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Monetary policy transmission below zero

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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 corporate loans with short maturities. The effect is most pronounced for banks that did not lower their own retail deposit rates below zero or held significant amounts of negative interest-bearing central bank deposits. We see a 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 (TLTROs) and quantitative easing (QE) appear to have mitigated these contractionary effects, even during the low-for-long period. In our examination of below-zero policy tools, we provide evidence that negative policy rates and TLTROs complement each other, while negative policy rates and QE do not.

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).

The era of negative policy rates diversified the policy toolboxes of central banks. The ECB turned to large-scale asset purchases under the mantle of quantitative easing (QE), as well as targeted and non-targeted longer-term refinancing operations (TLTROs and LTROs).[1] These unconventional monetary policy tools were used to further ease financial conditions as the policy rate fell to its effective lower bound.

The introduction of negative policy rates also means that the pass-through to bank lending rates becomes less straightforward. Banks cannot reduce their interest expense by as much as they lose interest income on lending (Borio et al., 2017; Claessens et al., 2018), as they are reluctant to lower deposit rates below zero on fears of triggering a wave of withdrawals. As retail deposits are an important aspect of euro-area bank funding, this could potentially have large implications for the transmission of monetary policy to bank lending rates.

Despite identifying numerous possible channels and trends, the large body of theoretical and empirical literature on the impact of negative policy rates on banks has yet to clarify the overall impact of negative rates (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 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.

This paper addresses the transmission of ECB monetary policy implemented using different tools to bank corporate lending rates at different maturities. We are interested in the potential change in interest rate pass-through after the introduction of negative policy rates in June 2014, as well as the experience of banks during 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". This policy commitment coincides with a share of banks shedding their reluctance to offer negative interest rates on retail deposits.[2] It is crucial to understand monetary policy transmission in the low-for-long period as the theoretical literature suggests that the effectiveness of negative rates can wane – or even reverse – the longer the negative-rate regime continues (Balloch et al., 2022).

Our analysis utilizes a novel bank-level dataset at monthly frequency on 137 individual banks from 13 euro area countries covering the period January 2010 to December 2020. Unlike most empirical papers

[1] Other central banks introduced TLTRO-like programs under different names. In the UK, for example, the program was called "funding for lending" (FFL).
[2] The low-for-long period is discussed in more detail in section 2.

that rely on the shorter data samples,[3] our data enable us to properly study the low-for-long period. Besides information on bank balance sheets, loan and deposit interest rates, central bank deposits and longer-term borrowing of banks, we utilize data from the responses of individual banks to the ECB's Bank Lending Survey used to control bank-level loan demand. We first take the shadow rate of Krippner (2005) 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 (T)LTRO announcement days. These separate shocks allow us to disentangle various types of monetary policy tools (specifically, short-term policy rates, targeted long-term refinancing operations, and quantitative easing).

Our paper contributes to the existing literature by providing 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. Policy rate cuts below the reversal rate force banks to raise their lending rates, resulting in a decline in lending and a slowdown in aggregate output growth.

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, Brunnermeier, and Koby (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. The level of the reversal rate decreases with the maturity of fixed-income assets held by banks. When banks have greater maturity mismatch, the capital gains channel is stronger relative to the net interest income channel, and the reversal rate is lower. 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, Brunnermeier, and Koby, 2023). Thus, the reversal rate can move higher when policy rates are at extremely low levels for an extended period.

Empirical evidence on the existence of the reversal rate has been mixed. For instance, Borio and Gambacorta (2017) provide empirical evidence that monetary policy is less effective in stimulating bank lending growth when interest rates reach a very low level. Molyneux et al. (2019) observe that before 2016 lending growth was slowest for OECD countries with negative central bank policy rates. Eggertsson et al. (2019) use a macro model calibrated on Swedish data. They find that banks begin to increase their loan rates when a -0.50 % policy rate erodes bank profitability. Looking at Swiss data, Basten and Mariathasan (2018) find that lending rates of especially longer-maturity mortgages were increased in the wake of negative policy rates. 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 than during positive policy rates. Bottero et al. (2021) 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,

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

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.

Besides providing evidence of the reversal rate existing in euro area after the fourth rate cut to -0.40 % in 2016, our study also provides a possible explanation for the mixed results found in the literature. As suggested by the theoretical reasoning, we show that detection of the reversal rate depends both on bank heterogeneity and loan maturities. It also requires that negative rates become persistent, i.e. the reversal rate only emerges during the low-for-long period.

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,[4] yet the literature dealing with time-varying effects between above and below zero is scarce. Instead, the focus in the low-rate environment has been on the effectiveness of conventional monetary policies such as short-term policy rates (e.g. Borio and Gambacorta, 2017; Claessens et al., 2018; Kwan et al., 2023). Previous empirical studies of unconventional measures (Albertazzi et al., 2021; Boeckx, de Sola Perea, and Peersman, 2020) do not distinguish between asset purchases and policies explicitly aimed at bank lending.

We look separately at the time-varying effects of short-term policy rates, QE, and (T)LTROs to see what happens to the transmission to bank lending rates when policy rates 1) initially fall below zero, and 2) after negative rates became persistent. We show that different monetary policy tools have diverse effects on bank lending rates and these effects change first as policy rates go below zero and then as banks enter the low-for-long period.

To our best knowledge, this paper provides the first examination of the complementarity of different monetary policy measures in the context of pass-through to bank lending rates.[5] Rostagno et al. (2019) suggest that different ECB policy measures may work as complements. Negative short-term policy rates, for example, could reinforce the impact of QE on term premium through the Gesell tax effect, thereby incentivizing a shift in portfolios from short-dated to long-dated securities. A negative short-term policy rate could also amplify the effect of TLTROs as stronger loan origination entitles banks to negative borrowing rates. QE, in turn, could complement negative short-term policy rates by providing extra liquidity that contributes to keeping overnight rate closer to the deposit facility rate. TLTROs might complement negative short-term policy rates by helping banks to exempt part of their reserves from the negative rate charge. Moreover, QE and TLTROs could serve as complements as QE decreases the return on bond holdings of banks relative to their return on loan creation. It further generates capital gains for banks and free up balance sheet capacity that can be redeployed to commercial lending under TLTRO.

We assess the complementarities of different monetary policy tools by looking at the effect on bank lending rates of an interaction between 1) a negative short-term policy rate shock and a QE shock and 2) a negative short-term policy rate shock and a TLTRO shock.

For the full 2010–2020 period, we find that changes in the overall monetary policy stance are transmitted as expected to bank corporate lending rates. When short-term policy rates are lowered below zero, transmission becomes weaker with the effect most pronounced for loans of short maturities. This finding

[4] 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); and Nelimarkka and Laine (2021).

[5] Laine and Pihlajamaa (2023) study the complementarities between policy tools when it comes to inflation effects. However, they leave the transmission mechanism as a black box. The complementarities of effects on bank lending are not considered.

seems to be driven by banks reluctant to lower their own retail deposit rates below zero or those with large amounts of negative interest-bearing central bank deposits. We posit that banks entered the low-for-long period in early 2016 when negative rates were generally perceived to be a more persistent phenomenon. During the period of low-for-long, we find evidence of the existence 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 most pronounced 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 mitigate the pass-through by lowering bank funding costs. Both TLTROs and QE had a positive effect on bank lending rates, even during the low-for-long period.

We also look at the complementarities of conventional and unconventional policy measures, finding evidence that policy rate cuts and TLTRO below zero complement each other when it comes to bank lending rates, while rate cuts and QE do not complement each other. The small number of observations of interactions between QE shocks and TLTRO shocks, however, precludes us from assessing the complementarity between the two unconventional tools.

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

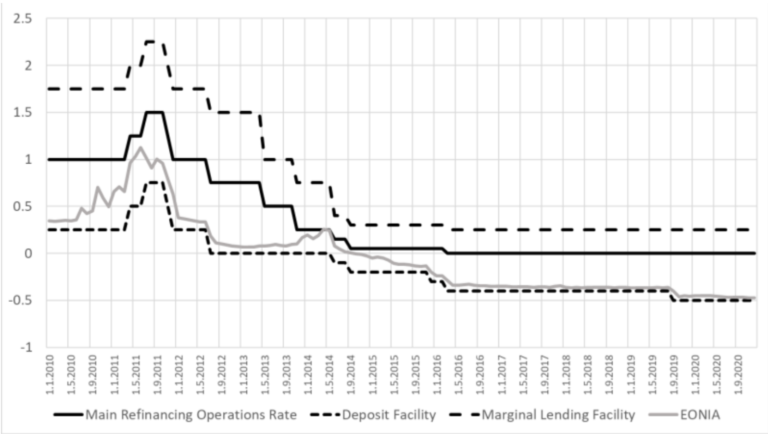
This section presents the main aspects of the ECB monetary policy during 2010–2020.[6]

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. Prior to the global financial crisis, the ECB relied on liquidity-sharing to make sure that the banking sector received the liquidity it required. Once inside the banking system, the additional liquidity was distributed among banks through the interbank market according to the needs of individual banks. 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. The ECB's deposit facility allows banks to make overnight deposits at a pre-set interest rate below the MRO rate, while its marginal lending facility provides banks overnight credit at a rate above the MRO rate. These two rates set the upper and lower bounds of the interest-rate corridor for money markets.

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

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

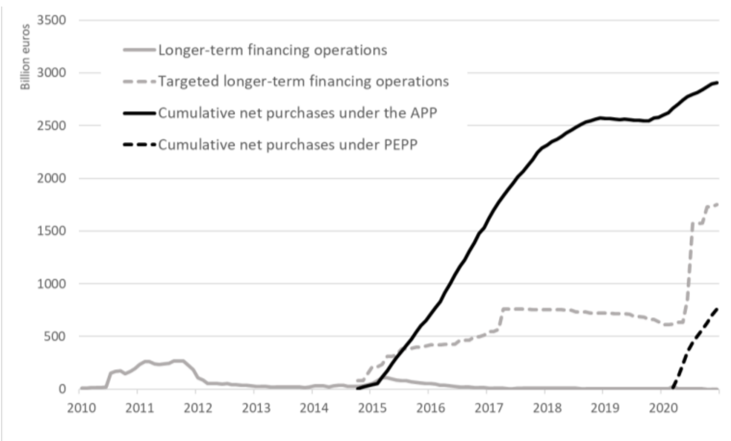


Source: ECB.

After the ECB lowered its deposit facility rate below zero in June 2014, it continued with other unconventional tools. Banks were offered long-term loans at highly favorable rates on condition that the money be used for lending to the private sector (TLTROs). Private and public financial assets were also acquired through its large-scale Asset Purchase Programme (APP). These unconventional tools created monetary policy space as interest rates started to be constrained by their effective lower bound.

