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Monetary policy transmission below zero: The reversal rate is real

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Monetary policy transmission below zero: The reversal rate is real

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Abstract

This study considers the pass-through of different ECB monetary policy measures to bank corporate lending rates of different maturities during 2010–2020. We find changes in the pass-through as policy rates first dip below zero in 2014 and again when negative interest rates become more persistent during the "low-for-long" period beginning in 2016. Overall, the transmission of monetary policy to bank lending rates appears to have become less efficient below zero, particularly in the case of loans with short maturities. We are the first to empirically identify reversal in the pass-through during the low-for-long period with banks raising their lending rates as monetary policy is eased. Unconventional monetary policy measures such as targeted longer-term refinancing operations appear to have mitigated these contractionary effects.

JEL codes: E52, E58, G21

Keywords: negative interest rates, unconventional monetary policy, lending rates, bank lending channel, euro area

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1. Introduction

Central banks shifted to accommodative monetary policies in the years following the global financial crisis of 2008. A few ventured beyond keeping policy rates close to zero, transitioning into negative territory. On June 5, 2014, the European Central Bank (ECB) became the first major central bank to set policy rates below zero, launching an era of negative rates that eventually lasted over eight years. Thus, it is hardly surprising that negative rates have become a subject of extensive study in recent years (Heider, Saidi, and Schepens, 2021; Balloch et al., 2022).

Nevertheless, the large body of theoretical and empirical literature has yet to clarify the overall impact of negative policy rates on banks (Balloch et al., 2022). Some argue that prolonged negative interest rates prompt banks to change their practices, so any observed immediate impact of negative rates, on which literature has focused so far, may differ from the medium-to-long-term impacts. Indeed, banks can benefit in the short run from capital gains when negative rates are implemented, helping them to withstand negative rates on the reserves they hold in the central bank. These capital gains are insufficient for the long haul, however, making it hard for banks to maintain profitability. In their empirical cross-country study, Claessens et al. (2018) find that for each additional year of low rates (even if policy rates stay unchanged) margins and profitability of banks erode by several basis points.

Abadi, Brunnermeier and Koby (2023) show that when policy rates are low enough further rate cuts may become contractionary for bank lending. This reversal interest rate is more likely to emerge if rates are kept low for long (Abadi et al., 2023; Balloch et al., 2022). In this paper, we study how the transmission of conventional and unconventional monetary policy to corporate lending rates changes as policy rates go below zero and whether there is any empirical evidence of a reversal rate in the euro area[1]. More specifically, we aim to answer the following questions. First, has the pass-through of ECB monetary policy through banks to corporate lending rates changed when the policy rates became negative and especially when negative interest rates became more persistent during the low-for-long period? Second, how does the transmission of different unconventional monetary policy measures work in this environment?

These questions are particularly important if the interest rates stay at lower levels in comparison to the past and we would be facing zero lower bound more often (Holston, Laubach and Williams, 2017; Kiley and Roberts, 2017). It is therefore essential to understand how monetary policy affects financial conditions in this environment. The transmission of monetary policy might change as policy rate cuts

[1] Altavilla et al. (2022) show that fluctuations in lending volumes are largely explained by demand shocks whereas developments in lending rates are mostly driven by supply shocks and borrower risk. This further validates our choice to focus on loan prices when empirically investigating the existence of the reversal rate.

may even turn contractionary, and other, unconventional monetary policy measures might be necessary to support the economy.

In our analysis we exploit detail bank-level dataset at monthly frequency on 137 individual banks from 13 euro area countries covering the period from January 2010 to December 2020. Unlike most empirical papers that rely on shorter data samples,[2] our data enable us to properly study the low-for-long period. For our purposes, the low-for-long period begins in 2016 when ECB forward guidance signaled that policy rates would remain in negative territory "for a prolonged time". Moreover, we utilize detail information on different loan maturities. Besides information on bank balance sheets, loan and deposit interest rates, central bank deposits and longer-term borrowing of banks, we employ data from the responses of individual banks to the ECB's Bank Lending Survey to control bank-level loan demand. We first take the shadow rate of Krippner (2015) as a measure of the ECB's overall policy stance, then isolate monetary policy shocks utilizing rate changes around the ECB's monetary policy decisions from the Euro Area Monetary Policy Event-Study Database (EA-MPD; see Altavilla et al., 2019) and bank bond yield changes on (targeted) longer-term refinancing operations ((T)LTRO) announcement days. These shock proxies allow us to disentangle various types of monetary policy tools: short-term policy rates, targeted long-term refinancing operations, and quantitative easing.

Our analysis adds to the existing literature in that it provides empirical evidence in favor of the theoretically reasoned reversal rate, i.e. the theoretical lower bound for policy-rate lowering, below which cuts become contractionary. Ulate (2021) shows theoretically that policy rate cuts work through two channels: by exerting downward pressure on loan rates (bank lending channel), and by declining deposit spreads leading to lower profitability and over time lower equity (net worth channel). The equilibrium behavior of the lending rate, depending on whether they are raised or lowered following a policy rate decline, is dictated by the relative importance of each channel.

Rather similarly, Abadi et al. (2023) model two channels following a policy rate cut affecting bank net worth. Banks make capital gains on their long-term assets (capital gains channel). As interest rates head lower, the pass-through from policy rates to deposit rates decline, compressing the profit margins of banks (net interest income channel). The reversal rate is the rate below which the net interest income effect of further interest rate cuts outweighs the capital gains effect. Further, if central bank promises to keep interest rates at low levels for a prolonged period with forward guidance, it is bound to become counterproductive over time even if its initial response is to boost lending (Abadi et al., 2023). Thus, the reversal rate can move higher when policy rates are at extremely low levels for an extended period.

Thus far, no empirical paper has found evidence of reversal rate. Borio and Gambacorta (2017) provide empirical evidence that monetary policy is less effective in stimulating bank lending when interest rates

[2] See Table 4 in Balloch et al. (2022) for details concerning the data used in existing empirical studies.

reach a very low level. Basten and Mariathasan (2023) find that rate cuts into negative territory can interrupt the pass-through from policy to mortgage rates. Molyneux et al. (2019) observe that before 2016 lending growth was slowest for OECD countries with negative central bank policy rates. Eggertsson et al. (2023) use a macro model calibrated on Swedish data to show that banks begin to increase their loan rates when a -0.50 % policy rate erodes bank profitability. Kwan, Ulate, and Voutilainen (2023) provide evidence that policy rate cuts continue to be transmitted to mortgage lending rates in Finland even when policy rates are below zero, although the pass-through is weaker in comparison to the period with positive policy rates. Bottero et al. (2022) find that negative interest rates have expansionary effects through portfolio rebalancing: below zero, ex-ante more liquid banks increase corporate lending more than other banks. In addition, Altavilla, Burlon, Giannetti, and Holton (2021), Albertazzi et al. (2021), and Erikson and Vestin (2019) find no evidence that monetary policy becomes ineffective when rates are negative.

In addition to being the first to present evidence of the reversal rate in the euro area after the fourth rate cut to -0.40 % in 2016, our study provides an explanation for the mixed results found in the existing literature. As suggested by the theoretical reasoning, we show that detection of the reversal rate depends both on bank heterogeneity and loan maturities. Previously, when studying the transmission of monetary policy to lending rates, most of the literature focused predominantly on average effects and thus reversed effect for certain types of banks or loans might have stayed undiscovered. Identifying reversal rate also requires that negative rates become persistent, i.e. the reversal rate only emerges during the low-for-long period.

The second contribution we make to the literature concerns the evidence on how changes in different monetary policy tools transmit to corporate lending rates with different maturities. Our paper provides a clear-cut study on how the pass-through of different monetary policy measures to bank lending rates has changed over time. The effects of unconventional monetary policy have been studied intensively in recent years,[3] yet the literature dealing with time-varying effects between above and below zero is scarce. Instead, the focus in the low-rate environment has so far been on the effectiveness of short-term policy rates (e.g. Borio and Gambacorta, 2017; Claessens et al., 2018; Kwan et al., 2023), or on unconventional measures but not distinguishing between different kind of tools (Albertazzi et al., 2021; Boeckx, de Sola Perea, and Peersman, 2020). We look separately at the time-varying effects of short-term policy rates, QE, and (T)LTROs.

Our main results are as follows. When short-term policy rates are lowered below zero, transmission becomes weaker with the effect most pronounced for loans of short maturities. This finding seems to be driven by banks reluctant to lower their own retail deposit rates below zero or those with large amounts

[3] For asset purchases, see Krishnamurthy and Vissing-Jorgensen (2011). For targeted and non-targeted longer-term refinancing operations, see Andrade, Cahn, Fraisse, and Mésonnier (2019); Benetton and Fantino (2021); Laine (2021).

of negative interest-bearing central bank deposits. During the period of low-for-long, we find evidence of the reversal rate. With further monetary policy easing during the period of low-for-long, banks no longer lowered their corporate lending rates, but instead started to raise them up. Again, this result is visible for short-maturity loans. Even if the transmission of short-term policy rate, a conventional policy measure, to bank lending rates is hampered below zero, unconventional monetary policy measures such as TLTROs mitigate the pass-through by lowering bank funding costs. Contractionary effects of reversal rate are mitigated especially when it comes to long-term loans explaining the result that overall monetary policy stance was found to be contractionary for short-term loans but expansionary for long-term loans.

The article has the following structure. Section 2 describes the main aspects of the monetary policy conducted by the ECB during the observation period 2010–2020. Section 3 presents our data and various measures of monetary policy. Section 4 provides an overview of the econometric methods used. Section 5 presents the results. Section 6 concludes with a few policy insights.

2. Monetary policy in euro area

This section presents the main aspects of the ECB monetary policy during 2010–2020.[4] It also discusses how we define the low-for-long period.

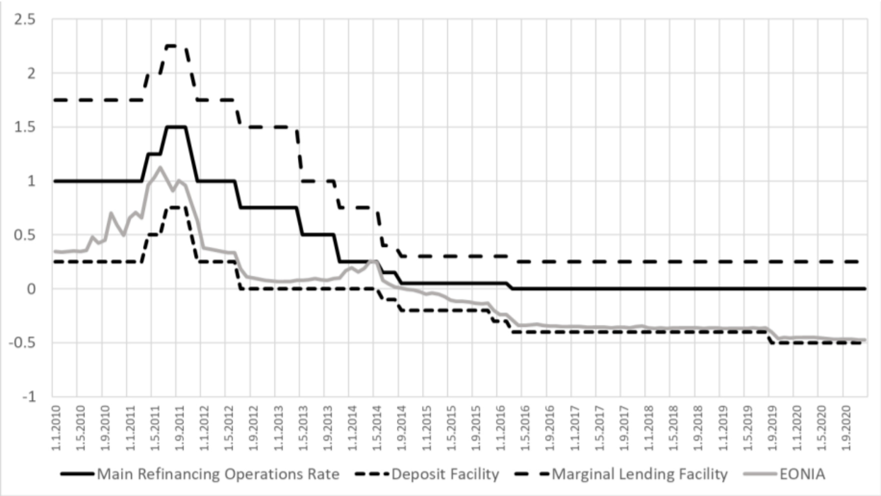
Policy rate-setting is the ECB's primary monetary policy tool (Figure 1). Its main refinancing operations (MROs) allow banks to borrow from the ECB on a weekly basis at pre-determined rates. Liquidity-sharing on the interbank market stalled with the onset of the financial crisis, and in October 2008 the ECB began carrying out its main refinancing operations as fixed-rate tenders with full allotment. This shift led to a build-up of liquidity inside the banking sector. Because of this excess liquidity, the shortest money-market rates (e.g. the Euro Overnight Index Average or EONIA) began to track the ECB's deposit facility rate rather than the MRO.

Following the ECB's initial cut of its deposit facility rate to -0.10 % in June 2014, key interest rates were lowered a total of five times. The final cut in September 2019 brought the deposit facility rate to -0.50 %. When the deposit facility rate is negative, banks have less to withdraw from their central bank accounts than their previous day's deposit. Individual banks can reduce their own excess liquidity by lending it out to other banks or purchasing assets, but as liquidity is always passed on from one bank to another, the banking system as a whole cannot shed its total excess liquidity.[5]

[4] For a more comprehensive description, see Rostagno et al. (2021).

[5] This burden was reduced in October 2019 with the adoption of a two-tier system for reserve remunerations.

Figure 1. ECB policy rates and EONIA (2010-2020)



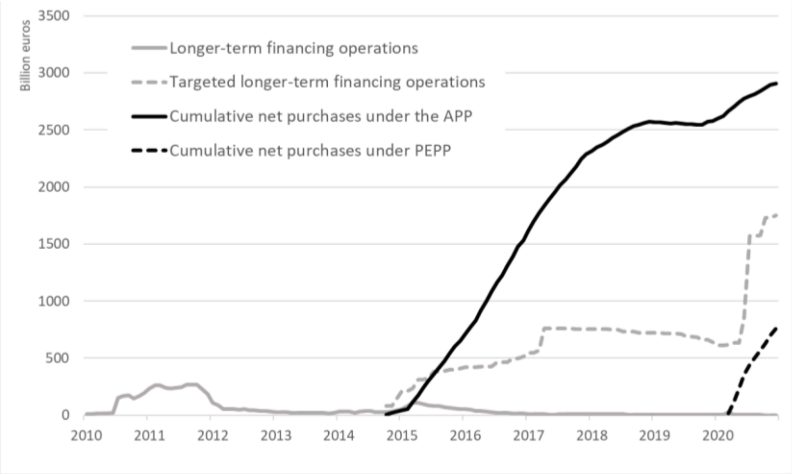
Source: ECB.

The ECB also contributed to lower banks' funding costs by lending funds on highly favorable terms under both non-targeted and targeted longer-term financing operations, (T)LTROs (Figure 2). Two LTROs with a maturity of three years were agreed upon in December 2011. The operations became targeted (i.e. TLTROs) in 2014 as the aim was refined such that banks would use the new liquidity to increase lending to non-financial corporations and households for consumption. The cost of TLTROs was bank-specific and became cheaper the more the recipient bank increased its lending to the private sector. The first series of TLTROs (TLTRO I) was announced in June 2014, followed by TLTRO II in March 2016 and TLTRO III in March 2019.

Additional excess liquidity was also created by the ECB's expanded asset purchase programme. The Eurosystem conducted net purchases of securities under several asset purchase programmes (PSPP, CBPP3, CSPP, and ABSPP[6]) at varying monthly purchase pace between October 2014 and December 2018. APP net purchases stalled between January and October 2019, but were restarted in November 2019 and kept running at a pace of 20 billion euros a month to end of our observation period in December 2020. In March 2020, as the first wave of the Covid-19 pandemic was hitting Europe, the ECB launched its Pandemic Emergency Purchase Programme (PEPP). It made additional purchases in all categories eligible under the APP (plus some extensions such as Greek government securities).

[6] PSPP stands for public sector purchase programme, CBPP3 is the third covered bond purchase programme, CSPP is the corporate sector purchase programme and ABSPP is the asset-backed securities purchase programme.

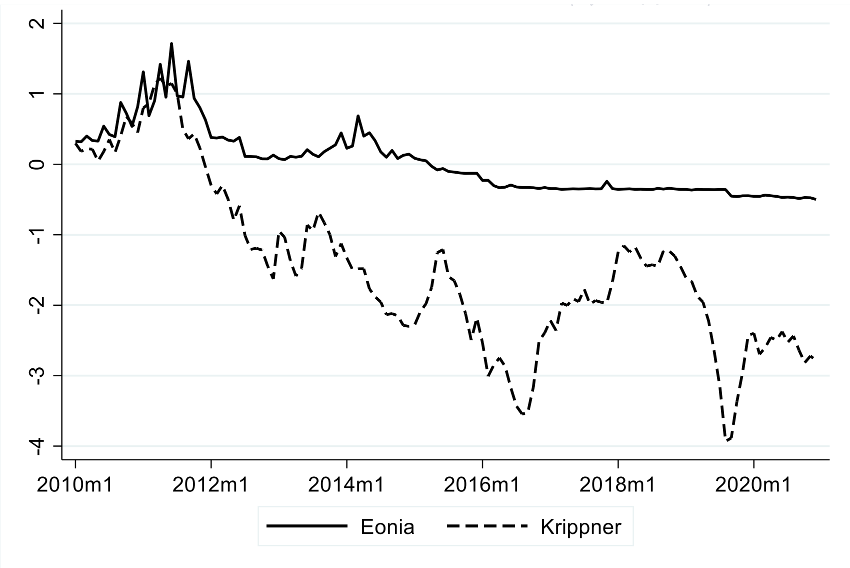
Figure 2. ECB's longer-term financing operations and asset purchases under the Asset Purchase Programme (APP) and Pandemic Emergency Purchase Programme (PEPP).



