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

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Abstract

This paper studies the distinct roles of expansionary rate-based monetary policy and quantitative easing, in spite of their concurrent implementation around the world. We exploit the introduction of negative monetary-policy rates in a fragmented euro area alongside cross-sectional heterogeneity in banks' balance sheets to show that banks that are more exposed to central banks' asset-purchase programs reduce their lending to the real economy when they incur relatively higher funding costs. When banks face a zero lower bound (ZLB) on retail deposit rates, an asset swap between securities and reserves reduces banks' net worth as the cost of holding reserves cannot be matched with a reduction in their cost of funding. Using administrative data from Germany, with deposit rates close to the ZLB, we also uncover that German banks rebalance their interbank lending from safe to risky countries, and that employment in Germany would have grown more in the absence of a ZLB on deposit rates.

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1 Introduction

Since the Great Financial Crisis the policy space for conventional, rate-based monetary stimulus has become increasingly limited. 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 tend to take place in low-rate environments, when the limit of conventional monetary stimulus has been reached, or are used to smooth short-term rates, quantitative easing and rate-setting monetary policy at the effective lower bound seem inextricably linked. This renders it unclear how lower rates and quantitative easing interact, and whether they substitute or complement each other (Brunnermeier and Koby, 2018; Sims and Wu, 2020, 2021).

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 (Di Maggio, Kermani, and Palmer, 2019; Beraja, Fuster, Hurst, and Vavra, 2018), it may be impeded 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 reduce their credit supply to the real economy relatively more.

How do negative monetary-policy rates and QE interact? 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. Cutting interest rates on these same reserves 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 the liability side. However, banks seem reluctant, or unable, to pass on negative rates to their depositors (Heider, Saidi, and Schepens, 2019; Eggertsson, Juelsrud, Summers, and Wold, 2019). This gives rise to cross-sectional heterogeneity in the pass-through of lower, 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 under negative rates, pass-through of lower

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

monetary-policy rates to banks' asset side remains strong, or becomes even stronger, as long-term assets are replaced with central-bank reserves.[2] As a consequence, high-deposit banks do not only yield negative rates on central-bank reserves on their asset side but also incur relatively higher funding costs, which in turn inhibits their ability to lend out funds to the non-financial sector. Empirically, we find evidence of such reversal for high-deposit banks. 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.

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 higher funding costs than do otherwise-funded banks.

To test how banks' exposure to negative monetary-policy rates and QE affects their asset portfolios, 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 conduct further analyses using microdata from Germany where a substantial portion of 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).

[2] According to Brunnermeier and Koby (2018), this implies that QE should optimally be employed only after the room for lowering rates is exhausted, and gives rise to what they dub the "reversal interest rate" below which further rate cuts depress bank lending.

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

This reflects our rationale that high-deposit banks, unlike 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, the resulting distinction between high- vs. low-deposit and high- vs. low-security banks is interacted 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. We obtain our 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 our preferred specification, a bank with a ten-percentage-point higher security and deposit ratio lends around 8.55% less 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 in the presence of a negative interest-rate 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 a negative interest-rate policy, 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. The negative interest rates on reserves are associated with a reduction in net worth if banks' 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] Consistently, we find that the newly created reserves are disproportionately held by

[4] Acharya and Rajan (2022) show theoretically that the creation of commercial bank liabilities following QE can

banks that have high security and deposit ratios, as their securities are swapped with reserves, and they are unable to reduce their balance sheet due to sticky customer deposits. We show this to hold true in low-rate environments such as the core of the euro area, while this is not the case in other countries of the euro area where sovereign yields (and deposit rates) are higher (Bittner, Bonfim, Heider, Saidi, Schepens, and Soares, 2022). As a result, instead of an increase in corporate lending, the asset purchases lead to higher excess reserves, relatively lower net worth, and less credit supply.

For the largest economy in the euro area, Germany, we can zoom in on this mechanism by means of administrative data from the Bundesbank. Using credit-registry data, we, first, corroborate our baseline result 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 closer to the zero lower bound. Combining the German credit-registry data with more detailed balance-sheet data than is 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, 2021). 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 high security and high 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 find that banks with ex-ante more securities sell more securities 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 share reduce their credit supply by more. This evidence addresses the potential concern that the pre-existing share of securities to total assets does not proxy well for banks'

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.

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 investigating the transmission of affected banks' credit contraction to firms' real outcomes. We find that around the implementation of QE, German firms in lending relationships with 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. To this end, we scrutinize German banks' interbank positions and find that consistent with precautionary liquidity hoarding, 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 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 negative interest rates in general and their bank-based transmission in particular. Brunnermeier and Koby (2018) 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.[5] 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) show that retail household deposit rates in Sweden are subject to a lower bound and that once this bound is reached, the pass-through to lending rates and credit volumes is substantially lower,

[5] 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; Gomez, Landier, Sraer, and Thesmar, 2021; Stein, 2012).

and bank equity values decline in response to further policy-rate cuts. Bottero, Minoiu, Peydró, Polo, Presbitero, and Sette (2021) show that negative interest-rate policies can 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. Ampudia and Van den Heuvel (2018) show 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.

In comparison to this literature on the transmission of negative monetary-policy rates,[6] we explore its interaction with large-scale asset purchases, or QE. Krishnamurthy and Vissing-Jorgensen (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 in the 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 a lot 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, Benetton and Fantino, 2021; Carpinelli and Crosignani, 2021; Peydró, Polo, and Sette, 2021; Crosignani, Faria-e Castro, and Fonseca, 2020; Grosse-Rueschkamp, Steffen, and Streitz, 2019; Acharya, Eisert, Eufinger, and Hirsch, 2019).

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,

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

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

The sole exception in the literature that studies the interaction between negative interest rates and QE is Brunnermeier and Koby (2018), who argue that QE should be employed only after interest-rate cuts are exhausted. When the central bank reduces interest rates, capital gains on banks' deposits increase and banks with large security holdings benefit disproportionately from these capital gains. Empirically, we find that banks that have a lot of security holdings do not benefit disproportionately more, but actually gain less when they also rely heavily on deposit funding during periods of QE.

2 Data

2.1 Bank Lending and Balance-Sheet Data

In the first part of the paper, we analyze credit supply in the syndicated-loan market in the euro area 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.[7]

We then merge the syndicated-loan data with Bankscope data comprising balance-sheet characteristics of banks. In particular, we use data on banks' security holdings, their customer deposits, as well as various other control variables.

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.[8] 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,[9] 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.[10] We enrich this dataset with security master data from the Centralised Securities Database (CSDB)[11] (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)[12] including banks' asset and liability positions (Gomolka, Schäfer, and Stahl, 2020). This allows us 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 data from Bureau van Dijk (BvD) Orbis.

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

[8] 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 said borrowers parent and all affiliated units is equal to or exceeds the threshold at any point in time during the reporting period.

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

[10] See also Timmer (2018).

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

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

3 Stylized Facts

We start with graphical evidence suggesting which balance-sheet characteristics determine the extent to which euro area banks are affected by quantitative easing, bearing in mind that the ECB's preceding introduction of negative monetary-policy rates in 2014 may have affected the transmission channels of quantitative easing thereafter.

Figure 1 shows that when the ECB kicked off its asset-purchase programs in 2015, banks' security holdings declined substantially. In 2013 and 2014 security holdings of banks remained 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.

Interestingly, at least in observational data, the ECB interventions are not associated with a strong increase in prices. In Figure 2 (and Figure A1 - Figure A3), which plots the price indices of several targeted euro area sovereign bonds before and after the large-scale asset purchases, the response of those price series to QE is not striking in terms of either magnitude or persistence. While we cannot rule out that in a counterfactual scenario in which the ECB had not conducted QE, prices would have fallen or risen less, the muted increase in prices suggests that any effects of higher security prices on bank net worth are potentially complemented with additional forces inducing banks to sell these securities.

The asset purchases of the ECB (or the respective central banks) induced an asset swap of securities for banks, which sold them to the ECB, with central-bank reserves. Figure 3 confirms that most banks saw an increase in their reserves between 2013 and 2016. The figure plots the correlation between the share of reserves out of total assets in 2013 and 2016. Banks on the 45-degree line have an equal share of reserves on their balance sheets in 2013 and in 2016. Banks that have a larger share of reserves in 2016 than in 2013 are above the 45-degree line and marked in green, while those that have a smaller share of reserves are below the 45-degree line and marked in red. The size of the bubble reflects the size of the reserves. The graph shows that most banks have a larger share of reserves in 2016, which yield negative interest rates, than in 2013, when the ECB's deposit facility rate was still zero.

This increase in reserves was stronger for banks with greater exposure to QE due to higher (pre-determined) security ratios, consistent with the idea that asset purchases swap securities with reserves on banks' balance sheets, as can be seen in the upper left panel of Figure 4. 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, as shown in the bottom right panel. We label such banks with higher pre-determined security ratios as "treated" more heavily by the ECB's asset-purchase programs.[13] The upper right panel of Figure 4 and the bottom left panel also show that banks that had larger pre-existing security ratios increased their interbank lending and the sum of interbank lending and reserves by more.

Taken together, the evidence suggests that high-security banks end up holding more negative interest-rate bearing assets relative to banks with less exposure to QE. In addition, liquid securities are not only replaced by central-bank reserves on affected banks' balance sheets, but the latter also become more active in (liquid) interbank lending. This raises the question to what extent high-security banks' treatment under QE affects their credit provision to the non-financial sector, to which we turn next.

4 Evidence from Syndicated Lending

4.1 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 and asset-purchase programs.

As pointed out by, among others, Brunnermeier and Koby (2018), Heider, Saidi, and Schepens (2019), and Eggertsson, Juelsrud, Summers, and Wold (2019), banks tend to face a zero lower bound on retail deposit rates, as 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 this "reversal rate" (for example, zero), customers may withdraw their deposits. As this friction is not present for wholesale funding sources, banks that rely more on retail deposit funding are more likely to be adversely affected by negative interest rates on central-bank reserves. This can then halt bank lending through a reduction in profits. Consequently, following Heider, Saidi, and Schepens (2019), we capture banks' exposure to negative monetary-

[13] In section 6, we provide more direct evidence for German banks, and thereby confirm, that pre-existing security holdings predict the selling of securities and a swap of securities with reserves when QE is implemented.

policy rates by their deposits-to-assets ratio.

Analogously, as argued before, banks that have a higher security ratio are more exposed to asset-purchase programs. First, they are more likely to be positively affected through asset-price appreciation than banks with lower security ratios (Brunnermeier and Sannikov, 2016). Second, banks with higher security ratios are more affected through a substitution of securities with central-bank reserves. For example, if the central bank buys 10% of the securities of each bank, a bank with a security ratio of 10% has 1% of its assets in central-bank reserves, whereas a bank with 20% securities on its balance sheet has 2% of its assets converted into central-bank reserves. If central-bank reserves yield negative rates and banks are unable to pass on negative interest rates to their funding costs, greater exposure to asset-purchase programs can reduce bank profitability and, thus, lead to a reduction in credit supply.

Figure 5 plots euro area banks' security ratios on the y-axis against their deposit ratios on the x-axis in a scatter plot. The size of the dots reflects the total assets of each bank in 2013. The average security ratio is just above 20% indicated by the dotted line on the y-axis. The average deposit ratio is significantly higher, at around 50%, indicated by the dotted line on the x-axis. The correlation coefficient between the security ratio and the deposit ratio is only -3% and statistically insignificant, indicating that banks with high deposit ratios, which are strongly exposed to negative monetary-policy rates, are not necessarily also strongly 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:

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

where $Amount_{i(l),j(l),t(l)}$ 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). $\textit{Security Ratio}_i$ is the share of securities over assets of bank i in 2012, and $\textit{Deposit Ratio}_i$ 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-time fixed effects, $\theta_{j,m(t)}$, and (banks') country-time fixed effects, $\phi_{c,m(t)}$, 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.

4.2 Baseline Results

Table 1 shows the results from estimating (1).[14] 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.

This result is robust to different definitions of *QE*. In columns 1 and 2, we define $\textit{QE}_{c,m(t)}$ as the government bond purchases of country c in a given month $m(t)$, 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.[15] In column 3, instead of scaling the asset purchases of government bonds with the 2012 securities held by banks in the respective country, we scale the purchases by the one-month lagged security holdings of the latter banks.

Our estimate of β_3 is virtually invariant across the first three columns, where we additionally vary the set of fixed effects. In column 1, we control for bank and borrower by time fixed effects. The latter are included so as to control for 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 in the same month from different banks. 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, the lending from banks to firms can be attributed to credit supply rather than credit demand. To estimate a regression with such borrower-time fixed effects, we implicitly restrict our sample to firms that borrow from at

[14] Table 1 only displays the coefficient on the triple interaction, as the double-interaction terms are difficult to interpret when the triple interaction is included. For completeness, we re-estimate (1) without the triple interaction in Table A1.

