we estimate the following regression specification:

$$\Delta \ln(y_j) = \beta \textit{Security \& Deposit Exposure}_j + \gamma \textit{Security Exposure}_j + \delta \textit{Deposit Exposure}_j + \theta_{k(j)} + \epsilon_j, \tag{4}$$

where $\Delta \ln(y_j)$ is the difference in the natural logarithm of German firm j's average total wage bill, number of employees, or tangible fixed assets in $2015-2016$ (during QE, the post-period) vs. $2013-2014$ (before QE, the pre-period), and *Security & Deposit Exposure*$_j$ is the average value of *Security Ratio*$_i$ $\times$ *Deposit Ratio*$_i$ (measured in 2012) of all German banks with which firm j

contracts (as of 2014), weighted by firm j's credit exposure to each bank i. *Security Exposure*$_j$ and *Deposit Exposure*$_j$ are defined accordingly using *Security Ratio*$_i$ and *Deposit Ratio*$_i$, respectively. $\theta_{k(j)}$ is a set of fixed effects based on firm j's NACE industry segment, NUTS-3 region, and/or firm-size categories according to the European Union's guidelines. As the level of observation in specification (4) is the result of a first difference within firms, $\theta_{k(j)}$ captures time-varying unobserved heterogeneity at the respective levels (as would industry-time, region-time, and size-time fixed effects without first-differencing).

An important prerequisite for our documented bank-level credit-supply responses to translate to firm-level real effects, such as employment, is that German firms cannot readily substitute credit across banks, i.e., credit from affected banks with credit from less affected banks. To test this, we first estimate (4) using as dependent variable the growth rate in firms' total credit outstanding, i.e., over all bank relationships based on the (quarterly) credit-registry data, between the QE period and the preceding period. In columns 1-3 of Table 10, we consider a four-year window around the implementation of QE, and find that firms that rely more heavily on banks that have a high security ratio and a high deposit ratio, and are therefore more exposed to QE and negative monetary-policy rates, see a drop in their total credit. This is also robust to using a longer, eight-year window in columns 4-6. The opposite signs of the coefficients on *Security & Deposit Exposure*$_j$ and *Security Exposure*$_j$ reflect countervailing effects and, as such, the potentially expansionary effects of QE (in line with, e.g., Rodnyansky and Darmouni, 2017) if deposit rates had not been close to the ZLB in Germany.

The estimates in Table 10 attest to the idea that German firms cannot fully compensate for the loss in credit access by affected banks by switching to other credit providers. This opens up the possibility of firm-level real effects on investment and employment, for which we test in Table 11. If German firms use credit to finance their employment and investment, the signs of the coefficients should be preserved after replacing the dependent variable with firm-level growth rates in employment and investment. This is indeed the case. Importantly, in columns 1-6 the coefficient on the interaction term *Security & Deposit Exposure*$_j$ is negative and almost always statistically significant. Firms that rely more heavily on banks that have a high security ratio and a high deposit ratio reduce their employment and wage bill by more. In columns 7-9 where we test for differential behavior in terms of capital expenditure, the interaction term is also negative but not statistically significant at conventional levels.

A key difficulty in using cross-sectional heterogeneity to quantify the real effects of monetary-policy transmission through banks is that general-equilibrium effects are differenced out (Nakamura and Steinsson, 2018). In the following, we assume that banks with no deposits and no securities are unaffected by negative rates and QE, respectively. This, however, neglects that lower interest rates can stimulate demand and credit supply for all banks. This, in turn, leads to potentially underestimating the total positive effects of QE and negative rates. With the caveat that we do not account for such confounding effects of QE and rate-setting monetary policy, we compute the aggregate effects of QE and negative rates solely due to the credit-supply channel.

The opposite signs of the coefficients on *Security & Deposit Exposure*$_j$ and *Security Exposure*$_j$ indicate that the positive employment effects of the credit-supply channel of QE are reduced by its adverse interaction with negative monetary-policy rates in the presence of a ZLB on deposit rates. Interpreting the coefficient on firms' security exposure and that on their deposit exposure as the effect of QE and conventional rate-based policy, respectively, we can decompose how much of the employment growth rate can be attributed to the policies separately and their interaction. This allows us to compare the employment growth rate of 4.3% in our sample[22] with a counterfactual scenario in which only negative monetary-policy rates were implemented. We derive the counterfactual growth rate by estimating (4) (column 6 of Table 11) and applying the following procedure.

We start out with the observed employment growth rate, $\Delta\ln(\textit{Employment}_j)$, which represents firm j's employment growth in the post-period following both the introduction of negative monetary-policy rates and the announcement of QE in the euro area. The fact that the ECB implemented large-scale asset purchases only after introducing negative monetary-policy rates motivates our counterfactual: what would have been total employment growth in the absence of QE? To answer this question, we assume that in the absence of QE, banks' security ratios are irrelevant for the transmission of rate-based monetary policy. In addition, we assume that because of it, there is no effect stemming from the interaction between banks' security and deposit ratios. We thus compute the counterfactual employment growth rate as

$$\Delta\ln(Employment_j) - \widehat{\beta}\textit{Security \& Deposit Exposure}_j - \widehat{\gamma}\textit{Security Exposure}_j. \tag{5}$$

To yield each firm j's counterfactual employment in the post-period, we multiply 1 plus the

[22]The employment growth rate in our sample is close to the total employment growth rate of 4.1% reported by the German statistical office. This partly reflects the representative nature of our sample of firms, which captures 34% of total employment in Germany.

above growth rate with each firm j's employment in the pre-period. We then aggregate up both employment in the pre-period and counterfactual employment in the post-period across all firms j, and compute the aggregate employment growth rate of the counterfactual scenario.

Based on this procedure, the counterfactual employment growth rate without QE is 4.24% and, as such, almost indistinguishable from the actual employment growth rate of 4.3%. This leads us to conclude that any positive employment effects of the credit-supply channel of QE are eradicated by the adverse interaction of QE and negative monetary-policy rates in the presence of a ZLB on deposit rates. Previous studies document that QE had strong positive employment effects through the bank lending channel in the U.S. (Foley-Fisher, Ramcharan, and Yu, 2016; Luck and Zimmermann, 2020). Our results provide a rationale for why QE has been potentially more successful in spurring employment in the U.S. than in the euro area, which is consistent with the observation that the U.S. experienced a stronger recovery during our period of study.

5.4 Interbank Lending

As affected banks see a drop in their net worth and subsequently reduce their lending to non-financial corporations, this opens up the possibility that they rebalance their loan or asset portfolios, in particular by increasing their portion of liquid assets. While corporate lending potentially leads to the creation of costly deposits elsewhere in the system, interbank loans are a means of transferring and redistributing reserves among banks, without increasing the total amount of reserves in the system (Diamond, Jiang, and Ma, 2021).

For this purpose, we consider the interbank portion of the German credit registry, i.e., banks lending to other banks, rather than firms, excluding intra-group lending. In columns 1 and 3 of Table 12, we estimate analogous specifications to those in columns 1 and 2 of Table 8. Large banks that are more exposed to QE and negative rates, which we have shown to reduce their credit supply to non-financial corporations, instead expand their supply of interbank loans. In column 2, the effect is somewhat stronger, albeit insignificantly so, for interbank lending to high-yield countries. In the last two columns, we replace $QE_q \times \textit{Security Ratio}_i$ by the actual change in security holdings over the course of one year, and find that high-deposit banks that sold off their securities during the QE period lent more to other banks in high-yield countries (column 6), but not on average (column 5).

These estimates suggest that affected banks at least partially replace illiquid corporate loans with liquid interbank loans. When doing so, they possibly reach for yield so as to counteract the adverse shock to their net worth. In Table A7 of the Online Appendix, we differentiate interbank lending by large and small banks within (columns 1 and 3) and outside the euro area (columns 2 and 4). The differential lending response is confined to large affected banks and their lending to other euro area banks. In columns 5 and 6, we test whether the lending response is significantly different for large vs. small banks, and this is the case only for interbank lending within the euro area (column 5).

6 Cross-Border Interbank Flows

We next zoom in on the implications of QE under negative monetary-policy rates for the distribution of interbank liquidity in the euro area. The micro-level results in Table 12 and Table A7 suggest that while German banks with greater exposure to QE and negative rates reduce their credit supply to the real sector, they expand their lending to other banks, and especially in the euro area. To investigate whether this loan-portfolio rebalancing could have any meaningful explanatory power for interbank flows between the core and the periphery in the euro area, we use aggregate data from the Bank for International Settlements covering the euro area during the negative interest-rate period from 2014 to 2018, and estimate the following regression specification at the country-pair level:

$$Flow_{c,j,q} = \beta_1 QE_{c,q} \times GIIPS_j + \beta_2 QE_{c,q} \times Core_c \times GIIPS_j + \chi_{c,j} + \gamma_{c,q} + \psi_{j,q} + \epsilon_{c,j,q}, \tag{6}$$

where $Flow_{c,j,q}$ is the percent change in bank claims of country (lender) c to country (borrower) j in quarter-year q. $QE_{c,q}$ is the amount of government bond purchases of country c by the ECB in quarter-year q, divided by the respective country's banks' total security holdings in 2012, and then standardized to have a 0 mean and a standard deviation of 1. $Core_c$ is an indicator variable for whether the lender country c is Germany, Finland, the Netherlands, or Austria. $GIIPS_j$ is an indicator variable for whether the borrower country j is Greece, Italy, Ireland, Portugal, or Spain. $\chi_{c,j}$, $\gamma_{c,q}$, and $\psi_{j,q}$ denote country pair, lender country by quarter-year, and borrower country by quarter-year fixed effects, respectively. Standard errors are double-clustered at the lender-country and borrower-country levels.

Table 13 shows the results from estimating (6) with and without borrower country by quarter-year fixed effects. When QE is conducted, core banks—not only in Germany—lend more to GIIPS banks (columns 1 and 4). Similar results are obtained when replacing $GIIPS_j$ by other measures of the riskiness of borrower country j as in Table 5. This correlation is also reflected in Figure 9, which plots the share of borrowing of GIIPS banks from core banks alongside the ECB bond holdings of core countries. This suggests that QE during the negative interest-rate policy period may have led to greater financial dependence of periphery banks on financial institutions from the core euro area.

7 Conclusion

This paper studies the interaction of large-scale asset purchases and rate-setting monetary policy. To do so, we exploit variation in the pass-through of negative monetary-policy rates to banks' funding costs in the euro area. We provide evidence that absorbing a large amount of securities from the banking sector in the presence of a zero lower bound on retail deposit rates reduces credit supply by deposit-reliant banks that are exposed to both QE and higher funding costs. Our results point to important policy implications for the conduct of accommodative monetary policy. QE is more likely to have expansionary effects if the pass-through of lower monetary-policy rates to bank funding costs is not impaired. If it is, QE can exacerbate the detrimental effects of higher funding costs on banks' profitability. Affected banks may counteract this adverse shock to their net worth by reaching for yield in the liquid interbank market.

We present suggestive evidence that this may have led to interbank flows from the core to the periphery in the euro area during the ECB's large-scale asset purchases. The potential ramifications of greater financial dependence of the periphery from the core in a fragmented euro area can be far-reaching. For instance, it could have given rise to greater misallocation, manifesting itself in increased dispersion of the return to capital and lower total factor productivity, because capital was directed to less productive firms (Gopinath, Kalemli-Özcan, Karabarbounis, and Villegas-Sanchez, 2017). Evaluating whether this was the case constitutes a fruitful avenue for future research.