Source: ECB.

As the ECB started to implement various unconventional monetary policy measures, the shortest money market rates (e.g. EONIA) ceased to capture fully the overall monetary policy stance or changes therein. The shadow rate, on the other hand, captures additional monetary policy easing through unconventional measures such as QE. The shadow rate, originally proposed by Black (1995), has since appeared in multiple forms in euro area estimates (e.g. Kortela, 2016; Krippner, 2015; Wu and Xia, 2016). All measures of shadow rate show monetary easing in the euro area after the short rate hit its effective lower bound. Because of regularly available updates, we use here the shadow rate estimates of Leo Krippner. Figure 3 depicts both the EONIA interbank overnight lending reference rate and Krippner's shadow rate for 2010–2020. Note that the shadow rate begins to deviate from the shortest money market rate already in the second half of 2011.

Figure 3. EONIA and Krippner's euro area shadow rate.



Sources: ECB, Krippner (2015).

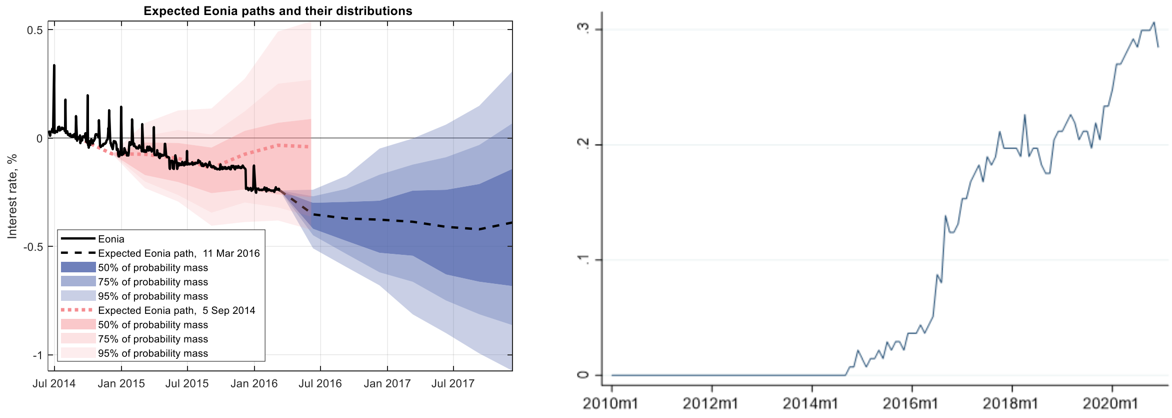
As stated above, our analysis focuses on the changes in the transmission of monetary policy through banks 1) when policy interest rates first dip into negative territory, and 2) when economic agents realize that negative rates are here to stay, i.e. when the economy enters the low-for-long period. Defining the period of negative rates is straightforward. It starts in June 2014 with the first deposit facility rate cut below zero and lasts until December 2020, the end of the observation period. Defining the start date for the low-for-long period is more challenging.

The ECB lowered its deposit facility rate a third time in December 2015 from -0.20 to -0.30 and again to -0.40 in March 2016. On January 21, 2016, ECB President Mario Draghi announced a shift in its forward guidance with the following statement after the monthly monetary policy meeting:[7]

> "Based on our regular economic and monetary analyses, and after the recalibration of our monetary policy measures last month, we decided to keep the key ECB interest rates unchanged, and we expect them to remain at present or lower levels for an extended period of time."

The change in the expected interest rate path was significant after these policy changes. Panel A of Figure 4 depicts the expected path (forward curve) of the euro area short-term rate and its distributions at two different points in time: i.e. the second rate cut in September 2014 (pink distribution) and the fourth rate cut in March 2016 (blue distribution). Note that even after the policy rate was lowered to - 0.20%, the scenario in which interest rates return to positive territory over the course of one year was within 50 percent confidence bands.[8] Entering 2016 however, this perception had changed. Looking at the probability distribution in March 2016, markets clearly started to understand that negative interest rates were a persistent phenomenon.

Figure 4. Expected euro area short-term rate paths and their option-implied probability distributions (Panel A). Share of banks having at least one retail deposit account at negative rate (Panel B).



Sources: ECB and authors' calculations.

[7] https://www.ecb.europa.eu/press/pressconf/2016/html/is160121.en.html.

[8] Derived from EURIBOR future option market assuming risk-neutrality following the method of Shimko (1993).

The change in perception of the persistence of negative interest rates is also visible when examining the number of banks in our dataset that started to claim negative interest rates on their retail depositors. As shown in Panel B of Figure 4, the share of banks with at least one retail deposit account (including both household and corporate, overnight, and other maturities) bearing negative interest rate, increased considerably from the beginning of 2016 to around 20 % by the end of 2017 and 30 % in 2020[9].

Based on the above reasoning, we set the start of the low-for-long period as January 2016 and it lasts until the end of our observation period December 2020.

3. Data

This section presents the data used and defines our monetary policy measures.

3.1 Data description

We employ different sources of data to create our unique dataset. First, our dependent variables, i.e., the lending rates for new loans, are drawn from the confidential ECB's individual MFI interest rates statistics (IMIR). We have bank-specific interest rate observations at monthly frequency on new domestic non-financial corporation (henceforth corporate) loans of different maturities. We use four dependent variables for our main estimations. The lending rate for corporate loans is a weighted average of lending rates for all new corporate loans of different maturities and size granted by a bank in each month. We also look at the lending rates for corporate loans separately for maturities of up to 1 year, 1 to 5 years, and over 5 years.

Our main explanatory variables are the measures for monetary policy. In our panel estimations, we use the euro area shadow rate by Krippner (2015) to account for changes in the overall monetary policy stance. We then use a local projection method to disentangle the effects of specific monetary policy measures: policy interest rate, (targeted) longer-term lending operations, and quantitative easing. To that end, we use Euro Area Monetary Policy Event-Study Database and our own calculations. Monetary policy measures used are discussed more thoroughly in section 3.2.

To form our bank-specific variables, capitalization (ratio of equity to total assets), liquidity (ratio of liquid assets to total assets), and bank size (log of total assets), we predominantly rely on monthly bank-

[9] Banks that started to claim negative interest rate on their retail depositors were on average not different from their non-negative-deposit rate counterparts with respect to their ex-ante (or ex-post) level of net interest margin. In addition, charging negative deposit rates does not correlate with the amount of variable interest lending nor the initial level of either lending or deposit rates. Out of the 13 countries in our sample, there were in total 9 countries where we observed banks charging negative deposit rates.

specific balance sheet information provided by the ECB (individual MFI balance sheet item data set, IBSI), the exception being liquidity where we use annual data from BankFocus. In addition, we use monthly observations on each bank's borrowing from the central bank under targeted and non-targeted longer-term operations, as well as each bank's monthly reserves in central bank deposit accounts. The data are from two confidential ECB datasets (bank-level borrowing and repayments from different longer-term refinancing operations and bank-level current account deposits).

With access to ECB's individual bank lending survey data with quarterly survey responses of individual banks, we have the possibility to control directly for loan demand encountered by each bank. Our question of interest is worded as follows:

> "Over the past three months (apart from normal seasonal fluctuations), how has the demand for loans or credit lines to enterprises changed at your bank? Please refer to the financing need of enterprises independent of whether this need will result in a loan or not."

Respondent could choose from "1) decreased considerably, 2) decreased somewhat, 3) remained basically unchanged, 4) increased somewhat, or 5) increased considerably." Based on the responses, we construct two dummies for loan demand: a dummy for increasing demand (equal to one if the bank responded 4 or 5), and a dummy for declining demand (equal to one if the bank responds with either 1 or 2). Each estimation includes both dummies.

To control for macroeconomic developments affecting all banks in one country at the same time, we include country-specific industrial production year-on-year growth and harmonized unemployment rate, both from Eurostat at monthly frequency. In addition, to take into account euro area wide macroeconomic developments and uncertainty, we further include normalized total returns of the euro area STOXX index, as well as the first principal component of short-, medium-, and long-term expectations of euro area GDP growth, inflation, and unemployment from the ECB Survey of Professional Forecasters SPF at monthly frequency.

Altogether our dataset is an unbalanced panel covering 137 individual euro area banks[10] from thirteen countries[11] for the period January 2010–December 2020. Definition of all variables used are presented in Table 1. Descriptive statistics for the full time period and three different sub-periods (period of

[10] Even if the number of individual banks may seem small, the sample is a good representation of the euro area banking sector as a whole (see Figure A1 in the Appendix). Our sample covers around 45 % of euro area banking sector total assets and around 40 % of total corporate lending outstanding. Although IMIR and IBSI datasets include over 300 banks during 2010–2020, especially the smaller coverage of the individual Bank Lending Survey (iBLS) ultimately limits our sample to 137 banks. However, as stated directly by the ECB, banks participating in BLS provide a representative sample of euro area banks and take into account the characteristics of the respective national banking structures. Further, we check that the distributions of our dependent variables are identical between our smaller sample and that of all banks in the IMIR database.

[11] Austria, Belgium, Estonia, Germany, Finland, France, Ireland, Italy, Lithuania, Luxembourg, Portugal, Slovakia, and Spain.

positive policy rates (January 2010-May 2014), period of *negative policy rates* (June 2014-December 2015) and period of *low-for-long* (January 2016-December 2020) can be found in Table 2[12].

3.2. Measuring monetary policy

As discussed in section 2, the ECB employed a number of monetary policy instruments during the eleven years covered by our dataset. Our focus is to determine whether the pass-through of monetary policy to bank corporate lending rates changed after policy interest rates entered into negative territory in June 2014 and further when banks entered the low-for-long period in 2016.

We start our analysis with panel regressions using the shadow rate by Krippner (2015) as an overall measure of the monetary policy stance. As argued in Albertazzi et al. (2021), the advantage of using the shadow rate (or short-term interest rate) as a monetary policy measure is that it considers both the announcement and the implementation of such measures. However, the level of shadow rate responds endogenously to macroeconomic developments which may bias the results.[13] We tackle this issue by controlling for a large set of macroeconomic variables such as inflation expectations that simultaneously affect monetary policy and bank lending.

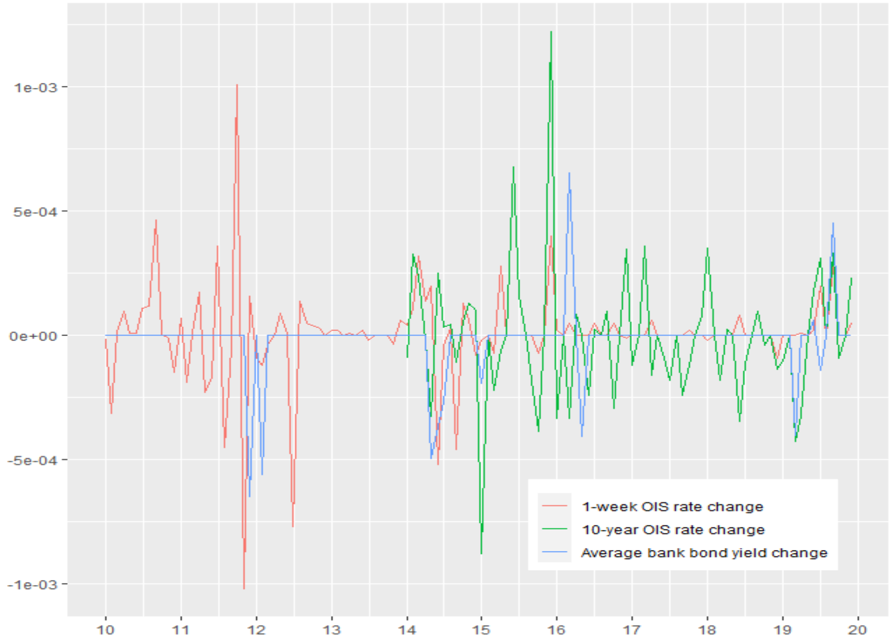
Another option is to use monetary policy shocks derived from external VAR models or event studies as in Boeckx et al. (2020) and Albertazzi et al. (2021).[14] One rationale for using monetary policy shocks or surprises rather than the shadow rate is that shocks and surprises represent exogenous variation in monetary policy. Shock (proxies) also allow one to disentangle between different types of monetary policy.

Thus, as our second step, we employ local projections method and three different monetary policy shocks to disentangle impacts of short-term policy rates, credit easing policies ((T)LTROs) and large-scale asset purchases (QE). We take the 1-week OIS surprise around the ECB's monetary policy decisions[15] to measure the impact of conventional monetary policy (short-term interest rate) and the 10-year OIS surprise to measure the impact of large-scale asset purchases (QE). Both of these shocks are derived from the euro area event-study database produced in accordance with Altavilla et al. (2019). To

[12] Data is winsorized so that 1% of observations are dropped from each side of the distribution from our dependent variables.
[13] Dealing with this issue in our setting is not as problematic as perhaps in some applications. As argued by Borio and Gambacorta (2017), the (expected) bank lending rates at the aggregate level are more likely to affect monetary policy decisions than the lending rates of individual banks. In other words, one can assume that monetary policy stance is exogenously determined from the perspective of a single bank. However, to overcome potential endogeneity problems in our ordinary panel regressions, we control for macroeconomic forecasts in addition to past developments. Adding macroeconomic forecasts to the regression means that we study the variation in the (shadow) policy rate for the given macroeconomic outlook, i.e. deviations from the policy rule (comparable to monetary policy shocks). See Bluedorn, Bowdler, and Koch (2017) for further discussion.
[14] Boeckx et al. (2020) estimate local projections based on shocks by Boeckx, Dossche, and Peersman (2017). Albertazzi et al. (2021) use cumulated OIS (Overnight Indexed Swap) rate movements around the ECB's monetary policy meetings in an otherwise quite standard bank lending channel panel regression as a robustness check, while their main regressions rely on traditional measures.
[15] To be precise, we use the monetary event window, that is the change in the median quote from the window 13:25-13:35 before the press release to the median quote in the window 15:40-15:50 after the press conference.

measure credit easing policies, we use bank bond yield changes around the ECB announcements involving (T)LTROs.[16] Figure 5 presents the time series of these three shocks for 2010–2020.

Figure 5. Monetary policy shocks used in local projections.



Sources: EA-MPD, Bloomberg and authors' calculations.

4. Methodology

This section presents the panel estimation used to study the transmission of the overall monetary policy stance and the local projection method used to account separately for various monetary policy shocks.