Following the ECB's initial cut of its deposit facility rate to -0.10 %, 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.[7]

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.

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

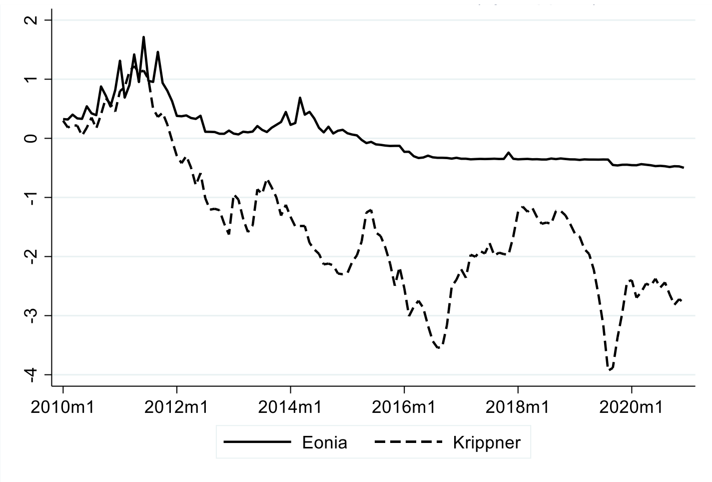
The ECB also contributed to lower banks' funding costs by lending funds on highly favorable terms under both non-targeted and targeted longer-term financing operations, (T)LTROs (Figure 2). Two LTROs with a maturity of three years were agreed upon in December 2011. These initial operations sought to ensure that banks had access to affordable funding over the longer term, thus enhancing the pass-through of interest rates to firms and households. 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[8]) 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. The overall Eurosystem holdings of assets purchased under the APP reached roughly 2.9 trillion euros by the end of 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). Cumulative PEPP net purchases amounted to 757 billion euros in December 2020

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.

[8] 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 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 to 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 -0.4 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:[9]

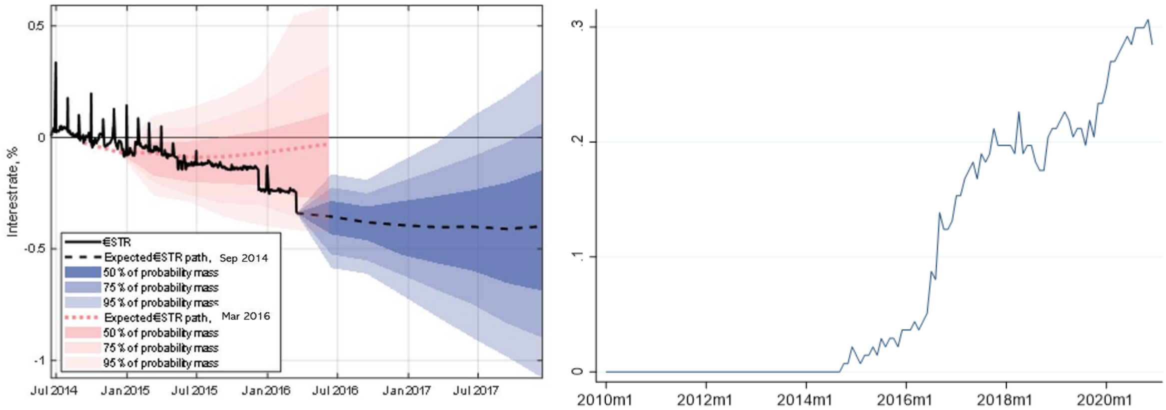
> "Based on our regular economic and monetary analyses, and after the recalibration of our monetary policy measures last month, we decided to keep the key ECB interest rates unchanged, and we expect them to remain at present or lower levels for an extended period of time."

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.[10] 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.

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

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

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



Sources: ECB and authors' calculations.

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.

Based on the above reasoning, we set the start of the low-for-long period as January 2016 and lasting 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*, *longer-term lending operations*, and *quantitative easing*. To that end, we use Euro Area Monetary Policy Event-Study Database. Monetary policy measures used are discussed more thoroughly in section 3.2.

To form our other independent variables, we predominantly rely on monthly bank-specific balance sheet information provided by the ECB (individual MFI balance sheet item data set, IBSI). Our main regression framework is based on the bank lending channel literature (Kashyap and Stein, 1995, 2000) and thus we use bank-specific variables that the existing literature finds to have the greatest effect on loan supply – *capitalization* (ratio of equity to total assets), *liquidity* (ratio of liquid assets to total assets), and *bank size* (log of total assets). These three attributes all affect the possibilities of banks to obtain external funding. These bank-specific variables are taken from the IBSI database, the exception being the liquidity measure where we had to rely on annual data from BankFocus.

In addition to these three traditional bank-specific variables, we augment the baseline specification to account for the extent to which banks actually relied on the various monetary policy measures. For this purpose, 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 figures are taken 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 their 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 euro area wide macroeconomic developments, we include euro area industrial production year-on-year growth as well as harmonized unemployment rate, both from Eurostat at monthly frequency. In addition, to control for uncertainty we use normalized total returns of the euro area STOXX index, as well as the first principal component of short-, medium-, and long-term expectations of 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[11] from thirteen countries[12] for the period January 2010–December 2020. Definition of all variables used are presented in Table 1. We distinguish between two separate sub-periods. Our period of *negative rates* runs from June 2014 through December 2020. Our period of *low-for-long* runs from January 2016 through

[11] 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.

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

December 2020. Descriptive statistics for the full timespan and for each sub-sample are presented in Table 2.

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 here is to determine whether the pass-through of monetary policy to bank corporate lending rates changed when policy interest rates first entered into negative territory or when banks entered the low-for-long period of persistent below-zero rates.

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] One drawback in the concept of shadow rate is that it groups together a range of unconventional monetary policy tools (in reality, different tools affect different parts of the yield curve and different risk premia). Moreover, the shadow rate does not capture all policy measures. For example, TLTROs affect bank lending policies without exerting much effect on the risk-free yield curve. Instead of (or in addition to) traditional rates, Boeckx et al. (2020) and Albertazzi et al. (2021) use monetary policy shocks derived from external VAR models or event studies in a panel data setting. One rationale for using monetary policy shocks or surprises rather than the EONIA or shadow rate is that shocks and surprises represent exogenous variation in monetary policy.

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.[14]

As our second step, we employ a local projections method and different monetary policy surprises. We take the 1-week OIS surprise around the ECB's monetary policy decisions to measure conventional monetary policy and the 10-year OIS surprise to measure QE. Both shocks are derived from the euro area event-study database produced in accordance with Altavilla et al. (2019). To measure credit easing policies, we use bank bond yield changes around the ECB announcements involving TLTROs.[15] Figure 5 presents the time series of these three shocks for 2010–2020.

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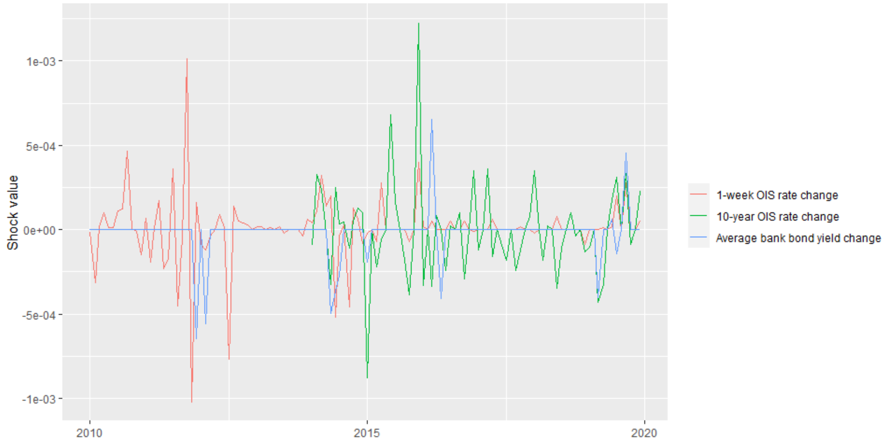
[13] Dealing with this issue in our setting is not as problematic as perhaps in some applications. As argued by Borio and Gambacorta (2017), the (expected) bank lending rates at the aggregate level are more likely to affect monetary policy decisions than the lending rates of individual banks. In other 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 macroeconomic 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] The OIS surprises are taken from the EA-MPD (see Altavilla, Brugnolini, Gürkaynak, Motto and Ragusa, 2019).

[15] We use the same days as Altavilla, Barbiero, Boucinha and Burlon (2020, 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. (2020): 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). The data are from Barclays.

Figure 5. Monetary policy shocks used in local projections.



Sources: EA-MPD 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

To study the transmission of the overall monetary policy stance to bank corporate lending rates, we follow the bank-lending channel methodology developed by Kashyap and Stein (1995, 2000).

Our baseline regression specification is:

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

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 euro-area-wide macroeconomic indicators (year-on-year growth rate of industrial production, harmonized unemployment rate, normalized stock returns from Eurostoxx, as well as macroeconomic forecasts for GDP growth, unemployment, and inflation); and $D_{i,t-3}^{L}$ is the bank-specific demand for loans for each loan category 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 should decrease. 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. Following the theoretical reasoning of Abadi et al. (2023), the level of the reversal rate should be lower the longer the maturity of fixed-income assets held by banks. 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.

We add bank-specific variables to control for the ability of banks to obtain external funding and to determine how extensively they rely on particular monetary policy measures. Capitalization, liquidity, and size are found in the bank lending channel literature to have the greatest effect on loan supply decisions as they impact the access of banks to external funding and thus their ability to 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, 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 euro-area-wide macroeconomic developments by including the year-on-year growth rate of euro area industrial production, the harmonized unemployment rate, and normalized stock returns from Eurostoxx stock index. In addition, we use 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 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 interpreting the regression coefficient of the shadow rate as causal effect on lending rate.[16]

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

The estimations are first conducted using the whole dataset covering the period 2010-2020. In order to clearly uncover the possible changes after monetary policy moved below zero, we further run the estimations for two subperiods. Period from June 2014 to December 2020 accounts for the period of negative rates and period from January 2016 to December 2020 focuses solely on the period of low-for-long.

[16] 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.

4.2. Local projections

To account for different monetary policy shocks, we turn to local projections as formalized by Jordà (2005).[17] 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. We estimate a model following Boeckx et al. (2020) such that:

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

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); X_t is the vector of macroeconomic control variables; and $Z_{i,t}$ 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 TLTRO shock and a QE shock).[18] Following the application of local projections by Boeckx et al. (2020) to similar data, we assume the 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 include 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.