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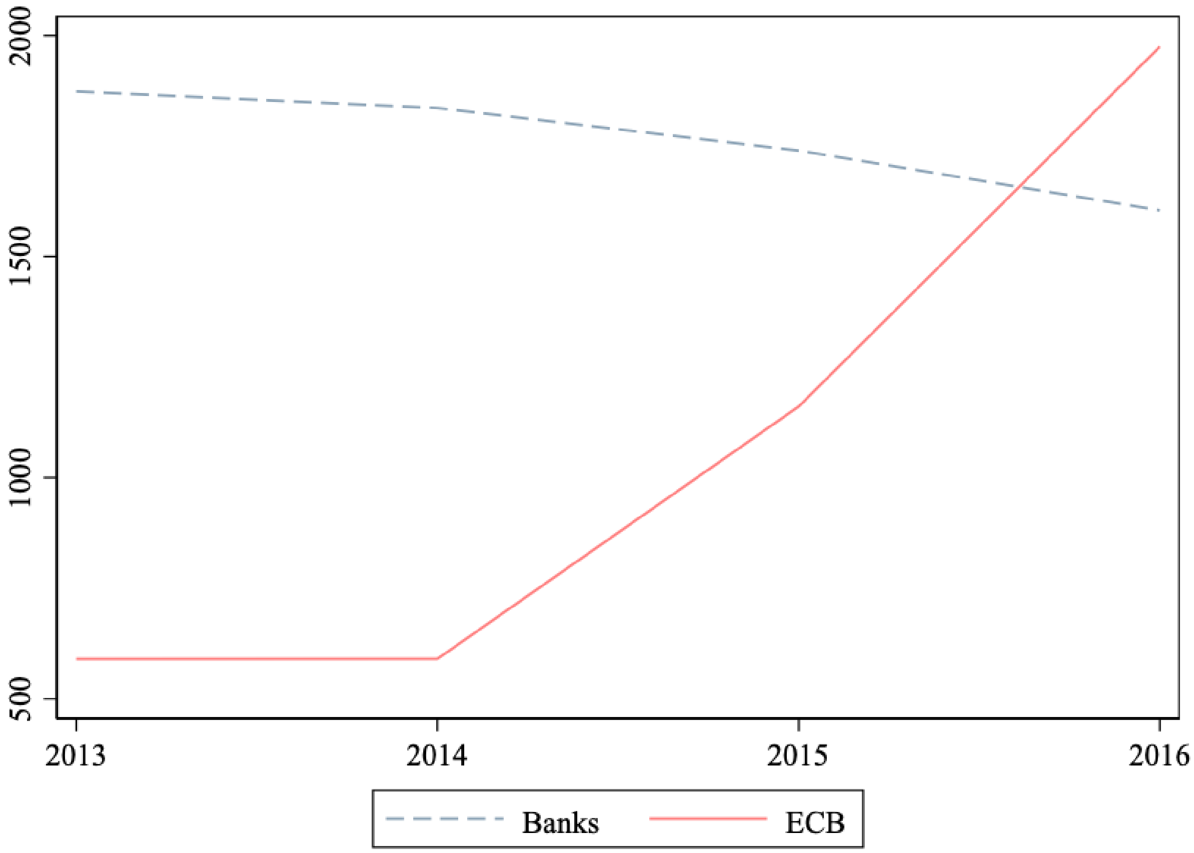
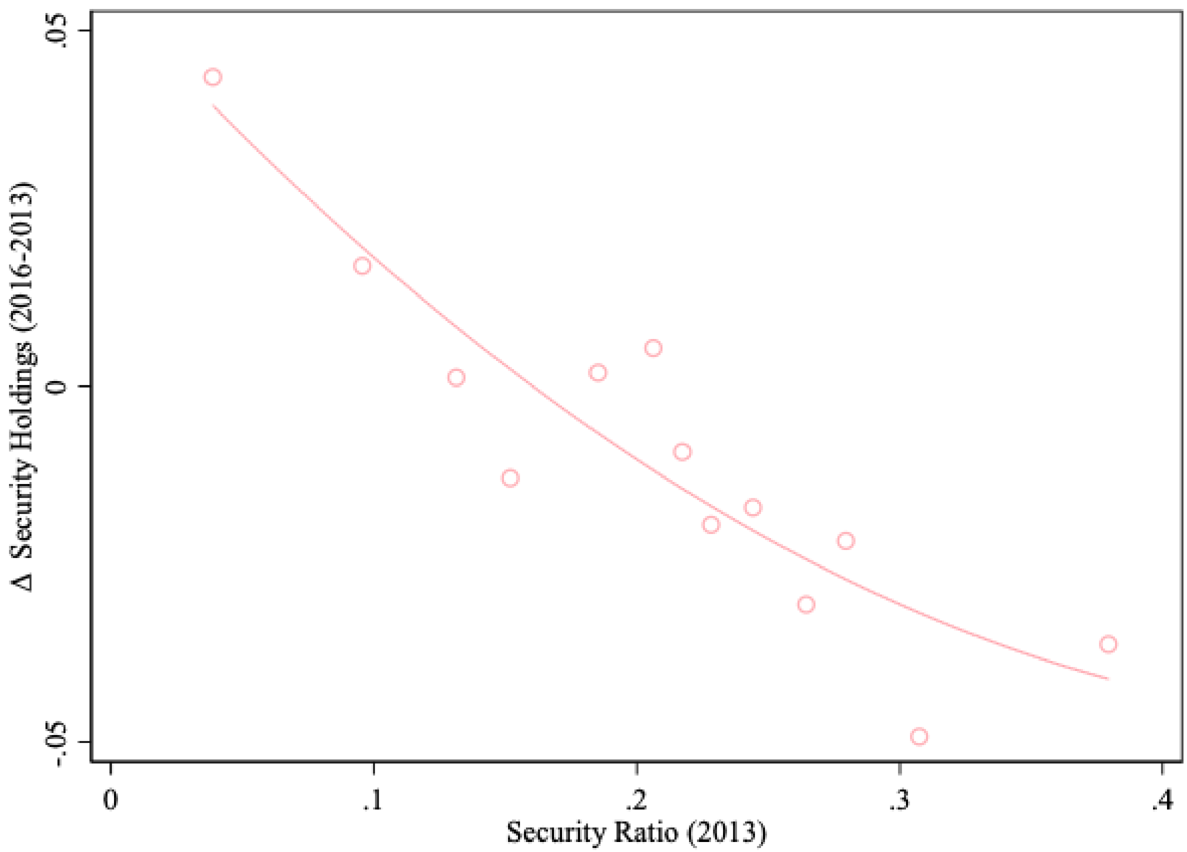
Figures

Figure 1: Security Holdings



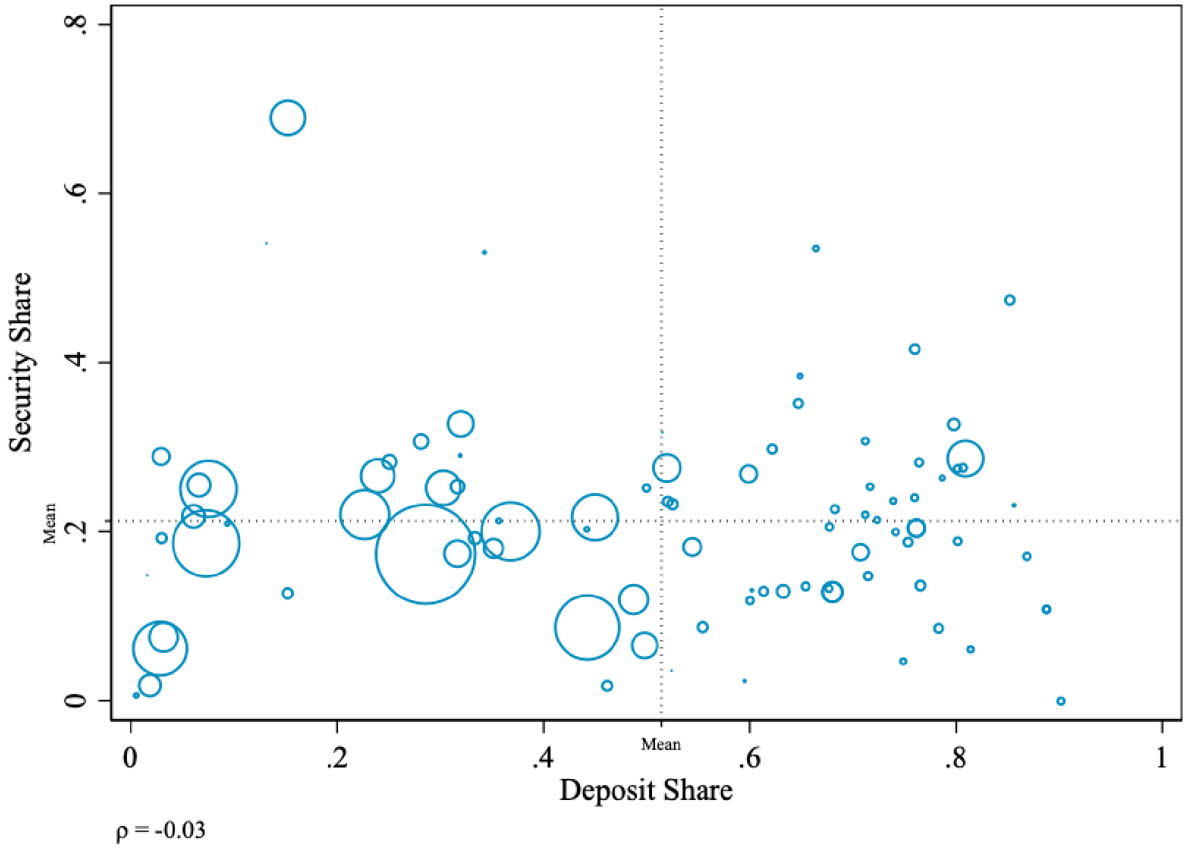
Notes: This graph shows the security holdings of euro area banks (dashed blue line) and of the ECB (solid red line) in € billions.

Figure 2: Δ Security Ratio against Past Security Ratio



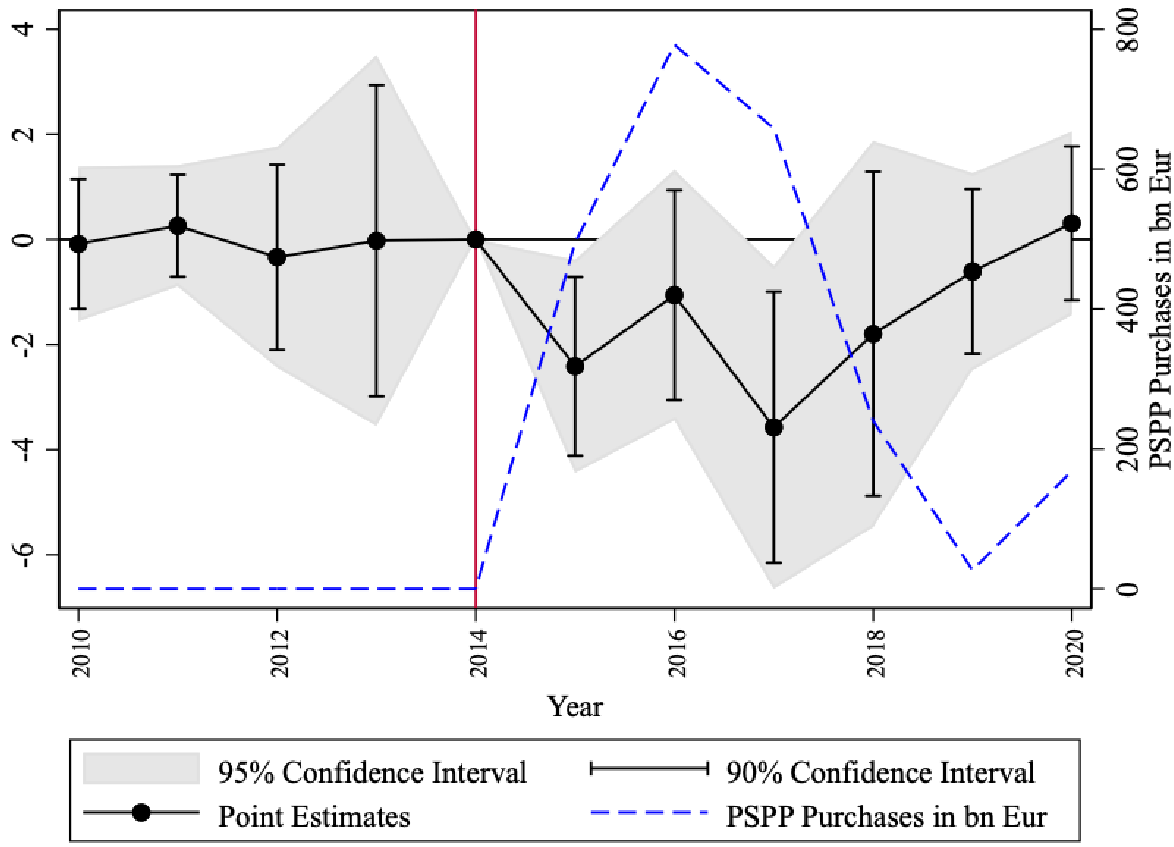
Notes: The figure shows a bin-scatter plot of euro area banks' change in security holdings over total assets between 2016 and 2013 against their security holdings over total assets in 2013.

Figure 3: Correlation between Deposit and Security Ratios



Notes: This graph shows a scatter plot of euro area banks' security ratio in 2012 against their deposit ratio in 2012. The size of the dots reflects the size of the respective bank in terms of total assets in 2013. ρ is the correlation coefficient between the security and deposit ratios. The dotted lines reflect their mean values.