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

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 all remaining columns, we also include bank i's country by time fixed effects, which control for time-varying unobserved heterogeneity associated with a given bank's country c.

In columns 4 and 5, we use the natural logarithm of the monthly purchases in country c and overall, respectively, instead of the scaled monthly purchases. In columns 6 and 7, we use the natural logarithm of holdings rather than the purchases, i.e., a stock measure of QE rather than a flow measure, in country c and overall, respectively. Across all specifications, our coefficient ranges from -0.95 to -0.62. In terms of economic magnitudes, a bank with a 50% security and a 50% deposit ratio (0.25) relative to a bank with a 40% security and a 40% deposit ratio (0.16) lends between 8.55% ($= 0.09 \times 0.95$) and 5.58% ($= 0.09 \times 0.62$) less in response to a one-standard-deviation increase in asset purchases. To measure an average effect on credit supply, we redefine *QE* in column 8 to be an indicator variable that equals one during the quantitative-easing period. The respective coefficient on the triple interaction implies an almost 20% difference in lending.

Figure 6 illustrates the result from column 1 in Table 1 graphically. It plots the coefficient β_3 multiplied with the amount of $QE_{c,m(t)}$ conducted in each month, which we normalize to be between zero (no purchases) and one (maximum amount of purchases) for this purpose. Banks that are strongly exposed to QE and negative rates supplied less credit when the ECB started purchasing securities amounting to €60 billion per month in March 2015. When purchases were ramped up to €80 billion between April 2016 and March 2017, credit supply of exposed banks declined even more. In April 2017 the ECB started tapering the amount of monthly asset purchases to €60 billion, in January 2018 to €30 billion, and in October 2018 to €15 billion. Once the ECB started to taper, the credit supply of exposed banks converged back towards those banks that had been less exposed to QE and negative rates.

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, we regress bank characteristics in 2012 on the interaction between the security ratio and the deposit ratio in the cross-section of banks. Affected banks, i.e., those with high security and deposit ratios, do not differ substantially in terms of other common bank characteristics, such as total assets, capitalization, or profitability. As such, it does not come as a surprise that our estimates are robust to including interaction terms of (all variants of) our *QE* measure with the above-mentioned control variables (Table A3).

Figure 7 plots the coefficient on the interaction of $Security\ Ratio_i$ and $Deposit\ Ratio_i$ annually between 2010 and 2019. Before the introduction of negative monetary-policy rates, there is no substantial 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) and replace the *QE* treatment variable with an indicator variable $Post_t$ that is equal to one 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 controlling for various fixed effects, such as borrower-month and country-month fixed effects. Therefore, we can conclude that banks' exposure to negative interest rates through their funding structure and to quantitative easing is jointly instrumental in explaining their lending behavior.

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) cut into negative rates. For this purpose, we replace the indicator variable $Post_t$ with the actual deposit facility rate. As the latter was actually zero in 2012, we start the sample period then.[16] The results are in Table 3. 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.

Brunnermeier and Koby (2018) argue that interest-rate cuts are more effective before QE than after QE, as banks benefit less from capital gains when fewer securities are on their balance sheet.

[16] 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.

To test this, Table 4 explores 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, (2) an *NIRP CUT BEFORE* QE_t period, (3) a QE_t period, and (4) an *NIRP CUT AFTER* QE_t period.

Table 4 shows, indeed, that banks that are more exposed to QE and negative interest 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 interest rates QE is implemented, treated banks lend less than their counterparts, but the effect becomes even stronger 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.

5 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, the response of equity returns can be indicative of profitability (English, Van den Heuvel, and Zakrajšek, 2018). To study the response of 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:

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

where $Return_{i,m}$ is the percent change in the equity prices of bank i between month-year m and $m-1$. $QE_{c,m}$ is the natural logarithm of the amount purchased (in month-year m) of the bonds of country c that bank i is incorporated in, divided by all banks' total security holdings of country c 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. $Deposit\ Ratio_i$ 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 5 shows the results from estimating (2). Banks with higher security and deposit ratios exhibit lower stock returns in response to asset purchases. 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 ($QE_{c,m} = 1$).

Figure 8 plots these predicted stock returns. Banks that have a high security ratio and a high deposit ratio are estimated to have significantly lower stock returns relative to other banks with lower security or deposit ratios. 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 9, 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 75$^{\text{th}}$ percentile) relative to a bank that has a low security and a low deposit ratio (both at the 25$^{\text{th}}$ percentile). The time variation is given by QE_m, which is the average of $QE_{c,m}$ (as defined in (2)) across countries in a given month-year.

By construction, before the implementation of 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 around -4% during the 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 constant returns of around -1% to -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 can vary widely (Bittner, Bonfim, Heider, Saidi, Schepens, and Soares, 2022; Heider, Saidi, and Schepens, 2021). In countries 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-funded banks to be more emphasized in countries where the zero lower bound on deposits is binding.

In Table 6, we exploit heterogeneity across countries in terms of their 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. As such, 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 countries that have a low index value see almost no reaction in stock returns (column 2). GIIPS countries (Greece, Italy, Ireland, and Spain), which tend to have higher deposit rates, also see a smaller response, but the effect is not statistically significant (column 3). In the last column, we show that banks' stock returns in countries that have higher bond yields ex ante 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.

Next, we zoom in on Germany, a country where deposit rates are close to the zero lower bound and negative monetary-policy rates are, thus, more likely to give rise to relatively higher funding costs for deposit-reliant banks.

6 Micro Evidence from Germany

6.1 Effect on Banks' Balance Sheets

The administrative data from the Bundesbank provide us with the possibility not only to observe credit relationships with different counterparties—in particular firms and other banks—over time but also to observe bank-level outcomes at the quarterly frequency.[17] In Table 7, we use this feature of our data to test whether banks highly exposed to both the ECB's asset-purchase programs and the negative interest-rate policy wind up with more 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), im-

[17] We provide summary statistics in Table A4.

posing a tax on banks that hold these reserves when the deposit facility rate is negative.

Although the aggregate amount of reserves in the banking system cannot change, an individual bank may reduce the newly created reserves by shifting the reserves to another bank within the euro area. To do so, the bank would also need to reduce the liability side of its balance sheet, e.g., by reducing customer or wholesale deposits. 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. In contrast, otherwise-funded banks—especially those that rely less on deposit funding—experience a stronger pass-through to their cost of funding, enabling them to better control their liability side.

Columns 1 to 3 of Table 7 show that German banks that have both a high security and a high customer deposit ratio have higher net central-bank reserves when QE is conducted, driven by the asset rather than the liability side, which is consistent with QE increasing reserves but not central-bank borrowing.[18] Moreover, as expected, banks with high security and deposit ratios do not see an outflow of deposits, as deposit rates are close to, and eventually stuck at, the ZLB in Germany (column 4).[19] In line with our estimates in Table 6, this confirms that affected banks face an adverse shock to their net worth.

To show that this negative net-worth effect stems from an asset swap of securities with central-bank reserves, on which banks pay a negative deposit facility rate since June 2014, we next document that our exposure measure 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 8, we use granular data on German banks' security holdings from the Securities Holdings Statistics (SHS). In columns 1 and 2, we find a significant average effect on security holdings for all high-security banks, as can also be seen graphically in Figure A4. This validates our approach that relies on measuring banks' exposure to QE by means of their security ratio (as in Rodnyansky and Darmouni, 2017). However, in the remaining columns of Table 8, 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).

[18]The results are similar to unreported results with Bankscope data for our sample of euro area banks.

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

6.2 Credit Supply

Having established that large banks with a higher security ratio in Germany are actually more prone to swapping their securities with central-bank reserves, we turn to estimating their differential credit-supply response as a function of their balance-sheet characteristics. In Table 9, 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, using the same definition of $QE_{c,q}$ as in the first two columns. 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. In this manner, we can test the effect on banks' intensive margin of lending.

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 similar in size to 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 9, 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 to 6, we estimate the same regressions, except that instead of differentiating 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.

While asset purchases should not affect prices if the assets in question are valued only for their pecuniary returns (Wallace, 1981; Cúrdia and Woodford, 2011), 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 would imply 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. However, empirically we do not find strong asset-price effects of QE (cf. Figure 2 and Figure A1 - Figure A3), which indicates that banks were willing to sell their securities without a large adjustment in prices. Several explanations can rationalize these findings.

Under both quantitative easing and negative monetary-policy rates, large banks, particularly those engaging in repo transactions, sold their government security holdings more aggressively and reduced their lending to firms the most. This observation is consistent with two distinct mechanisms that could be at play simultaneously. The first channel is a form of "reverse" financial repression,[20] whereby banks that sell government bonds to the ECB do so because of moral suasion. After all, banks came under pressure to buy additional domestic government debt during the European sovereign debt crisis in 2011 (Ongena, Popov, and Van Horen, 2019). It would be reasonable to expect the same kind of channel to be operative in reverse. In particular, providing elastic supply of bonds by selling bonds to the ECB during episodes of quantitative easing despite a weak price response could be reciprocated in the future. A bank's incentives to cooperate with the central bank should be higher the more dependent it is on future directives. For instance, large euro area banks may be more likely to fall under that category if they are active in repo markets and the prospect of an ECB repo facility would be detrimental to their business lines.

Second, affected banks engage in a wide range of distinct activities—such as wholesale banking, retail banking, and investment banking—and exhibit a large degree of organizational complexity. In decentralized banks, frictions across operating units can emerge when funds need to be reallocated, as each agent seeks to maximize the expected gross output from the assets under her control due to private benefits proportional to gross output (Stein, 2002). In our context, it is possible that fixed income traders maximize their private benefits by fulfilling their market-maker function without internalizing the negative pecuniary externality that the additionally created reserves impose for other parts of their banks.

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 under the program. 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 pre-determined $\textit{Security Ratio}_i$ 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.

Doing so, we confirm in column 1 of Table 10 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

[20] Chari, Dovis, and Kehoe (2020) present a model of financial repression that shows under which conditions policies that force banks to hold government debt are optimal in the aggregate.

from non-financial corporations. This is motivated by the fact that the ZLB is more binding for households than for corporate deposits.[21] In this manner, we can compare similarly deposit-reliant banks that source these 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 11, we estimate (almost) the same specifications as in the first two columns of Table 10, 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 with central-bank reserves, we find a statistically and economically significant coefficient on the relevant interaction term only for security sales.

6.3 Firm-level Real Effects

So far, we have established that banks that are more exposed to QE and negative monetary-policy rates reduce their credit supply by more when QE is conducted and affected banks are constrained by the ZLB on retail deposit 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 section, 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 relative credit supply 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:

$$\Delta \ln(y_j) = \beta \textit{Deposit \& Security Exposure}_j + \gamma \textit{Deposit Exposure}_j + \delta \textit{Security Exposure}_j + \theta_{k(j)} + \epsilon_j, \tag{3}$$

where $\Delta \ln(y_j)$ is the difference in the natural logarithm of borrower 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 *Deposit & Security Exposure*$_j$ is the average value

[21] See, among others, Heider, Saidi, and Schepens (2019) and Altavilla, Burlon, Giannetti, and Holton (2021).

of *Deposit Ratio*$_i$ $\times$ *Security Ratio*$_i$ (measured in 2012) of all banks with which firm j contracts (as of 2014), weighted by firm j's credit exposure to each bank i. *Deposit Exposure*$_j$ and *Security Exposure*$_j$ are defined accordingly using *Deposit Ratio*$_i$ and *Security 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 Union (2003). Standard errors are clustered at the firm level, which is the level of observation.

As the level of observation in specification (3) 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).

In columns 1 to 6 of Table 12, the coefficients on the interaction term *Deposit & Security Exposure*$_j$ are negative and almost always statistically significant. 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, reduce their employment and wage bill by more. In columns 7 to 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). One approach is to assume that banks with no deposits and no securities are unaffected by negative rates and QE, respectively. This would, however, neglect that lower interest rates can stimulate demand and credit supply for all banks. This would, in turn, result in underestimating the total positive effects of QE and negative rates. Instead, we aim to compute the aggregate effects of QE and negative rates due to the credit-supply channel.

Interpreting the coefficient on the deposit ratio and that on the security ratio as the effect of conventional rate-based policy and QE, 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 policy rates were implemented. We derive the counterfactual growth rate by estimating (3) (column 6 of Table 12) and applying the following procedure.

We start out with the observed employment growth rate, i.e., the dependent variable,

[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.