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 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, 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

[17] 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).
[18] Shocks are defined in more detail in section 3.2.

5.2. moves to local projections and monetary policy shocks, presenting the results for the three different monetary policy measures separately (policy interest rate, (T)LTROs, and asset purchase programmes). Section 5.3. considers the potential complementarities of the negative short-term interest rate, QE, and TLTRO.

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 time spans. We estimate what happens to bank corporate lending rates when there is a change in the shadow rate, for 1) our full observation period (2010–2020), 2) during the period of negative policy rates (June 2014–2020), and 3) during the low-for-long period (2016–2020). For each period, we look at four different corporate lending rates. The first three columns in Table 3 present the results for the overall corporate lending rate, a weighted average of all new corporate loans of different maturities. Columns 4 to 6 focus on corporate lending rates of short maturities up to 1 year. Columns 7 to 9 present results for corporate lending rates of medium-term maturities (1–5 years) and columns 10 to12 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 full 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 Albertazzi et al. (2021). We further note that the size of the coefficient is about double that of new corporate loans of short maturities compared to those with long maturities. The transmission of monetary policy to bank lending rates seems to be stronger for long-maturity loans.

Second, we see that this coefficient stays positive and significant during the period of negative rates only for a subset of corporate lending rates with medium and long maturities (columns 8 and 11). Even for these two subgroups of loans, the size of the coefficient decreases significantly from the full period. For the weighted average corporate lending rate and lending rates of up to 1 year maturity loans, coefficients cease to be statistically significant, indicating that the transmission of monetary policy is clearly hampered 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 move to the low-for-long period. For the weighted average of all corporate loans and separately for loans of short maturities (columns 3 and 6), the coefficient of the shadow rate is negative and statistically significant (stronger for corporate loans of short maturities). This seems to suggest 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 (at the 10 % level) coefficient, although it is clearly smaller than for the other time spans.

Our finding that the pass-through of monetary policy to bank lending rates persists for the corporate loans of long maturities even during negative rates and the low-for-long period corroborates the theoretical insight of Abadi et al. (2023) that the reversal rate should decrease in the maturity of assets held by banks. The longer the overall maturity of assets, the longer it takes for banks to hit the reversal rate and for accommodative monetary policy to become contractionary.

As shown empirically by Gambacorta (2009) and Takaoka and Takahashi (2022), monetary policy can also influence risk-taking and encourage banks to replace shorter maturity loans with longer maturity loans. This 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 lower their lending rates. 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.

Based on these panel regressions, we draw the following conclusions:

Looking at the full period of our sample, monetary policy transmission to bank corporate lending rates worked as expected. With the easing of monetary policy, banks lowered their corporate lending rates. When policy rates turned negative, this transmission mechanism weakened overall, particularly for corporate loans of short maturities. When negative policy rates became persistent, the transmission mechanism reversed, again particularly for corporate loans of short maturities. As monetary policy was eased during the low-for-long period, banks raised their lending rates. Furthermore, 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 lending rates in euro area. We next move to investigate the role of different monetary policy instruments and dynamics of these effects.

5.2. The effect of individual monetary policy measures

5.2.1 Policy interest rate

After looking at the effect of the overall monetary policy stance on bank 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. 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.

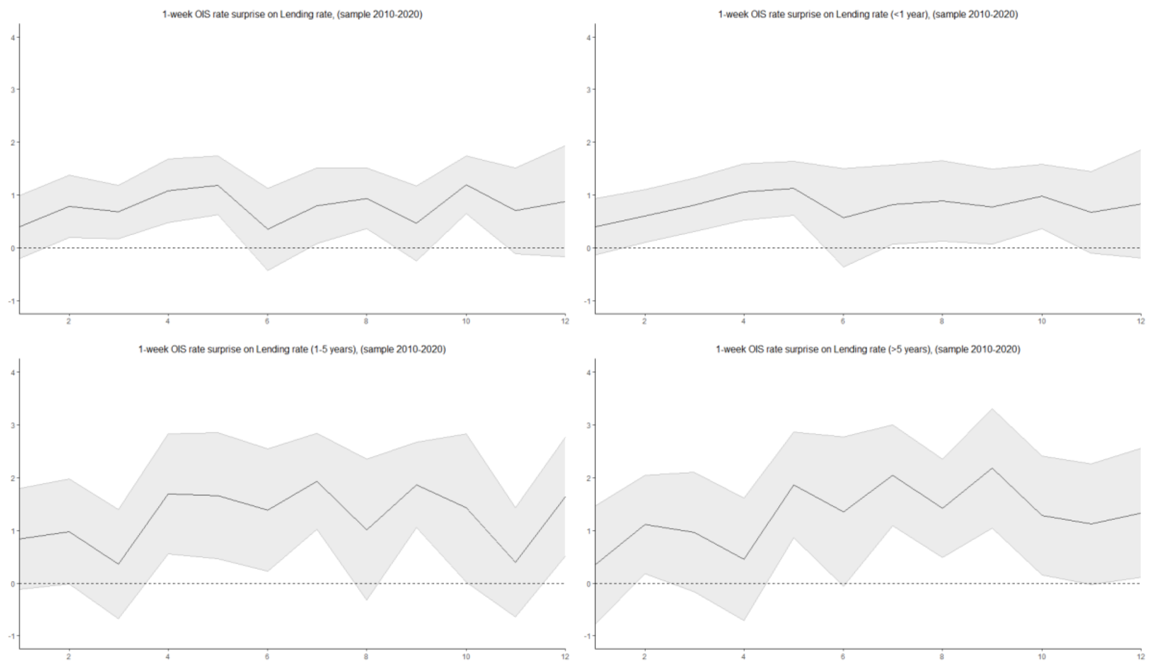
Figure 6 shows the local projection results for 12-month horizons for the overall corporate loan rate and for the three different maturities. Time span is 2010-2020 and the monetary policy shock is proxied by the 1-week rate surprise. The results suggest that short-term rate changes transmit to bank 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 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 the low-for-long period subsample, which runs from 2016 to 2020.[19] 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 to increase their corporate lending rates. The coefficient is negative and statistically significant two months after the short-term interest rate shock for the average corporate lending rates (and particularly the lending rate for corporate loans of short maturities).

These results are in line with our initial panel estimations for the overall monetary policy stance.

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.



[19] In Figure A3 in the Appendix, we provide results using the counter period 2010–2015 for comparison.

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 (June 2014–December 2020). Time horizon 12 months.

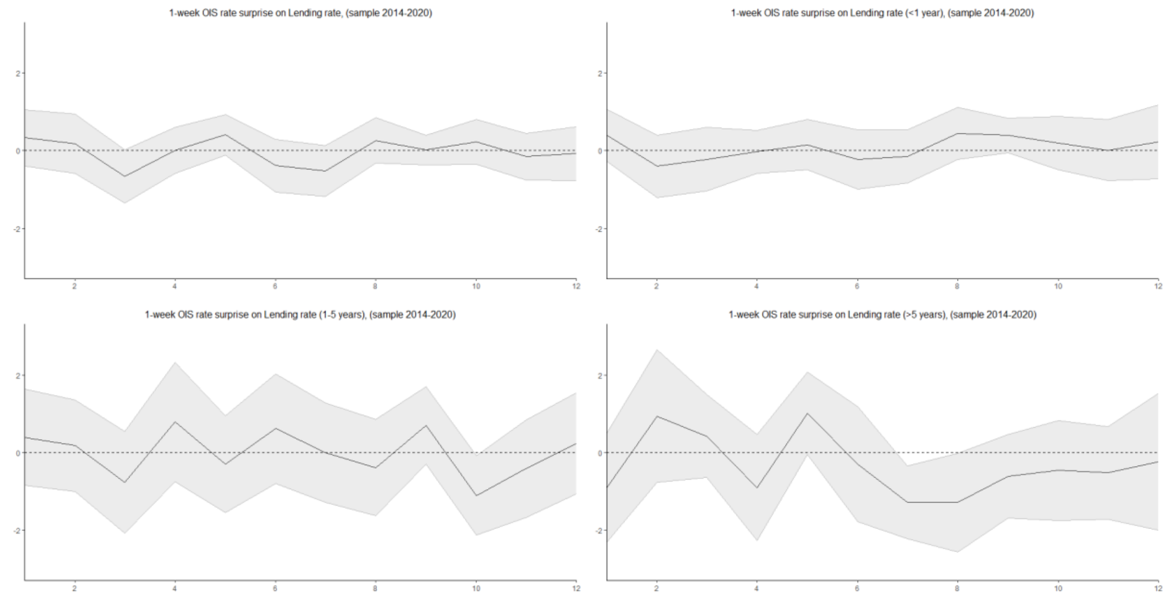
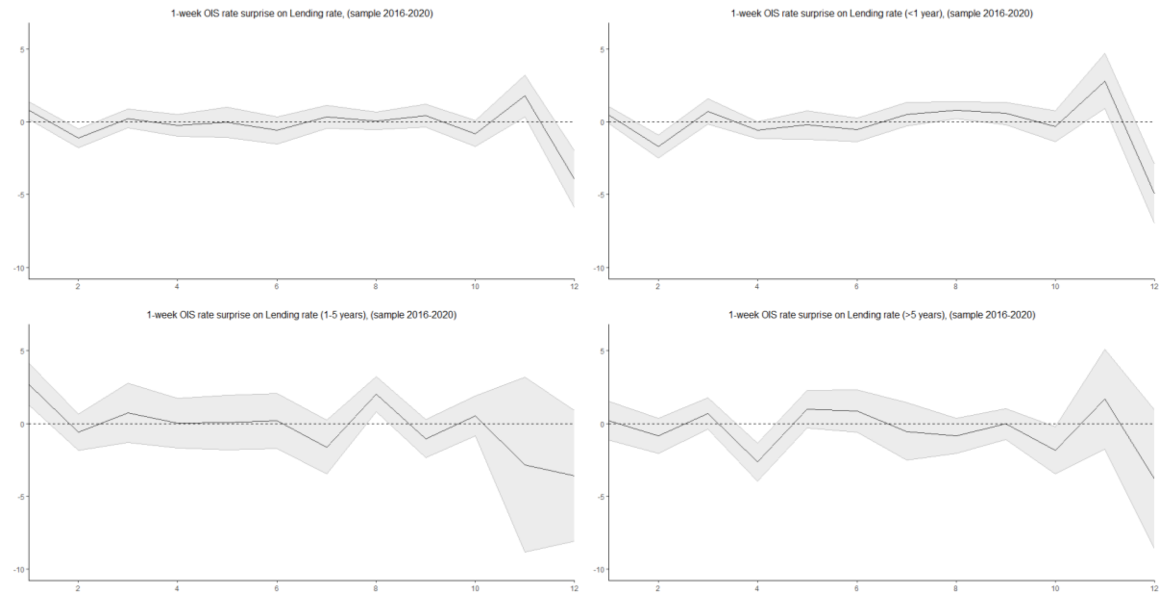


Figure 8. Effect of short-term rate shock for the overall corporate lending rate and three different maturities (less than 1 year, 1-5 years and over 5 years), low-for-long period (January 2016–December 2020). Time horizon 12 months.