Figure 4: Time-varying Coefficients

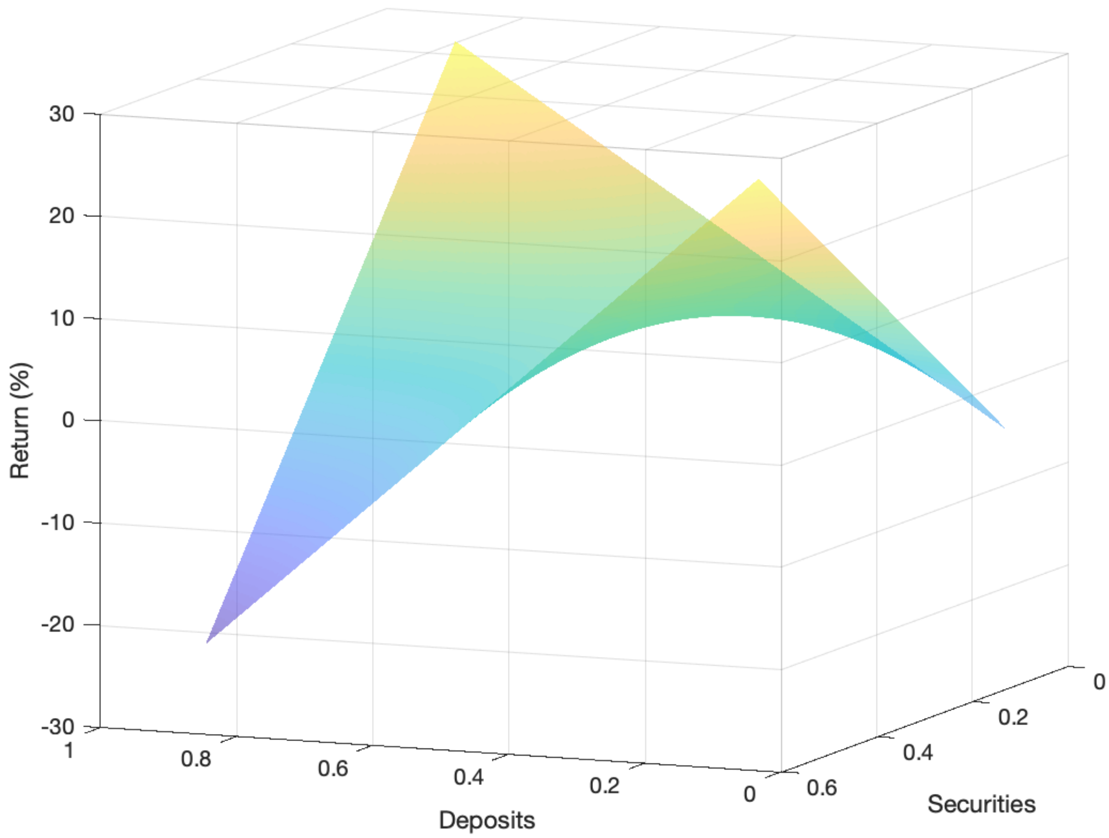


Notes: This figure plots the estimates of $\beta_{3,\tau}$ (left y-axis) from the following regression:

$$
\begin{aligned}
\ln(Lending_{i(l),j(l),t(l)}) = & \sum_{\tau \neq 2014} \beta_{1,\tau} \times Security\ Ratio_i \times \mathbb{1}_{[t=\tau]} + \sum_{\tau \neq 2014} \beta_{2,\tau} \times Deposit\ Ratio_i \times \mathbb{1}_{[t=\tau]} \\
& + \sum_{\tau \neq 2014} \beta_{3,\tau} \times Security\ Ratio_i \times Deposit\ Ratio_i \times \mathbb{1}_{[t=\tau]} \\
& + \mu_i + \theta_{j,m(t)} + \phi_{c(i),m(t)} + \epsilon_{i,j,t}.
\end{aligned}
$$

The blue dashed line shows the net purchases by the ECB under the public sector purchase program (PSPP) in € billions (right y-axis).

Figure 5: Stock-return Response to QE Purchases

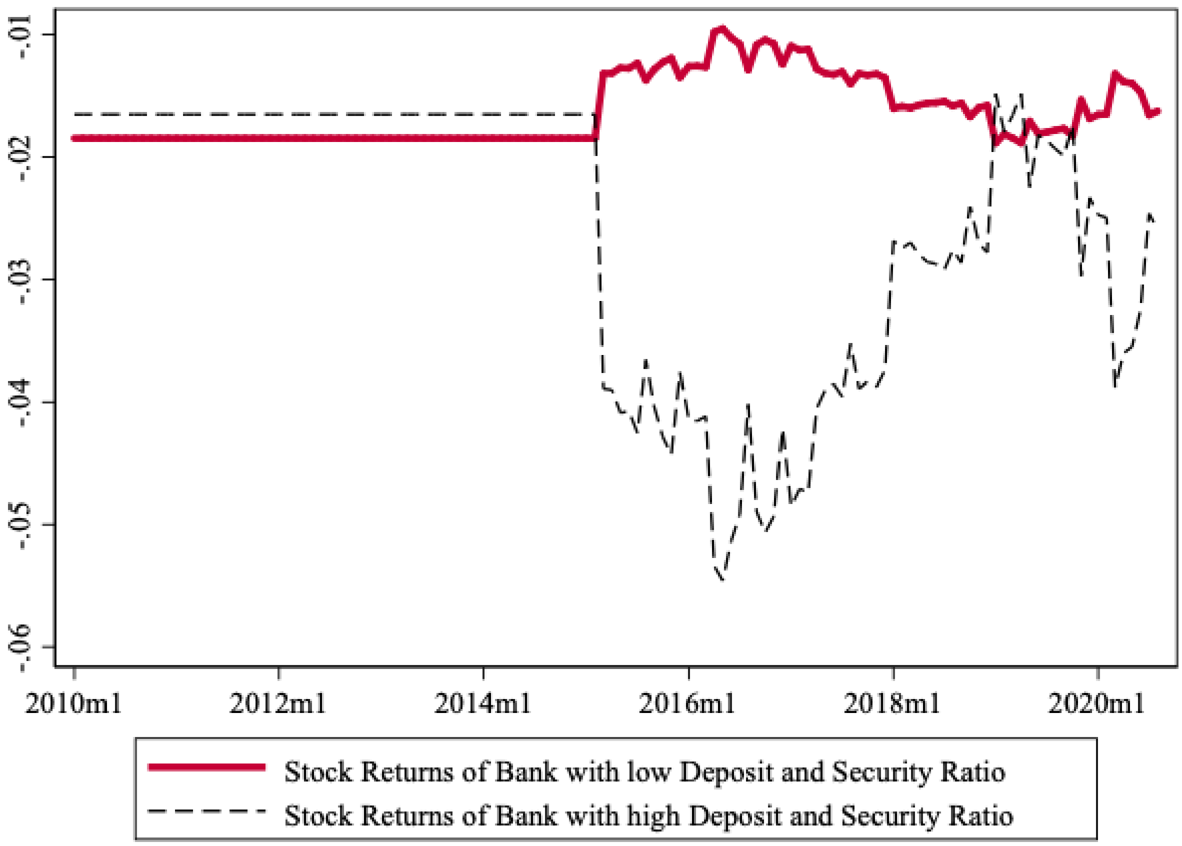


Notes: This graph shows the predicted stock returns as a function of euro area banks' security ratio and their deposit ratio, based on the following regression specification:

$$\begin{aligned} Return_{i,m} =& \alpha + \gamma_1 QE_{c(i),m} + \gamma_2 Security\ Ratio_i + \gamma_3 Deposit\ Ratio_i \\ &+ \gamma_4 Security\ Ratio_i \times Deposit\ Ratio_i + \gamma_5 Security\ Ratio_i \times QE_{c(i),m} \\ &+ \gamma_6 Deposit\ Ratio_i \times QE_{c(i),m} + \gamma_7 Security\ Ratio_i \times Deposit\ Ratio_i \times QE_{c(i),m} + \epsilon_{i,m}. \end{aligned}$$

Returns are then predicted using a one-standard-deviation increase in asset purchases, i.e., $QE_{c(i),m} = 1$.

Figure 6: Estimated Stock Returns

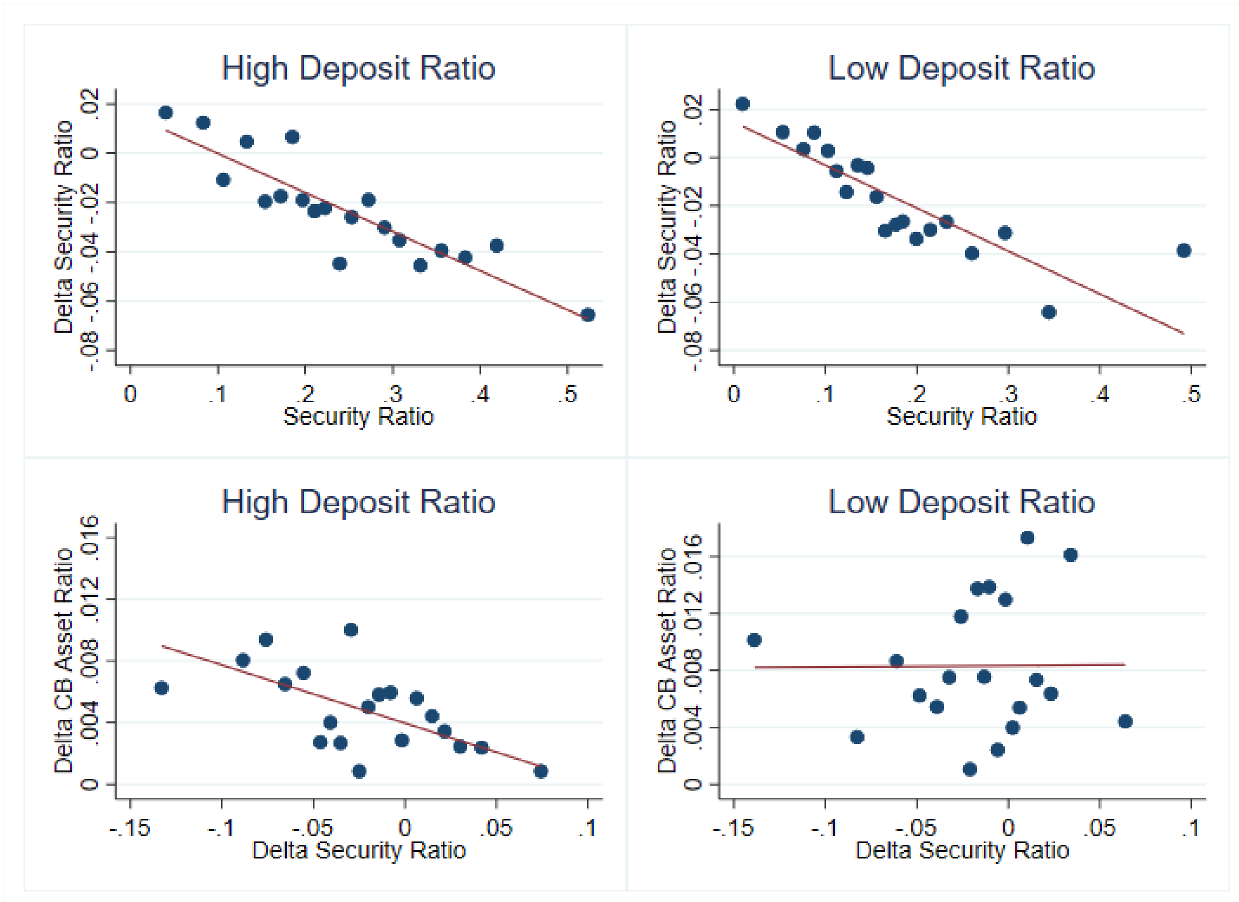


Notes: This graph shows the predicted stock returns for a euro area bank with a low (high) deposit and a low (high) security ratio, both at the 25^{th} (75^{th}) percentile of the respective distribution, based on the following regression specification:

$$\begin{aligned} Return_{i,m} =& \alpha + \gamma_1 QE_{c(i),m} + \gamma_2 Security\ Ratio_i + \gamma_3 Deposit\ Ratio_i \\ &+ \gamma_4 Security\ Ratio_i \times Deposit\ Ratio_i + \gamma_5 Security\ Ratio_i \times QE_{c(i),m} \\ &+ \gamma_6 Deposit\ Ratio_i \times QE_{c(i),m} + \gamma_7 Security\ Ratio_i \times Deposit\ Ratio_i \times QE_{c(i),m} + \epsilon_{i,m}. \end{aligned}$$

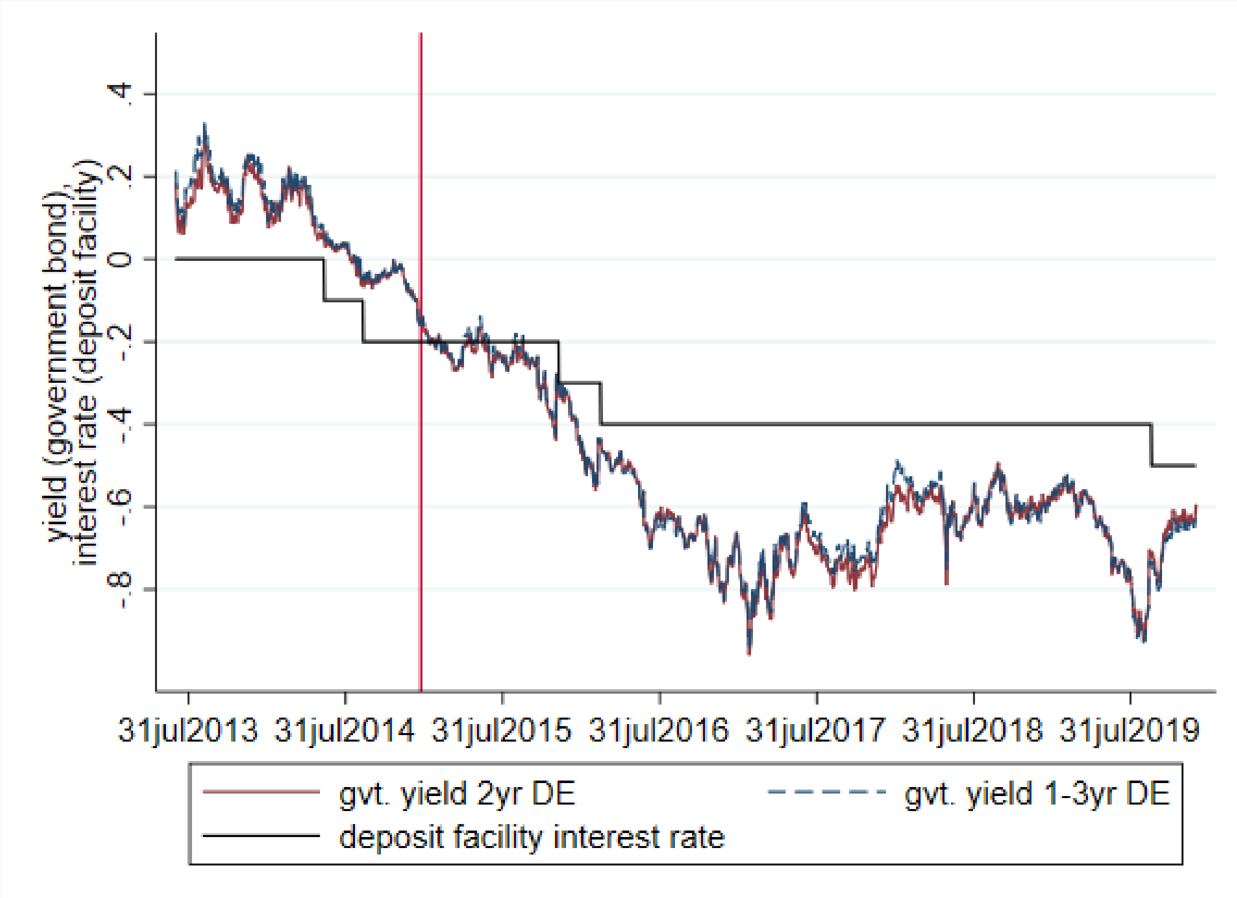
Returns are then predicted using QE_m, which is the average value of $QE_{c(i),m}$ (as defined in (2)) across all euro area countries, over time (measured in months).