4.1. Panel estimation

Changes in monetary policy stance directly affect money-market interest rates and, indirectly, lending rates that banks set for their customers. To study the transmission of the overall monetary policy stance to bank corporate lending rates, we use the following baseline regression:

$$r_{i,t}^{L} = \vartheta_i + \partial MP_{t-1} + \alpha X_{i,t-1} + \delta Y_{t-1} + \rho D_{i,t-3}^{L} + \varepsilon_{i,t}, \quad (1)$$

[16] We use the same days as Altavilla, Barbiero, Boucinha and Burlon (2023, Appendix B): 8.5.2014, 5.6.2014, 3.7.2014, 29.7.2014, 22.1.2015, 10.3.2016, 3.5.2016. In addition, we use the following days not covered by the study of Altavilla et al. (2023): 8.12.2011 (3-year LTRO announcement), 28.2.2012 (eligibility of Greek bonds used as collateral in monetary policy operations), 7.3.2019 (TLTRO III announcement), 6.6.2019 (details about the operations), 29.7.2019 (legal act published), 12.9.2019 (TLTRO rate reduced). We use a single series of average yield to maturity of euro area banks (senior unsecured bonds). Based on this single series we calculate daily change. The data are from Bloomberg.

where $r_{i,t}^{L}$ is the average interest rate on new corporate loans for different maturities L charged by bank i in month t; ϑ_i captures bank fixed-effects; MP_{t-1} is the measure of the monetary policy stance (Krippner shadow rate); $X_{i,t-1}$ is a vector of bank-specific variables lagged by one month (liquidity (ratio of liquid assets to total assets), capitalization (ratio of capital and reserves to total assets), bank size (log of total assets), central bank deposits (ratio of bank's central bank deposits to total assets), and central bank operations (share of borrowed loans from central bank longer term operations to the outstanding amount of bank loans to the private sector)); Y_{t-1} is a vector of country-specific macroeconomic indicators (year-on-year growth rate of industrial production and harmonized unemployment rate) and euro-area-wide indicators (normalized stock returns from Eurostoxx, and macroeconomic forecasts for GDP growth, unemployment, and inflation); and $D_{i,t-3}^{L}$ is the bank-specific demand for corporate loans lagged by three months.

If monetary policy is being transmitted to the real economy, banks should lower their lending rates as monetary policy eases, i.e. the Krippner shadow rate decreases. As firms can turn to financial markets for at least some of their funding and banks compete with one another for customers, any reduction in bank borrowing costs should appear to firms as reduced loan rates. The coefficient for the overall monetary policy stance (Krippner shadow rate), is thus expected to be positive.

Moreover, different monetary policy measures impact the yield curve at different maturities. The central bank steers the short end of the yield curve by adjusting its policy rate, whereas asset purchases compress the longer end of the yield curve. Monetary policy easing and lower interest rate environment can also influence bank risk-taking, which might yield a different impact on the pass-through depending on loan maturity. Thus, we expect differences in the transmission mechanism of the overall monetary policy stance (coefficients for Krippner shadow rate) for loans of different maturities and for different time periods.

Following the bank lending channel literature (Kashyap and Stein 1995, 2000) we add bank-specific variables capitalization, liquidity and bank size to control for the ability of banks to obtain external funding and thus supply loans. We also add the amount of bank borrowings from longer-term ECB operations (relative to the bank's outstanding loans to the private sector) to account for how extensively the bank relied on favorable central bank lending and could thus lower its funding costs, as well as the amount of deposits the bank has at the ECB (relative to the bank's total assets) to determine the bank's share of assets bearing negative interest rates at the central bank after 2014.

We control for country specific macroeconomic developments affecting all banks inside a country by including the year-on-year growth rate of industrial production and the harmonized unemployment rate. To control for euro area wide developments, we include the normalized stock returns from Eurostoxx stock index as well as the expectations of future GDP growth, unemployment rate and inflation using macroeconomic forecasts from the Survey of Professional Forecasters (SPF) for different horizons.

Instead of choosing any specific SPF forecasting horizon, we take the first principal component across all horizons (separately for each different forecasting variable). Macroeconomic forecasts are added as control variables in addition to past macroeconomic outcomes because they help interpret the regression coefficient of the shadow rate as causal effect on lending rate.[17]

We account for bank-specific corporate loan demand using bank-specific responses from the ECB's Bank Lending Survey. We use two dummy variables in each estimation: an increased demand dummy and a declined demand dummy. As BLS is conducted quarterly, we use three month lagged values.

In order to clearly uncover the possible changes in monetary policy transmission as policy rates were lowered below zero, and later during the low-for-long period, we run the panel estimations for three different subperiods. Period of positive policy rates runs from January 2010 to May 2014, period of negative policy rates from June 2014 to December 2015 and finally the period from January 2016 to December 2020 comprises solely the low-for-long period.

4.2. Local projections

To account for different monetary policy shocks, we turn to local projections as formalized by Jordà (2005).[18] This approach enables us to estimate the effects of policy shocks at different horizons and thereby tease out the timing and dynamics of these effects.[19] Furthermore, high-frequency monetary policy surprises provide us an alternative identification strategy for causal effects. We estimate a model following Boeckx et al. (2020) such that:

$$r_{i,t+h}^{L} = a_{i,h} + \rho_h(L)Y_{t-1} + \gamma_h(L)X_{i,t-1} + \theta_h Shock_t + e_{i,t+h} \quad (2)$$

for different h. In the equation, $r_{i,t}^{L}$ is the bank lending rate for firms at different maturities L charged by bank i at time t, $a_{i,h}$ are bank-specific fixed effects (for different h); Y_t is the vector of macroeconomic control variables; and $X_{i,t}$ is the vector of bank-specific control variables. $Shock_t$ is a proxy variable for monetary policy shock (we use three shocks: a policy rate shock, a (T)LTRO shock and a QE shock).[20] Following the application of local projections by Boeckx et al. (2020) to similar data, we assume the

[17] The idea here is that expectations about key macroeconomic variables affect both policy and bank lending choices. Regressions that ignore these expectations suffer from an omitted variable problem and biased estimates. Adding macroeconomic forecasts as control variables allows us to study the variation in the shadow policy rate for a given macroeconomic outlook, i.e. detect deviations from the policy rule that can be interpreted as monetary policy shocks. A more detailed discussion of this approach is provided by Bluedorn, Bowdler, and Koch (2017). Local projections with event-study-based policy surprises (introduced in the next subsection) provide an alternative approach to causal interpretation.

[18] Although formalized by Jordà (2005), the idea of estimating regression coefficients of a model where the left-hand-side variable is several periods ahead the right-hand-side variable is much older (e.g., Cox, 1961).

[19] Note that panel regression introduced earlier constitute a special case of local projection where only one horizon (h=0) is considered. In other words, by employing local projections we extend the standard panel regression analysis and look at different horizons instead of only one horizon.

[20] Shocks are defined in more detail in section 3.2.

number of lags in the baseline specification to be 3. The regressions are estimated using OLS. In the figures, we show 90 % confidence intervals for θ_h. The confidence intervals are calculated based on nonparametric robust covariance matrix estimator a la Driscoll and Kraay (1998).

As in the panel estimation presented in section 4.1, we control for expectations about the macroeconomic environment at the euro area level by including GDP growth, inflation, and unemployment forecasts from the Survey of Professional Forecasters (SPF), and the current environment by including normalized Eurostoxx stock return, as well as country-specific industrial production growth and unemployment rates. Bank-specific controls include liquidity, capitalization, and bank size[21]. We control for credit demand using dummy variables based on the bank lending survey. In addition, we control for the stance of monetary policy prior the shock using the EONIA and Krippner shadow rates.

Because our proxy variables for monetary policy shocks can be assumed to be exogenous, control variables are not necessary for identification. Nevertheless, adding control variables to the regression reduces the confidence intervals and helps produce more accurate estimates. In addition, adding macro controls to the model removes a potential concern that, for example, more stimulating surprises might occur when the economic situation is bad. The control variables are lagged because we do not want to control out a potential effect of monetary policy on lending rates via immediate effects on the variables used as controls (e.g. Jordà, 2005; Plagborg-Møller and Wolf, 2021). In some cases, as explained in sections 5.2.2 and 5.2.3, we add one or more contemporaneous policy surprises as control variables to disentangle different types of monetary policies from each other. For example, when studying asset purchases via surprise change in the long-term rate, we add a 1-week rate surprise as a control variable because the long-term rate may be affected by contemporaneous short-term rate surprises.

5. Results

This section presents our results. Section 5.1. starts with panel estimations where the main explanatory variable of interest is the shadow rate used to account for the overall monetary policy stance. Section 5.2. moves to local projections and monetary policy shocks, presenting the results for three different monetary policy measures separately (policy interest rate, (T)LTROs, and asset purchase programmes).

[21] Central bank deposits and the amount of longer-term funding from central banks are omitted here as bank-specific controls because they are used as interactions with monetary policy shock variables when assessing the impact of bank heterogeneity in Sections 5.2.1. and 5.2.2.

5.1. Overall monetary policy stance

We start our estimations with panel regressions as described in section 4.1. Our explanatory variable of interest is the lagged value of the Krippner shadow rate. Table 3 presents the results. We look at four sets of results for three different subperiods. We estimate what happens to bank corporate lending rates when there is a change in the shadow rate, for 1) the observation period of positive policy rates (January 2010–May 2014), 2) the period of negative policy rates (June 2014–December 2015), and 3) the low-for-long period (January 2016– December 2020). For each period, we look at four different corporate lending rates. The first column in each subperiod presents the results for the overall corporate lending rate, a weighted average of all new corporate loans of different maturities. The second column focuses on corporate lending rates of short maturities up to 1 year, the third one present results for corporate lending rates of medium-term maturities (1–5 years) and the fourth column reports the results for corporate lending rates of long-term maturities (over 5 years).

Three results stand out. First, the coefficient for the Krippner shadow rate is positive and statistically significant when looking at the estimations for the positive policy rate period for each corporate lending rate. As the monetary policy stance became more accommodative, banks lowered their lending rates for non-financial corporations. Thus, the pass-through to bank lending rates was working as suggested by e.g. Albertazzi et al. (2021). We further note that the size of the estimated coefficient for Krippner concerning the loan rates of new corporate loans of short maturities is about three times lower than the coefficient concerning long maturities. Following a one unit decrease in the Krippner shadow rate we observe a 10-basis-point drop in the corporate lending rates of short maturities and a 36-basis-point drop for loans of long maturity.

Second, we see that the estimated coefficients of the shadow rate stay positive during the period of negative policy rates. However, they are no longer statistically significant and are much smaller in size. This indicates that the transmission of monetary policy is clearly hampered as policy rates fall below zero. This result is in line with earlier studies in that the pass-through of policy rates to bank lending rates becomes less straightforward after negative policy rates are introduced (e.g. Borio et al., 2017; Claessens et al., 2018).

Third, the coefficients change again when we examine the low-for-long period. For the weighted average of all corporate loans and separately for loans of short maturities, the coefficient of the shadow rate is negative and statistically significant (stronger for corporate loans of short maturities). This suggests that after banks started to perceive the negative rate environment as a long-lasting phenomenon, the transmission of monetary policy reached its reversal rate. This is in line with the conclusion of Balloch et al. (2022), who argue that the effectiveness of negative rates may wane or reverse as rates become more negative or remain negative over longer time periods. As monetary policy became more accommodative, banks increased their corporate lending rates, particularly for loans of shorter maturities. For corporate loans of medium maturities, the coefficient remains positive, although very close to zero and it fails to be statistically significant. For the new corporate loans of the longest maturity group, we still observe a positive and statistically significant coefficient, although it is clearly smaller than the corresponding coefficient for the other time spans.[22] To sum up, during the low-for-long period, following a one unit decrease in the Krippner shadow rate we observe a 4-basis-point increase in the lending rate of short-term corporate loans and a 6-basis-point drop in the lending rate for loans of long maturities.

As shown empirically by Gambacorta (2009) and Takaoka and Takahashi (2022), monetary policy can influence risk-taking and encourage banks to replace shorter maturity loans with longer maturity loans. This shift towards longer-term loans and the following increased competition may explain why the pass-through of lower interest rates prevails for corporate loans of longer maturity. While empirical studies of the pass-through of monetary policy to bank lending rates for different loan maturities are scarce, Arce et al. (2020) observe that banks whose income is most impacted by negative interest rates have relatively more short-maturity loans on their balance sheets. This might indicate that debtors of longer maturity loans are less impacted by negative interest rates and are thus able to continue to transmit lower rates for new long-term loans. Analyzing residential mortgage loans, Schelling and Towbin (2020) find that during negative interest rates lending spreads are lowered only for long maturity loans where yields are typically higher and provide higher margins for banks.

All in all, looking at the above zero policy rate period of our sample, monetary policy transmission to bank corporate lending rates worked as expected. With the easing of monetary policy, banks lower their corporate lending rates. When policy rates turns negative, this transmission mechanism weakened. Finally, when negative policy rates become persistent, the transmission mechanism reverses, particularly for corporate loans of short maturities. We find evidence for profitability channel: as banks realize that their profitability is challenged long-term during the low-for-long period, they stop passing policy-induced rate cuts and even raise lending rates to their corporate customers especially for short-term loans. Throughout our estimations, we find that monetary policy transmission is each time stronger and more efficient for corporate loans of longer maturities.

Overall, these results provide us with the big picture concerning the transmission of monetary policy to corporate lending rates in the euro area. We next move to investigate the role of different monetary policy instruments and dynamics of these effects.

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[22] Although Equation (1) controls for bank specific loan demand, this might be insufficient to clean out certain confounding effects if for example loan demand changes are firm specific or even bank-firm specific. To reassure our results and to help rule out a demand story, we re-estimate our panel regressions using monthly volume of bank credit as the dependent variable (year-on-year change of outstanding corporate loans). The results indicate that during the low-for-long period, any additional decrease of the Krippner shadow rate was followed by banks reducing the amount of corporate lending, so the coefficients are positive and statistically significant, and stronger for shorter maturities. For the other subperiods we observe negative coefficients, although they remain statistically insignificant. Results are not presented here but are available upon request.

5.2. Individual monetary policy measures

5.2.1 Policy interest rate

After looking at the effect of the overall monetary policy stance on bank corporate lending rates for various time spans, we now aim to analyze whether there are differences in the effects of specific monetary policy tools used by ECB.[23] Such differences are crucial from a policy standpoint. We start with the conventional tool, the short-term policy rate. As discussed in section 4.2., this is proxied by a 1-week OIS rate shock.[24] Figure 6 shows the local projection results for 12-month horizons for the overall corporate loan rate and three different maturities. Time span is 2010-2020 and the monetary policy shock is proxied by the 1-week rate surprise. The results suggest that (unexpected) short-term rate changes transmit to bank lending rates approximately one-to-one. There are minor variations for bank loans of different maturities; transmission seems stronger for loans of longer maturities, while confidence intervals clearly overlap.

Once policy rates fall below zero, things change. The results in Figure 7 suggest that the pass-through of policy rate changes to bank lending rates was impaired below zero as policy rate changes no longer had the same impact on bank lending rates. Note that in this particular exercise we utilize both positive and negative short-term rate surprises during the period of negative rates. Even though rates were not raised after 2014, market participants at times anticipated more aggressive rate cuts than what was actually decided at ECB policy meetings (i.e. contractionary rate surprises). Using just the negative rate surprises for this negative-period subsample, the results already provide evidence of the reversal rate (see Appendix, Figure A2), i.e. unexpected negative rate cuts compelled banks to raise their lending rates.

As negative rates become a more persisting phenomenon, we again see changes in the estimated coefficients. Figure 8 presents the results of local projection regressions estimated using only the low-for-long period subsample, which runs from 2016 to 2020.[25] We see some horizons with negative and statistically significant coefficients, suggesting the existence of the reversal rate, where additional (here unexpected) rate cuts made banks increase their corporate lending rates.