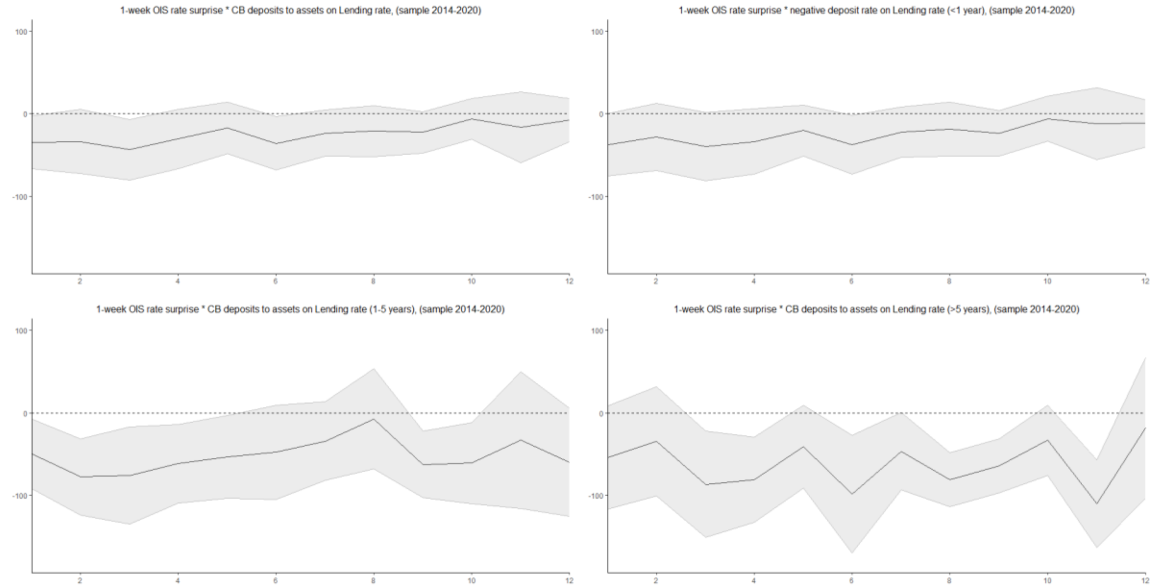


To see whether bank heterogeneity matters for the existence of the reversal rate, we first examine the impact of negative rates on bank profitability following the theory of Ulate (2021). We expect to find evidence of the reverse effect on lending rates when a sufficient fraction of a bank's reserves are subject to the negative policy rate. As our dataset includes the actual share of central bank deposits to bank's total assets, we have a close proxy of banks' exposure to negative interest rates.[20]

[20] Other measures are found in the literature. For example, Demiralp et al. (2021) use a direct measure of excess liquidity.

In Figure 9, we augment Equation (2) with an interaction term that includes our shock proxy and the lagged share of central bank deposits on bank i's balance sheet. We find some evidence that banks with more central bank deposits (i.e. bearing the additional cost of the negative central bank deposit rate) raised lending rates for their borrowers. This result provides support to 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 are look here at the average effect of negative policy rates (1-week OIS effect in full sample vs. post-2014).[21]

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.

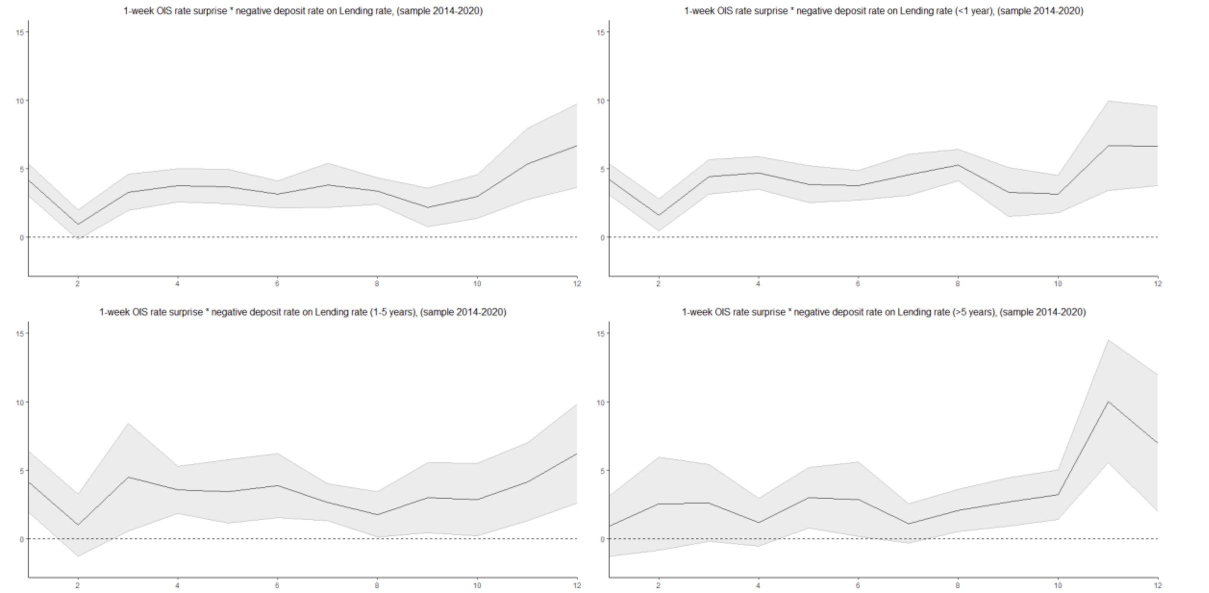


Bank heterogeneity also matters in the ability of banks to keep lowering their interest expenses as policy rates go below zero. As argued by Abadi et al. (2023) and Eggertsson et al. (2019), the key constraint preventing policy rate pass-through to bank lending rates in a below-zero environment is that some banks cannot lower their retail deposit rates into negative territory. We address this question by augmenting Equation (2) with the interaction term between our short-term policy rate shock and lagged dummy variable that is given a value of 1 if bank i set at least one of its retail deposit rates negative.[22] Figure 10 shows the coefficient of this interaction term for different h.

[21] 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).

[22] The total shares of these banks appear in Panel B of Figure 4.

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.



Our results indicate that banks that managed to lower their retail deposit rates below zero were 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. (2019), i.e. that banks who 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 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. 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 subsample of the period of negative rates. 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 as a bank enters the low-for-long period. This also holds for shorter maturities (Figure 13). Even so, caution is warranted in interpreting these results due to the tiny number of TLTRO announcement days for these shorter subperiods.

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.

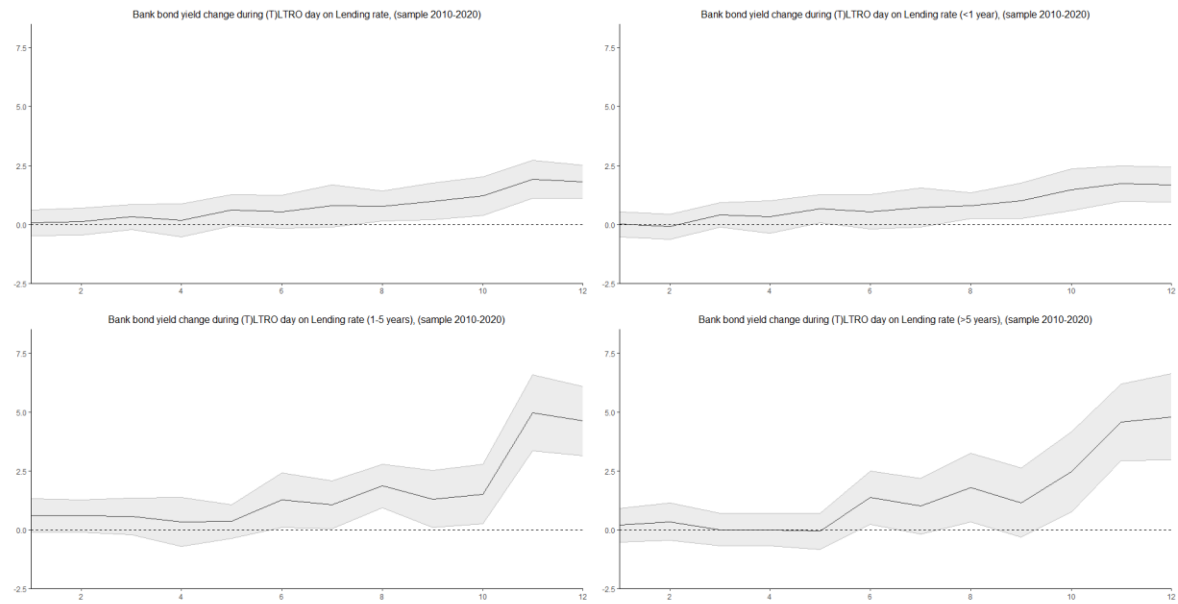


Figure 12. Effect of (T)LTRO shock for the overall corporate lending rate and three different maturities (less than 1 year, 1-5 years and over 5 years), period of negative rates (June 2014–December 2020). Time horizon 12 months.