Figure 7: Δ Security Ratio against Past Security Ratio and Δ Central Bank Asset Ratio against Δ Security Ratio for Banks with High and Low Deposit Ratio



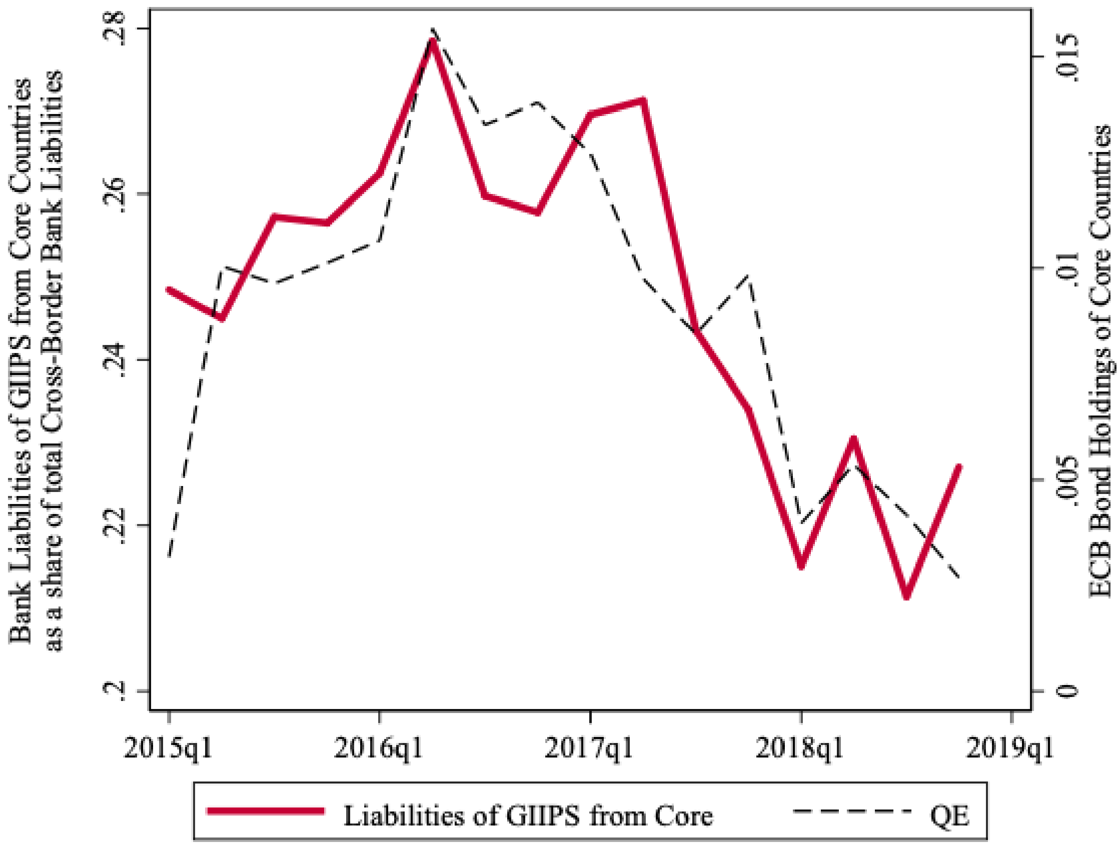
Notes: The figures in the top show a bin-scatter plot of German banks' change in security holdings over total assets between 2017 and 2014 against their security holdings over total assets in 2012. The figures in the bottom show a bin-scatter plot of German banks' change in central bank assets over total assets between 2017 and 2014 against their change in security holdings over total assets between 2017 and 2014. The figures to the left show these relationships for German banks with above median deposit ratio to households, whereas the figures to the right cover German banks with below median deposit ratio to households.

Figure 8: Government Bond Yields and Deposit Facility Rate



Notes: The graph shows the evolution of government bond yields and the deposit facility rate. The deposit facility rate is one of three key interest rates for the euro area set by the Governing Council of the ECB (solid black line). Banks can use the deposit facility to make overnight deposits with the Eurosystem. The bond yields are based on a two-year government bond index for Germany (solid maroon line) and one- to three-year government bond indices for Germany (dashed navy line). The vertical red line represents the announcement of the public sector purchase program (PSPP) on January 22, 2015.

Figure 9: Cross-border Banking Flows



Notes: This graph shows the capital flows from the banking sector in core countries to that in GIIPS countries along with the ECB bond holdings of core countries over time.

Tables

Table 1: Syndicated-lending Response by Banks with Different Exposure to QE and Negative Rates

	Dependent Variable: Lending							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
QE × Security Ratio × Deposit Ratio	-0.815**	-0.938**	-0.841*	-0.644**	-0.949***	-0.845**	-1.336***	-2.006**
	(0.309)	(0.448)	(0.428)	(0.300)	(0.347)	(0.334)	(0.436)	(0.804)
QE × Security Ratio	0.316**	0.214	0.157	0.196	0.247**	0.215*	0.340***	0.580
	(0.128)	(0.142)	(0.130)	(0.153)	(0.116)	(0.122)	(0.123)	(0.348)
QE × Deposit Ratio	0.170**	0.238**	0.217**	0.156*	0.250**	0.227**	0.339***	0.509**
	(0.078)	(0.112)	(0.107)	(0.079)	(0.094)	(0.091)	(0.114)	(0.214)
QE	-0.077*							
	(0.041)							
R-squared	0.975	0.976	0.976	0.976	0.975	0.975	0.975	0.976
N	6,382	6,311	6,311	6,311	5,913	5,913	5,863	6,311
Bank FE	✓	✓	✓	✓	✓	✓	✓	✓
Borrower × Month-year FE	✓	✓	✓	✓	✓	✓	✓	✓
Country × Month-year FE	–	✓	✓	✓	✓	✓	✓	✓
Specification	$\frac{App_{c(i),m(t)}}{BSecH_{c(i),2012}}$	$\frac{App_{c(i),m(t)}}{BSecH_{c(i),2012}}$	$\frac{App_{c(i),m(t)}}{BSecH_{c(i),2012}}$ Residual	$\frac{App_{c(i),m(t)}}{BSecH_{c(i),2012}}$ Predicted	$\ln(1 + App_{c(i),m(t)})$	$\ln(1 + App_{c(i),m(t)})$ Residual	$\ln(1 + App_{c(i),m(t)})$ Predicted	QE dummy

Notes: The level of observation is a syndicated loan to firm j by euro area bank i in country c on date t. The sample period is 2014 to 2020. The dependent variable is the natural logarithm of the euro amount of debt issued between firm j and bank i on date t. *QE* measures the implementation of the public sector purchase program (PSPP) of the ECB, and is always standardized to have a 0 mean and a standard deviation of 1. In columns 1-2, $QE_{c(i),m(t)}$ is the amount of government bond purchases (by the ECB in month-year $m(t)$) of country c that bank i is incorporated in, divided by the respective country's banks' total security holdings in 2012 ($\frac{App_{c(i),m(t)}}{BSecH_{c(i),2012}}$). In column 3, we use the residual of a regression in which this measure is regressed on the two-year lags of GDP growth and inflation of country c. In column 4, we predict the same measure ($\frac{App_{c(i),m(t)}}{BSecH_{c(i),2012}}$) with the interaction between the ECB capital share of country c and the natural logarithm of one plus the total amount of securities purchased by the ECB. In column 5, $QE_{c(i),m(t)}$ is the natural logarithm of one plus the amount of government bonds of country c purchased by the ECB in month-year $m(t)$ ($\ln(1 + App_{c(i),m(t)})$). In column 6, we use the residual of a regression in which this measure is regressed on the two-year lags of GDP growth and inflation of country c. In column 7, we predict the same measure ($\ln(1 + App_{c(i),m(t)})$) with the interaction between the ECB capital share of country c and the natural logarithm of one plus the total amount of securities purchased by the ECB. In column 8, $QE_{m(t)}$ is a dummy equal to 1 after March 2015. *Security Ratio*$_i$ is the share of securities over assets of bank i in 2012, and *Deposit Ratio*$_i$ is the share of deposits over assets of bank i in 2012. Standard errors are clustered at the bank level.

Table 2: Syndicated-lending Response by Banks with Different Exposure to QE—Before vs. After Introduction of Negative Rates

	Dependent Variable: Lending		
	(1)	(2)	(3)
Post × Security Ratio × Deposit Ratio	-1.136**	-1.190**	-1.517**
	(0.473)	(0.551)	(0.617)
R-squared	0.977	0.978	0.978
N	10,278	10,148	10,116
Bank FE	✓	✓	✓
Borrower × Month-year FE	✓	✓	✓
Country × Month-year FE	-	✓	✓
Interacted Controls	-	-	✓

Notes: The level of observation is a syndicated loan to firm j by euro area bank i in country c on date t. The sample period is 2010 to 2020. The dependent variable is the natural logarithm of the euro amount of debt issued between firm j and bank i on date t. $Post_t$ is a dummy that equals 1 after the ECB introduced negative monetary-policy rates (June 11, 2014). $Security\ Ratio_i$ is the share of securities over assets of bank i in 2012, and $Deposit\ Ratio_i$ is the share of deposits over assets of bank i in 2012. The double interactions between $Post_t$ and the two variables $Security\ Ratio_i$ and $Deposit\ Ratio_i$ are included in the regressions, but are not reported in the table. Column 3 includes the interactions between $Post_t$ and the following bank-level control variables as of 2012: (1) the natural logarithm of total assets, (2) the simple capital ratio, (3) the tier 1 capital ratio, (4) the return on assets, and (5) the return on capital. Standard errors are clustered at the bank level.

Table 3: Syndicated-lending Response by Banks with Different Exposure to QE—Staggered Implementation of Negative Rates

	Dependent Variable: Lending		
	(1)	(2)	(3)
1 NIRP CUT BEFORE QE $\times$ Security Ratio $\times$ Deposit Ratio	0.039	-0.079	-0.072
	(0.656)	(0.924)	(0.922)
2 QE $\times$ Security Ratio $\times$ Deposit Ratio	-2.404***	-2.278*	-2.461*
	(0.804)	(1.239)	(1.243)
3 NIRP CUT AFTER QE $\times$ Security Ratio $\times$ Deposit Ratio	-1.191**	-1.280**	-1.264**
	(0.576)	(0.534)	(0.533)
R-squared	0.977	0.978	0.978
N	10,278	10,148	10,116
Bank FE	✓	✓	✓
Borrower $\times$ Month-year FE	✓	✓	✓
Country $\times$ Month-year FE	-	✓	✓
Interacted Controls	-	-	✓

Notes: The level of observation is a syndicated loan to firm j by euro area bank i in country c on date t. The sample period is 2010 to 2020. The dependent variable is the natural logarithm of the euro amount of debt issued between firm j and bank i on date t. $NIRP\ CUT\ BEFORE\ QE_t$ is a dummy that equals 1 after negative monetary-policy rates were introduced and before QE was implemented. QE_t is a dummy that equals 1 after QE was implemented and before further interest-rate cuts (with QE) were implemented. $NIRP\ CUT\ AFTER\ QE_t$ is a dummy that equals 1 after further interest-rate cuts (with QE) were implemented. *Security Ratio*$_i$ is the share of securities over assets of bank i in 2012, and *Deposit Ratio*$_i$ is the share of deposits over assets of bank i in 2012. The various double interactions between the three variables *Security Ratio*$_i$, *Deposit Ratio*$_i$, and the *QE* indicators are included in the regressions, but are not reported in the table. Column 3 includes the interactions between the *QE* indicators and the following bank-level control variables as of 2012: (1) the natural logarithm of total assets, (2) the simple capital ratio, (3) the tier 1 capital ratio, (4) the return on assets, and (5) the return on capital. Standard errors are clustered at the bank level.