Δln(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 therefore compute the counterfactual employment growth rate as

$$\Delta \ln(y_j) - \widehat{\beta} \textit{Deposit \& Security Exposure}_j - \widehat{\delta} \textit{Security Exposure}_j. \tag{4}$$

To yield each firm j's counterfactual employment in the post-period, we multiply 1 plus the 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 our 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 negative interaction of QE and negative monetary-policy rates in the presence of a ZLB on deposit rates. Previous studies document that QE has 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. had a stronger recovery than the euro area during our period of study.

6.4 Interbank Lending

As affected banks 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. This would be consistent with Diamond, Jiang, and Ma (2021) insofar as interbank loans are a means of transferring and redistributing reserves among banks, without increasing the total amount of reserves in the system.

To investigate this, we next consider the interbank portion of the German credit registry, i.e., we consider bank lending to other banks, rather than firms, excluding intra-group lending. In columns 1 and 3 of Table 13, we estimate analogous specifications to those in columns 1 and 2 of Table 9. Large banks that are 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 $\textit{Security Ratio}_i \times QE_q$ 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 replace illiquid loans to the real sector with liquid interbank loans on their asset side. When doing so, they possibly reach for yield in response to the adverse shock to net worth that they incur due to the negative deposit facility rate charged on their additional central-bank reserves. In Table 14, 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 versus small banks, and this is the case only for interbank lending within the euro area (column 5).

7 Cross-Border Interbank Flows

We next zoom in on the implications of QE under negative policy rates for the distribution of interbank liquidity in the euro area. The micro-level results in Table 13 and Table 14 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 potential reach-for-yield behavior has 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, and estimate the following regression specification at the country-pair level:

$$Flow_{c,j,q} = \beta_1 Core_c \times GIIPS_j + \beta_2 QE_{c,q} \times Core_c \times GIIPS_j + \gamma_{c,q} + \psi_{j,q} + \epsilon_{c,j,q}, \quad (5)$$

where $Flow_{c,j,q}$ is the percent change in bank claims of (source) country c to (recipient) country j in quarter-year q. $QE_{c,q}$ is the amount purchased of the bonds of country c in quarter-year q divided by the banks' total security holdings of country c in 2012, and then standardized to have a 0 mean and a standard deviation of 1. The sample starts in 2014. $Core_c$ is an indicator variable for whether the lending country c is Germany, Finland, the Netherlands, or Austria. $GIIPS_j$ is an indicator variable for whether the borrowing country j is Greece, Italy, Ireland, Spain, or Portugal. $\gamma_{c,q}$ and $\psi_{j,q}$ denote source-country by quarter-year and host-country by quarter-year fixed effects, respectively. Standard errors are double-clustered at the source-country and host-country levels.

Table 15 shows the results of estimating (5). When QE is conducted, core-country banks—not only in Germany—lend more to GIIPS-country banks. Figure 10 plots the share of borrowing of GIIPS banks from core banks in red. The black dashed line shows the ECB bond holdings of core countries. There is a strong correlation between the two measures, suggesting 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.

8 Conclusion

This paper studies the consequences of the interaction between negative monetary-policy rates and large-scale asset purchases. 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 some important policy implications for the conduct of 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 an 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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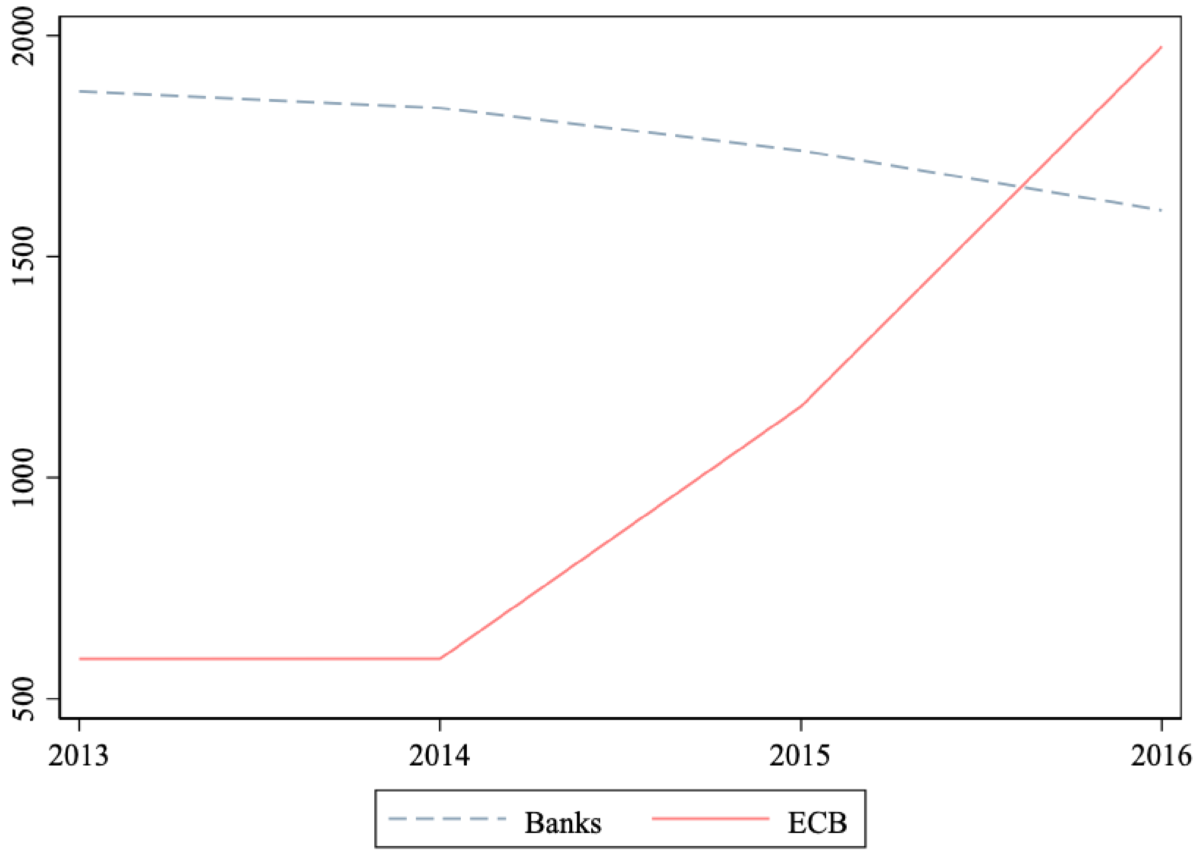
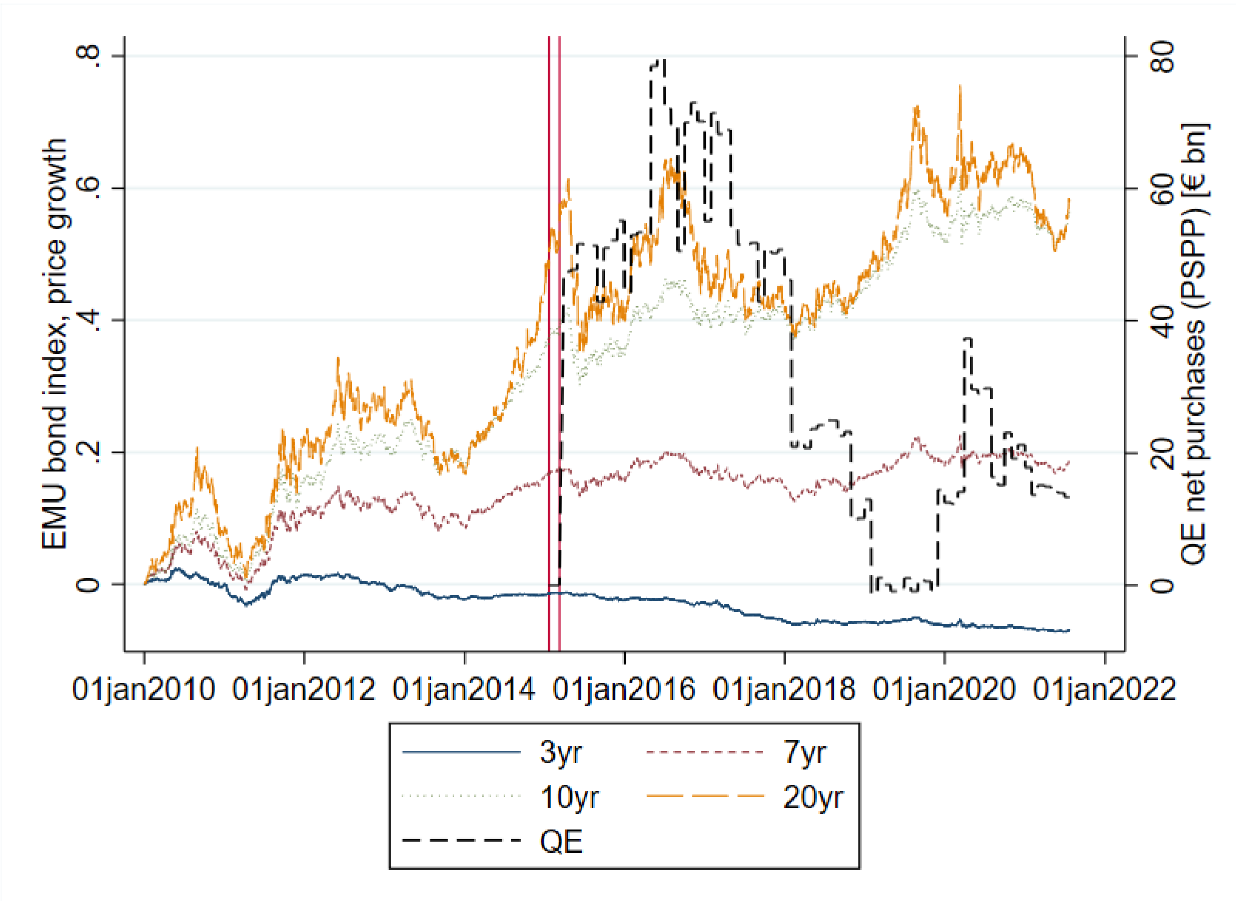
Figures

Figure 1: Security Holdings



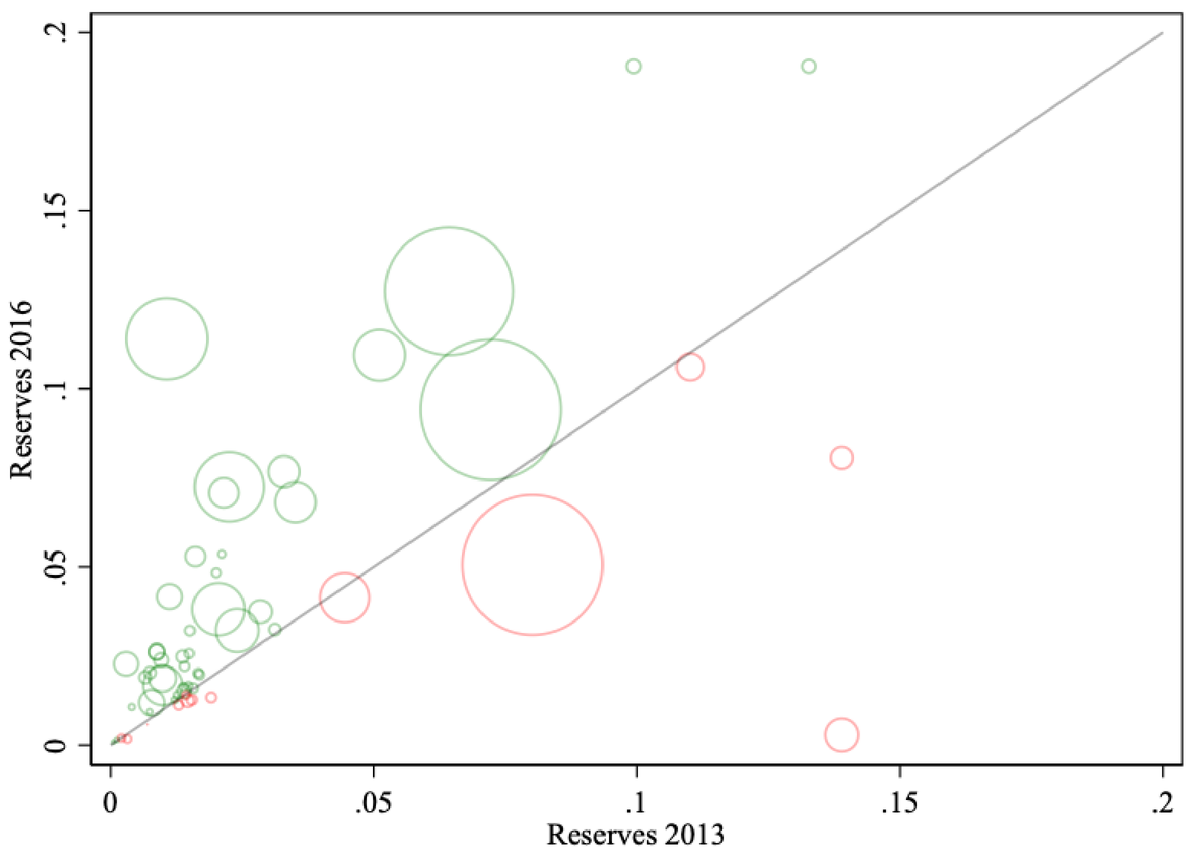
Notes: This graph shows the security holdings of euro area banks (dashed blue line) and the ECB (solid red line) in €billions.