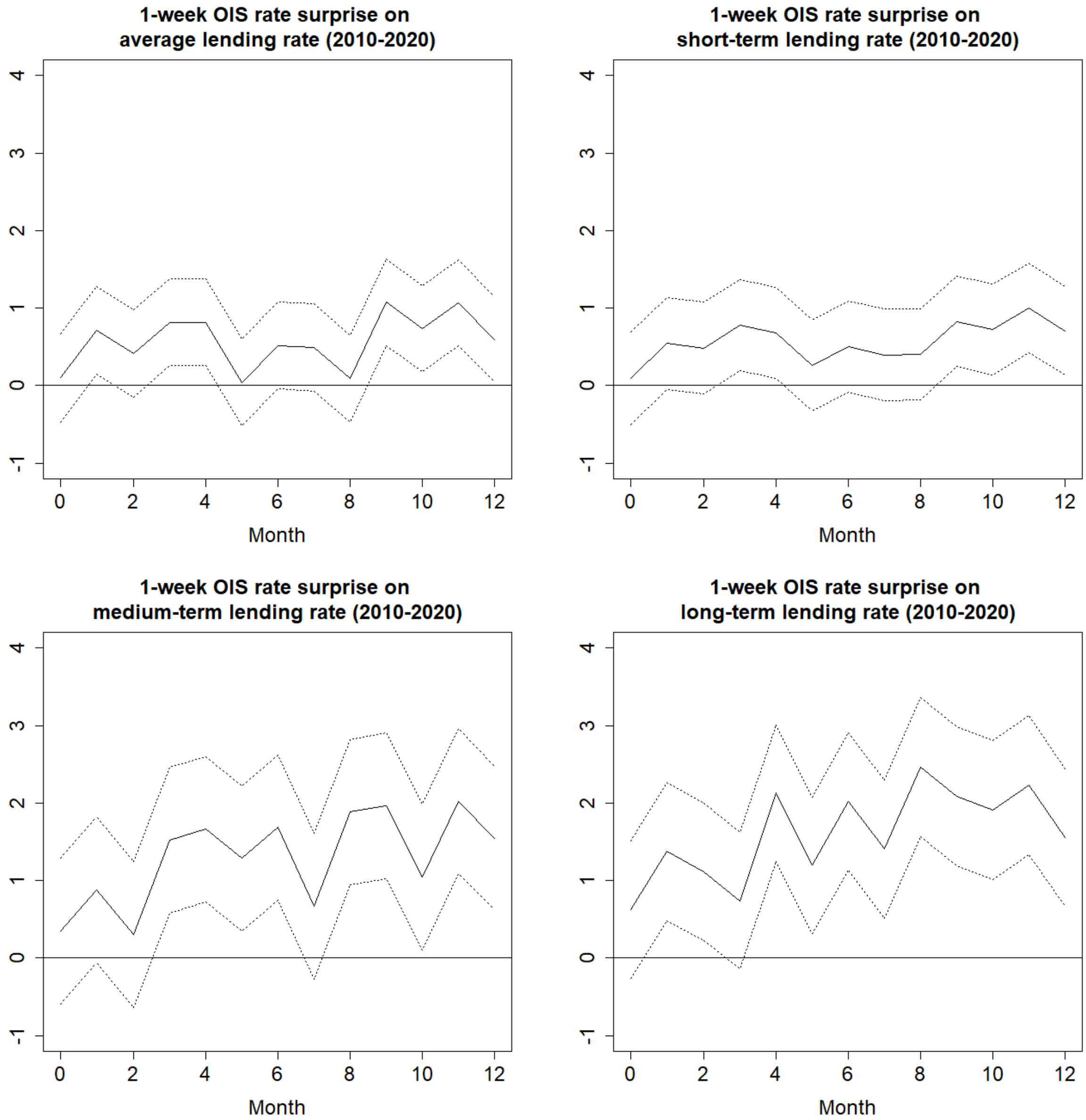
[23] We present our results using slightly different subsamples in comparison to our initial analysis: 2010-2020, 2014-2020 and 2016-2020. In other words, we use full calendar years and overlapping samples. We do this because estimating local projection impulse response functions using data only from the period June 2014 – December 2015 would be problematic due to small number of observations. Using data from this period with 3 lags and horizons 0-12 would mean that we would only look at effects of rate surprises from September 2014 to December 2014. We include the beginning of the year 2014 to our "negative rates" sample (2014-2020) because we want to make sure that surprises related to going into negative territory are included in the sample. Using surprises after June 2014 would mean that the surprises that occurred as the transformation from positive to negative rates happened during the spring 2014 would be left out from the sample. Appendix presents the results based on the alternative subsamples (rolling window analysis).

[24] We also try using 1-month rate surprise instead of 1-week rate surprise. This does not affect the results.

[25] To further validate our definition of the low-for-long period, Table A1 in Appendix provides results using rolling window approach instead of subjectively chosen subsamples. Results confirm that negative and statistically significant coefficients can only be found for time windows that incorporate at least year 2016. Time window ending in 2015 only includes positive statistically significant coefficients.

These results are in line with our initial panel estimations for the overall monetary policy stance and indicate that the reversal effect of the monetary policy stance likely originates from persistently negative short term interest rates.[26]

Figure 6. Effect of short-term rate shock for the overall corporate lending rate and three different maturities (less than 1 year, 1-5 years and over 5 years), full observation period (January 2010–December 2020). Time horizon 12 months. 90 % confidence intervals a la Driscoll and Kraay (1998) are reported.



[26] We conduct several robustness checks to our baseline specification. For example, we employ loan amount as a dependent variable. In addition, we use 6 lags instead of 3 lags. The results from these alternative specifications are in line with our baseline results.

Figure 7. Effect of short-term rate shock for the overall corporate lending rate and three different maturities (less than 1 year, 1-5 years and over 5 years), period of negative rates (January 2014–December 2020). Time horizon 12 months. 90 % confidence intervals a la Driscoll and Kraay (1998) are reported.

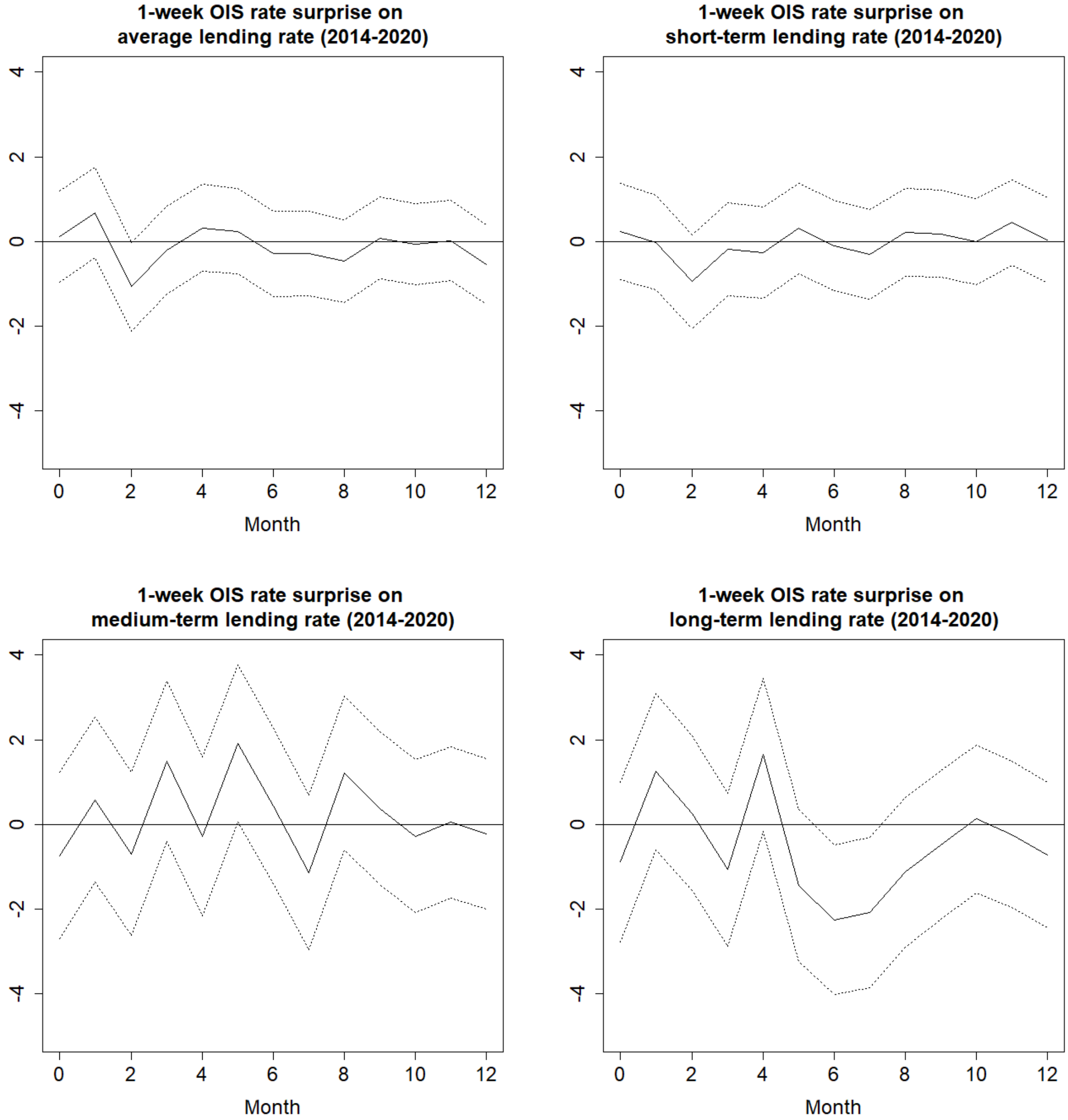
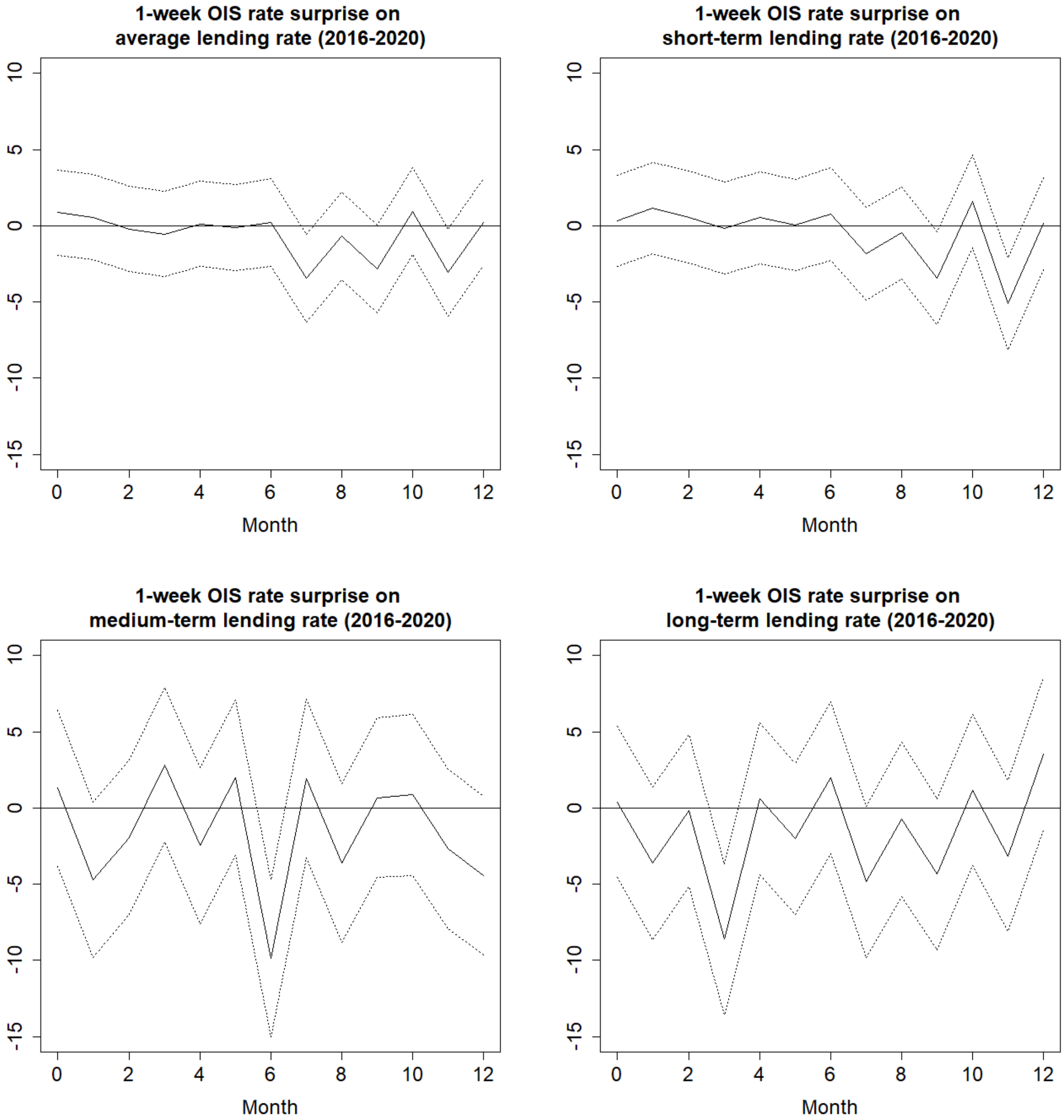


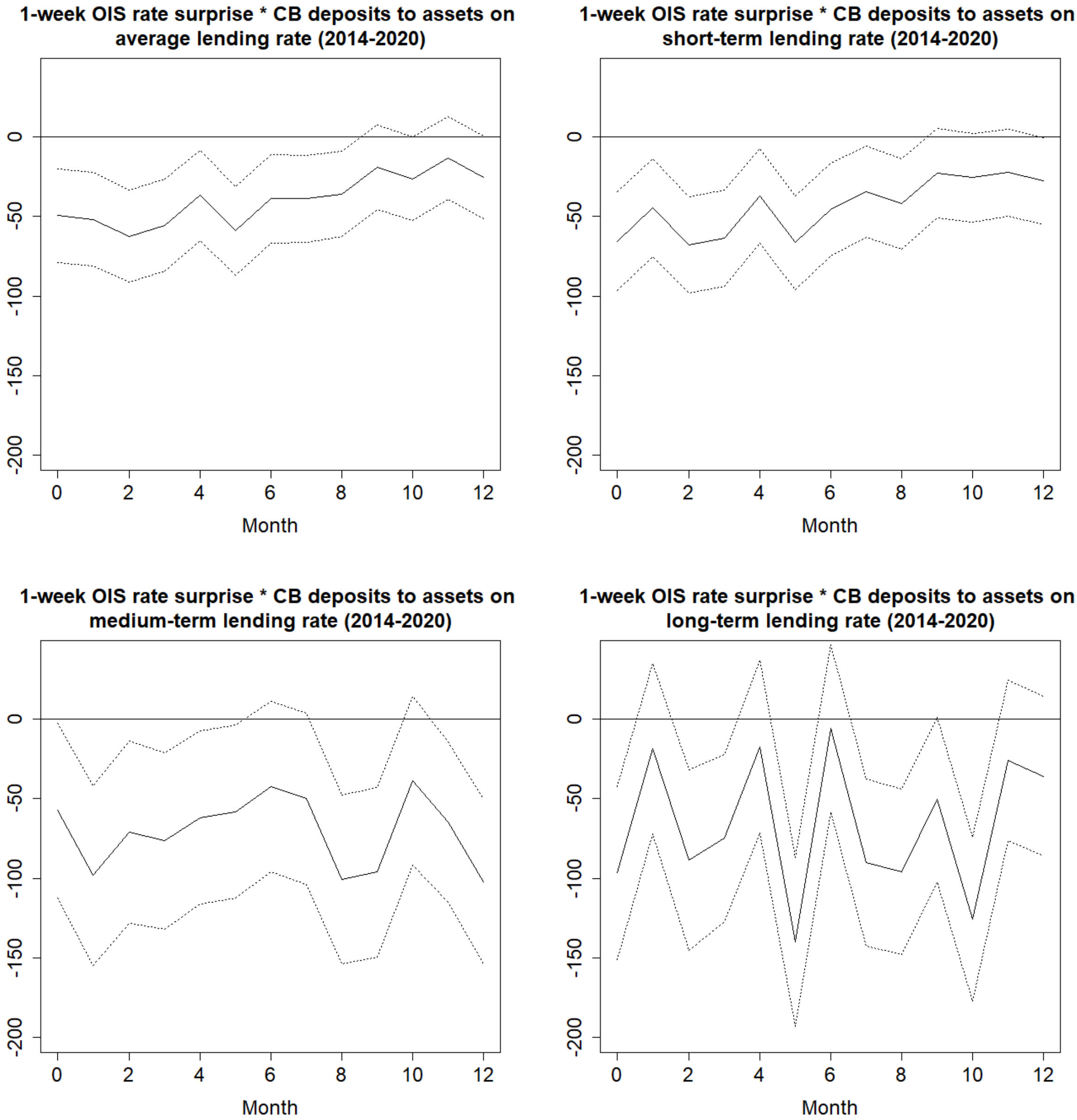
Figure 8. Effect of short-term rate shock for the overall corporate lending rate and three different maturities (less than 1 year, 1-5 years and over 5 years), low-for-long period (January 2016–December 2020). Time horizon 12 months. 90 % confidence intervals a la Driscoll and Kraay (1998) are reported.