Table 4: Effect on Profitability of Banks with Different Exposure to QE and Negative Rates

	Dependent Variable: Stock Return				
	(1)	(2)	(3)	(4)	(5)
QE $\times$ Security Ratio $\times$ Deposit Ratio	-0.341**	-0.327**	-0.314**	-0.342***	-0.374**
	(0.160)	(0.145)	(0.130)	(0.104)	(0.166)
R-squared	0.010	0.025	0.323	0.337	0.342
N	2,013	2,013	2,013	2,013	1,925
Bank FE	-	✓	-	✓	✓
Time FE	-	-	✓	✓	✓
Interacted Controls	-	-	-	-	✓

Notes: The level of observation is the monthly stock return of euro area bank i in country c in month-year m. The sample period is 2010 to 2020. The dependent variable is the difference in the natural logarithm of the equity prices of bank i between month-year m and $m-1$. $QE_{c(i),m(t)}$ is the amount of government bond purchases (by the ECB in month-year $m(t)$) of country c that bank i is incorporated in, divided by the respective country's banks' total security holdings in 2012, and is standardized to have a 0 mean and a standard deviation of 1. *Security Ratio*$_i$ is the share of securities over assets of bank i in 2012, and *Deposit Ratio*$_i$ is the share of deposits over assets of bank i in 2012. The various double interactions between the three variables *Security Ratio*$_i$, *Deposit Ratio*$_i$ and $QE_{c(i),m(t)}$, and their levels (if not absorbed by fixed effects) are included in the regressions, but are not reported in the table. Column 5 includes the interactions between $QE_{c(i),m(t)}$ and the following bank-level control variables as of 2012: (1) the natural logarithm of total assets, (2) the simple capital ratio, (3) the tier 1 capital ratio, (4) the return on assets, and (5) the return on capital. Standard errors are clustered at the bank level.

Table 5: Effect on Profitability of Banks with Different Exposure to QE and Negative Rates—Heterogeneity across Countries

	Dependent Variable: Stock Return			
	(1)	(2)	(3)	(4)
QE × Security Ratio × Deposit Ratio	-3.352***	-1.296**	-0.380**	-1.970***
	(0.428)	(0.494)	(0.159)	(0.538)
QE × Security Ratio × Deposit Ratio × Risky	3.011***	1.000**	0.663	0.542*
	(0.490)	(0.391)	(0.550)	(0.289)
R-squared	0.343	0.343	0.343	0.366
N	1,925	1,925	1,925	1,673
Bank FE	✓	✓	✓	✓
Time FE	✓	✓	✓	✓
Interacted Controls	✓	✓	✓	✓
Risky	Not Germany	Low Index	GIIPS	Bond Yields

Notes: The level of observation is the monthly stock return of euro area bank i in country c in month-year m. The sample period is 2010 to 2020. The dependent variable is the difference in the natural logarithm of the equity prices of bank i between month-year m and $m-1$. $QE_{c(i),m(t)}$ is the amount of government bond purchases (by the ECB in month-year $m(t)$) of country c that bank i is incorporated in, divided by the respective country's banks' total security holdings in 2012, and is standardized to have a 0 mean and a standard deviation of 1. *Security Ratio*$_i$ is the share of securities over assets of bank i in 2012, and *Deposit Ratio*$_i$ is the share of deposits over assets of bank i in 2012. *Risky*$_c$ captures the riskiness of the country that bank i is incorporated in. *Risky*$_c$ is defined as all countries except for Germany in column 1, a dummy for a low (below-median) Bittner, Bonfim, Heider, Saidi, Schepens, and Soares (2022) index in column 2, indicating a greater distance to the ZLB, a dummy for a GIIPS (Greece, Italy, Ireland, Portugal, or Spain) country in column 3, and the government bond yield of country c in 2014 in column 4. The various remaining interactions between *Deposit Ratio*$_i$, *Security Ratio*$_i$, $QE_{c(i),m(t)}$, and *Risky*$_c$ are included in the regressions, but are not reported in the table. Standard errors are clustered at the bank level.

Table 6: Security Holdings of Banks with Different Exposure to QE and Negative Rates

	Dependent Variable: Security Holdings					
	(1)	(2)	(3)	(4)	(5)	(6)
QE × Security Ratio	-0.150***	-0.162***	-0.266***	-0.290***	-0.112	-0.135
	(0.047)	(0.046)	(0.077)	(0.075)	(0.094)	(0.099)
R-squared	0.952	0.974	0.932	0.950	0.955	0.985
N	3,625,419	3,602,180	1,797,212	1,787,733	1,825,439	1,814,447
Bank FE	✓	-	✓	-	✓	-
Security FE	✓	-	✓	-	✓	-
Time FE	✓	✓	✓	✓	✓	✓
Bank × Security FE	-	✓	-	✓	-	✓
Sample	Full	Full	Large Banks	Large Banks	Small Banks	Small Banks

Notes: The level of observation is German bank i's holdings in security s in quarter-year q. The sample period spans the first time negative monetary-policy rates are introduced (2014q3) up until 2018q4. The dependent variable is the natural logarithm of the euro amount held in security s by bank i in quarter-year q. QE_q is the amount of German government bonds purchased by the ECB in quarter-year q divided by all German banks' total German sovereign bond holdings in 2012, and is standardized to have a 0 mean and a standard deviation of 1. $Security\ Ratio_i$ is the share of securities over assets of bank i in 2012. Bank i is considered to be a large bank if its total assets exceed €50 billion in 2012. Otherwise, the bank is a small bank. Standard errors are double-clustered at the bank and security levels. Source: Research Data and Service Centre (RDSC) of the Deutsche Bundesbank, Security Holdings Statistics (SHS), and balance-sheet statistics (BISTA).

Table 7: Effect on Balance Sheets of Banks with Different Exposure to QE and Negative Rates

	$\frac{\text{CB assets}}{\text{Assets}}$ (1)	$\frac{\text{CB liabilities}}{\text{Assets}}$ (2)	$\frac{\text{CB net assets}}{\text{Assets}}$ (3)	$\frac{\text{Liabilities}}{\text{Assets}}$ (4)
QE $\times$ Security Ratio $\times$ Deposit Ratio	0.059***	-0.004	0.104***	0.260**
	(0.016)	(0.008)	(0.040)	(0.112)
R-squared	0.740	0.733	0.674	0.759
N	19,479	19,479	19,479	19,479
Bank FE	✓	✓	✓	✓
Time FE	✓	✓	✓	✓

Notes: The level of observation is German bank i in quarter-year q. The sample period spans the first time negative monetary-policy rates are introduced (2014q3) up until 2018q4. The dependent variable in column 1 is central-bank assets of bank i in quarter-year q divided by total assets of bank i in 2012. The dependent variables in columns 2-4 are constructed similarly, where the numerator is central-bank liabilities of bank i in quarter-year q in column 2, central-bank assets minus liabilities of bank i in quarter-year q in column 3, and liabilities of bank i in quarter-year q in column 4. QE_q is the amount of German government bonds purchased by the ECB in quarter-year q divided by all German banks' total German sovereign bond holdings in 2012, and is standardized to have a 0 mean and a standard deviation of 1. $Security\ Ratio_i$ is the share of securities over assets of bank i in 2012, and $Deposit\ Ratio_i$ is the share of deposits over assets of bank i in 2012. The various double interactions between QE_q and the two variables $Security\ Ratio_i$ and $Deposit\ Ratio_i$ are included in the regressions, but are not reported in the table. Standard errors are clustered at the bank level. Source: Research Data and Service Centre (RDSC) of the Deutsche Bundesbank, balance-sheet statistics (BISTA).

Table 8: Credit-supply Response by Banks with Different Exposure to QE and Negative Rates—Credit-registry Evidence

	Dependent Variable: Lending					
	(1)	(2)	(3)	(4)	(5)	(6)
QE × Security Ratio × Deposit Ratio	-2.071**	0.036	0.036	-3.166***	0.079	0.075
	(0.720)	(0.057)	(0.058)	(0.333)	(0.062)	(0.064)
Large Bank × QE × Security Ratio × Deposit Ratio			-2.113***			
			(0.802)			
Repo Bank × QE × Security Ratio × Deposit Ratio						-3.665***
						(0.369)
R-squared	0.920	0.945	0.934	0.917	0.946	0.934
N	353,363	1,272,435	1,963,138	307,312	1,342,966	1,963,138
Bank × Firm FE	✓	✓	✓	✓	✓	✓
Firm × Time FE	✓	✓	✓	✓	✓	✓
Sample	Large Banks	Small Banks	Full	Repo Banks	Non-repo Banks	Full

Notes: The level of observation is credit to German firm j by German bank i in quarter-year q. The sample period spans the first time negative monetary-policy rates are introduced (2014q3) up until 2018q4. The dependent variable is the natural logarithm of the euro amount outstanding between firm j and bank i in quarter-year q. QE_q is the amount of German government bonds purchased by the ECB in quarter-year q divided by all German banks' total German sovereign bond holdings in 2012, and is standardized to have a 0 mean and a standard deviation of 1. *Security Ratio*$_i$ is the share of securities over assets of bank i in 2012, and *Deposit Ratio*$_i$ is the share of deposits over assets of bank i in 2012. Bank i is considered to be a large bank if its total assets exceed €50 billion in 2012. Otherwise, the bank is a small bank. Bank i is a repo bank if the bank conducts repo transactions. Otherwise, the bank is a non-repo bank. The various remaining interactions between *Deposit Ratio*$_i$, *Security Ratio*$_i$, QE_q, *Large Bank*$_i$, and *Repo Bank*$_i$ are included in the regressions, but are not reported in the table. Standard errors are clustered at the bank level. Source: Research Data and Service Centre (RDSC) of the Deutsche Bundesbank, German credit register (BAKIS-M), and balance-sheet statistics (BISTA).

Table 9: Credit-supply Response by Banks with Different Exposure to QE and Negative Rates—Robustness

	Dependent Variable: Lending			
	(1)	(2)	(3)	(4)
Deposit Ratio × Δ ln securities (one year)	0.127*			
	(0.070)			
Deposit Ratio HH × Δ ln securities (one year)		0.130*		
		(0.076)		
Deposit Ratio NFC × Δ ln securities (one year)		0.089		
		(0.229)		
Deposit Ratio × Δ ln securities (one quarter)			0.125	
			(0.082)	
Deposit Ratio HH × Δ ln securities (one quarter)				0.168**
				(0.081)
Deposit Ratio NFC × Δ ln securities (one quarter)				-0.456**
				(0.205)
R-squared	0.938	0.938	0.938	0.938
N	1,671,560	1,671,560	1,714,208	1,714,208
Bank × Firm FE	✓	✓	✓	✓
Firm × Time FE	✓	✓	✓	✓

Notes: The level of observation is credit to German firm j by German bank i in quarter-year q. The sample period spans the first time negative monetary-policy rates are introduced (2014q3) up until 2018q4. The dependent variable is the natural logarithm of the euro amount outstanding between firm j and bank i in quarter-year q. $\Delta \ln \ securities_{i,q}$ is the change in logged security holdings of bank i from q to q minus one year (or one quarter in the last two columns), and is always controlled for separately. *Deposit Ratio*$_i$ is the share of deposits over assets of bank i in 2012. The numerator of said ratio is further decomposed into household deposits (*Deposit Ratio HH*$_i$) and deposits from non-financial corporations (*Deposit Ratio NFC*$_i$). Standard errors are clustered at the bank level. Source: Research Data and Service Centre (RDSC) of the Deutsche Bundesbank, German credit register (BAKIS-M), and balance-sheet statistics (BISTA).

Table 10: Effect on Firm-level Credit

	Dependent Variable: Δln(Total Credit)					
	(1)	(2)	(3)	(4)	(5)	(6)
Security & Deposit Exposure	-1.145***	-1.336**	-1.548**	-1.751***	-1.986***	-2.141**
	(0.444)	(0.520)	(0.606)	(0.639)	(0.741)	(0.840)
Security Exposure	0.516***	0.587***	0.685***	0.767***	0.828***	0.925***
	(0.173)	(0.197)	(0.223)	(0.244)	(0.278)	(0.308)
Deposit Exposure	0.458***	0.460***	0.490***	0.749***	0.774***	0.824***
	(0.088)	(0.103)	(0.117)	(0.125)	(0.145)	(0.163)
R-squared	0.038	0.152	0.215	0.044	0.163	0.230
N	6,099	5,795	5,161	6,118	5,814	5,180
Industry FE	✓	-	-	✓	-	-
Region FE	✓	-	-	✓	-	-
Size FE	✓	-	-	✓	-	-
Industry × Region FE	-	✓	-	-	✓	-
Industry × Size FE	-	✓	-	-	✓	-
Industry × Region × Size FE	-	-	✓	-	-	✓
Period	2013 − 2016			2011 − 2018		

Notes: The level of observation is German firm j. The dependent variable is the difference in the natural logarithm of borrower firm j's total credit averaged over 2015 − 2016 vs. 2013 − 2014 in columns 1-3, and averaged over 2015 − 2018 vs. 2011 − 2014 in columns 4-6. *Security & Deposit Exposure*$_j$ is the average value of *Security Ratio*$_i$ × *Deposit Ratio*$_i$ (measured in 2012) of all German banks with which firm j contracts (as of 2014), weighted by firm j's credit exposure to each bank i. *Security Exposure*$_j$ and *Deposit Exposure*$_j$ are defined accordingly using *Security Ratio*$_i$ and *Deposit Ratio*$_i$, respectively. Fixed effects are based on firm j's NACE industry segment, NUTS-3 region, and/or firm-size categories according to the European Union's guidelines. Robust standard errors are shown in parentheses. Source: Research Data and Service Centre (RDSC) of the Deutsche Bundesbank, German credit register (BAKIS-M), balance-sheet statistics (BISTA), and BvD Orbis.