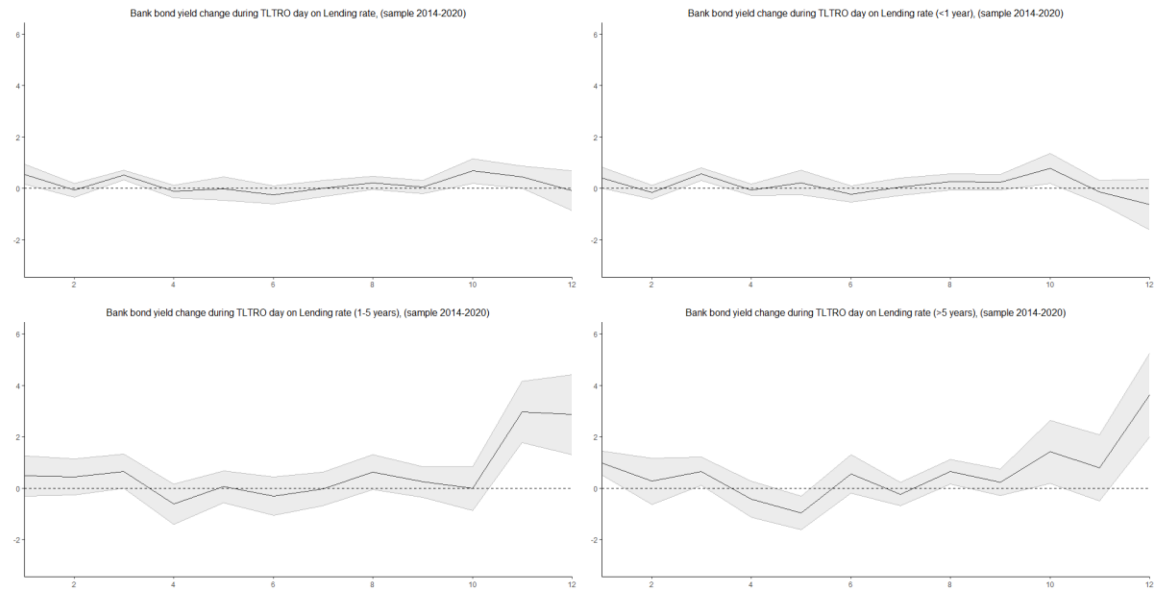
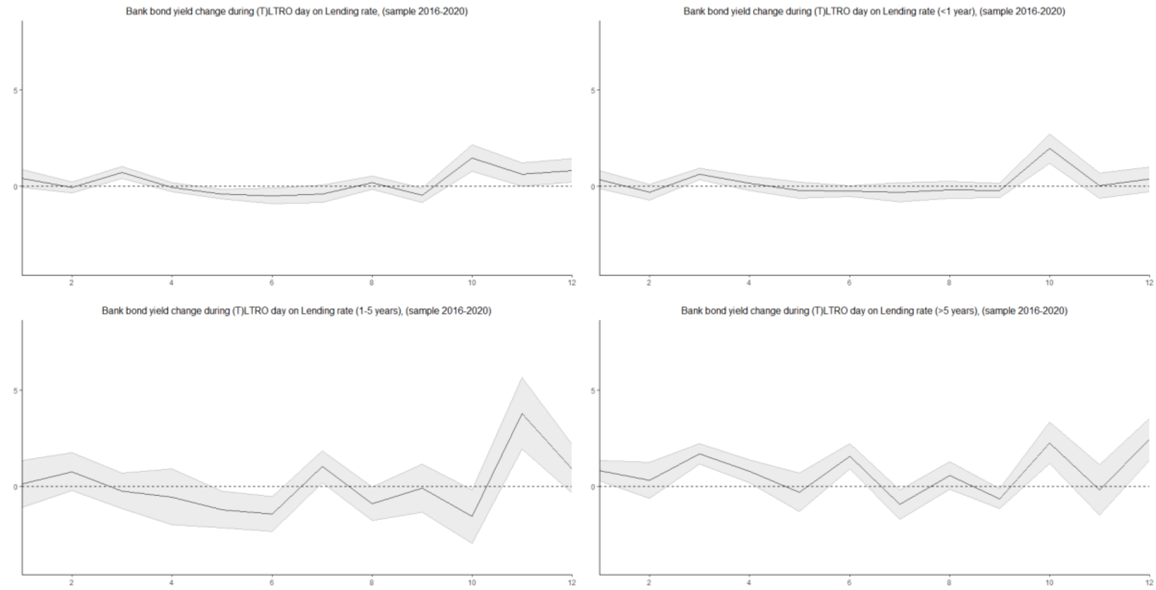


Figure 13. Effect of (T)LTRO shock for the overall corporate lending rate and three different maturities (less than 1 year, 1-5 years and over 5 years), low-for-long period (2016–2020). Time horizon 12 months.

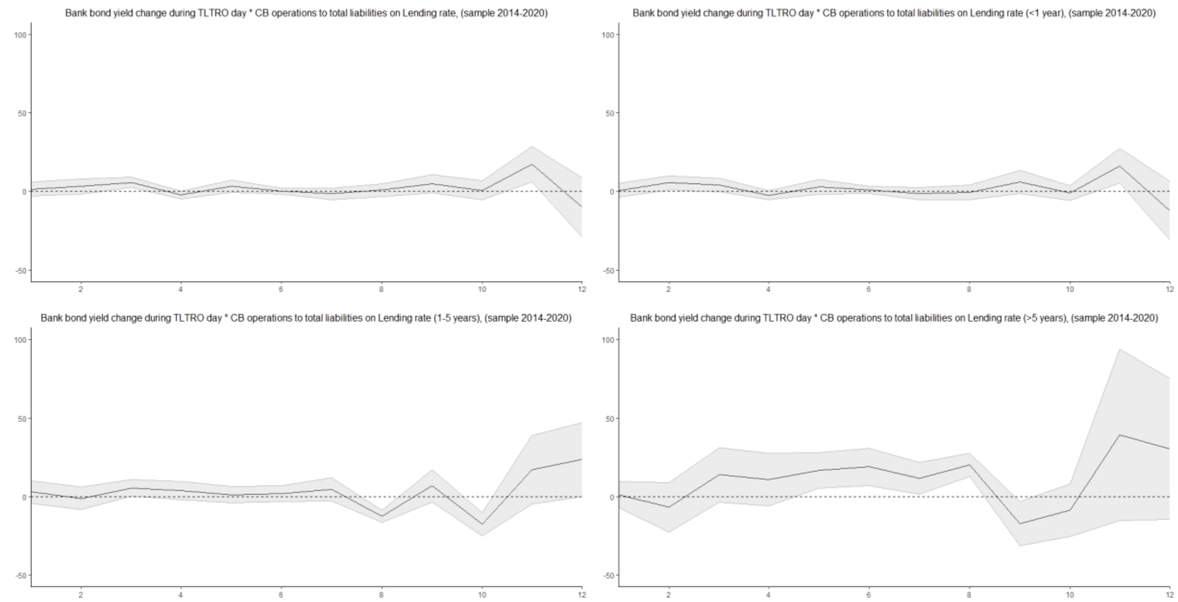


The results above assess the effect on average bank lending rates. However, one may assume that the effects are stronger for banks that participated in these operations and received more financing on favorable terms.[23] Our dataset includes an actual measure of each bank's amount of funds lent from 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.

[23] 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.



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.[24] 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.

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 a positive effect on lending rates of long maturity loans. That is, as QE induced an unexpected decrease at the longer end of the yield curve, banks lowered their lending rates for loans

[24] 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).

of long maturities. This could stem from the fact that they are more likely to be closer substitutes for long-term bonds.

When concentrating solely on the low-for-long period (Figure 16), we still find a positive effect on average lending rates at around five months after the shock, but it seems to be driven slightly more by short-term 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 (June 2014–December 2020). Time horizon 12 months.

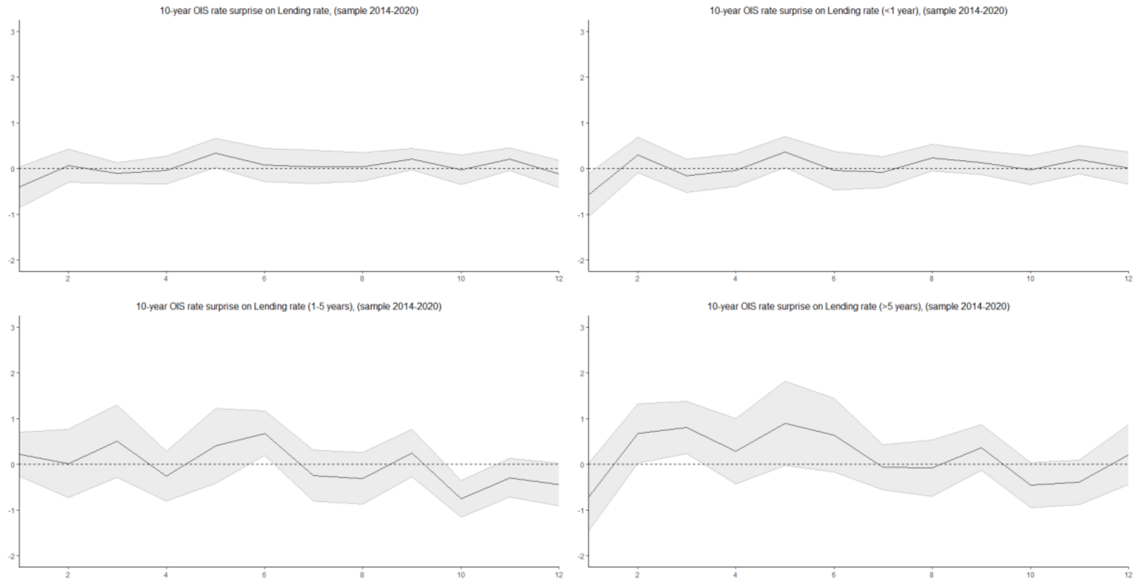
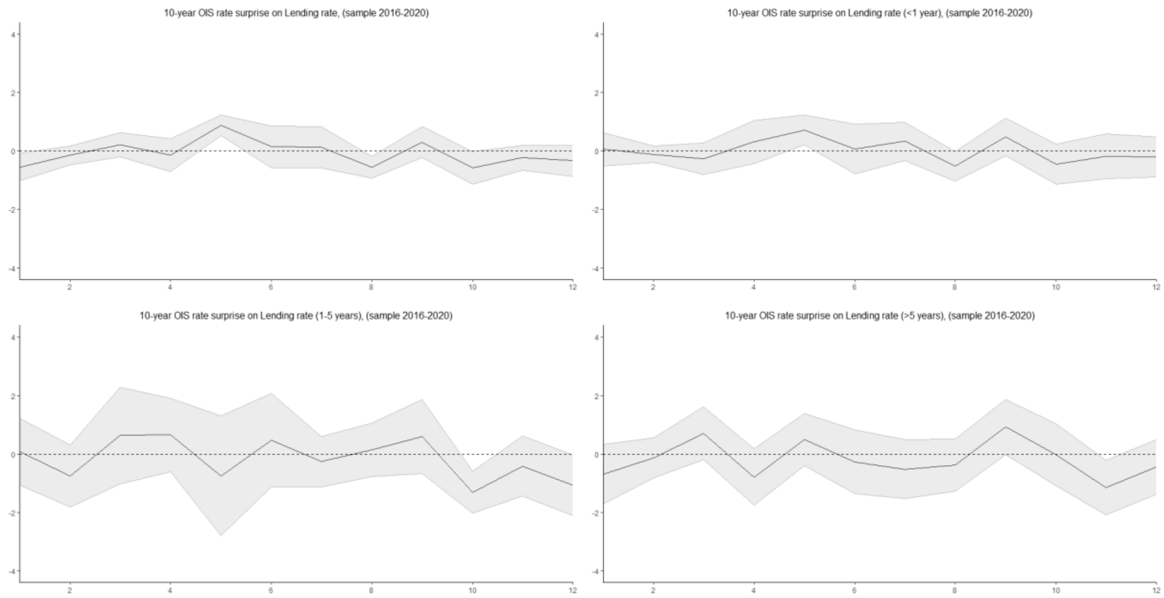


Figure 16. Effect of QE shock for the overall corporate lending rate and three different maturities (less than 1 year, 1-5 years and over 5 years), low-for-long period (January 2016–December 2020). Time horizon 12 months.