To understand our reversal rate result better we assess if it gets stronger for the banks that are most exposed to negative rates. Following Demiralp et al. (2021) we analyze whether the banks with high share of central bank deposits behave differently from an average bank. We augment Equation (2) to include an interaction term of our shock proxy and the lagged share of central bank deposits on bank i's balance sheet. Figure 9 presents the results providing evidence that banks with more central bank deposits (i.e. bearing the additional cost of the negative central bank deposit rate) raise lending rates for their borrowers. This result corroborates the theoretical reasoning of Ulate (2021). It contradicts the findings of the empirical study of Demiralp et al. (2021), who show that the banks with high excess liquidity prior negative interest rates grant more loans after rates go below zero relative to banks with low excess liquidity, suggesting that negative interest rates boost loan growth. Unlike Demiralp et al.

(2021), we study the average effect of negative policy rates (1-week OIS effect in full sample vs. post-2014).[27]

Figure 9. Effect of short-term policy rate shock on banks with high share of central bank deposits for the overall corporate lending rate and three different maturities (less than 1 year, 1-5 years and over 5 years), period of negative rates. Time horizon 12 months. 90 % confidence intervals a la Driscoll and Kraay (1998) are reported.

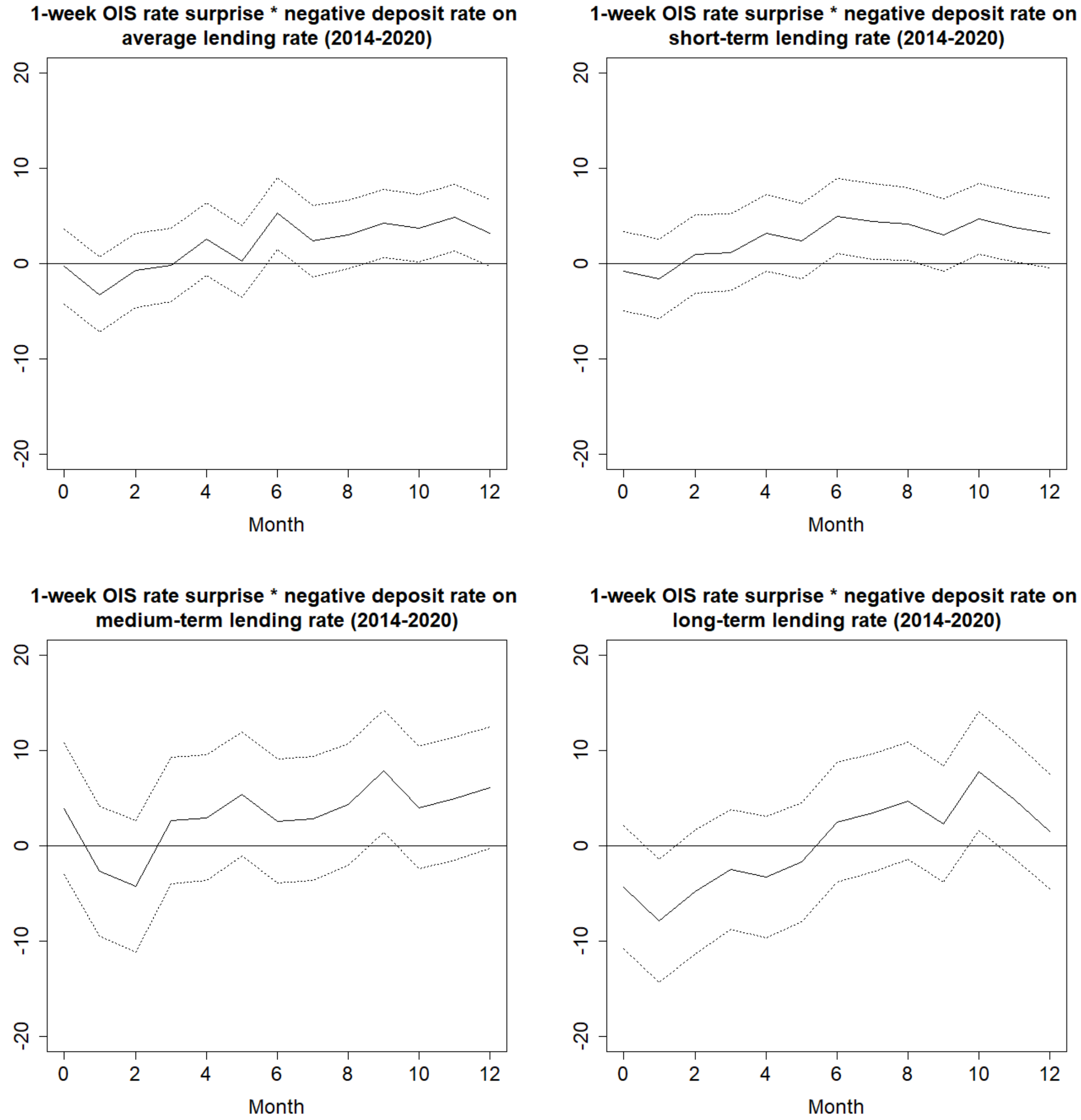


Bank heterogeneity also matters in the ability of banks to keep lowering their interest expenses as policy rates go below zero. As argued by Abadi et al. (2023) and Eggertsson et al. (2023), the key constraint preventing policy rate pass-through to bank lending rates in a below-zero environment is that some banks cannot lower their retail deposit rates into negative territory. We address this question by

[27] Discussing negative interest rate policy (NIRP), Demiralp et al. (2021) states: "For the conclusions stemming from the DiD specification in Eq. (3) regarding the role of NIRP in influencing lending behaviour to hold, it is necessary to assume that the lending of low excess liquidity (EL) banks provides an appropriate counterfactual for the lending of high EL banks in the absence of NIRP." It is possible that NIRP affects all the banks (as Figure 7 suggests).

augmenting Equation (2) with the interaction term between our short-term policy rate shock and lagged dummy variable that has a value of 1 if bank i sets at least one of its retail deposit rates negative.[28] Figure 10 reports the coefficient of this interaction term for different h.

Figure 10. Effect of short-term rate shock on banks with retail deposit rates negative for the overall corporate lending rate and three different maturities (less than 1 year, 1-5 years and over 5 years), period of negative rates. Time horizon 12 months. 90 % confidence intervals a la Driscoll and Kraay (1998) are reported.



Our results indicate that banks that manage to lower their retail deposit rates below zero are still transmitting changes in interest rates to their borrowers. This is fully in line with the reasoning of Abadi et al. (2023) and Eggertsson et al. (2023) who argue that those banks that can further decrease their interest expenses can pass on costs from changes in the short-term policy rate to their customers in the form of lower lending rates. Indeed, these results clearly demonstrate that bank heterogeneity matters

[28] The total shares of these banks in our sample is presented in Panel B of Figure 4.

for the transmission of policy rates to bank lending and may be a defining factor in whether further rate cuts below zero become contractionary.

5.2.2 (T)LTROs

Besides lowering the conventional monetary policy measure eventually below zero, the ECB introduced a variety of different unconventional monetary policy tools. In 2011, the ECB announced longer-term refinancing operations (LTROs) with a maturity of 3 years. Those operations were followed by targeted longer-term refinancing operations (TLTROs) starting in 2014. In this subsection, we study the transmission of those instruments to bank lending rates. This time, in Equation (2), (T)LTRO related policy changes are proxied by the average bank bond yield change during the days in which the ECB announced about the operations[29]. In addition, we augment the equation with contemporaneous 1-week and 10-year rate surprises to ensure that our (T)LTRO proxy is not contaminated by other monetary policy tools.

The results for the full sample are shown in Figure 11. The results suggest that these policies affect lending rates with some lag as the full effect does not materialize until after a year has passed. Following a 10-basis-point change in (T)LTRO-induced bank bond yields we observe a roughly 20-basis-point change in lending rates. As with short-term policy rates, this effect is more pronounced for lending rates of longer maturities.

Figure 12 shows the results for the period of negative rates and targeted operations. The estimated effects in this subsample are much smaller (although positive) for the weighted average corporate lending rate and the lending rate for corporate loans of short maturities. For medium and long maturities, positive and statistically significant results remain. Notably, TLTROs seem to have a slightly stronger positive effect for shorter maturities as a bank enters the low-for-long period (Figure 13). Even so, caution is warranted in interpreting these results due to the tiny number of TLTRO announcement days for these shorter subperiods. In addition, the time-varying effectiveness of TLTROs likely reflects differences in their "calibration": the first, second and third series of TLTROs differed when it comes to maturity and incentives.

[29] It should be noted that our (T)LTRO shock proxy series includes two LTRO related yield movements and all variation after 2014 is related to targeted operations.

Figure 11. Effect of (T)LTRO shock for the overall corporate lending rate and three different maturities (less than 1 year, 1-5 years and over 5 years), full observation period (January 2010–December 2020). Time horizon 12 months. 90 % confidence intervals a la Driscoll and Kraay (1998) are reported.

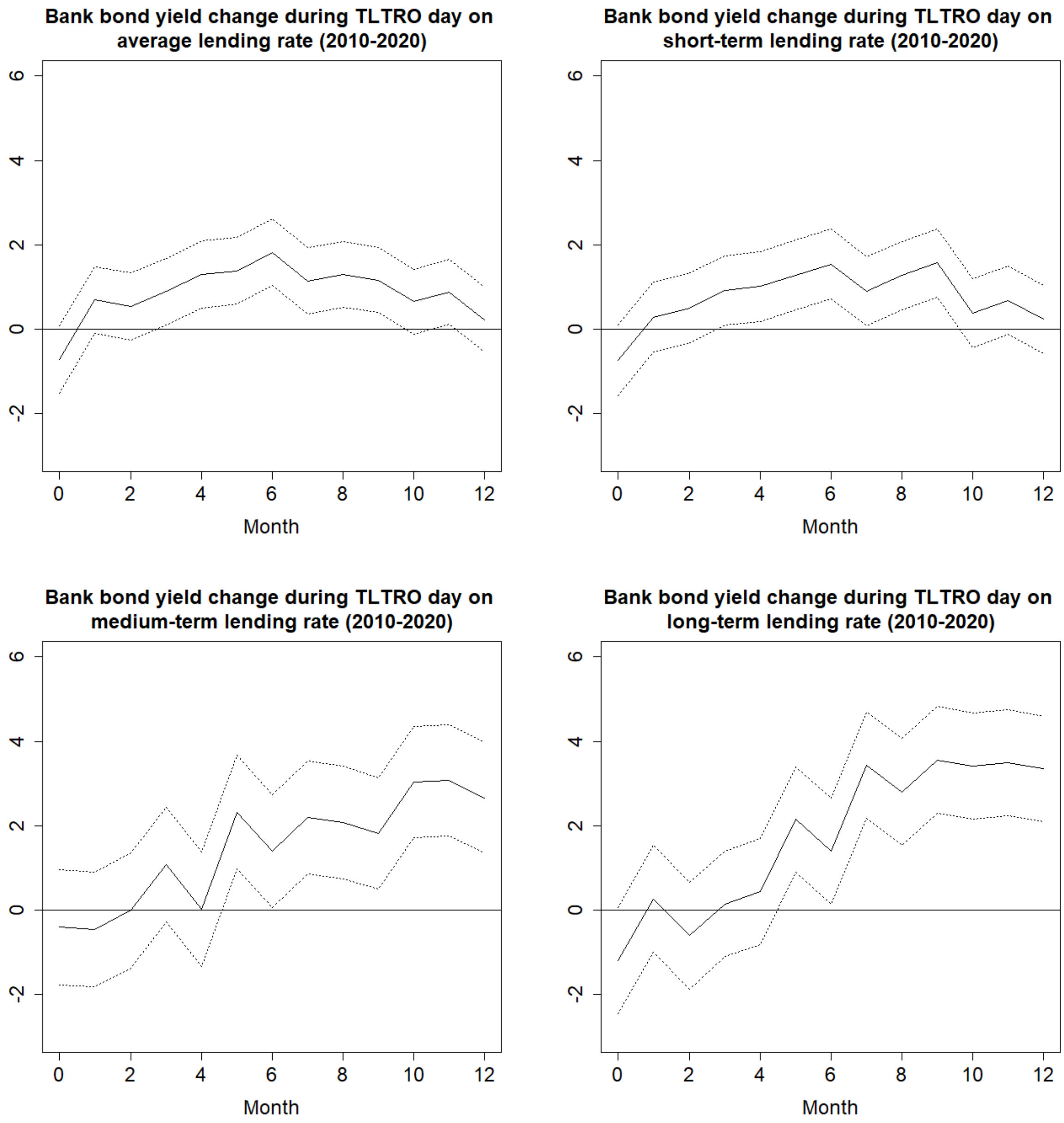


Figure 12. Effect of (T)LTRO shock for the overall corporate lending rate and three different maturities (less than 1 year, 1-5 years and over 5 years), period of negative rates (January 2014–December 2020). Time horizon 12 months. 90 % confidence intervals a la Driscoll and Kraay (1998) are reported.