Table 11: Firm-level Real Effects of Bank Credit Supply

	Δln(Wage bill)			Δln(Employment)			Δln(Tangible fixed assets)		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Security & Deposit Exposure	-0.233***	-0.199**	-0.142	-0.265***	-0.222**	-0.177*	-0.019	-0.071	-0.235
	(0.068)	(0.080)	(0.092)	(0.077)	(0.088)	(0.103)	(0.150)	(0.178)	(0.209)
Security Exposure	0.118***	0.099***	0.093***	0.076***	0.055*	0.051	0.010	0.024	0.059
	(0.025)	(0.030)	(0.034)	(0.029)	(0.033)	(0.038)	(0.058)	(0.068)	(0.077)
Deposit Exposure	0.054***	0.053***	0.054***	0.076***	0.076***	0.073***	0.012	0.021	0.045
	(0.013)	(0.015)	(0.017)	(0.015)	(0.016)	(0.019)	(0.030)	(0.035)	(0.039)
R-squared	0.046	0.169	0.223	0.033	0.158	0.208	0.024	0.141	0.205
N	6,098	5,791	5,163	6,145	5,840	5,208	6,109	5,804	5,171
Industry FE	✓	-	-	✓	-	-	✓	-	-
Region FE	✓	-	-	✓	-	-	✓	-	-
Size FE	✓	-	-	✓	-	-	✓	-	-
Industry × Region FE	-	✓	-	-	✓	-	-	✓	-
Industry × Size FE	-	✓	-	-	✓	-	-	✓	-
Industry × Region × Size FE	-	-	✓	-	-	✓	-	-	✓

Notes: The level of observation is German firm j. The dependent variable in columns 1-3 is the difference in the natural logarithm of borrower firm j's average total wage bill in $2015-2016$ vs. $2013-2014$. The dependent variable in columns 4-6 is the difference in the natural logarithm of borrower firm j's average number of employees in $2015-2016$ vs. $2013-2014$. The dependent variable in columns 7-9 is the difference in the natural logarithm of borrower firm j's tangible fixed assets in $2015-2016$ vs. $2013-2014$. *Security & Deposit Exposure*$_j$ is the average value of *Security Ratio*$_i$ $\times$ *Deposit Ratio*$_i$ (measured in 2012) of all German banks with which firm j contracts (as of 2014), weighted by firm j's credit exposure to each bank i. *Security Exposure*$_j$ and *Deposit Exposure*$_j$ are defined accordingly using *Security Ratio*$_i$ and *Deposit Ratio*$_i$, respectively. Fixed effects are based on firm j's NACE industry segment, NUTS-3 region, and/or firm-size categories according to the European Union's guidelines. Robust standard errors are shown in parentheses. Source: Research Data and Service Centre (RDSC) of the Deutsche Bundesbank, German credit register (BAKIS-M), balance-sheet statistics (BISTA), and BvD Orbis.

Table 12: Interbank Lending by Banks with Different Exposure to QE and Negative Rates

	Dependent Variable: Lending					
	(1)	(2)	(3)	(4)	(5)	(6)
QE × Security Ratio × Deposit Ratio	4.334*	4.890*	-0.096	-0.035		
	(2.021)	(2.248)	(0.114)	(0.186)		
QE × Security Ratio × Deposit Ratio × Yield		0.129		-0.046		
		(0.662)		(0.126)		
Δ ln securities (one year) × Deposit Ratio					0.045	0.132
					(0.181)	(0.184)
Δ ln securities (one year) × Deposit Ratio × Yield						-0.086**
						(0.041)
R-squared	0.881	0.881	0.893	0.893	0.894	0.894
N	40,794	40,794	524,170	524,170	514,486	514,486
Bank (lender) × Bank (borrower) FE	✓	✓	✓	✓	✓	✓
Bank (borrower) × Time FE	✓	✓	✓	✓	✓	✓
Sample	Large Banks	Large Banks	Small Banks	Small Banks	Full	Full

Notes: The level of observation is credit to bank (borrower) j by German bank (lender) i in quarter-year q. The sample period spans the first time negative monetary-policy rates are introduced (2014q3) up until 2018q4. The dependent variable is the natural logarithm of the euro amount outstanding between bank j (borrower) and bank i (lender) in quarter-year q. QE_q is the amount of German government bonds purchased by the ECB in quarter-year q divided by all German banks' total German sovereign bond holdings in 2012, and is standardized to have a 0 mean and a standard deviation of 1. *Security Ratio*$_i$ is the share of securities over assets of bank i in 2012, and *Deposit Ratio*$_i$ is the share of deposits over assets of bank i in 2012. *Yield*$_c$ is the yield of long-term (10-year) government bonds of the borrower's country prior to the introduction of negative monetary-policy rates. $\Delta \ln \ securities_{i,q}$ is the change in logged security holdings of bank (lender) i from q to q minus one year. A bank (lender) i is considered to be a large bank if its total assets exceed €50 billion in 2012. Otherwise, the bank is a small bank. The various remaining interactions between *Deposit Ratio*$_i$, *Security Ratio*$_i$, QE_q, *Yield*$_c$ and $\Delta \ln \ securities_{i,q}$, and their levels (if not absorbed by fixed effects) are included in the regressions, but are not reported in the table. Standard errors are clustered at the bank (lender) level. Source: Research Data and Service Centre (RDSC) of the Deutsche Bundesbank, German credit register (BAKIS-M), and balance-sheet statistics (BISTA).

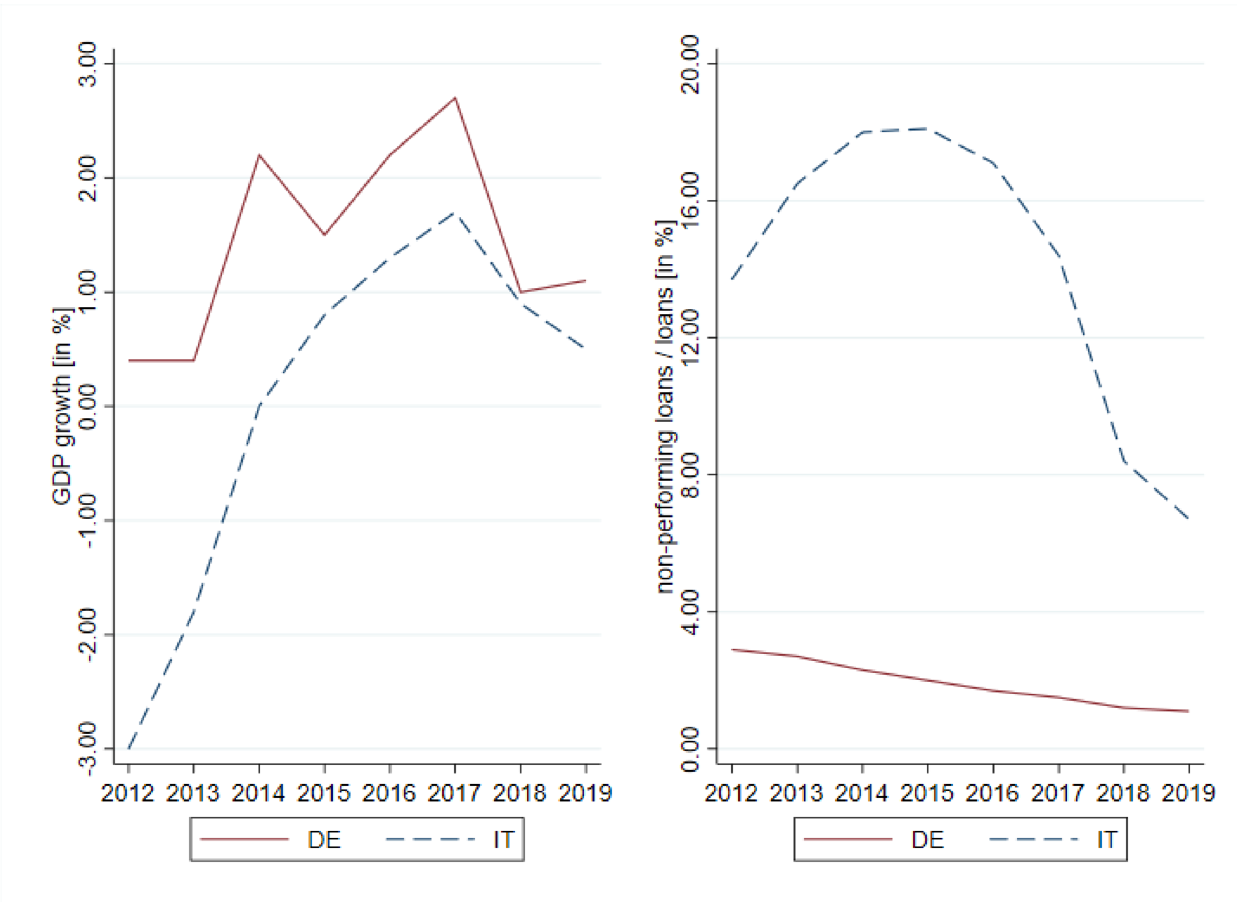
Table 13: Cross-border Banking Flows

	Dependent Variable: Bilateral Cross-Border Bank Lending					
	(1)	(2)	(3)	(4)	(5)	(6)
QE × Core × GIIPS	0.005***			0.004***		
	(0.001)			(0.000)		
QE × Core × High Yield		0.006*			0.008***	
		(0.003)			(0.003)	
QE × Core × Low Index			0.005			0.004
			(0.004)			(0.004)
R-squared	0.054	0.054	0.054	0.127	0.127	0.127
N	65,533	65,533	65,533	65,441	65,441	65,441
Lender × Borrower FE	✓	✓	✓	✓	✓	✓
Lender × Time FE	✓	✓	✓	✓	✓	✓
Borrower × Time FE	-	-	-	✓	✓	✓

Notes: The level of observation is the bilateral banking flow from country (lender) c to country (borrower) j in the euro area in quarter-year q. The dependent variable is the percent change in bank claims of country c to country j. The sample period is 2014 to 2020. $QE_{c,q}$ is the amount of government bond purchases of country c by the ECB in quarter-year q, divided by the respective country's banks' total security holdings in 2012, and is standardized to have a 0 mean and a standard deviation of 1. $Core_c$ is a dummy for whether the lender country c is Germany, Finland, the Netherlands, or Austria. $GIIPS_j$ is a dummy for whether the borrower country j is Greece, Italy, Ireland, Portugal, or Spain. $High\ Yield_j$ is a dummy for whether the borrower country j has a high (above median) sovereign yield in 2014. $Low\ Index_j$ is a dummy for a low (below-median) Bittner, Bonfim, Heider, Saidi, Schepens, and Soares (2022) index, indicating a greater distance to the ZLB in borrower country j. The double interactions between $QE_{c,q}$ and the three variables $GIIPS_j$, $High\ Yield_j$, and $Low\ Index_j$ are included in the regressions, but are not reported in the table. Standard errors are double-clustered at the lender-country and borrower-country levels.