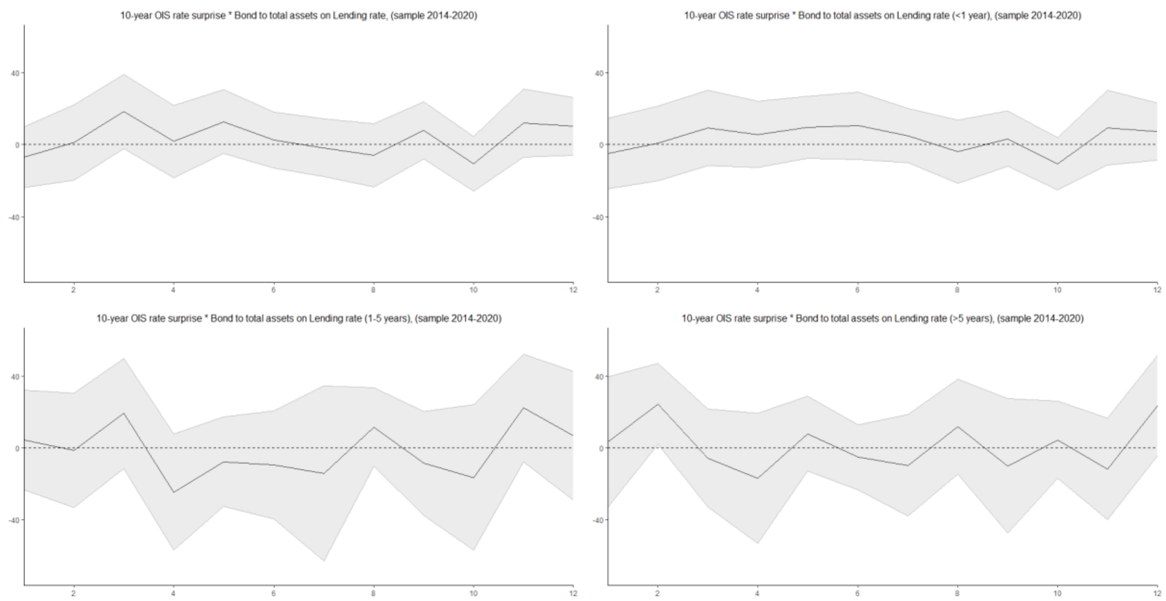


Bank heterogeneity can again affect the impact of QE. When asset purchases have a large impact on security prices, the mark-to-market value of bank security holdings increases, raising bank net worth (Brunnermeier and Sannikov, 2014). Assuming that commercial banks target somewhat constant leverage ratios, 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, find 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 focused 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.



5.3. Interaction of monetary policy measures

As argued by Rostagno et al. (2021), different monetary policy tools, in addition of having an effect on their own, also work as complementarities. While some empirical evidence about these complementarities has been provided in the context of inflation effects (Laine and Pihlajamaa, 2023), to our best knowledge there exists no research studying potential complementarities when it comes to bank lending.

We focus here on two interactions: the first between the short-term policy rate and TLTROs, and the second between the short-term policy rate and QE. In line with Rostagno et al. (2021), who specifically focus on negative interest rate policy (NIRP), we look only at the period of negative rates. We skip the separate analysis for the period of low-for-long as a shorter time window contains too few observations to be meaningful. Moreover, we are unable to extend the analysis of complementarities to the two unconventional tools (TLTRO and QE) as there are hardly any months where TLTRO announcements coincide with QE shocks.

Figure 18 presents the results for the interaction term between short-term negative policy rate and TLTROs. The coefficients are positive and statistically significant for the average lending rate and lending rate for short-term maturities at the longer horizon. For medium maturity corporate loans, we observe a rather immediate positive impact, as for the longer maturity loans this positive impact comes after about 6 months. As proposed by Rostagno et al. (2021, we indeed find evidence of complementarities between TLTROs and the negative policy rate. Still, the number of shock interactions is quite small, so again caution is warranted in interpreting these results.

Figure 18. Complementary effect of short-term policy rate shock and (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. Time horizon 12 months.

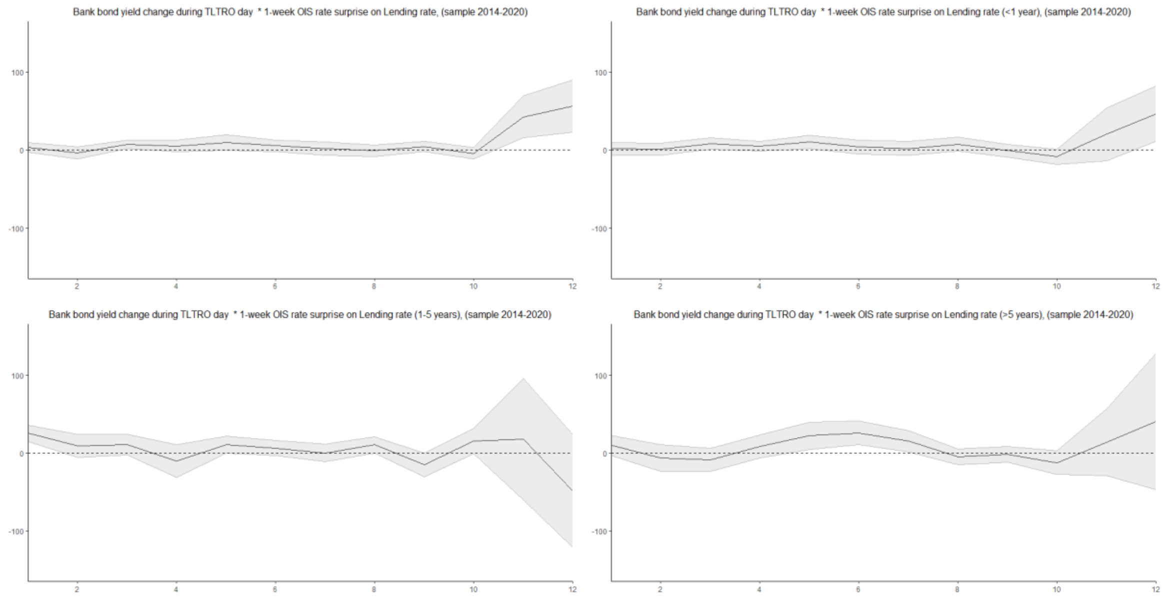
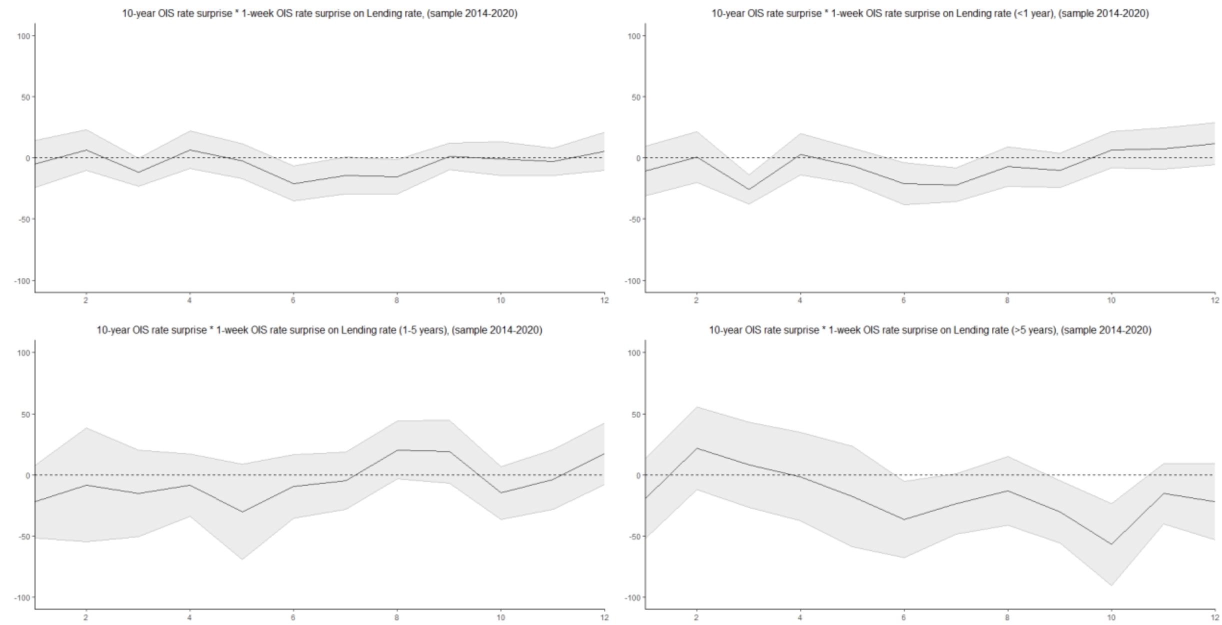


Figure 19 shows the estimated coefficients for the interaction term between the short-term negative policy rate and QE shocks. The coefficients are significantly negative, which suggests that there are no complementarities between negative policy rate and QE when it comes to the pass-through of bank lending rates and that they might in fact be exclusionary.

Figure 19. Complementary effect of short-term policy rate shock and 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. Time horizon 12 months.



One possible explanation for this result could be related to the signaling effect of QE. The ECB stated that an effect of asset purchases is to send a signal that the central bank plans to keep its key interest rates low for an extended period of time. Looking at the discussion in Abadi et al. (2023), however, it is more accurate to say that a promise to keep interest rates low for a prolonged period of time may initially stimulate bank lending but later become contractionary as the net worth of banks is drained over time, forcing them at some point to pull back on lending due to the financial constraints. Thus, QE could eventually have a contractionary impact on bank lending when implemented below zero.