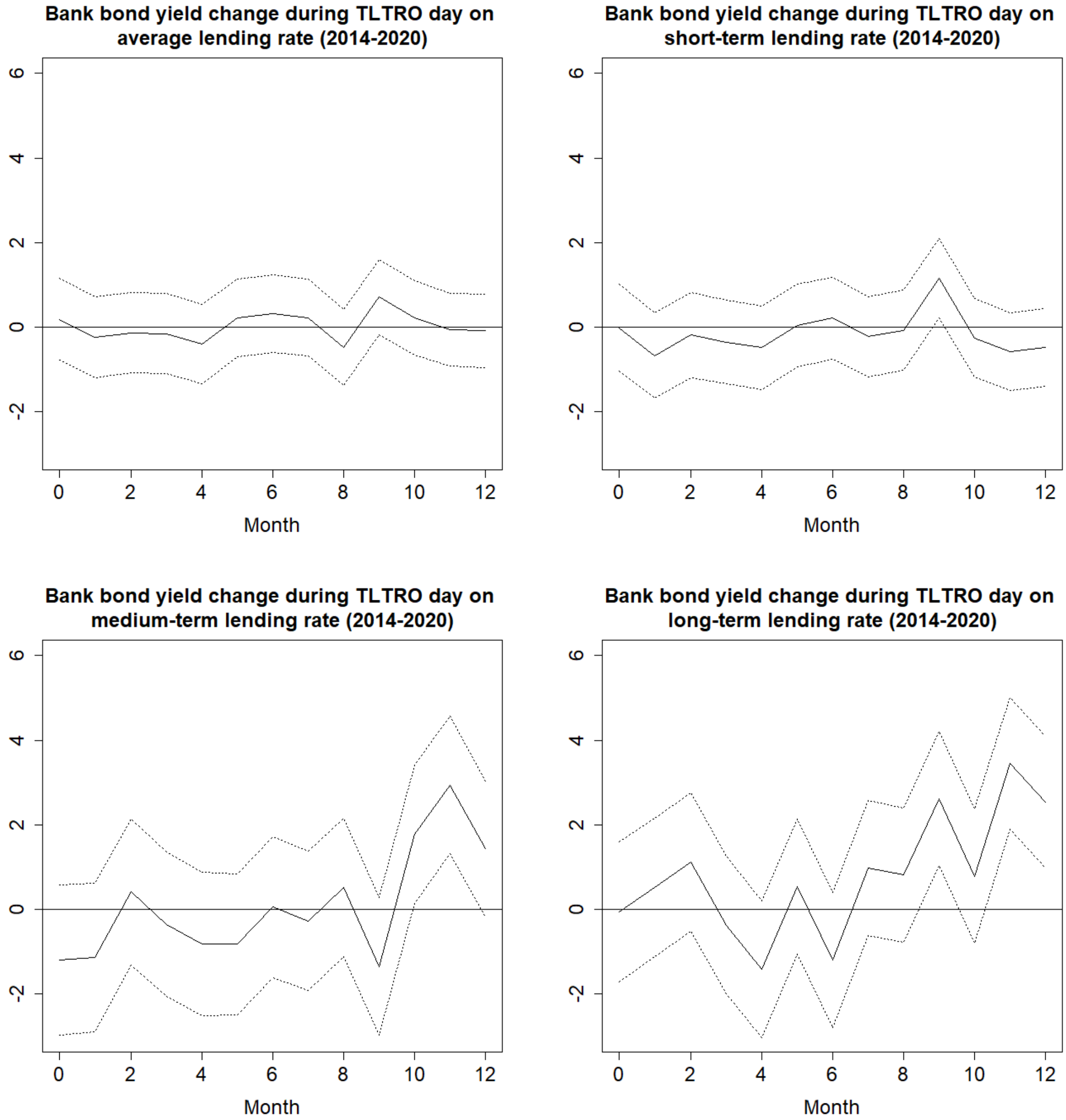
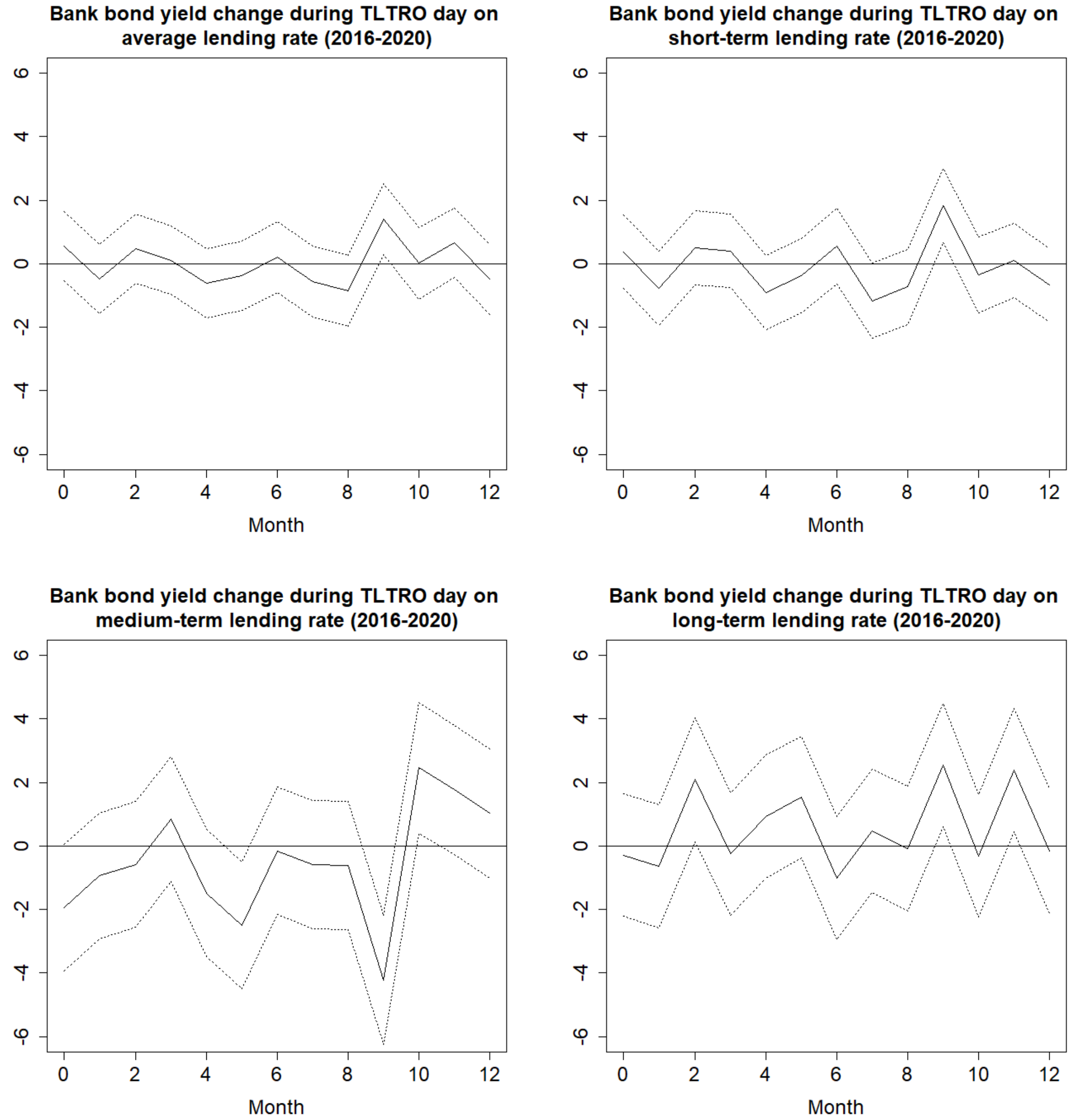


Figure 13. Effect of (T)LTRO shock for the overall corporate lending rate and three different maturities (less than 1 year, 1-5 years and over 5 years), low-for-long period (2016–2020). Time horizon 12 months. 90 % confidence intervals a la Driscoll and Kraay (1998) are reported.

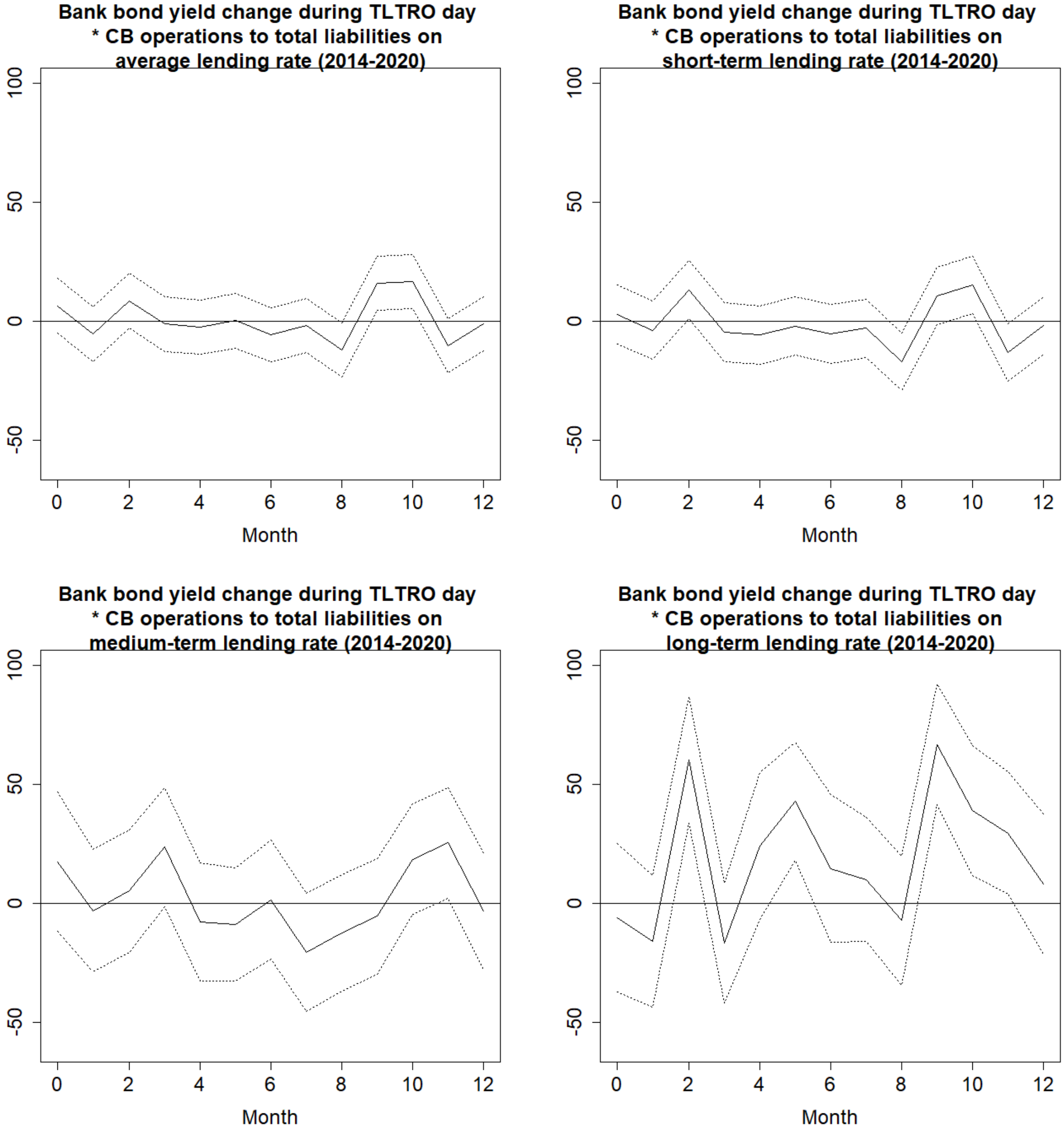


The results above assess the effect on average bank lending rates. However, one may assume that the effects are stronger for banks that participated in these operations and received more financing on favorable terms.[30] Our dataset includes an actual measure of each bank's amount of funds lent from these longer-term operations, so we can test this directly.

We augment the model by an interaction term with our (T)LTRO measure and lagged share of central bank funding on bank i's balance sheet. Figure 14 shows the results.

[30] This is in line with Gertler and Kiyotaki (2010), where an injection of liquidity from a lender of last resort relieves the bank's credit constraint, which then further alleviates liquidity shocks to the non-financial sector.

Figure 14. Effect of (T)LTRO shock on banks with high share of TLTRO loans for the overall corporate lending rate and three different maturities (less than 1 year, 1-5 years and over 5 years), period of negative rates. Time horizon 12 months. 90 % confidence intervals a la Driscoll and Kraay (1998) are reported.



We see that the interaction is positive and significant especially when it comes to loans of long maturities. The result is intuitive as the TLTROs had a built-in incentive for lending in certain time window. The banks were rewarded with a lower interest rate by the ECB if lending was increased during this relatively long monitoring period. It thus made less sense to lend short-term as the ECB only cared about the overall lending change at the end of the period.[31] We conclude that as TLTROs contributed to mitigate the pass-through of monetary policy easing to bank lending rates (even on average), this effect was stronger for banks taking on more funding directly from these operations.

[31] For example, in the case of TLTRO II launched in 2016, the potential reward to banks for lending depended on their total growth in lending (loans to firms and households, excluding lending for house purchases) from February 2016 to January 2018. Therefore, there were less incentives for lending short-term (at least immediately after the announcement).

5.2.3 Asset purchase programmes

Finally, we focus on the ECB large-scale asset purchase programmes, or QE proxied by the 10-year OIS rate shock. We include in Equation (2) the 1-week OIS rate surprise as a contemporaneous control variable. This is because as conventional monetary policy may affect long-term rates, asset purchases do not affect short-term rates contemporaneously. For QE, we only have observations starting in 2014, when ECB launched the APP package and other large-scale asset purchase programmes. The full period of 2010–2020 is thus omitted in this subsection.

Figure 15 presents the results for the period of negative rates. The results suggest that QE had no effect on the average corporate lending rates; the coefficients are statistically insignificant. However, there is evidence that QE had some positive effect on lending rates of medium and long maturity loans at short horizon. That is, as QE induced an unexpected decrease at the longer end of the yield curve, banks lowered their lending rates for loans of long maturities. This could stem from the fact that they are more likely to be closer substitutes for long-term bonds. Focusing solely on the low-for-long period (Figure 16), we find no evidence of favorable effect on lending rates.

Figure 15. Effect of QE shock for the overall corporate lending rate and three different maturities (less than 1 year, 1-5 years and over 5 years), period of negative rates (January 2014–December 2020). Time horizon 12 months. 90 % confidence intervals a la Driscoll and Kraay (1998) are reported.

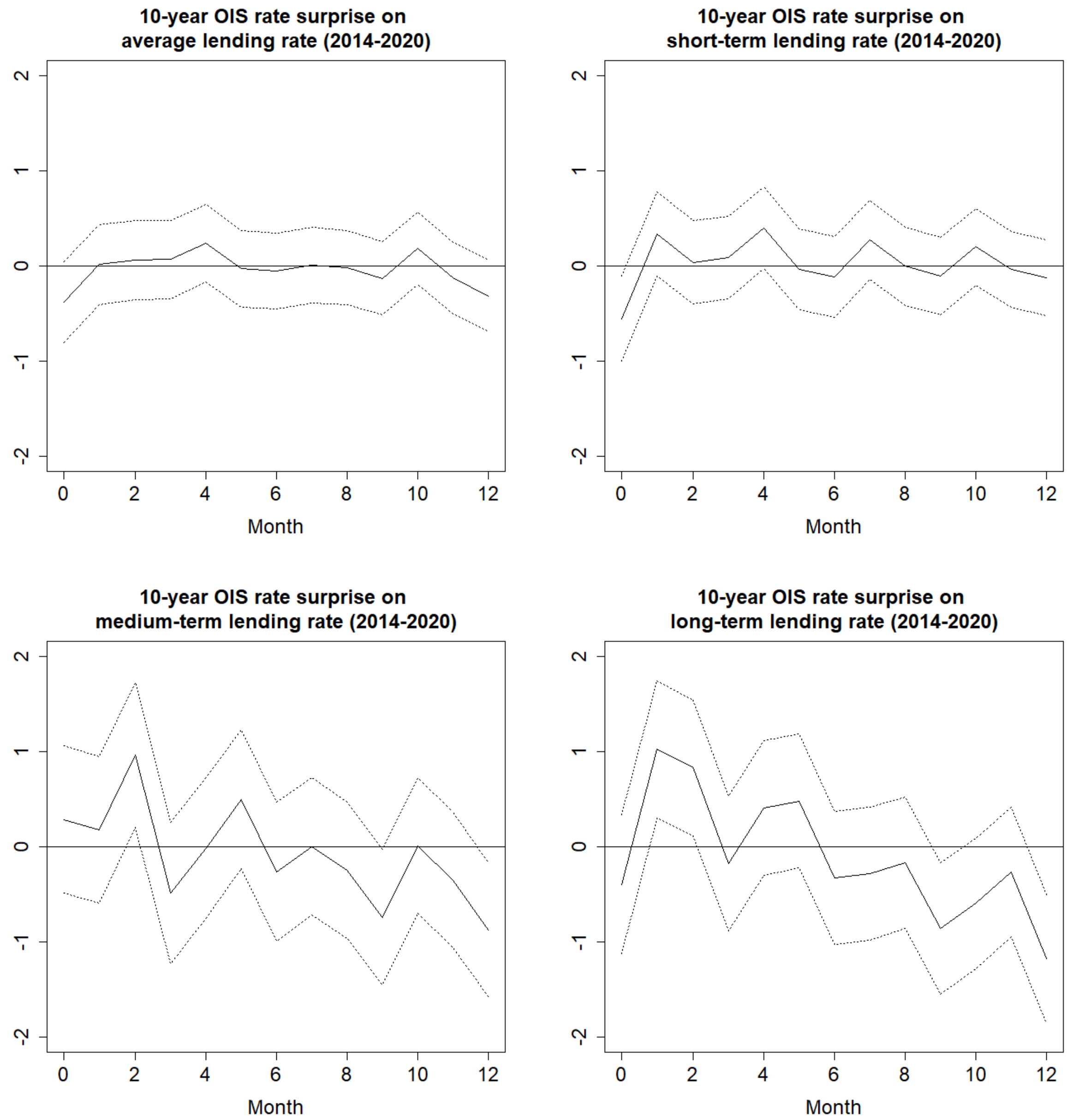
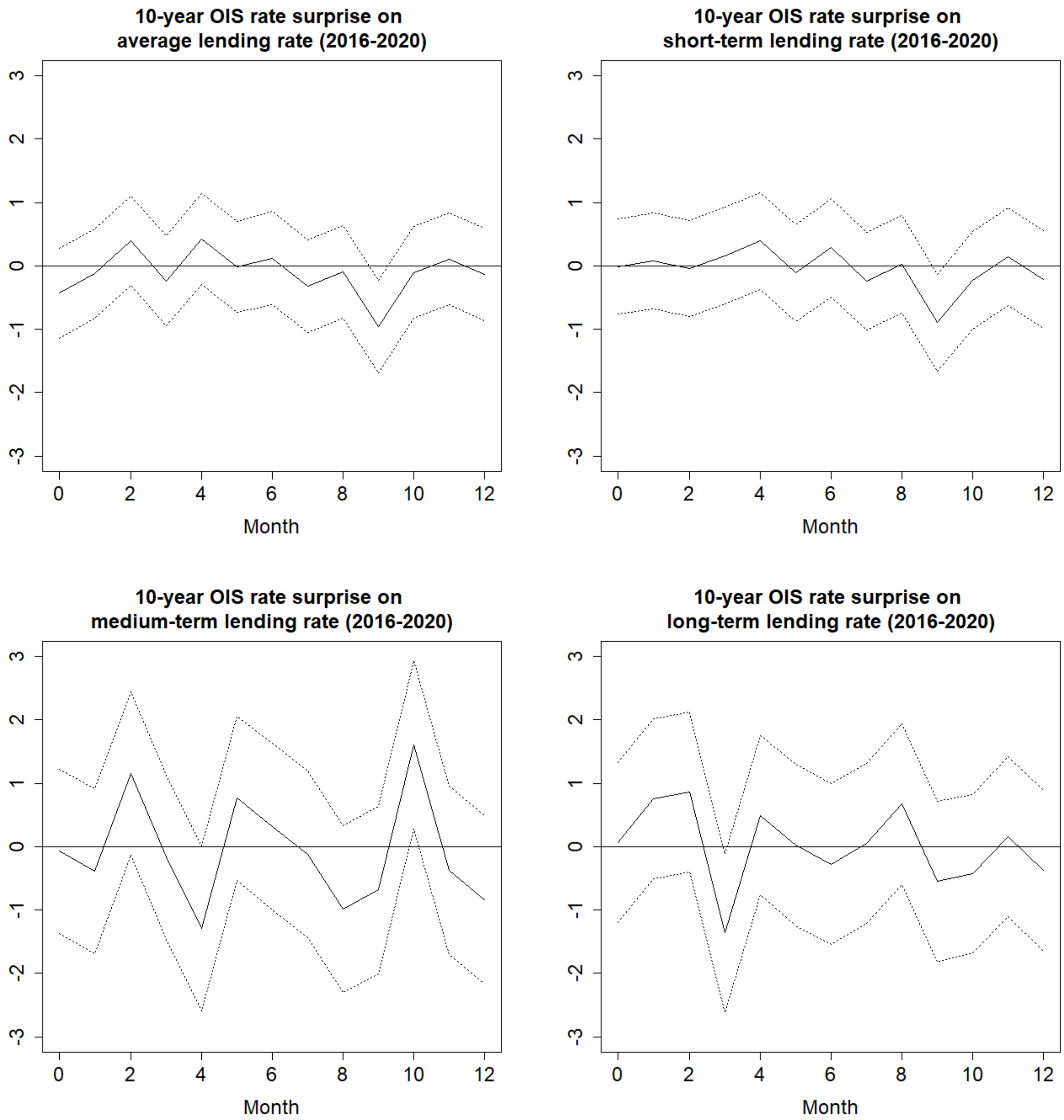