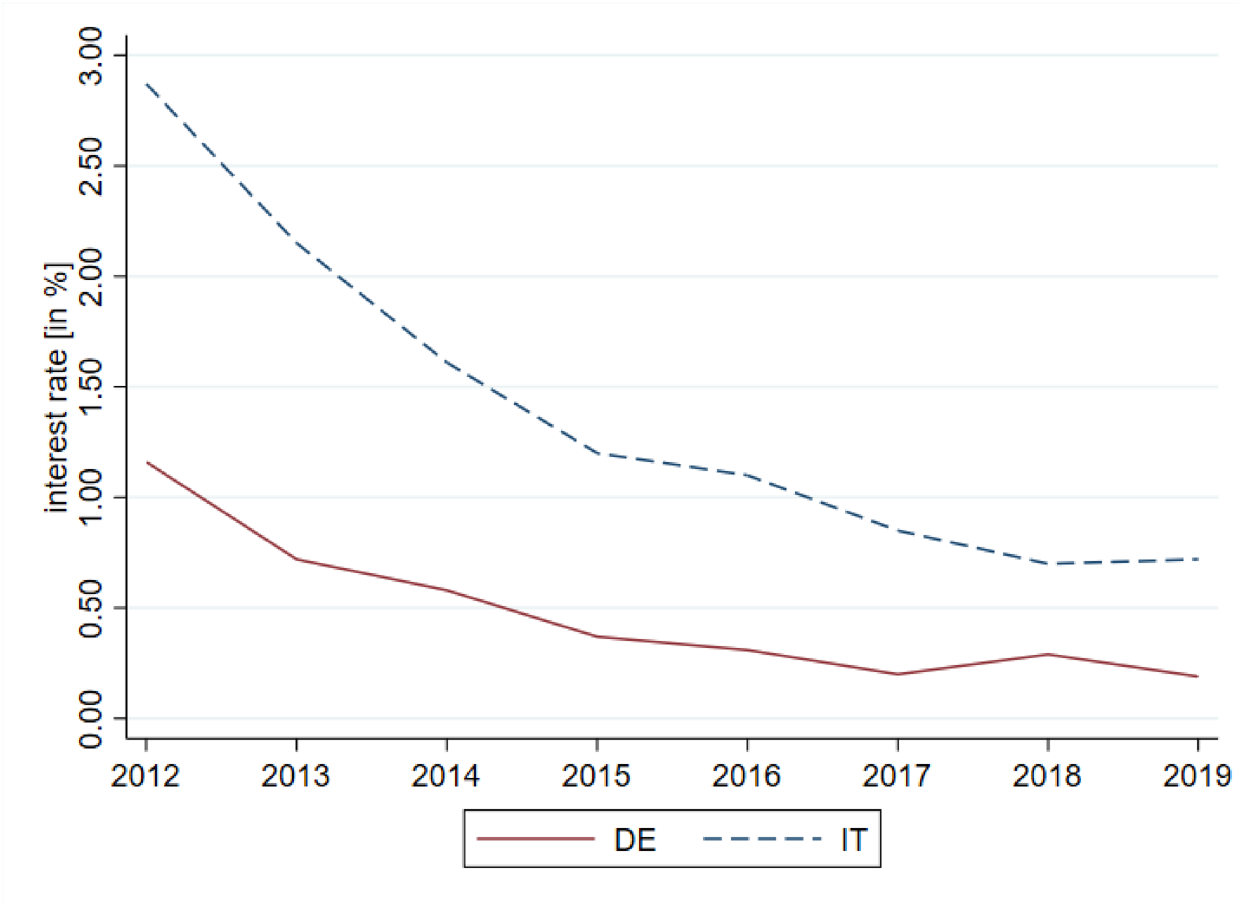
ONLINE APPENDIX—NOT FOR PUBLICATION

Figure A1: GDP Growth and Non-Performing Loans in Germany and Italy



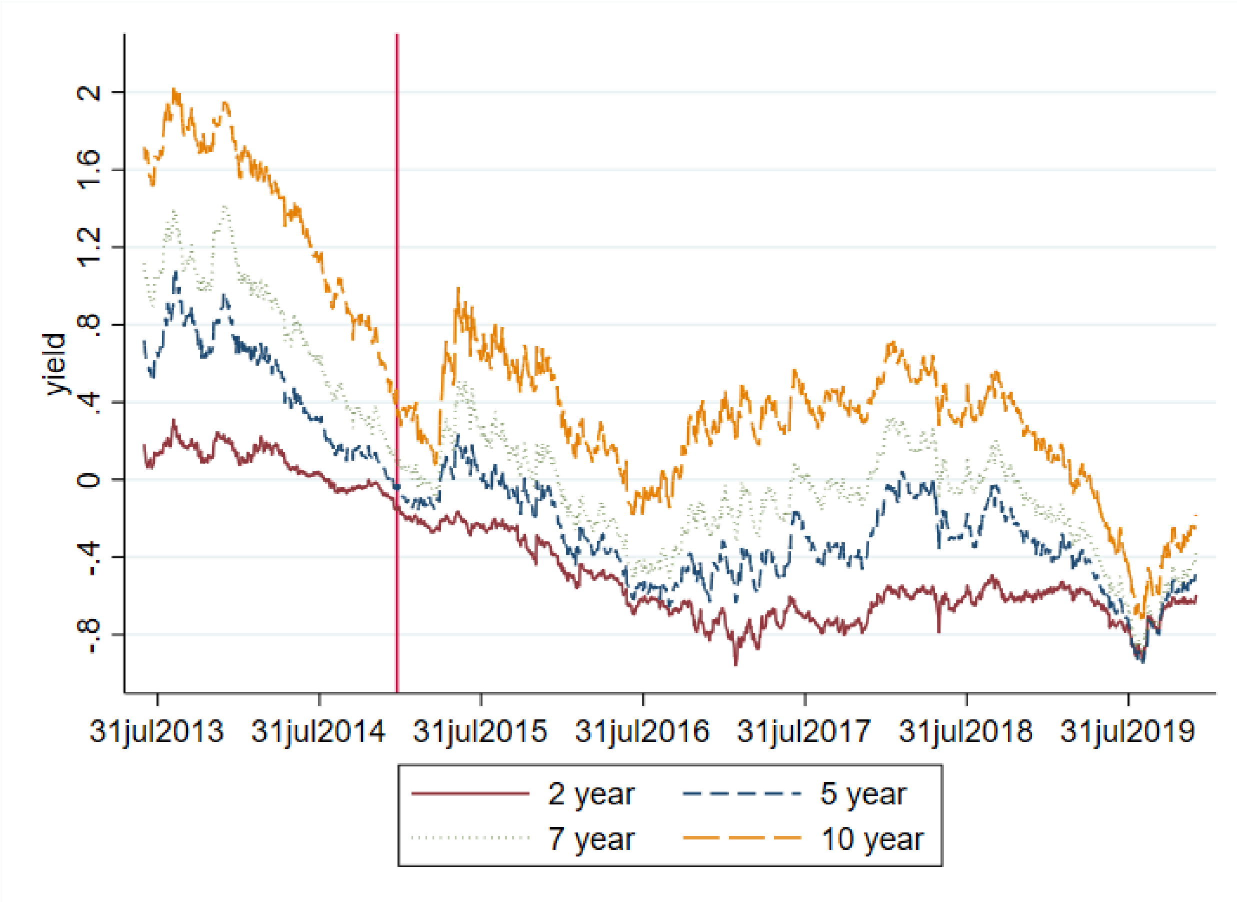
Notes: The graph shows the evolution of annual GDP growth [in %] in Germany and Italy in the left figure and non-performing loans to loans [in %] in the right figure. The figures are shown for Germany (solid maroon line) and Italy (dashed navy line).

Figure A2: Interest Rates on Household Deposits [in %] in Germany and Italy



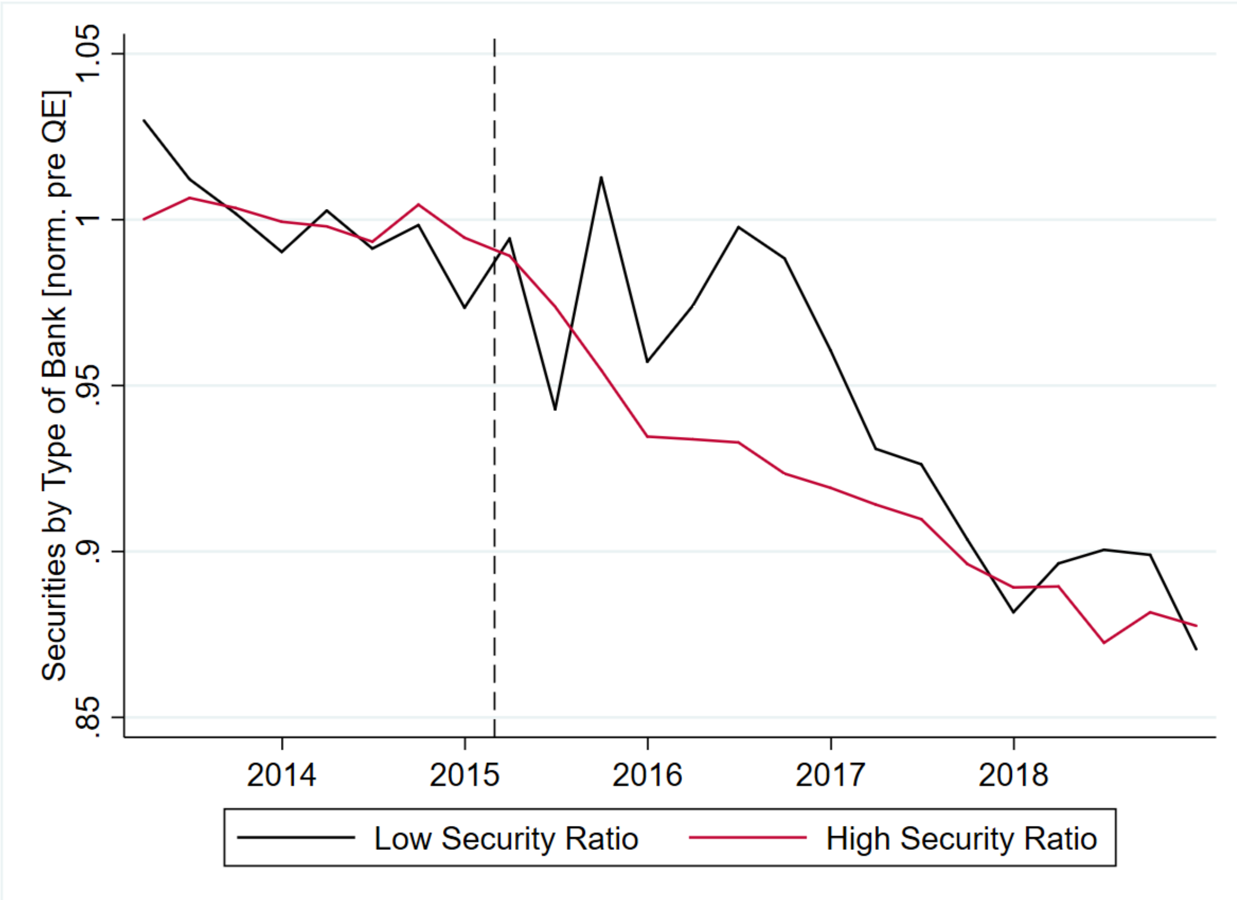
Notes: The graph shows the evolution of interest rates on household deposits [in %]. The figure is shown for Germany (solid maroon line) and Italy (dashed navy line).

Figure A3: Government Bond Yield Term Structure



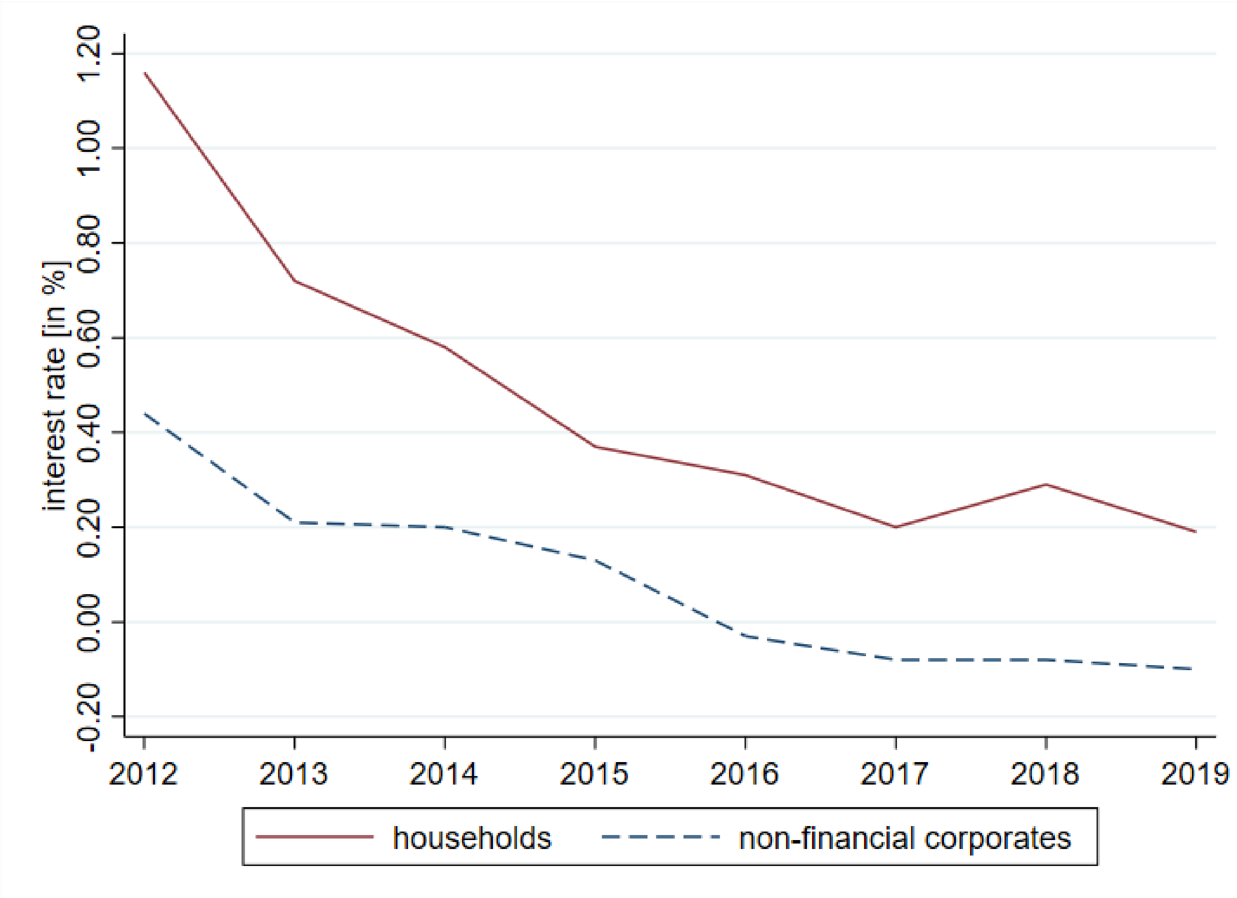
Notes: The graph shows the evolution of government bond yields for different maturities. The bond yields are based on two-year (solid maroon line), five-year (dashed navy line), seven-year (dotted green line), and ten-year government bond indices for Germany (long dashed orange line). The vertical red line represents the announcement of the public sector purchase program (PSPP) on January 22, 2015.

Figure A4: Security Holdings in Germany Before and After QE



Notes: This graph shows the development of security holdings by German banks with high and low security ratios (separated by the median as of 2012) between 2013 and 2019. Source: Research Data and Service Centre (RDSC) of the Deutsche Bundesbank, Security Holdings Statistics (SHS), and balance-sheet statistics (BISTA).

Figure A5: Interest Rates on Household Deposits and on Deposits for Non-Financial Corporates [in %] in Germany



Notes: The graph shows the evolution of interest rates on deposits [in %] in Germany. The figure is shown for interest rates on household deposits (solid maroon line) and deposits for non-financial corporates (dashed navy line).