Figure 2: Bond Prices: Economic and Monetary Union of the European Union



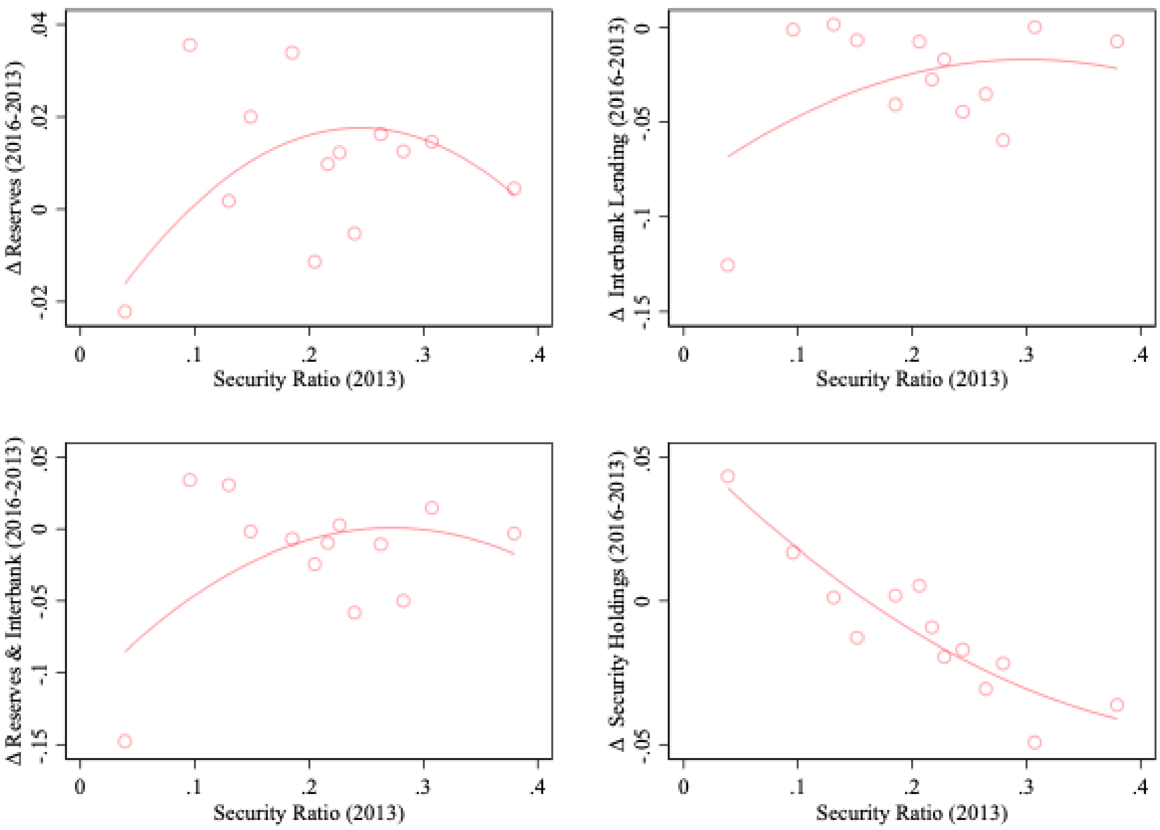
Notes: This graph shows the price development of bond indices for the European Monetary Union (EMU) with different maturities and QE net purchases by the ECB under the public sector purchase program (PSPP) in €billions. The bond indices for the EMU with maturities of 3, 7, 10, and 20 years are plotted as growth rates relative to the beginning of 2010 (left y-axis). The QE net purchases (PSPP) by the ECB are shown in the dashed black line referring to the right y-axis. The first vertical red line represents the announcement of the PSPP (January 22, 2015), and the second one marks its implementation (March 9, 2015).

Figure 3: Reserves Before and After QE



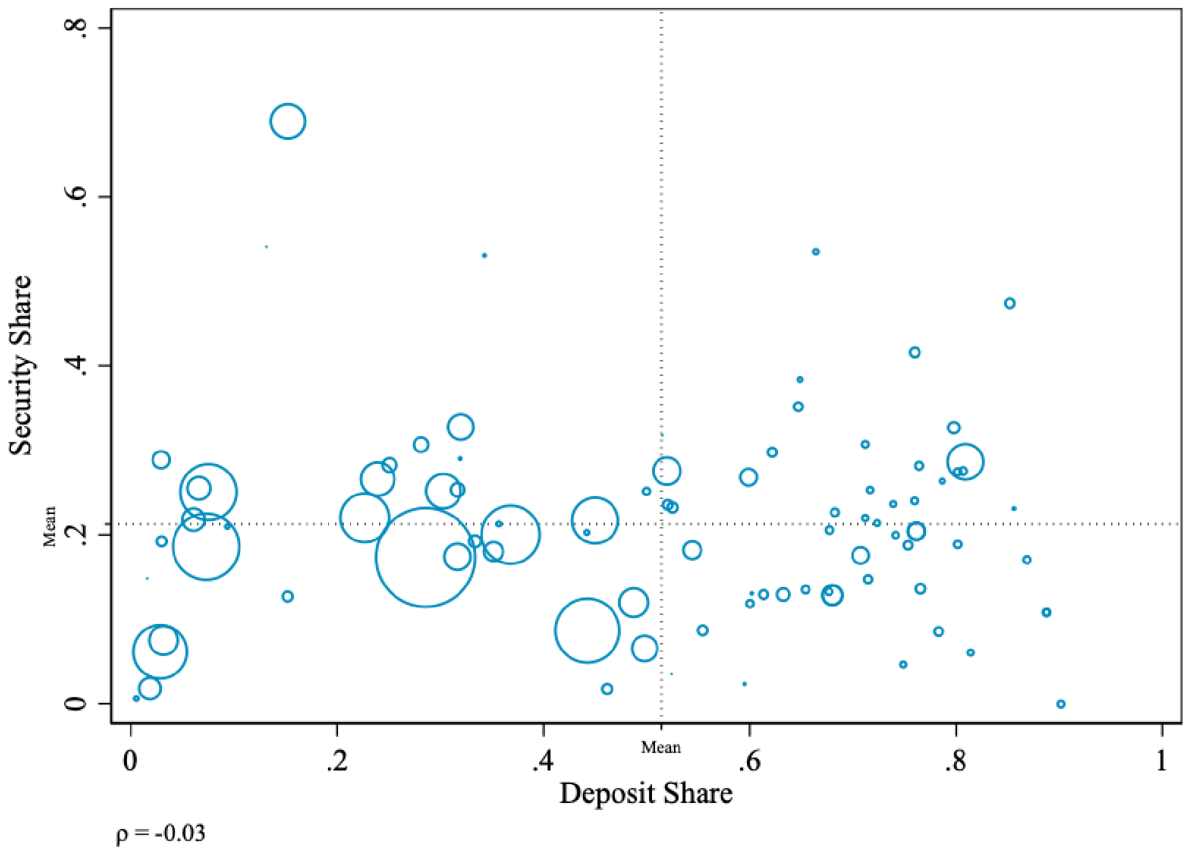
Notes: This graph plots the share of euro area banks' reserves out of total assets in 2013 (x-axis) against the same share in 2016 (y-axis). The green (red) circles reflect banks that increased (decreased) their total reserve holdings, while the size of the circle reflects the size of the reserves in 2013.

Figure 4: Δ Bank Variables against Security Ratio



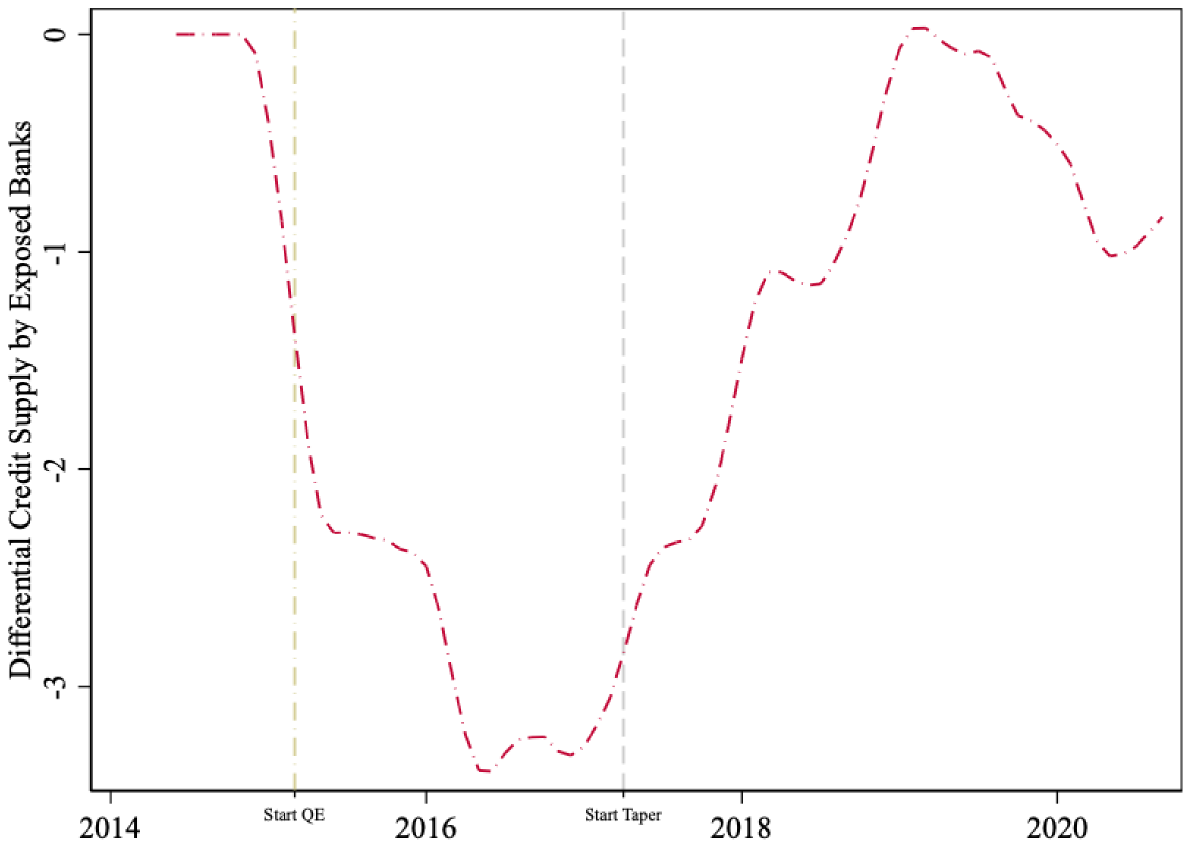
Notes: The upper left panel shows a scatter plot of the change in euro area banks' reserves over total assets between 2013 and 2016 against their security ratio in 2013. The upper right panel shows their change in interbank lending over total assets against their security ratio in 2013. The bottom left panel shows the change in their reserves and interbank lending over total assets against their security ratio in 2013 on the. The bottom right panel shows their change in security holdings over total assets against their security ratio in 2013.