Figure 16. Effect of QE shock for the overall corporate lending rate and three different maturities (less than 1 year, 1-5 years and over 5 years), low-for-long period (January 2016–December 2020). Time horizon 12 months. 90 % confidence intervals a la Driscoll and Kraay (1998) are reported.

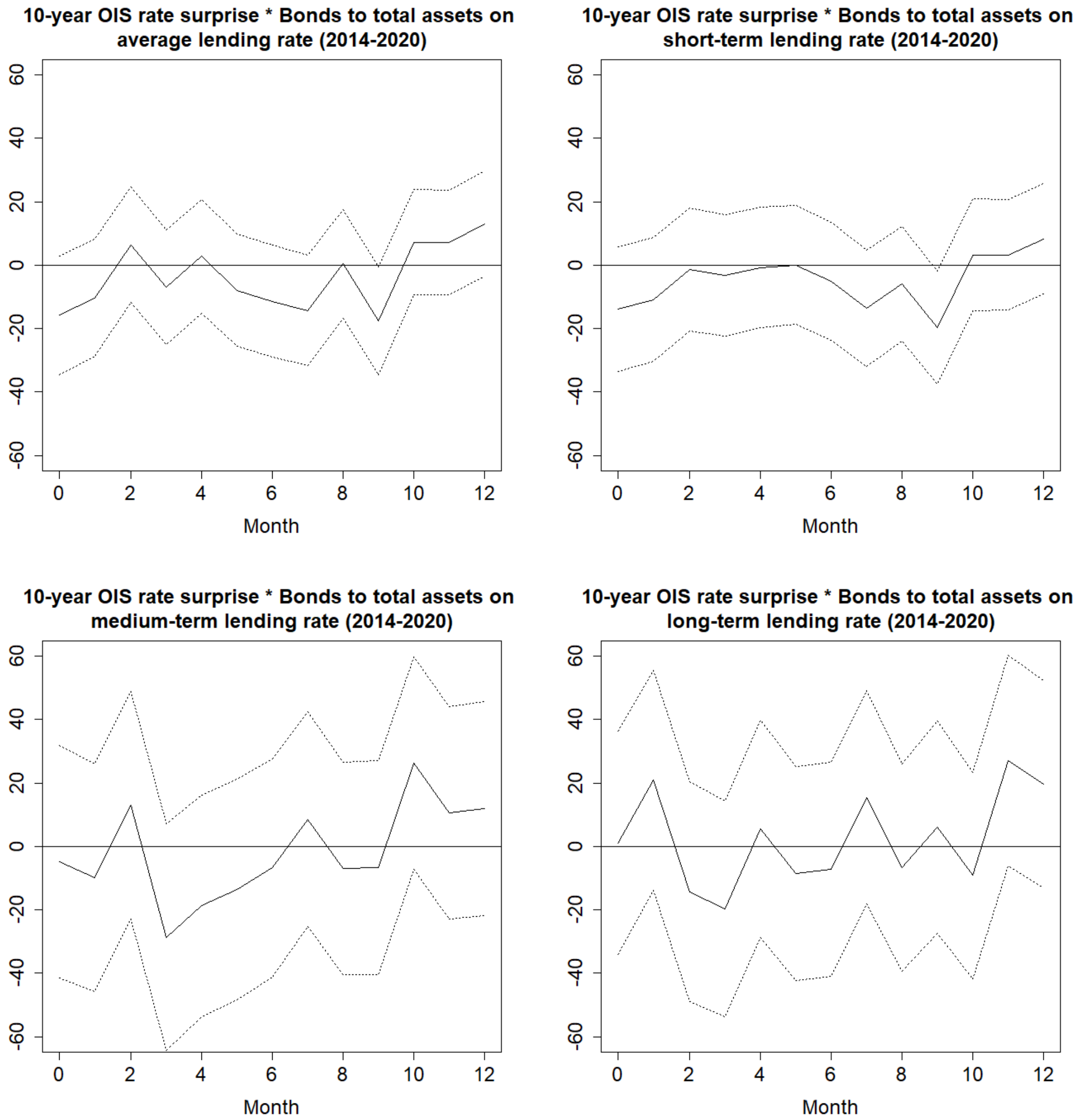


Bank heterogeneity can again affect the impact of QE. With asset purchases having a large impact on security prices, the mark-to-market value of bank security holdings increases, raising bank net worth (Brunnermeier and Sannikov, 2014). Assuming that commercial banks target somewhat constant leverage ratios, this induces banks to expand their lending (Adrian and Shin, 2010), which here would be related to lower lending rates. To account for bank heterogeneity, we use bank-level data on bond holdings.

Figure 17 shows the estimated coefficients for interaction term between 10-year rate surprise and the lagged share of bonds in bank i's total assets. Our results, however, provide no evidence that QE policies would have any stronger effect on lending rates of banks directly more exposed to bond purchases.

However, the PSPP and CBPP3 asset purchase programmes, which focus on asset-backed securities and covered bonds, are linked to loans to the private sector granted by banks – not to the bonds they are holding. Although their share is small compared to the PSPP focusing on public sector bonds, this could partly explain why banks specifically holding more bonds are not differently affected by QE shocks in our estimations.

Figure 17. Effect of QE shock on banks with high share of bond holdings for the overall corporate lending rate and three different maturities (less than 1 year, 1-5 years and over 5 years), period of negative rates. Time horizon 12 months. 90 % confidence intervals a la Driscoll and Kraay (1998) are reported.



6. Conclusion

In this paper, we study how various monetary policy measures by the ECB transmit to corporate lending rates in a negative interest rate environment. Utilizing a detail bank-level dataset covering 137 individual banks from 13 euro area countries at monthly frequency for the period from January 2010 to December 2020, we examine how the pass-through changed when policy rates turned negative in June 2014 and further after early 2016 when negative rates came to be regarded as persistent due to the ECB's revised forward guidance and additional rate cuts.

We find several noteworthy results. First, the transmission of the overall ECB monetary policy stance weakens during the period of negative rates. Second, as negative rates become more persistent during the low-for-long period, we find evidence in favor of the reversal rate. Following further monetary policy easing, banks started raising their lending rates. Third, loan maturities matter. The reversal effect of the pass-through of overall monetary policy during the low-for-long period is most pronounced for corporate loans of short maturities and stems in particular from persistently negative short-term policy rates. Fourth, bank heterogeneity plays a role. Weaker transmission is driven by banks that did not lower their own retail deposit rates below zero, as well as by the banks with more negative interest-bearing central bank deposits on their balance sheets. Fifth, even if the transmission of short-term policy rate to bank lending rates is hampered below zero, unconventional monetary policy measures – especially TLTROs – help mitigate the pass-through by lowering bank lending rates especially for loans of longer maturities.

Our analysis helps in understanding why previous empirical studies struggled to find common ground on the existence of the reversal rate. Our results confirm what previous literature suggests that its existence depends greatly on bank heterogeneity, but we also show that different loan maturities play an important role. Furthermore, by employing long enough data sample with negative rates we confirm that negative rates must first become persistent before seeking to uncover evidence of the reversal rate.

Looking to the policy implications of these findings, we can see policy rate cuts cease to have the desired effect on private-sector lending costs as period of negative rates becomes persistent. Without the mitigating effects of additional policies specifically aimed at lowering bank funding costs, further rate cuts below zero run the risk of becoming contractionary. Moreover, although reducing volatility and uncertainty about future interest rate developments, central bank signaling a low-for-long environment could bring the reversal rate forward.

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Table 1. Definitions of variables

Variable	Definition	Source
NFC lending rate	NFC loan rate weighted average (weighted average calculated using the amount of new loans provided every month)	ECB IMIR
NFC lending rate, up to 1 year	NFC loan rate for new loans up to 1 year of maturity	ECB IMIR
NFC lending rate, 1 to 5 years	NFC loan rate for new loans 1 to 5 years of maturity	ECB IMIR
NFC lending rate, over 5 years	NFC loan rate for new loans over 5 years of maturity	ECB IMIR
Krippner	euro area shadow rate by Krippner (2015)	Macrobond
Liquidity	liquid assets to total assets ratio	Bank Focus
Capitalization	equity to total assets ratio	ECB IBSI
Size	log of bank total assets	ECB IBSI
Central bank deposits	banks' monthly reserves in central bank deposit accounts	ECB confidential database
Central bank operations	banks' borrowings from the central bank targeted and non-targeted longer-term operations	ECB confidential database
Industrial production	Country specific industrial production year-on-year growth	Eurostat
Unemployment	Country specific harmonized unemployment rate	Eurostat
Stock Return	Euro area, STOXX index, total return, close (in EUR), normalized	STOXX, Macrobond
Exp.euro area inflation	expected rate of inflation in the euro area, 1st principal component of short, medium and long-term expectations	ECB Survey of Professional Forecasters
Exp.euro area unemployment	expected rate of unemployment in the euro area, 1st principal component of short, medium and long-term expectations	ECB Survey of Professional Forecasters
Exp.euro area GDP	expected rate of GDP in the euro area, 1st principal component of short, medium and long-term expectations	ECB Survey of Professional Forecasters
Demand increase	dummy for increasing NFC loan demand (equals one if a bank responded either 4 or 5)	ECB individual Bank Lending Survey
Demand decrease	dummy for decreasing NFC loan demand (equals one if a bank responded either 1 or 2)	ECB individual Bank Lending Survey

Table 2. Summary statistics

	Full time span (Jan 2010- Dec 2020)			Positive policy rates (Jan 2010- May 2014)			Negative policy rates (June 2014- Dec 2015)			Period of low-for-long (Jan 2016- Dec 2020)		
Variable	# of obs	Mean	Std.dev	# of obs	Mean	Std.dev	# of obs	Mean	Std.dev	# of obs	Mean	Std.dev
NFC lending rate	11557	2.366	1.111	4197	3.044	1.089	1865	2.355	1.005	5495	1.853	0.855
NFC lending rate, up to 1 year	11426	2.312	1.102	4121	2.936	1.118	1841	2.316	1.020	5464	1.841	0.854
NFC lending rate, 1 to 5 years	10407	2.806	1.637	3746	3.993	1.514	1653	2.734	1.358	5008	1.942	1.202
NFC lending rate, over 5 years	9880	2.995	1.614	3433	4.242	1.494	1537	2.945	1.297	4910	2.138	1.154
Krippner	13020	-1.533	1.149	4939	-0.434	0.900	2069	-1.960	0.337	6012	-2.289	0.726
Liquidity	13020	0.187	0.147	4939	0.173	0.141	2069	0.160	0.146	6012	0.207	0.150
Capitalization	12519	0.096	0.049	4562	0.088	0.048	2000	0.104	0.054	5957	0.100	0.047
Size	12519	10.780	1.487	4562	10.864	1.442	2000	10.653	1.519	5957	10.759	1.507
Central bank deposits	13020	0.013	0.031	4939	0.006	0.024	2069	0.010	0.024	6012	0.020	0.036
Central bank operations	13020	0.190	4.618	4939	0.000	0.006	2069	0.017	0.068	6012	0.404	6.790
Industrial production	13020	1.206	7.267	4939	1.664	6.053	2069	2.877	8.870	6012	0.254	7.428
Unemployment	13020	9.176	5.009	4939	10.553	5.656	2069	9.980	5.122	6012	7.769	3.908
Stock return	13020	0.037	0.971	4939	-1.031	0.426	2069	0.189	0.296	6012	0.862	0.486
Exp.euro area inflation	13020	-0.011	1.630	4939	1.440	1.102	2069	-1.476	0.835	6012	-0.698	1.256
Exp.euro area unemployment	13020	0.044	1.736	4939	1.255	1.184	2069	1.454	0.412	6012	-1.436	1.110
Exp.euro area GDP	13020	-0.023	1.188	4939	-0.933	0.435	2069	-0.109	0.314	6012	0.755	1.256
Demand increase	13020	0.175	0.380	4939	0.103	0.304	2069	0.220	0.414	6012	0.219	0.414
Demand decrease	13020	0.158	0.365	4939	0.225	0.417	2069	0.131	0.337	6012	0.112	0.316