Table A1: Descriptive Statistics: Syndicated-loan Data

	Mean	SD	P25	P75	N
Lending	18.626	1.326	17.784	19.494	6,311
$\ln(1 + App_{c(i),m(t)})$	7.282	3.130	7.189	9.319	5,995
$\frac{App_{c(i),m(t)}}{BSecH_{c(i),2012}}$	0.006	0.005	0.001	0.010	6,311
Security Ratio	0.194	0.050	0.174	0.220	6,311
Deposit Ratio	0.334	0.151	0.250	0.442	6,311

Notes: The level of observation is a syndicated loan to firm j by euro area bank i in country c on date t. The sample period is 2014 to 2020. Lending is the natural logarithm of the euro amount of debt issued between firm j and bank i on date t. $App_{c(i),m(t)}$ is the amount (in mn euros) of government bond purchases (by the ECB in month-year $m(t)$) of country c that bank i is incorporated in. $\frac{App_{c(i),m(t)}}{BSecH_{c(i),2012}}$ is the amount of government bond purchases (by the ECB in month-year $m(t)$) of country c that bank i is incorporated in, divided by the respective country's banks' total security holdings in 2012. *Security Ratio*$_i$ is the share of securities over assets of bank i in 2012, and *Deposit Ratio*$_i$ is the share of deposits over assets of bank i in 2012.

Table A2: Correlation of Bank-level Exposure Variables with Other Balance-sheet Characteristics

	(1) ln(Assets)	(2) Capital Ratio	(3) T1 Capital Ratio	(4) RoA	(5) RoC
Security Ratio	3.228	0.003	-0.021	-0.048	93.280
	(3.865)	(0.096)	(0.064)	(0.030)	(223.547)
Deposit Ratio	-2.028	0.031	0.044^{**}	-0.012	-27.462
	(1.532)	(0.030)	(0.020)	(0.012)	(69.741)
Security Ratio × Deposit Ratio	-4.821	0.052	-0.004	0.085	47.590
	(6.988)	(0.153)	(0.102)	(0.054)	(356.948)
R-squared	0.171	0.114	0.230	0.047	0.026
N	66	60	50	66	52

Notes: The level of observation is a euro area bank i in the year 2012. The dependent variable is (1) the natural logarithm of total assets, (2) the simple capital ratio, (3) the tier 1 capital ratio, (4) the return on assets, and (5) the return on capital. *Security Ratio*$_i$ is the share of securities over assets of bank i in 2012, and *Deposit Ratio*$_i$ is the share of deposits over assets of bank i in 2012.

Table A3: Syndicated-lending Response by Banks with Different Exposure to QE and Negative Rates—Robustness

	Dependent Variable: Lending							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
QE × Security Ratio × Deposit Ratio	-1.227**	-1.100**	-1.143**	-1.141**	-1.117**	-0.808**	-0.790**	-2.434**
	(0.462)	(0.506)	(0.532)	(0.432)	(0.433)	(0.376)	(0.360)	(0.994)
R-squared	0.975	0.976	0.976	0.975	0.975	0.976	0.976	0.976
N	6,362	6,291	6,291	5,893	5,844	6,291	6,291	6,291
Bank FE	✓	✓	✓	✓	✓	✓	✓	✓
Borrower × Month-year FE	✓	✓	✓	✓	✓	✓	✓	✓
Country × Month-year FE	–	✓	✓	✓	✓	✓	✓	✓
Specification	$\frac{App_{c(i),m(t)}}{BSecH_{c(i),2012}}$	$\frac{App_{c(i),m(t)}}{BSecH_{c(i),2012}}$	$\frac{App_{c(i),m(t)}}{BSecH_{c(i),m(t)-1}}$	$\ln(App_{c(i),m(t)})$	$\ln(App_{m(t)})$	$\ln(H_{c(i),m})$	$\ln(H_{m(t)})$	$QEDummy$
Interacted Controls	✓	✓	✓	✓	✓	✓	✓	✓

Notes: The level of observation is a syndicated loan to firm j by euro area bank i in country c on date t. The sample period is 2014 to 2020. The dependent variable is the natural logarithm of the euro amount of debt issued between firm j and bank i on date t. *QE* measures the implementation of the public sector purchase program (PSPP) of the ECB, and is always standardized to have a 0 mean and a standard deviation of 1. In columns 1-2, $QE_{c(i),m(t)}$ is the amount of government bond purchases (by the ECB in month-year $m(t)$) of country c that bank i is incorporated in, divided by the respective country's banks' total security holdings in 2012. In column 3, $QE_{c(i),m(t)}$ has the same numerator, but is now scaled by country c's banks' total security holdings in the previous month-year. In column 4, $QE_{m(t)}$ is the natural logarithm of one plus the amount of government bonds of country c purchased by the ECB in month-year $m(t)$. In column 5, $QE_{m(t)}$ is the natural logarithm of the amount of all government bonds purchased by the ECB in month-year $m(t)$. In column 6, $QE_{c(i),m(t)}$ is the natural logarithm of the amount of country c government bonds *held* by the ECB in month-year $m(t)$. In column 7, $QE_{m(t)}$ is the natural logarithm of the amount of all government bonds *held* by the ECB in month-year $m(t)$. In column 8, $QE_{m(t)}$ is a dummy equal to 1 after March 2015. *Security Ratio*$_i$ is the share of securities over assets of bank i in 2012, and *Deposit Ratio*$_i$ is the share of deposits over assets of bank i in 2012. The various double interactions between the three variables *Security Ratio*$_i$, *Deposit Ratio*$_i$ and $QE_{c(i),m(t)}$, and their levels (if not absorbed by fixed effects) are included in the regressions, but are not reported in the table. All regressions include the interactions between $QE_{c(i),m(t)}$ and the following bank-level control variables as of 2012: (1) the natural logarithm of total assets, (2) the simple capital ratio, (3) the tier 1 capital ratio, (4) the return on assets, and (5) the return on capital. Standard errors are clustered at the bank level.

Table A4: Syndicated-lending Response by Banks with Different Exposure to QE—Interaction with Deposit Facility Rate

	Dependent Variable: Lending		
	(1)	(2)	(3)
Deposit Facility × Security Ratio × Deposit Ratio	3.154*	3.516	4.571**
	(1.704)	(2.105)	(2.239)
R-squared	0.975	0.976	0.976
N	8,311	8,213	8,181
Bank FE	✓	✓	✓
Borrower × Month-year FE	✓	✓	✓
Country × Month-year FE	-	✓	✓
Interacted Controls	-	-	✓

Notes: The level of observation is a syndicated loan to firm j by euro area bank i in country c on date t. The sample period is 2012 to 2020. The dependent variable is the natural logarithm of the euro amount of debt issued between firm j and bank i on date t. *Deposit Facility*$_t$ is the ECB's deposit facility rate. *Security Ratio*$_i$ is the share of securities over assets of bank i in 2012, and *Deposit Ratio*$_i$ is the share of deposits over assets of bank i in 2012. The double interactions between *Deposit Facility*$_t$ and the two variables *Security Ratio*$_i$ and *Deposit Ratio*$_i$ are included in the regressions, but are not reported in the table. Column 3 includes the interactions between *Deposit Facility*$_t$ and the following bank-level control variables as of 2012: (1) the natural logarithm of total assets, (2) the simple capital ratio, (3) the tier 1 capital ratio, (4) the return on assets, and (5) the return on capital. Standard errors are clustered at the bank level.

Table A5: Descriptive Statistics: German Credit Registry

	Mean	SD	P25	P75	N
Lending	6.809	2.061	5.948	8.017	4,409,608
Security Ratio	0.162	0.105	0.073	0.214	4,409,608
Deposit Ratio	0.406	0.206	0.175	0.569	4,409,608
Deposit Ratio HH	0.326	0.198	0.093	0.483	4,409,608
Deposit Ratio NFC	0.080	0.046	0.056	0.089	4,409,608
QE	0.039	0.971	-0.844	0.501	4,409,608
Δ ln securities (one year)	0.003	0.244	-0.102	0.078	4,355,468
Δ ln securities (one quarter)	0.002	0.119	-0.037	0.030	4,356,233

Notes: The level of observation is credit to German firm j by German bank i in quarter-year q. The sample period spans the first time negative monetary-policy rates are introduced (2014q3) up until 2018q4. $Lending_{i,j,q}$ is the natural logarithm of the euro amount outstanding between firm j and bank i in quarter-year q. *Security Ratio*$_i$ is the share of securities over assets of bank i in 2012. *Deposit Ratio*$_i$ is the share of deposits over assets of bank i in 2012. The numerator of said ratio is further decomposed into household deposits (*Deposit Ratio HH*$_i$) and deposits from non-financial corporations (*Deposit Ratio NFC*$_i$). *QE*$_q$ is the amount of German government bonds purchased by the ECB in quarter-year q divided by all German banks' total German sovereign bond holdings in 2012, which we standardize to have a 0 mean and a standard deviation of 1. $\Delta \ln\ securities_{i,q}$ (one year) is the change in logged security holdings of bank i from q to q minus one year, accordingly for $\Delta \ln\ securities_{i,q}$ (one quarter). Source: Research Data and Service Centre (RDSC) of the Deutsche Bundesbank, German credit register (BAKIS-M), Security Holdings Statistics (SHS), and balance-sheet statistics (BISTA).

Table A6: Credit-supply Response by Banks with Different Exposure to QE and Negative Rates—Robustness, Buying vs. Selling

	Dependent Variable: Lending			
	(1)	(2)	(3)	(4)
Deposit Ratio × Δ ln securities (one year)	0.201**	0.023		
	(0.080)	(0.059)		
Deposit Ratio HH × Δ ln securities (one year)			0.202**	0.029
			(0.088)	(0.056)
Deposit Ratio NFC × Δ ln securities (one year)			0.188	-0.067
			(0.277)	(0.334)
R-squared	0.943	0.949	0.943	0.949
N	780,780	633,571	780,780	633,571
Bank × Firm FE	✓	✓	✓	✓
Firm × Time FE	✓	✓	✓	✓
Change in securities	Sell	Buy	Sell	Buy

Notes: The level of observation is credit to German firm j by German bank i in quarter-year q. The sample period spans the first time negative monetary-policy rates are introduced (2014q3) up until 2018q4. The dependent variable is the natural logarithm of the euro amount outstanding between firm j and bank i in quarter-year q. $\Delta \ln \ securities_{i,q}$ is the change in logged security holdings of bank i from q to q minus one year, and is always controlled for separately. *Deposit Ratio*$_i$ is the share of deposits over assets of bank i in 2012. The numerator of said ratio is further decomposed into household deposits (*Deposit Ratio HH*$_i$) and deposits from non-financial corporations (*Deposit Ratio NFC*$_i$). The analysis is run separately for banks selling securities ($\Delta securities_{i,q} < 0$, columns 1 and 3) and banks buying securities ($\Delta securities_{i,q} > 0$, columns 2 and 4). Standard errors are clustered at the bank level. Source: Research Data and Service Centre (RDSC) of the Deutsche Bundesbank, German credit register (BAKIS-M), and balance-sheet statistics (BISTA).

Table A7: Interbank Lending by Banks with Different Exposure to QE and Negative Rates—Euro Area vs. Rest of World

	Dependent Variable: Lending					
	(1)	(2)	(3)	(4)	(5)	(6)
QE × Security Ratio × Deposit Ratio	5.387*	2.910	-0.145	0.080	-0.140	0.102
	(2.423)	(2.246)	(0.124)	(0.197)	(0.123)	(0.196)
Large Bank × QE × Security Ratio × Deposit Ratio					4.390*	2.698
					(2.258)	(1.978)
R-squared	0.882	0.879	0.893	0.884	0.892	0.884
N	25,508	15,286	419,618	104,552	449,130	121,014
Bank (lender) × Bank (borrower) FE	✓	✓	✓	✓	✓	✓
Bank (borrower) × Time FE	✓	✓	✓	✓	✓	✓
Sample	Large Banks	Large Banks	Small Banks	Small Banks	Full	Full
Scope	EA	Non-EA	EA	Non-EA	EA	Non-EA

Notes: The level of observation is credit to bank (borrower) j by German bank (lender) i in quarter-year q. The sample period spans the first time negative monetary-policy rates are introduced (2014q3) up until 2018q4. The dependent variable is the natural logarithm of the euro amount outstanding between bank (borrower) j and bank (lender) i in quarter-year q. QE_q is the amount of German government bonds purchased by the ECB in quarter-year q divided by all German banks' total German sovereign bond holdings in 2012, and is standardized to have a 0 mean and a standard deviation of 1. *Security Ratio*$_i$ is the share of securities over assets of bank (lender) i in 2012. *Deposit Ratio*$_i$ is the share of deposits over assets of bank (lender) i in 2012. A bank (lender) i is considered to be a large bank if its total assets exceed €50 billion in 2012. Otherwise, the bank is a small bank. In columns 1, 3, and 5 only lending to banks (borrowers) within the euro area (EA) is considered, whereas in columns 2, 4, and 6 only lending to banks (borrowers) outside the euro area (non-EA) is considered. The various remaining interactions between *Deposit Ratio*$_i$, *Security Ratio*$_i$, QE_q, and *Large Bank*$_i$ are included in the regressions, but are not reported in the table. Standard errors are clustered at the bank (lender) level. Source: Research Data and Service Centre (RDSC) of the Deutsche Bundesbank, German credit register (BAKIS-M), and balance-sheet statistics (BISTA).