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 novel 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 weakened 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 dampening of the pass-through below zero, as well as the reversal effect during the low-for-long period is most pronounced for corporate loans of short maturities. Fourth, bank heterogeneity matters. Weaker transmission is driven by banks that did not lower their own retail deposit rates below zero, as well as by those banks that had 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, both TLTROs and QE help mitigate the pass-through by lowering bank lending rates. Lastly, whereas negative short-term negative policy rate and TLTROs work as complements to incentivize banks to lower their lending rates further, negative short-term policy rates and QE do not.

Our analysis helps in understanding why previous empirical studies have 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 their desired effect on private-sector lending costs as period of negative rates proceeds. 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 and induce banks to tighten credit conditions.

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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
bank size	log of total assets	ECB IBSI
CB_depo	banks' monthly reserves in central bank deposit accounts	ECB condifential database
CB_operations	banks' borrowings from the central bank targeted and non-targeted longer-term operations	ECB condifential database
industrial production	euro area industrial production year-on-year growth	Eurostat
unemployment	euro area harmonized unemployment rate	Eurostat
zstockreturn	Euro area, STOXX index, total return, close (in EUR), normalized	STOXX, Macrobond
SPF exp. inflation	expected rate of inflation in the euro area, 1st principal component of short, medium and long-term expectations	ECB Survey of Professional Forecasters
SPF exp. unemployment	expected rate of unemployment in the euro area, 1st principal component of short, medium and long-term expectations	ECB Survey of Professional Forecasters
SPF exp. GDP	expected rate of GDP in the euro area, 1st principal component of short, medium and long-term expectations	ECB Survey of Professional Forecasters
dem_i_nfc	dummy for increasing NFC loan demand (equals one if a bank responded either 4 or 5)	ECB individual Bank Lending Survey
dem_d_nfc	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 (2010–2020)					Negative interest rates (6/2014-2020)					Low-for-long (2016-2020)				
Variable	# of obs	Mean	Std.dev	Min	Max	# of obs	Mean	Std.dev	Min	Max	# of obs	Mean	Std.dev	Min	Max
NFC lending rate	11 557	2.366	1.111	0.546	6.540	7 360	1.980	0.922	0.546	6.540	5 495	1.853	0.855	0.546	6.510
NFC lending rate, up to 1 year	11 426	2.312	1.102	0.480	6.425	7 305	1.961	0.922	0.480	6.417	5 464	1.841	0.854	0.480	6.336
NFC lending rate, 1 to 5 years	10 407	2.806	1.637	0.351	8.645	6 661	2.139	1.289	0.351	8.629	5 008	1.942	1.202	0.351	8.629
NFC lending rate, over 5 years	9 880	2.995	1.614	0.778	8.905	6 447	2.331	1.238	0.778	8.821	4 910	2.138	1.154	0.778	8.821
Krippner	13 020	-1.533	1.149	-3.932	1.225	8 081	-2.205	0.665	-3.932	-1.155	6 012	-2.289	0.726	-3.932	-1.155
liquidity	13 020	0.187	0.147	-0.025	0.891	8 081	0.195	0.150	-0.025	0.891	6 012	0.207	0.150	0.001	0.891
capitalization	12 519	0.096	0.049	0.013	0.428	7 957	0.101	0.049	0.019	0.428	5 957	0.100	0.047	0.023	0.372
bank size	12 519	10.780	1.487	5.979	14.060	7 957	10.732	1.511	6.061	14.060	5 957	10.759	1.507	6.575	14.060
CB_depo	13 020	0.013	0.031	0.000	0.199	8 081	0.017	0.034	0.000	0.199	6 012	0.020	0.036	0.000	0.199
CB_operations	13 020	0.190	4.618	0.000	206.574	8 081	0.305	5.859	0.000	206.574	6 012	0.404	6.790	0.000	206.574
industrial production	13 020	0.666	4.344	-28.489	9.353	8 081	0.252	4.629	-28.489	5.561	6 012	-0.331	5.185	-28.489	5.561
unemployment	13 020	10.013	1.510	7.200	12.200	8 081	9.290	1.378	7.200	11.600	6 012	8.651	0.952	7.200	10.400
zstockreturn	13 020	0.037	0.971	-1.688	1.743	8 081	0.690	0.533	-0.234	1.743	6 012	0.862	0.486	-0.108	1.743
SPF exp. inflation	13 020	-0.011	1.630	-3.090	2.688	8 081	-0.897	1.211	-3.090	1.411	6 012	-0.698	1.256	-3.090	1.411
SPF exp. unemployment	13 020	0.044	1.736	-2.807	2.921	8 081	-0.696	1.597	-2.807	2.155	6 012	-1.436	1.110	-2.807	0.511
SPF exp. GDP	13 020	-0.023	1.188	-1.599	5.944	8 081	0.534	1.158	-0.548	5.944	6 012	0.755	1.256	-0.304	5.944
dem_i_nfc	13 020	0.175	0.380	0.000	1.000	8 081	0.219	0.414	0.000	1.000	6 012	0.219	0.414	0.000	1.000
dem_d_nfc	13 020	0.158	0.365	0.000	1.000	8 081	0.117	0.322	0.000	1.000	6 012	0.112	0.316	0.000	1.000

Table 3. Panel regressions

VARIABLES	NFC lending rates: all maturities			NFC lending rates: short maturity (up to 1 year)			NFC lending rates: medium maturity (1-5 years)			NFC lending rates: long maturity (over 5 years)		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	Full time span	Negative rates	Low-for-long period	Full time span	Negative rates	Low-for-long period	Full time span	Negative rates	Low-for-long period	Full time span	Negative rates	Low-for-long period
Krippner	**0.206*****	**0.016**	**-0.027***	**0.185*****	**0.005**	**-0.031****	**0.336*****	**0.077*****	**0.003**	**0.386*****	**0.122*****	**0.051***
	(0.009)	**(0.013)**	**(0.014)**	**(0.010)**	**(0.014)**	**(0.015)**	**(0.015)**	**(0.024)**	**(0.025)**	**(0.015)**	**(0.023)**	**(0.026)**
Liquidity	-1.176***	-0.705***	-0.707***	-1.217***	-0.727***	-0.698***	-1.564***	-0.322	0.273	-1.252***	0.117	0.571**
	(0.122)	(0.121)	(0.129)	(0.123)	(0.125)	(0.132)	(0.166)	(0.211)	(0.259)	(0.160)	(0.221)	(0.274)
Capitalization	-0.612	1.265***	1.543***	0.179	2.073***	2.134***	-1.687**	0.981	1.874*	0.611	2.434***	3.055***
	(0.413)	(0.446)	(0.480)	(0.403)	(0.465)	(0.500)	(0.768)	(0.822)	(0.993)	(0.847)	(0.861)	(0.959)
Size	-0.024	0.460***	0.302***	0.050	0.511***	0.340***	0.158**	0.352**	-0.346*	0.645***	0.987***	0.467**
	(0.055)	(0.075)	(0.078)	(0.055)	(0.075)	(0.078)	(0.079)	(0.137)	(0.180)	(0.097)	(0.159)	(0.225)
Central bank deposits	-0.638	-0.201	1.107**	-1.240***	-0.165	0.990**	-0.210	-4.075***	-1.344	0.382	-3.767***	-3.788***
	(0.414)	(0.482)	(0.452)	(0.433)	(0.510)	(0.484)	(0.613)	(0.866)	(0.897)	(0.639)	(0.872)	(0.837)
Central bank operations	0.005*	-0.000	-0.003	0.007**	0.001	0.001	0.366***	0.061	0.196***	0.007***	-0.001	-0.008
	(0.003)	(0.003)	(0.004)	(0.003)	(0.001)	(0.000)	(0.068)	(0.084)	(0.075)	(0.003)	(0.004)	(0.006)
Industrial production	-0.015***	-0.014***	0.001	-0.015***	-0.012***	0.002	-0.023***	-0.024***	0.004	-0.005*	-0.019***	0.009*
	(0.002)	(0.003)	(0.003)	(0.002)	(0.003)	(0.003)	(0.003)	(0.005)	(0.005)	(0.003)	(0.005)	(0.005)
Unemployment	0.326***	0.339***	0.132***	0.321***	0.290***	0.094**	0.263***	0.440***	0.070	0.117**	0.403***	0.003
	(0.032)	(0.039)	(0.040)	(0.033)	(0.041)	(0.042)	(0.050)	(0.066)	(0.069)	(0.046)	(0.067)	(0.071)
Exp.unemployment	-0.208***	-0.114***	-0.043	-0.212***	-0.080***	-0.013	-0.129***	-0.168***	-0.049	0.017	-0.093*	0.064
	(0.026)	(0.029)	(0.029)	(0.027)	(0.030)	(0.030)	(0.041)	(0.049)	(0.050)	(0.038)	(0.050)	(0.051)
Exp.inflation	-0.028***	0.012	0.023**	-0.030***	0.010	0.015	-0.011	-0.022	-0.021	0.007	0.048***	0.064***
	(0.007)	(0.010)	(0.011)	(0.007)	(0.011)	(0.012)	(0.012)	(0.017)	(0.020)	(0.011)	(0.017)	(0.019)
Exp.GDP	-0.014	-0.037***	-0.020***	-0.007	-0.037***	-0.022***	-0.041***	-0.036***	-0.019	-0.065***	-0.061***	-0.022*
	(0.010)	(0.008)	(0.007)	(0.009)	(0.008)	(0.007)	(0.014)	(0.013)	(0.013)	(0.015)	(0.013)	(0.012)
Stock return	-0.317***	0.049**	-0.038	-0.313***	0.048*	-0.030	-0.517***	0.012	-0.143***	-0.482***	-0.004	-0.145***
	(0.014)	(0.025)	(0.025)	(0.014)	(0.026)	(0.026)	(0.023)	(0.044)	(0.045)	(0.021)	(0.041)	(0.042)
Demand_increase	-0.015	-0.019	-0.008	-0.012	-0.000	0.017	-0.146***	-0.148***	-0.088***	-0.119***	-0.060**	-0.012
	(0.016)	(0.015)	(0.014)	(0.017)	(0.016)	(0.015)	(0.027)	(0.027)	(0.027)	(0.025)	(0.027)	(0.028)
Demand_decrease	0.048***	0.002	0.014	0.037**	-0.010	0.000	0.150***	0.090**	0.081**	0.127***	0.100***	0.112***
	(0.018)	(0.017)	(0.017)	(0.019)	(0.019)	(0.018)	(0.031)	(0.035)	(0.036)	(0.029)	(0.034)	(0.035)
Constant	-0.801	-6.549***	-3.004***	-1.679**	-6.771***	-3.186***	-1.031	-6.123***	4.268**	-4.657***	-11.984***	-2.940
	(0.679)	(0.953)	(0.984)	(0.688)	(0.957)	(0.994)	(0.952)	(1.620)	(2.072)	(1.087)	(1.851)	(2.566)
Bank FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
# of observations	11,434	7,372	5,513	11,312	7,317	5,482	10,310	6,676	5,027	9,782	6,463	4,929
R-squared	0.690	0.750	0.808	0.665	0.724	0.784	0.656	0.638	0.706	0.711	0.656	0.709