Table 3. Panel regressions

	Positive policy rates (Jan 2010 - May 2014)				Negative policy rates (Jun 2014 - Dec 2015)				Low-for-long (Jan 2016 - Dec 2020)			
VARIABLES	all maturities	up to 1 year maturity	1-5years of maturity	over 5 years maturity	all maturities	up to 1 year maturity	1-5years of maturity	over 5 years maturity	all maturities	up to 1 year maturity	1-5years of maturity	over 5 years maturity
Krippner	**0.121*** **	**0.095*** **	**0.298*** **	**0.357*** **	**0.007**	**0.026**	**0.117**	**0.109**	**-0.026***	**-0.036** **	**0.002**	**0.058** **
	(0.025)	**(0.027)**	**(0.045)**	**(0.046)**	**(0.045)**	**(0.047)**	**(0.088)**	**(0.079)**	**(0.014)**	**(0.014)**	**(0.024)**	**(0.025)**
Liquidity	-0.916***	-1.006***	-0.854***	-0.148	-0.074	0.062	-0.612	-0.410	-0.568***	-0.530***	0.357	0.768***
	(0.155)	(0.164)	(0.285)	(0.294)	(0.407)	(0.455)	(0.834)	(0.577)	(0.129)	(0.132)	(0.260)	(0.275)
Capitalization	6.308***	6.302***	1.534	5.579**	-2.959*	-3.870**	-13.451***	-1.511	1.064**	1.496***	1.601	2.431**
	(0.798)	(0.783)	(1.868)	(2.249)	(1.712)	(1.633)	(3.269)	(4.310)	(0.480)	(0.498)	(1.032)	(0.977)
Size	0.341**	0.332**	-0.090	0.257*	0.277	0.122	0.653	0.987	0.216***	0.241***	-0.410**	0.417*
	(0.137)	(0.145)	(0.135)	(0.151)	(0.359)	(0.339)	(0.571)	(0.730)	(0.075)	(0.076)	(0.178)	(0.216)
Central bank deposits	2.288***	1.952**	3.695***	4.250***	1.810**	1.939**	-0.250	-1.243	0.476	0.254	-1.714*	-4.303***
	(0.833)	(0.861)	(1.311)	(1.442)	(0.875)	(0.885)	(1.947)	(2.599)	(0.444)	(0.477)	(0.901)	(0.841)
Central bank operations					0.531**	0.293	0.896	1.347*	-0.002	0.001***	0.198***	-0.008
					(0.238)	(0.228)	(0.729)	(0.744)	(0.005)	(0.000)	(0.074)	(0.006)
Industrial production	-0.012***	-0.013***	-0.025***	-0.016***	0.019***	0.017***	0.006	-0.001	0.005***	0.003**	0.005**	0.010***
	(0.003)	(0.003)	(0.006)	(0.005)	(0.006)	(0.005)	(0.008)	(0.009)	(0.001)	(0.001)	(0.002)	(0.002)
Unemployment rate	0.197***	0.198***	0.222***	0.169***	0.198***	0.209***	0.165***	0.196***	0.075***	0.088***	0.042***	0.071***
	(0.010)	(0.010)	(0.018)	(0.018)	(0.027)	(0.026)	(0.052)	(0.060)	(0.008)	(0.009)	(0.014)	(0.016)
Exp. euro area unemployment	-0.222***	-0.219***	-0.195***	-0.176***	0.512***	0.502***	0.804***	0.812***	-0.000	-0.004	-0.025	0.007
	(0.022)	(0.023)	(0.040)	(0.039)	(0.061)	(0.060)	(0.129)	(0.123)	(0.012)	(0.012)	(0.021)	(0.019)
Exp. euro area inflation	-0.019	-0.012	-0.000	-0.051**	0.084***	0.092***	0.177***	0.184***	0.027**	0.021*	-0.017	0.047**
	(0.014)	(0.014)	(0.024)	(0.023)	(0.018)	(0.018)	(0.035)	(0.039)	(0.011)	(0.012)	(0.019)	(0.019)
Exp. euro area GDP	0.025	0.095**	-0.083	-0.256***	0.179**	0.150*	0.137	0.148	-0.021***	-0.023***	-0.019	-0.022*
	(0.043)	(0.044)	(0.076)	(0.076)	(0.086)	(0.082)	(0.167)	(0.162)	(0.007)	(0.007)	(0.013)	(0.012)
Stock Return	-0.167***	-0.210***	-0.130*	0.020	-0.023	-0.003	-0.082	-0.093	-0.052**	-0.028	-0.144***	-0.155***
	(0.046)	(0.048)	(0.078)	(0.074)	(0.065)	(0.066)	(0.128)	(0.127)	(0.021)	(0.022)	(0.040)	(0.036)
Demand increase	-0.062**	-0.062*	0.022	-0.096*	-0.011	0.006	-0.166**	-0.048	-0.015	0.008	-0.091***	-0.024
	(0.031)	(0.033)	(0.058)	(0.054)	(0.037)	(0.036)	(0.069)	(0.072)	(0.013)	(0.015)	(0.026)	(0.028)
Demand decrease	-0.048*	-0.047*	0.020	0.026	-0.014	-0.011	-0.079	0.037	0.009	-0.004	0.076**	0.103***
	(0.026)	(0.026)	(0.043)	(0.042)	(0.034)	(0.030)	(0.065)	(0.067)	(0.016)	(0.018)	(0.036)	(0.035)
Constant	-3.060**	-2.995**	3.332**	-0.705	-2.910	-1.290	-5.297	-9.859	-1.291	-1.801**	5.345***	-2.860
	(1.434)	(1.515)	(1.413)	(1.585)	(3.752)	(3.555)	(5.946)	(7.596)	(0.786)	(0.794)	(1.850)	(2.271)
# of observations	3,992	3,925	3,569	3,261	1,859	1,835	1,649	1,534	5,513	5,482	5,027	4,929
R-squared	0.768	0.767	0.671	0.717	0.821	0.824	0.661	0.662	0.812	0.788	0.706	0.713

This table shows the results of fixed effects panel regressions as indicated in Equation (1). The dependent variable is the average interest rate on new corporate loans for short, medium, and long maturity as well as all maturities together. We report results for all maturities in separately for three different time spans. First period is the time of positive policy rates (January 2010 - May 2014). Second is the period of negative policy rates (June 2014-December 2015). Third period is the low-for-long period (January 2016-December 2020). Monetary policy stance is measured by the lagged value of Krippner shadow rate (*Krippner). Liquidity* is the ratio of liquid to total assets. *Capitalization* is the ratio of capital and reserves to total assets. *Size* is the log of bank's total assets. *Central bank deposits* is the ratio of bank's central bank deposits to total assets. *Central bank operations* is the share of borrowed loans from central bank longer term operations to the outstanding amount of bank loans to the private sector. Bank specific variables are lagged by one month. *Industrial production* and *unemployment rate* are country specific indicators controlling for the macroeconomic development in each country. They are used as year-on-year growth rates. *Exp.euro area unemployment*, *Exp. euro area inflation* and *Exp.euro area GDP* are euro area wide forecasts from the Survey of Professional Forecasters (SPF). *Stock return* stands for normalized stock returns from Eurostoxx. All euro area and country variables are lagged by one month. *Demand increase* and *Demand decrease* are dummy variables describing bank-specific demand for loans lagged by three months. Standard errors clustered at bank level appear in brackets below estimated coefficients.*, **, *** denote an estimate significantly different from 0 at the 10%, 5% and 1% level, respectively.

Appendix

Figure A1. Representativeness of our sample

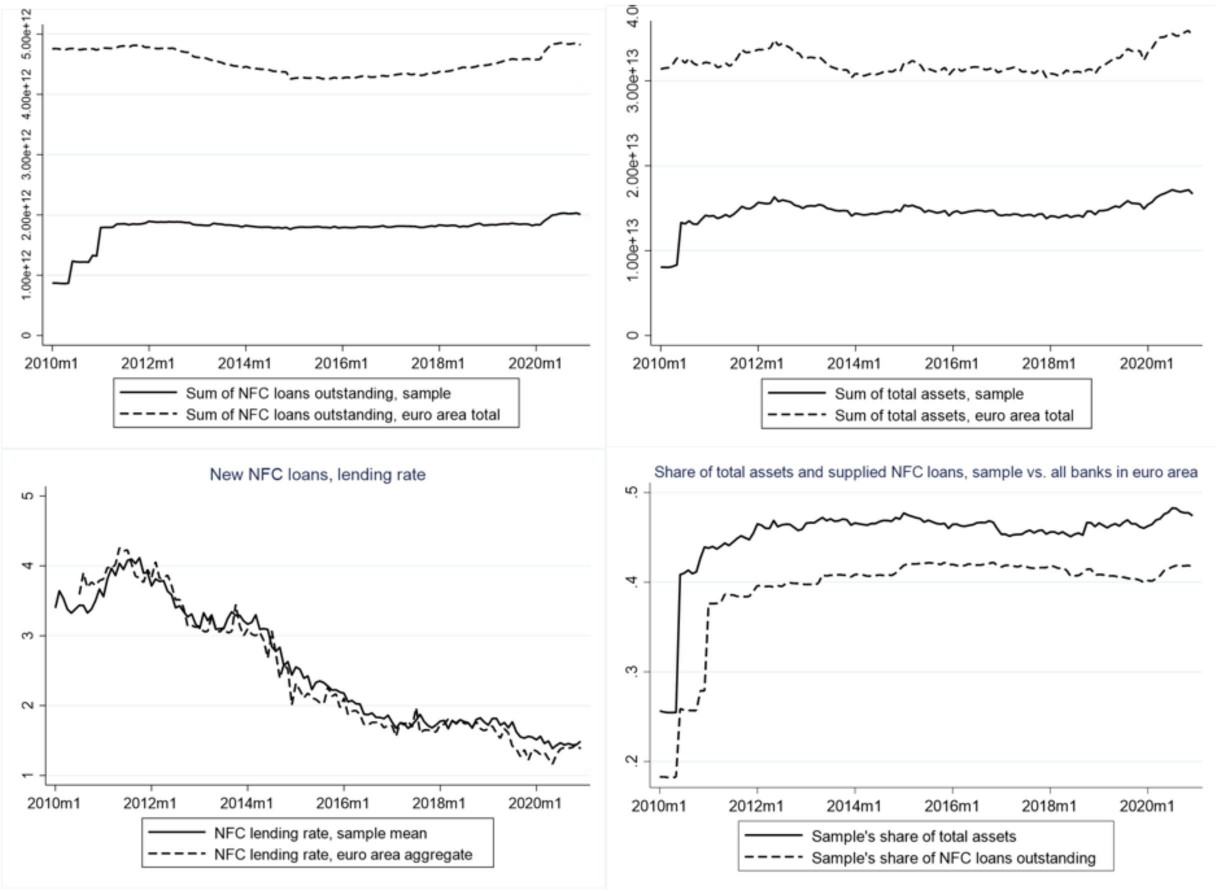

Figure A2. Results regarding the short-term rate surprise for the negative rates sample (2014–2020) when only negative rate surprises are considered. The results show that rate cut surprises in the below zero environment increase lending rates. Note that the figure reports regression coefficients as such (not multiplied by -1).

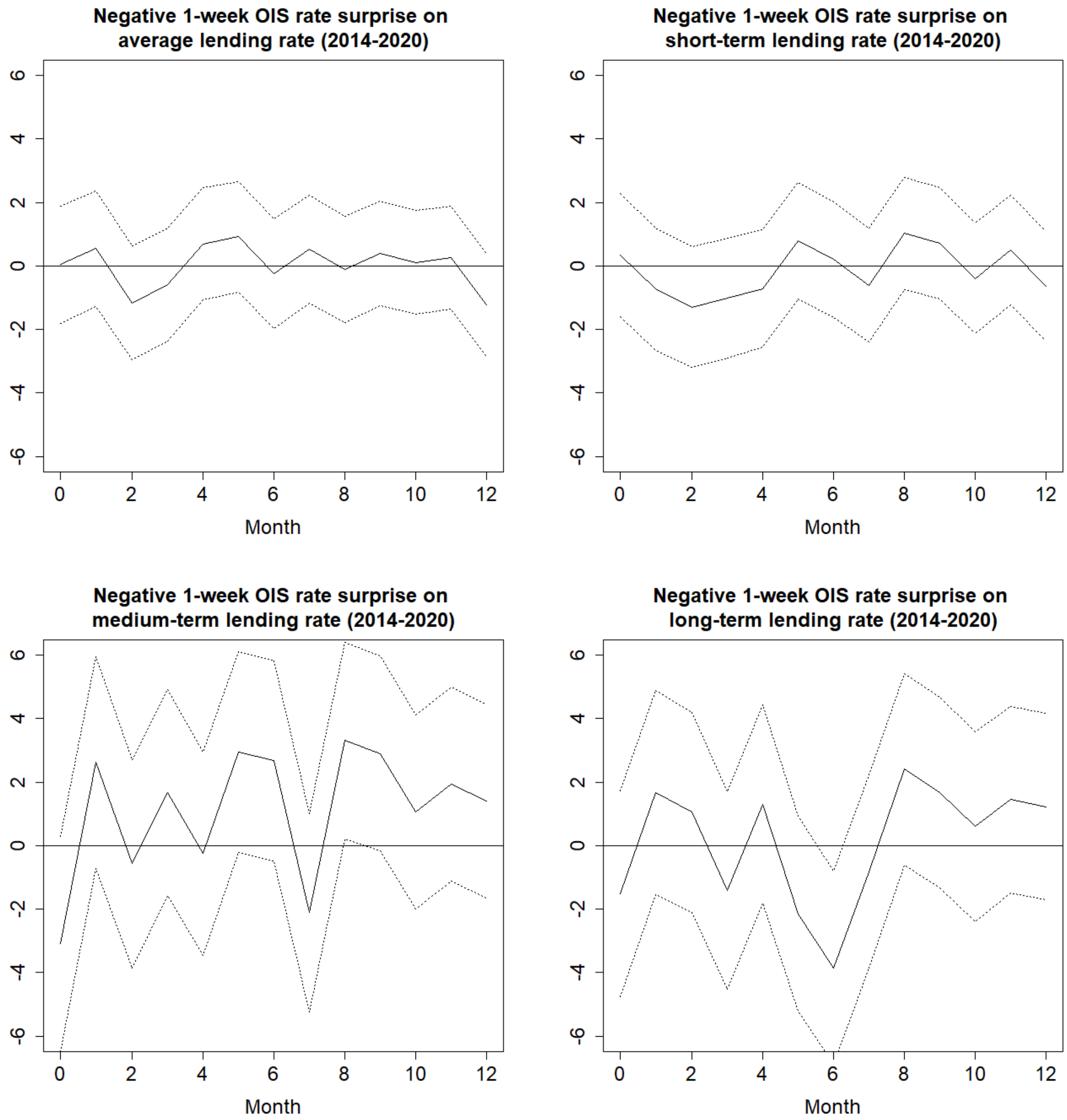

Table A1. Rolling window results. Monetary policy is measured using 1-week OIS surprise. Endogenous variable is average lending rate.

Horizon / Subsample	2010-2014	2011-2015	2012-2016	2013-2017	2014-2018	2015-2019	2016-2020
0	0,01	0,07	0,63	1,03	0,13	0,11	0,86
1	0,15	0,44	1,60***	1,68***	1,28***	1,37*	0,56
2	0,01	0,34	0,54	-0,35	-1,58***	-1,04**	-0,23
3	0,65**	0,67**	1,25**	0,46	-0,09	-0,89	-0,55
4	0,28	0,43	0,53	0,25	0,03	-0,15	0,12
5	-0,34	-0,35	0,50	0,87	1,03**	-1,67**	-0,13
6	0,34	0,13	0,05	-0,28	-0,56	-0,66	0,23
7	0,40	-0,02	-0,36	-0,40	0,25	-1,00*	-3,43***
8	-0,15	-0,56	-0,78	-0,96**	-0,66**	-0,31	-0,69
9	1,10**	0,22	-0,95***	-0,87*	0,53	0,31	-2,85
10	0,42	-0,34	-1,08***	-0,73	-0,22	0,79	0,96
11	0,70	0,04	0,33	0,21	0,47	-0,06	-3,07**
12	0,13	-0,52	-1,28***	-0,62	-0,81	1,25	0,21

The models include our standard set of control variables that are used in all the local projection analyses: GDP growth, inflation, and unemployment forecasts from Survey of Professional Forecasters (SPF) to control for expectations about the macroeconomic environment, as well as growth in industrial production, the unemployment rate, and Eurostoxx stock return to control for the current environment. Bank-specific controls include liquidity, capitalization, and bank size. We control for credit demand using dummy variables based on the bank lending survey. In addition, we control for the stance of monetary policy prior the shock using the EONIA and Krippner shadow rates. 3 lags of each control variables are included. The standard errors are calculated based on nonparametric robust covariance matrix estimator a la Driscoll and Kraay (1998). *, **, *** denote an estimate significantly different from 0 at the 10%, 5% and 1% level, respectively.