Figure 5: 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 6: Estimated Credit Supply by Differentially Exposed Banks

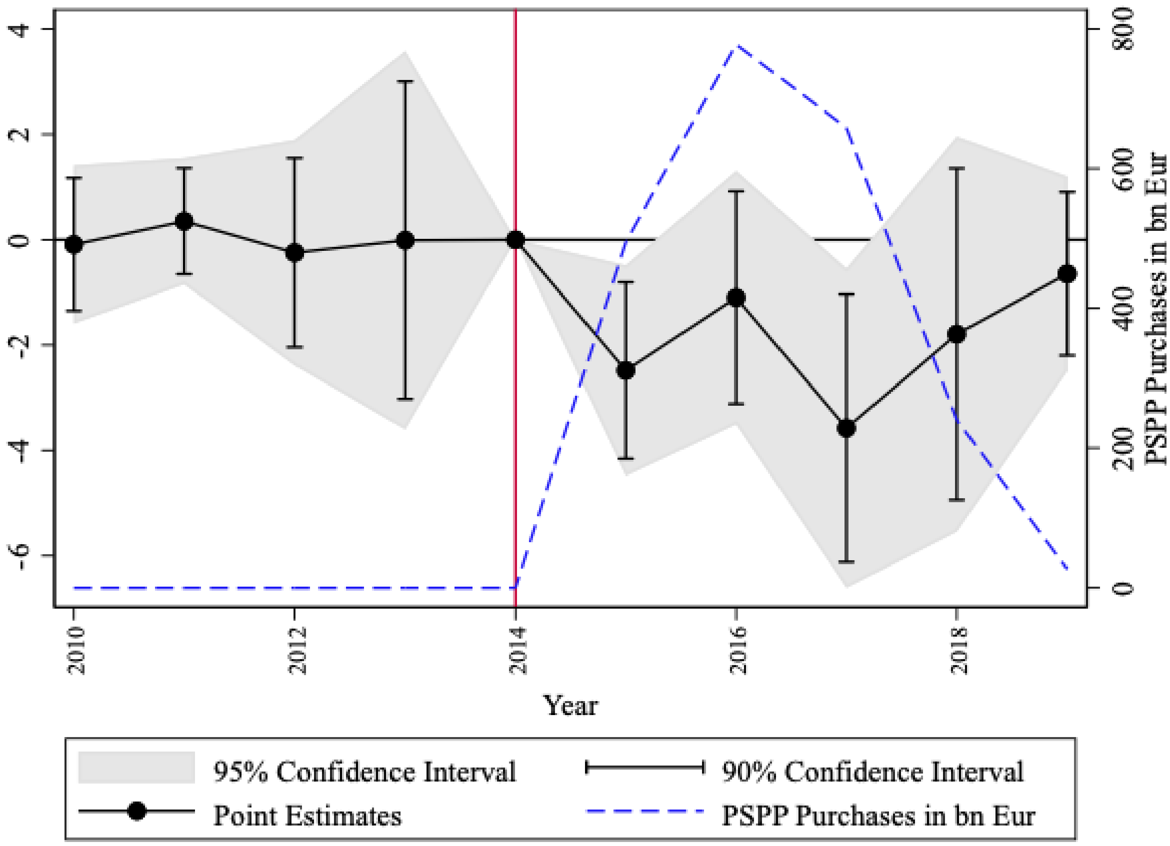


Notes: This graph shows the predicted differential effect on the credit supply by exposed banks over time. In particular, it plots the estimates of $\beta_3 \times QE_{c,m(t)}$, based on the following regression specification:

$$\begin{aligned}\ln(Amount)_{i(l),j(l),t(l)} = \; & \beta_1 QE_{c,m(t)} \times Security\ Ratio_i + \beta_2 QE_{c,m(t)} \times Deposit\ Ratio_i \\ & + \beta_3 QE_{c,m(t)} \times Security\ Ratio_i \times Deposit\ Ratio_i + \mu_i + \theta_{j,m(t)} + \phi_{c,m(t)} + \epsilon_{i,j,t},\end{aligned}$$

where $QE_{c,m(t)}$ is the natural logarithm of the purchased amount of the bonds of country c in month-year $m(t)$ divided by all banks' total security holdings of country c in 2012, and then rescaled between zero (no purchases) and one (maximum amount of purchases).

Figure 7: Time-varying Coefficients

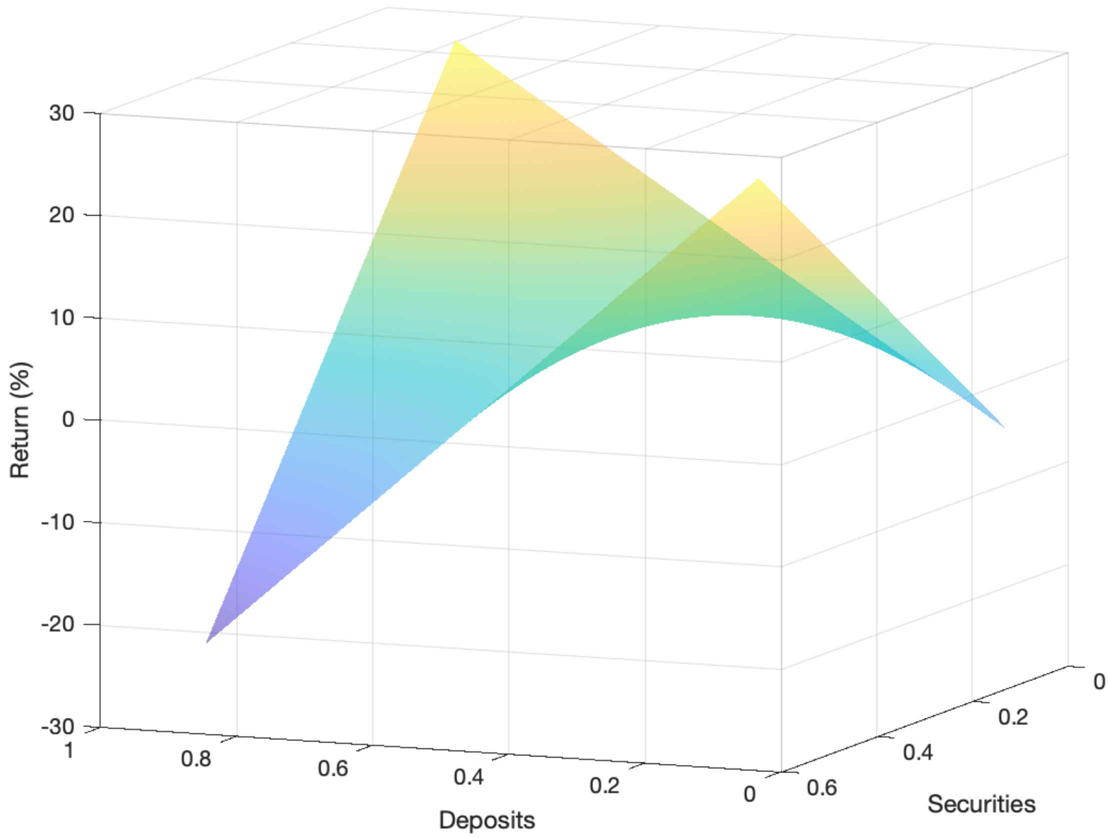


Notes: On the left y-axis, this figure plots the estimates of $\beta_{3,\tau}$ from the following regression:

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

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

Figure 8: Stock-return Response to QE Purchases

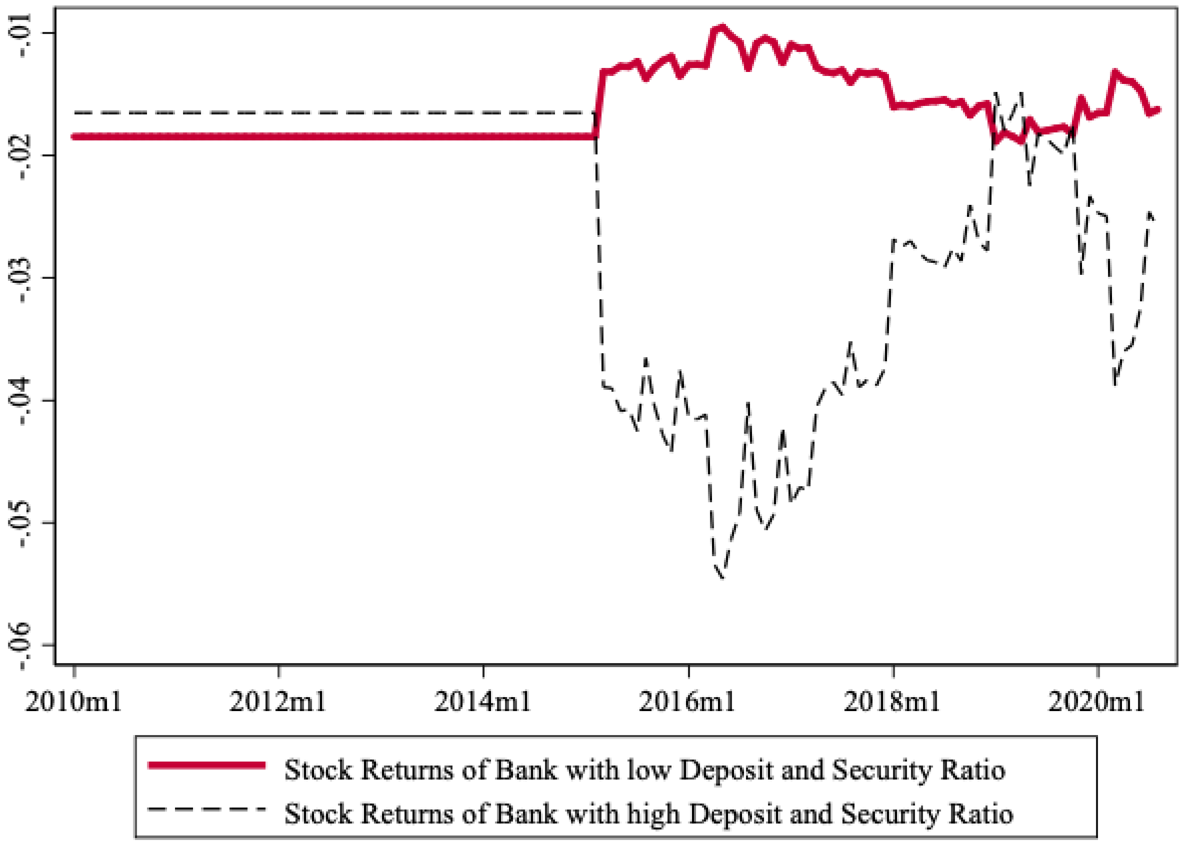


Notes: This graph shows the predicted stock returns as a function of the deposit and the security ratio, based on the following regression specification:

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

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

Figure 9: Estimated Stock Returns

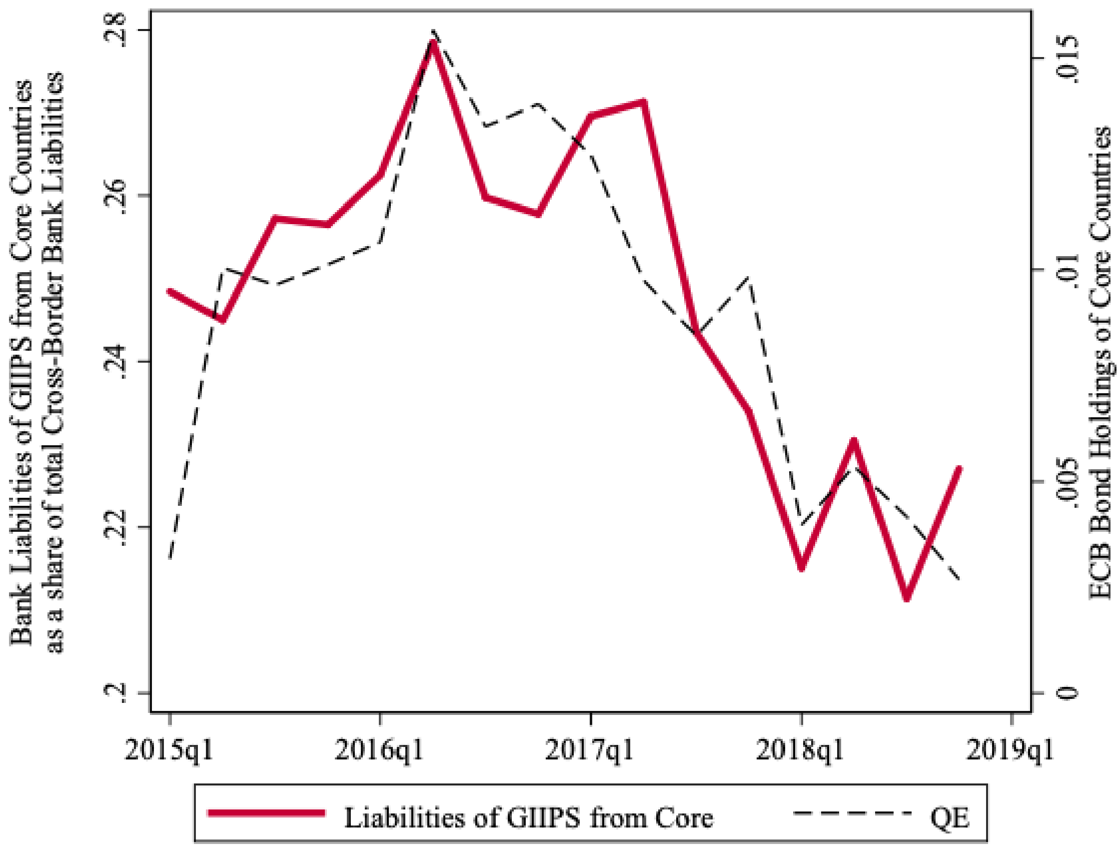


Notes: This graph shows the predicted stock returns for a bank with a low (high) deposit and a low (high) security ratio, both at the 25$^{\text{th}}$ (75$^{\text{th}}$) percentile of the respective distribution, based on the following regression specification:

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

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

Figure 10: Cross-border Banking Flows



Notes: This graph shows the banking capital flows from core to GIIPS countries and 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**	-0.950**	-0.949***	-0.954***	-0.633**	-0.622**	-2.006**
	(0.309)	(0.448)	(0.468)	(0.347)	(0.332)	(0.286)	(0.273)	(0.804)
R-squared	0.975	0.976	0.976	0.975	0.975	0.976	0.976	0.976
N	6,382	6,311	6,311	5,913	5,863	6,311	6,311	6,311
Bank FE	✓	✓	✓	✓	✓	✓	✓	✓
Borrower × Month FE	✓	✓	✓	✓	✓	✓	✓	✓
Country × Month FE	–	✓	✓	✓	✓	✓	✓	✓
Specification	$\frac{App_{c(i),m(t)}}{BSecH_{c(i),2012}}$	$\frac{App_{c(i),m(t)}}{BSecH_{c(i),2012}}$	$\frac{App_{c(i),m(t)}}{BSecH_{c(i),m(t)-1}}$	$ln(App_{c(i),m(t)})$	$ln(App_{m(t)})$	$ln(H_{c(i),m})$	$ln(H_{m(t)})$	$QEDummy$

Notes: The level of observation is credit to firm *j* by bank *i* in country *c* on day *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 day *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), $QE_{c,m(t)}$ is the natural logarithm of the purchased amount of the bonds of country *c* in month-year *m(t)* divided by all banks' total security holdings of country *c* in 2012. In column (3), $QE_{c,m(t)}$ has the same numerator, but is now scaled by the banks' total security holdings of country *c* in the previous month-year. In column (4), $QE_{m(t)}$ is the natural logarithm of 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), $QE_{c,m(t)}$ 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 one after March 2015 (not standardized). $Security\ Ratio_i$ is the share of securities over assets a bank held in 2012. $Deposit\ Ratio_i$ is the share of deposits over assets of a bank in 2012. The various double interactions between the three variables $Deposit\ Ratio_i$, $Security\ Ratio_i$ and $QE_{(c,)m(t)}$ are included in the regression, but are not reported in the table. 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 $\times$ Security Ratio $\times$ Deposit Ratio	-1.405**	-1.595*	-2.016**
	(0.661)	(0.882)	(0.971)
R-squared	0.975	0.976	0.976
N	8,311	8,213	8,181
Bank FE	✓	✓	✓
Borrower $\times$ Month FE	✓	✓	✓
Country $\times$ Month FE	-	✓	✓
Interacted Controls	-	-	✓

Notes: The level of observation is credit to firm *j* by bank *i* in country *c* on day *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 day *t*. $Post_t$ is a dummy that equals one after the ECB introduced negative interest rates (June 11, 2014). $Security\ Ratio_i$ is the share of securities over assets a bank held in 2012. $Deposit\ Ratio_i$ is the share of deposits over assets of a bank in 2012. The various double interactions between the three variables $Deposit\ Ratio_i$, $Security\ Ratio_i$ and $Post_t$ are included in the regression but are not reported in the table. Column (3) includes the interaction between $Post_t$ and the following control variables as of 2012: (1) logged assets ($\ln(Assets_i)$), (2) the simple capital ratio ($Capital\ Ratio_i$), (3) the Tier 1 capital ratio ($T1\ Capital\ Ratio_i$), (4) the return on assets (RoA_i), and (5) the return on capital (RoC_i). Standard errors are clustered at the bank level.

Table 3: Syndicated-lending Response by Banks with Different Exposure to QE—Interaction with Deposit Facility Rate

	Dependent Variable: Lending		
	(1)	(2)	(3)
Deposit Facility $\times$ Security Ratio $\times$ 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 $\times$ Month FE	✓	✓	✓
Country $\times$ Month FE	-	✓	✓
Interacted Controls	-	-	✓

Notes: The level of observation is credit to firm *j* by bank *i* in country *c* on day *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 day *t*. $Deposit\ Facility_t$ is the ECB's deposit facility rate. $Security\ Ratio_i$ is the share of securities over assets a bank held in 2012. $Deposit\ Ratio_i$ is the share of deposits over assets of a bank in 2012. The various double interactions between the three variables $Deposit\ Ratio_i$, $Security\ Ratio_i$ and $Deposit\ Facility_t$ are included in the regression but are not reported in the table. Column (3) includes the interaction between $Deposit\ Facility_t$ and the following control variables as of 2012: (1) logged assets (ln$(Assets_i)$), (2) the simple capital ratio ($Capital\ Ratio_i$), (3) the Tier 1 capital ratio ($T1\ Capital\ Ratio_i$), (4) the return on assets (RoA_i), and (5) the return on capital (RoC_i). Standard errors are clustered at the bank level.

Table 4: 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 × Security Ratio × Deposit Ratio	0.039	-0.079	-0.072
	(0.656)	(0.924)	(0.922)
2 QE × Security Ratio × Deposit Ratio	-2.404***	-2.278*	-2.461*
	(0.804)	(1.239)	(1.243)
3 NIRP CUT AFTER QE × Security Ratio × 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 × Month FE	✓	✓	✓
Country × Month FE	-	✓	✓
Interacted Controls	-	-	✓

Notes: The level of observation is credit to firm *j* by bank *i* in country *c* on day *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 day *t*. $NIRP\ CUT\ BEFORE\ QE_t$ is a dummy that equals 1 after negative interest 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 a bank held in 2012. $Deposit\ Ratio_i$ is the share of deposits over assets of a bank in 2012. The various double interactions between the three variables $Deposit\ Ratio_i$, $Security\ Ratio_i$ and the QE indicators are included in the regression but are not reported in the table. Column (3) includes the interaction between the QE indicators and the following control variables as of 2012: (1) logged assets (ln($Assets_i$)), (2) the simple capital ratio ($Capital\ Ratio_i$), (3) the Tier 1 capital ratio ($T1\ Capital\ Ratio_i$), (4) the return on assets (RoA_i), and (5) the return on capital (RoC_i). Standard errors are clustered at the bank level.

Table 5: 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 bank *i* in country *c* in 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 $m-1$. $QE_{c,m(t)}$ is the natural logarithm of the purchased amount of the bonds of country *c* in month-year *m(t)* divided by all banks' total security holdings of country *c* in 2012. $Security\ Ratio_i$ is the share of securities over assets a bank held in 2012, and is standardized to have a 0 mean and a standard deviation of 1. $Deposit\ Ratio_i$ is the share of deposits over assets of a bank in 2012. The various double interactions between the three variables $Deposit\ Ratio_i$, $Security\ Ratio_i$ and $QE_{c,m(t)}$, and their levels (if not absorbed by fixed effects) are included in the regression but are not reported in the table. Column (5) includes the interaction between $QE_{c,m(t)}$ and the following control variables as of 2012: (1) logged assets (ln($Assets_i$)), (2) the simple capital ratio ($Capital\ Ratio_i$), (3) the Tier 1 capital ratio ($T1\ Capital\ Ratio_i$), (4) the return on assets (RoA_i), and (5) the return on capital (RoC_i). Standard errors are clustered at the bank level.

Table 6: 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	✓	✓	✓	✓
Month FE	✓	✓	✓	✓
Interacted Controls	✓	✓	✓	✓
Risky	Not Germany	Low Index	GIIPS	Bond Yields

Notes: The level of observation is the monthly stock return of bank *i* in country *c* in 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 $m-1$. $QE_{c,m(t)}$ is the natural logarithm of the purchased amount of the bonds of country *c* in month-year *m(t)* divided by all banks' total security holdings of country *c* 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 a bank held in 2012. $Deposit\ Ratio_i$ is the share of deposits over assets of a bank in 2012. $Risky_c$ captures the riskiness of the country where the bank *i* is located. $Risky_c$ 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 low exposure to negative interest rates, a dummy for a GIIPS (Greece, Italy, Ireland, Spain) country in column (3), and the government bond yield of the country in 2014 in column (4). The various interactions between $Deposit\ Ratio_i$, $Security\ Ratio_i$, $QE_{c,m(t)}$, and $Risky_c$ are included in the regression but are not reported in the table. Standard errors are clustered at the bank level.

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

	CB assets	CB liabilities	CB net assets	Deposits
	(1)	(2)	(3)	(4)
QE × Security Ratio × Deposit Ratio	0.030**	0.001	0.024*	0.013
	(0.014)	(0.005)	(0.014)	(0.009)
R-squared	0.648	0.721	0.661	0.953
N	19,285	19,285	19,091	19,283
Bank FE	✓	✓	✓	✓
Time FE	✓	✓	✓	✓

Notes: The level of observation is bank *i* in quarter *q*. The sample period spans from the first time negative interest rates are introduced (2014q3) to 2018q4. The dependent variable in column (1), $CB\ assets_{i,q}$, is defined as central bank assets of bank *i* at quarter *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* at quarter *q* ($CB\ liabilities_{i,q}$ in column 2), central bank assets minus liabilities of bank *i* at quarter *q* ($CB\ net\ assets_{i,m}$ in column 3) and deposits ($Deposits_i$ in column 4). QE_q is the amount of German government bonds purchased by the ECB in quarter q divided by all 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 a bank held in 2012. $Deposit\ Ratio_i$ is the share of deposits over assets of a bank in 2012. 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: 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 bank i's holdings in security s in quarter q. The sample period spans from the first time negative interest rates are introduced (2014q3) to 2018q4. The dependent variable is the natural logarithm of the euro amount held in security s by bank i in quarter q. QE_q is the amount of German government bonds purchased by the ECB in quarter q divided by all 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 a bank held in 2012. A bank i is considered to be a $Large\ Bank_i$ when total assets exceed 50€billions in 2012. Otherwise, the bank is a $Small\ Bank_i$. Standard errors are clustered at the bank level and security level. Source: Research Data and Service Centre (RDSC) of the Deutsche Bundesbank, Security Holdings Statistics (SHS), and balance-sheet statistics (BISTA).

Table 9: 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 firm j by bank i (reporting requirement in the German credit register) in quarter q. The sample period spans from the first time negative interest rates are introduced (2014q3) to 2018q4. The dependent variable is the natural logarithm of the euro amount outstanding between firm j and bank i in quarter q. QE_q is the amount of German government bonds purchased by the ECB in quarter q divided by all 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 a bank held in 2012. $Deposit\ Ratio_i$ is the share of deposits over assets of a bank in 2012. A bank i is considered to be a $Large\ Bank_i$ when total assets exceed 50€billions in 2012. Otherwise, the bank is a $Small\ Bank_i$. A bank i is considered a $Repo\ Bank_i$ when the bank conducts repo transactions. Otherwise, the bank is a $Non\ Repo\ Bank_i$. 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: 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 firm j by bank i (reporting requirement in the German credit register) in quarter q. The sample period spans from the first time negative interest rates are introduced (2014q3) to 2018q4. The dependent variable is the natural logarithm of the euro amount outstanding between firm j and bank i in quarter q. $\Delta \ln\ securities_{i,q}$ is the change in logged security holdings of bank i from q to q minus one year (one quarter respectively). $Deposit\ Ratio_i$ is the share of deposits over assets of a bank in 2012. This term is split up into household deposits ($Deposit\ Ratio\ HH_i$) and deposits from non-financial corporates ($Deposit\ Ratio\ NFC_i$). 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 11: 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 firm *j* by bank *i* (reporting requirement in the German credit register) in quarter *q*. The sample period spans from the first time negative interest rates are introduced (2014q3) to 2018q4. The dependent variable is the natural logarithm of the euro amount outstanding between firm *j* and bank *i* in quarter *q*. $\Delta \ln \ securities_{i,q}$ is the change in logged security holdings of bank *i* from *q* to *q* minus one year. $Deposit\ Ratio_i$ is the share of deposits over assets of a bank in 2012. This term is split up into household deposits ($Deposit\ Ratio\ HH_i$) and deposits from non-financial corporates ($Deposit\ Ratio\ NFC_i$). The analysis is split 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 12: Real Effects of Bank Credit Supply

Variable	Δln(Wage bill) (1)	(2)	(3)	Δln(Employment) (4)	(5)	(6)	Δln(Tangible fixed assets) (7)	(8)	(9)
Deposit & Security 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
Size FE	✓	-	-	✓	-	-	✓	-	-
Industry FE	✓	-	-	✓	-	-	✓	-	-
Region FE	✓	-	-	✓	-	-	✓	-	-
Industry × Region FE	-	✓	-	-	✓	-	-	✓	-
Industry × Size FE	-	✓	-	-	✓	-	-	✓	-
Industry × Region × Size FE	-	-	✓	-	-	✓	-	-	✓

Notes: The level of observation is firm *j*. The dependent variable in columns (1) to (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) to (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) to (9) is the difference in the natural logarithm of borrower firm j's tangible fixed assets in $2015-2016$ vs. $2013-2014$. *Deposit & Security Exposure*$_j$ is the average value of *Deposit Ratio*$_i$ $\times$ *Security Ratio*$_i$ (measured in 2012) of all banks with which firm j contracts (as of 2014), weighted by firm j's credit exposure to each bank i. *Deposit Exposure*$_j$ and *Security Exposure*$_j$ are defined accordingly using *Deposit Ratio*$_i$ and *Security Ratio*$_i$, respectively. A set of fixed effects are based on firm j's NACE industry segment, NUTS-3 region, and/or firm-size categories according to Union (2003). Source: Research Data and Service Centre (RDSC) of the Deutsche Bundesbank, German credit register (BAKIS-M), balance-sheet statistics (BISTA), and BvD Orbis.