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. For each maturity we report three specifications one for full time span (January 2010-December 2020), the second for the period with negative rates (June 2014-December 2020) and the third for the low-for-long period (January 2016-December 2020). Monetary policy stand is measured by the lagged value of Krippner shadow rate (*Krippner*). *Liquidity* is the ratio of liquid to total assets. *Capitalization* is ratio of capital and reserves to total assets. *Size* is 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* are euro area indicators used as the year-on-year growth rate. *Exp. unemployment, exp. inflation, exp. GDP* are forecasts from Survey of Professional Forecasters (SPF). *Stock return* stands for normalized stock returns from Eurostoxx. All euro area variables are lagged by one month. *Demand_increase* and *demand_decrease* is dummy variable 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

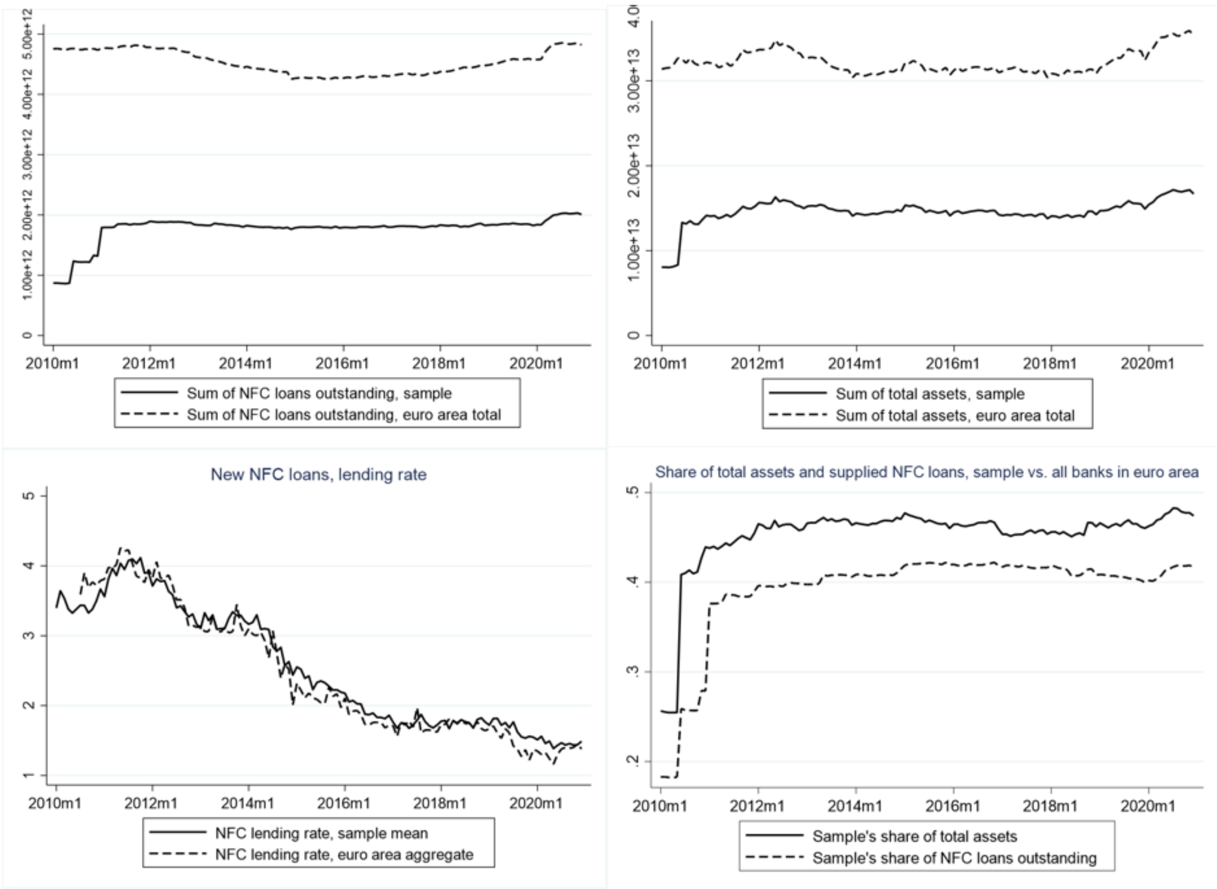


Figure A2. Results regarding the short-term rate surprise for the negative rates sample (2014–2020) when only negative rate surprises are considered. The results show that rate cut surprises in the below zero environment increase lending rates. Note that the figure reports regression coefficients as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

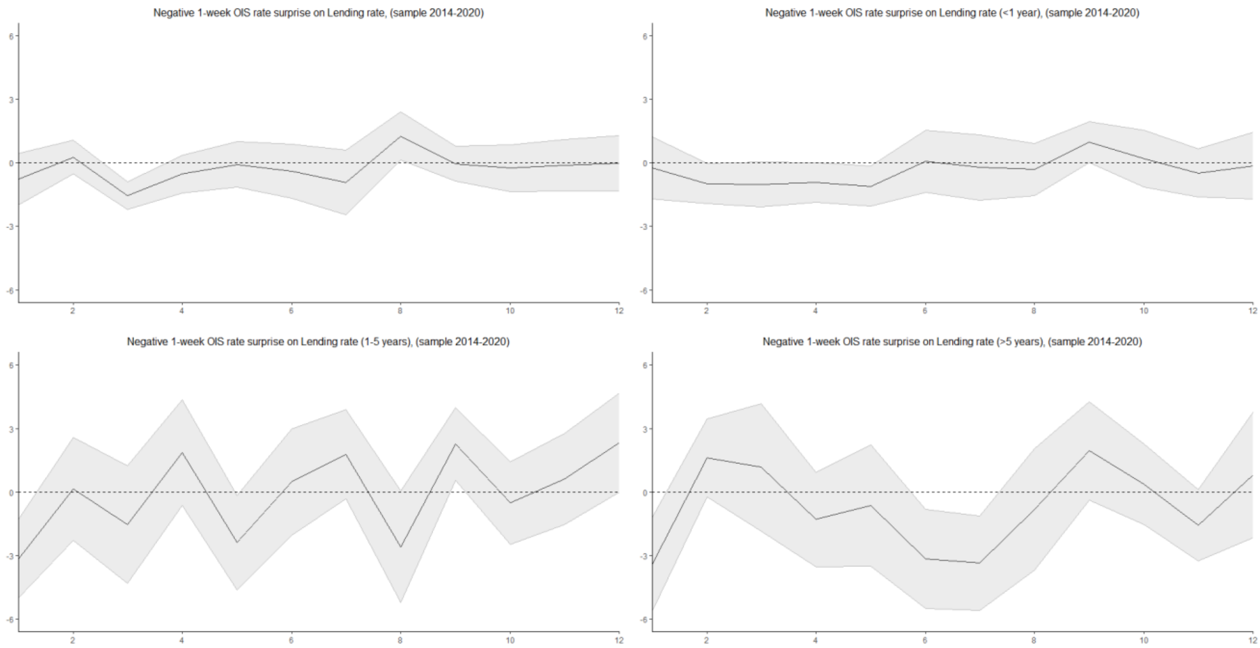
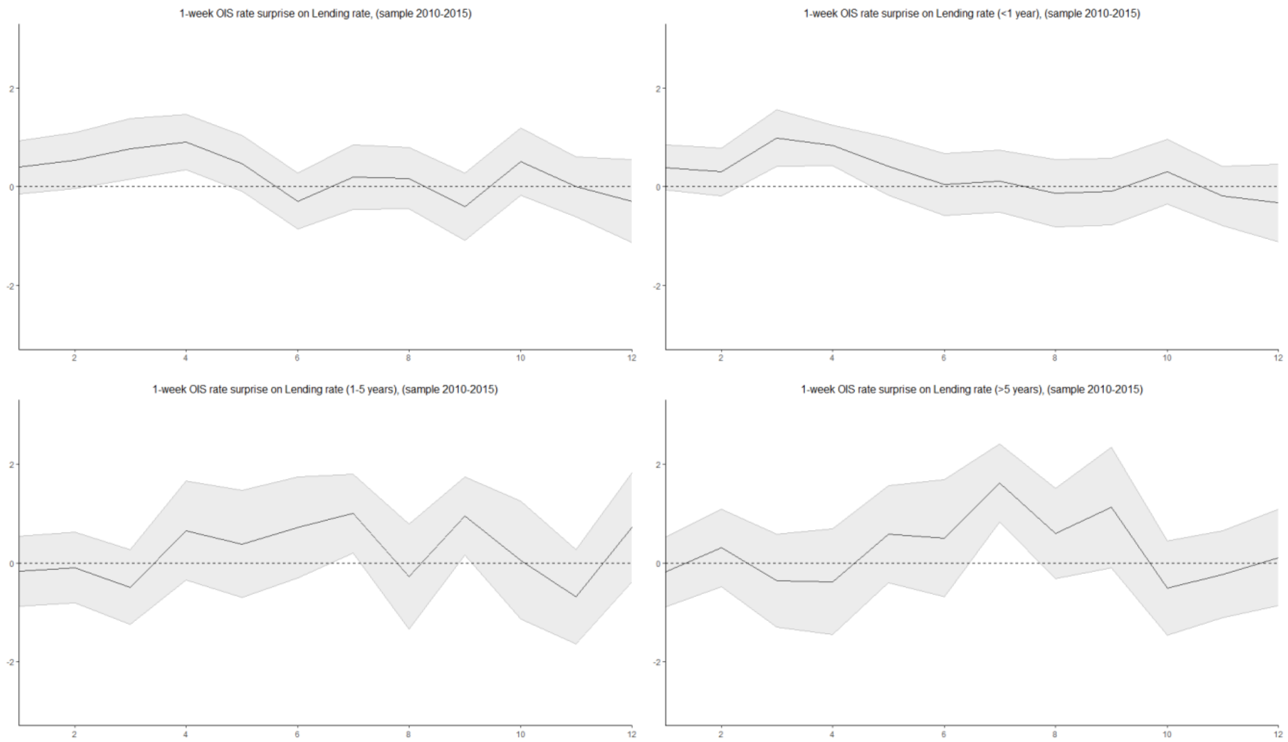


Figure A3. Results using the sample prior the low-for-long period (January 2010- December 2015). During this period, conventional monetary policy still had its intended effects on lending rates.



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