Table 13: 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					0.0449	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 bank (lender) *i* (reporting requirement in the German credit register) in quarter *q*. The sample period spans from the first time negative interest rates are introduced (2014q3) to 2018q4. The dependent variable is the natural logarithm of the euro amount outstanding between bank *j* (borrower) and bank *i* (lender) in quarter *q*. QE_q is the amount of German government bonds purchased by the ECB in quarter *q* divided by all 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 a bank (lender) held in 2012. $Deposit\ Ratio_i$ is the share of deposits over assets of a bank (lender) 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 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) is considered to be a $Large\ bank_i$ when total assets exceed 50€billions in 2012. Otherwise, the bank is a $Small\ bank_i$. 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 14: 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 bank (lender) *i* (reporting requirement in the German credit register) in quarter *q*. The sample period spans from the first time negative interest rates are introduced (2014q3) to 2018q4. The dependent variable is the natural logarithm of the euro amount outstanding between bank (borrower) j and bank (lender) i in quarter q. QE_q is the amount of German government bonds purchased by the ECB in quarter *q* divided by all 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 a bank (lender) held in 2012. $Deposit\ Ratio_i$ is the share of deposits over assets of a bank (lender) in 2012. A bank (lender) is considered to be a $Large\ Bank_i$ when total assets exceed 50€billions in 2012. Otherwise, the bank is a $Small\ Bank_i$. In columns (1), (3) and (5) only lending to banks (borrower) within the euro area (EA) is considered, whereas in columns (2), (4) and (6) only lending to banks (borrower) outside the euro area (non-EA) is considered. 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).

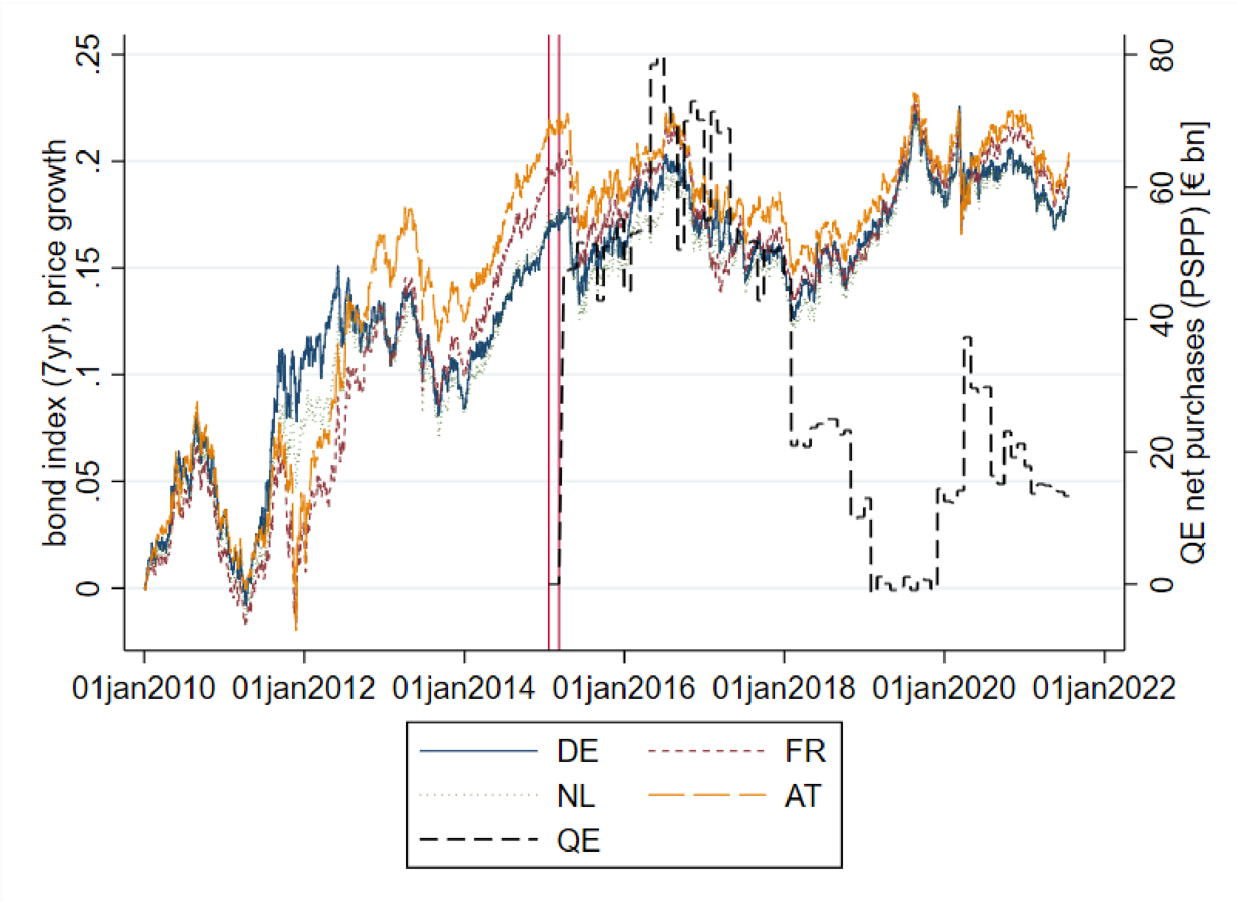
Table 15: Cross-border Banking Flows

	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 × Month FE	✓	✓	✓	✓	✓	✓
Borrower × Month FE	-	-	-	✓	✓	✓

Notes: The level of observation is the bilateral banking flow from country *c* to country *j* in quarter *q*. The dependent variable is the percentage change in bank claims of country *c* to country *j*. The sample period is 2014 to 2020. $QE_{c,q}$ is the amount of country *c* government bonds purchased by the ECB in quarter *q* divided by all banks' total security holdings of country *c* in 2012, and is standardized to have a 0 mean and a standard deviation of 1. $Core_i$ is a dummy if the lending country *c* is "Germany," "Finland," "Netherlands," or "Austria." $GIIPS_j$ is a dummy if the Borrowing country *c* is "Greece," "Italy," "Ireland," "Spain," or "Portugal." $High\,Yield_j$ is a dummy if the borrowing country 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 of exposure to negative interest rates. Standard errors are double clustered at the lender and borrower country.

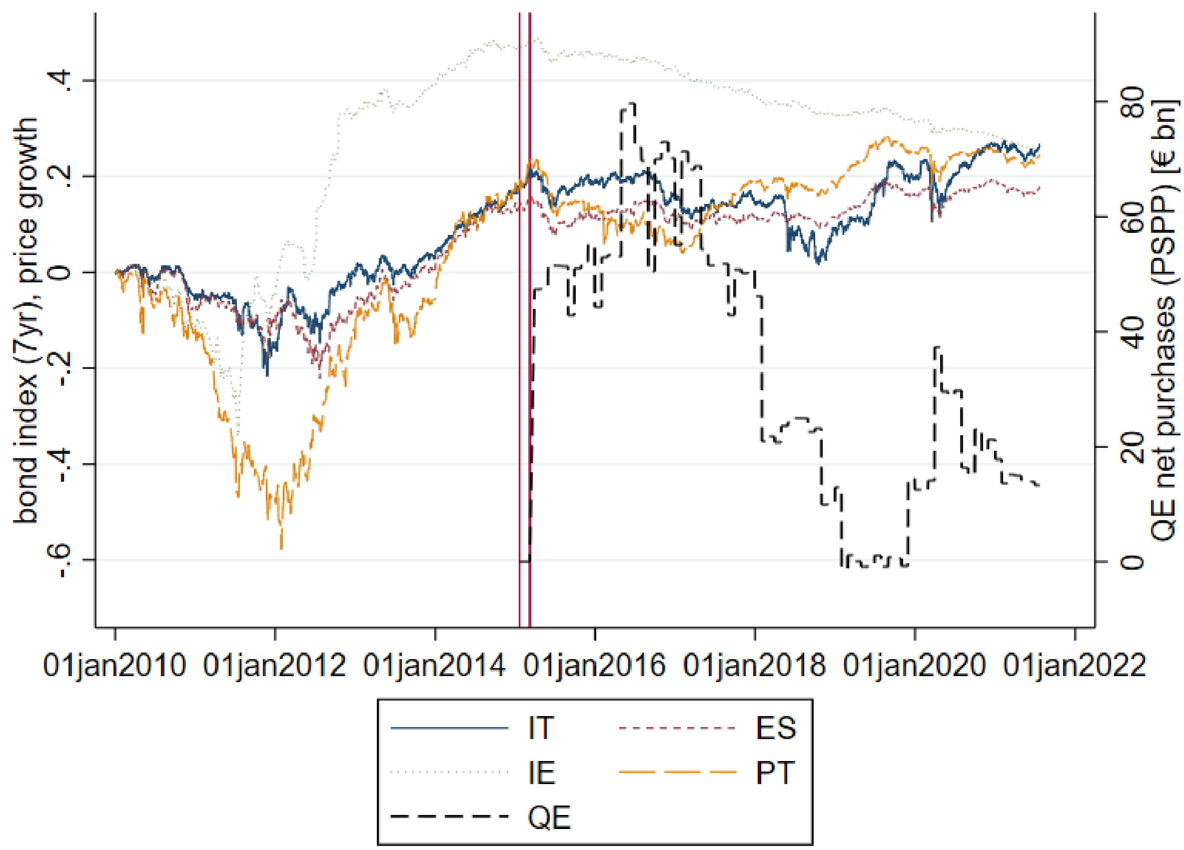
ONLINE APPENDIX—NOT FOR PUBLICATION

Figure A1: Bond Prices: Core Countries



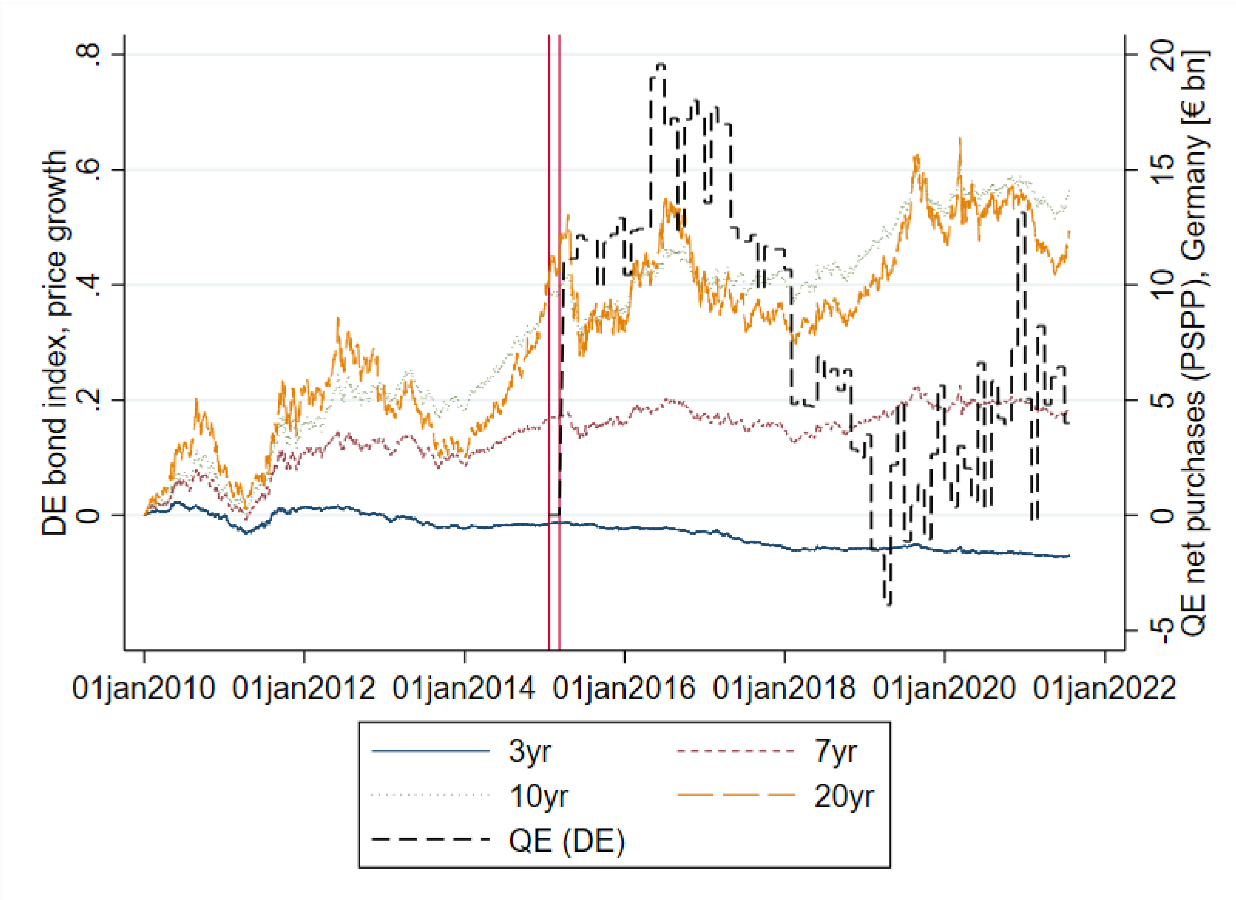
Notes: This graph shows the price development of European bond indices and QE net purchases by the ECB under the public sector purchase program (PSPP) in €billions. The bond indices for Germany, France, Netherlands, and Austria with a maturity of 7 years each are plotted as growth rates relative to the beginning of 2010 (left y-axis). The QE net purchases (PSPP) by the ECB are shown in the dashed black line referring to the right y-axis. The first vertical red line represents the announcement of the PSPP (January 22, 2015), and the second one marks its implementation (March 9, 2015).

Figure A2: Bond Prices: Periphery Countries



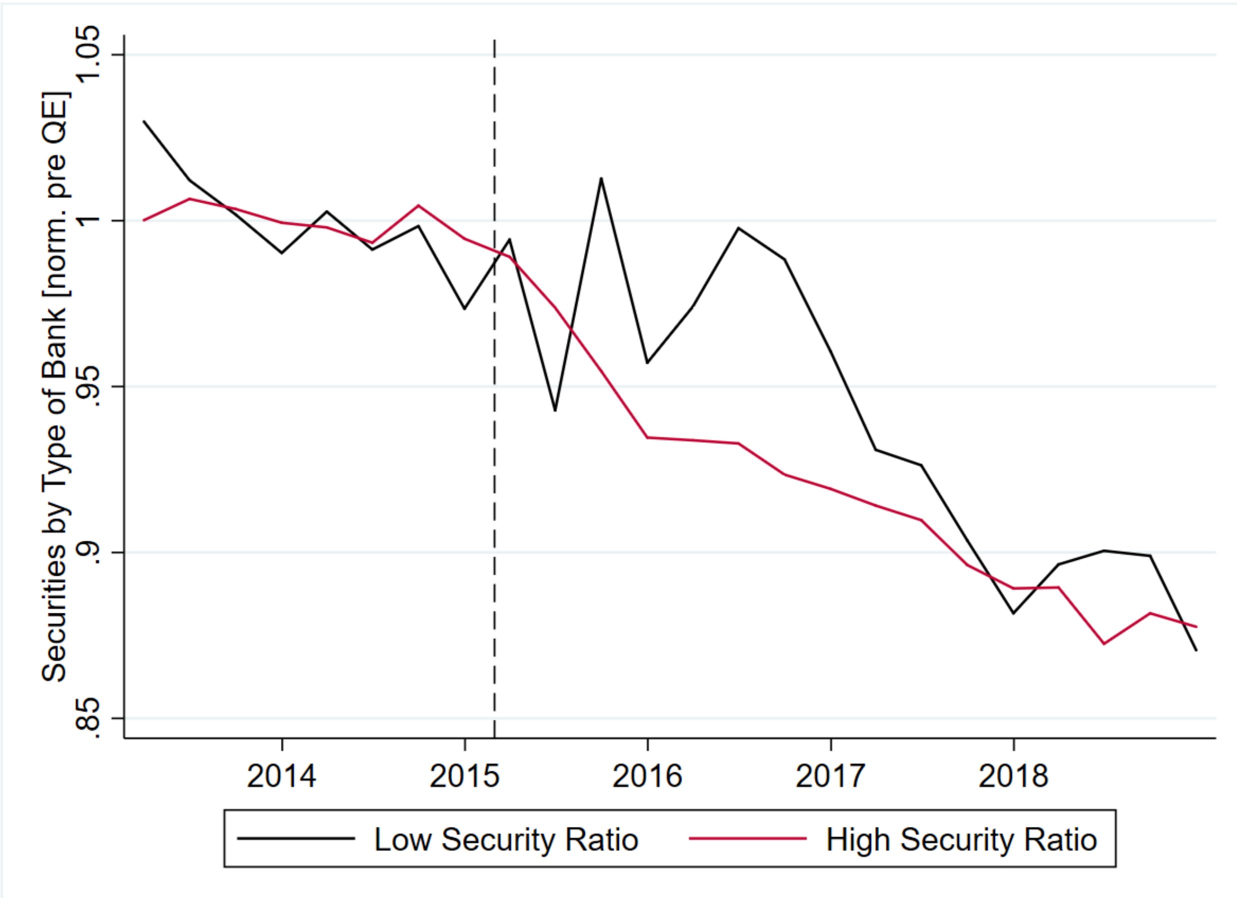
Notes: This graph shows the price development of European bond indices and QE net purchases by the ECB under the public sector purchase program (PSPP) in €billions. The bond indices for Italy, Spain, Ireland, and Portugal with a maturity of 7 years each are plotted as growth rates relative to the beginning of 2010 (left y-axis). The QE net purchases (PSPP) by the ECB are shown in the dashed black line referring to the right y-axis. The first vertical red line represents the announcement of the PSPP (January 22, 2015), and the second one marks its implementation (March 9, 2015).

Figure A3: Bond Prices: Germany



Notes: This graph shows the price development of German bond indices with different maturities and QE net purchases by the ECB under the public sector purchase program (PSPP) in €billions. The bond indices for Germany with maturities of 3, 7, 10, and 20 years are plotted as growth rates relative to the beginning of 2010 (left y-axis). The QE net purchases (PSPP) of German bonds by the ECB are shown in the dashed black line referring to the right y-axis. The first vertical red line represents the announcement of the PSPP (January 22, 2015), and the second one marks its implementation (March 9, 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).

Table A1: Baseline Table without Triple Interaction

	Dependent Variable: Lending							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
QE × Security Ratio	-0.018	-0.135	-0.132	-0.059	-0.054	-0.017	-0.020	-0.067
	(0.057)	(0.089)	(0.093)	(0.090)	(0.082)	(0.085)	(0.082)	(0.223)
QE × Deposit Ratio	-0.014	0.026	0.024	0.037	0.031	0.015	0.017	0.069
	(0.019)	(0.023)	(0.023)	(0.026)	(0.030)	(0.026)	(0.027)	(0.080)
R-squared	0.975	0.976	0.976	0.975	0.975	0.976	0.976	0.976
N	6,382	6,311	6,311	5,913	5,863	6,311	6,311	6,311
Bank FE	✓	✓	✓	✓	✓	✓	✓	✓
Borrower × Month FE	✓	✓	✓	✓	✓	✓	✓	✓
Country × Month FE	–	✓	✓	✓	✓	✓	✓	✓
Specification	$\frac{App_{c(i),m(t)}}{BSecH_{c(i),2012}}$	$\frac{App_{c(i),m(t)}}{BSecH_{c(i),2012}}$	$\frac{App_{c(i),m(t)}}{BSecH_{c(i),m(t)-1}}$	$ln(App_{c(i),m(t)})$	$ln(App_{m(t)})$	$ln(H_{c(i),m})$	$ln(H_{m(t)})$	$QEDummy$

Notes: The level of observation is credit to firm *j* by bank *i* in country *c* on day *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 day *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), $QE_{c,m(t)}$ is the natural logarithm of the purchased amount of the bonds of country *c* in month-year *m(t)* divided by all banks' total security holdings of country *c* in 2012, and is always standardized to have a 0 mean and a standard deviation of 1. In column (3), $QE_{c,m(t)}$ has the same numerator, but is now scaled by the banks' total security holdings of country *c* in the previous month-year. In column (4), $QE_{m(t)}$ is the natural logarithm of 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), $QE_{c,m(t)}$ 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 one after March 2015 (not standardized). $Security\ Ratio_i$ is the share of securities over assets a bank held in 2012. $Deposit\ Ratio_i$ is the share of deposits over assets of a bank in 2012. Standard errors are clustered at the bank level.

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

	(1)	(2)	(3)	(4)	(5)
	Log(Assets)	Capital Ratio	T1 Capital Ratio	RoA	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 at the bank-level in 2012. The dependent variable is (1) logged assets (ln($Assets_i$)), (2) the simple capital ratio ($Capital\ Ratio_i$), (3) the Tier 1 capital ratio ($T1\ Capital\ Ratio_i$), (4) the return on assets (RoA_i), and (5) the return on capital (RoC_i). $Security\ Ratio_i$ is the share of securities over assets a bank held in 2012. $Deposit\ Ratio_i$ is the share of deposits over assets of a bank 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 FE	✓	✓	✓	✓	✓	✓	✓	✓
Country × Month 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 credit to firm *j* by bank *i* in country *c* on day *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 day *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), $QE_{c,m(t)}$ is the natural logarithm of the purchased amount of the bonds of country *c* in month-year *m(t)* divided by all banks' total security holdings of country *c* in 2012. In column (3), $QE_{c,m(t)}$ has the same numerator, but is now scaled by the banks' total security holdings of country *c* in the previous month-year. In column (4), $QE_{m(t)}$ is the natural logarithm of 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), $QE_{c,m(t)}$ 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 one after March 2015 (not standardized). $Security\ Ratio_i$ is the share of securities over assets a bank held in 2012. $Deposit\ Ratio_i$ is the share of deposits over assets of a bank in 2012. The various double interactions between the three variables $Deposit\ Ratio_i$, $Security\ Ratio_i$ and $QE_{(c,)m(t)}$ are included in the regression but are not reported in the table as they are difficult to interpret. The results without the triple interaction can be found in Table A1. All regressions include the interaction between $QE_{c,m(t)}$ and the following control variables as of 2012: (1) logged assets (ln($Assets_i$)), (2) the simple capital ratio ($Capital\ Ratio_i$), (3) the Tier 1 capital ratio ($T1\ Capital\ Ratio_i$), (4) the return on assets (RoA_i), and (5) the return on capital (RoC_i). Standard errors are clustered at the bank level.

Table A4: 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 log securities (one year)	0.003	0.244	-0.102	0.078	4,355,468
Δ log securities (one quarter)	0.002	0.119	-0.037	0.030	4,356,233

Notes: The level of observation is credit to firm *j* by bank *i* (reporting requirement in the German credit register) in quarter *q*. The sample period spans from the first time negative interest rates are introduced (2014q3) to 2018q4. $Lending_{i,j,q}$ is the natural logarithm of the euro amount outstanding between firm *j* and bank *i* in quarter *q*. QE_q is the amount of German government bonds purchased by the ECB in quarter *q* divided by all banks' total German sovereign bond 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 a bank held in 2012. $\Delta \ln\ securities_{i,q}$ (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). $Deposit\ Ratio_i$ is the share of deposits over assets of a bank in 2012. This term is split up into household deposits ($Deposit\ Ratio\ HH_i$) and deposits from non-financial corporates ($Deposit\ Ratio\ NFC_i$). 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).