Should we pay banks to lend? Evidence from the Eurosystem's TLTRO and the euro area credit registry*

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Abstract

Since March 2020 the Eurosystem has provided conditional subsidies to some Euro-Area banks, via the new terms of its "Targeted Longer-Term Refinancing Operations" (TLTRO). Under this program, banks can borrow from the Eurosystem at a rate as low as -1%, conditional on their lending performance to the "real economy". By keeping the borrowed funds on their central bank accounts at -0.5%, banks can earn a 50 basis points profit, a significant margin by money market standards. This paper uses the new Euro-Area credit registry data (AnaCredit) to assess the effectiveness of this measure. To overcome reverse causality, we use a novel identification strategies based on the cut-off dates set before the pandemic and unexpected changes of parameters. We find a significant effect of TLTRO on credit supply.

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1 Introduction

For more than a decade, major central banks have used so-called "funding for lending" schemes, providing loans to banks, at a preferential rate, conditional on financing the "real economy". This new instrument was introduced to stimulate demand even as short-term interest rates were close or at their effective lower bound. The Bank of Japan pioneered this approach in 2010, followed by the Bank of England in 2012, and recently the Federal Reserve discussed using such instrument (Carlson, D'Amico, Fuentes-Albero, Schlusche, and Wood (2020)). But it's probably the Eurosystem that has made the most extensive use of funding-for-lending, with its "Targeted Longer Term Refinancing Operations" (TLTRO), which started in 2014, and have since then replaced all other types of central bank refinancing in the Euro-Area (Figure 1).

On 12 March 2020, the Eurosystem changed the pricing of TLTRO and made the program fundamentally different from any other central bank scheme we know of. With this change, banks could borrow for at least two years at a rate as low as -1%, if they exceed the lending target set by the Eurosystem.[1] For the first time in its history, the Eurosystem lends at rate lower than the remuneration of banks' reserves (currently -0.5%). Thus, banks are able to borrow at the TLTRO, and deposit these reserves with the Eurosystem at a higher interest rate (Figure 2) earning a 50 basis points margin, an extremely profitable trade by the standards of the money market.[2] At the time of writing, there were EUR 2,190 bn of TLTRO III borrowings outstanding, meaning that the Eurosystem could pay a subsidy up to EUR 11 bn per year (2,190 times 50 bps). To put this figure in perspective, it corresponds approximately to the dividend payments made by the Bundesbank (EUR 5.9 bn) and the Banque de France (EUR 3.4 bn) to their Treasury in 2019.[3]

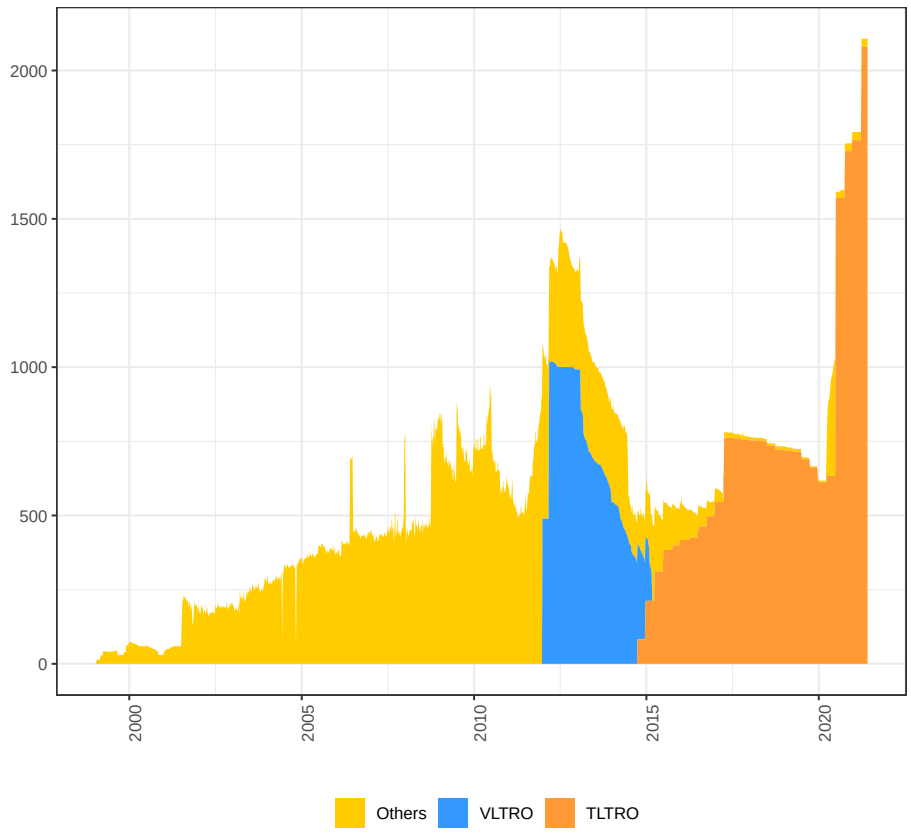
The first contribution of our paper is to design a simple theoretical model to understand the channels through which TLTRO may stimulate loan supply, and the role of the different

[1] In order to pay the interest rate of -1% over June 2020 to June 2022, banks' loan to households and non-financial corporations portfolio (excluding mortgages) had to increase over some "reference periods". The March 2020 decision provided that banks could borrow at are as low as -75 basis points. This rate was lowered to -1% on 30 April 2020 for the period June 2020-June 2021. In December 2020, this period was extended from June 2021 to June 2022. For more details, see section 3.

[2] On aggregate, the liquidity created by TLTROs is deposited with the Eurosystem (accounting identity).

[3] The ECB distributes dividends to its shareholders, the National Central Banks, which in turn may distribute dividends to their shareholders, national governments (in the case of France and Germany). National central banks' profits include ECB dividends, monetary policy operations undertaken by themselves (e.g. TLTRO lending to banks in their country) and other revenues arising for instance from FX reserves or government deposits. These two central banks accounted for 47% of ECB capital key in 2019.

Figure 1: Central bank refinancing in the Euro-Area, by type of operations (EUR billion)

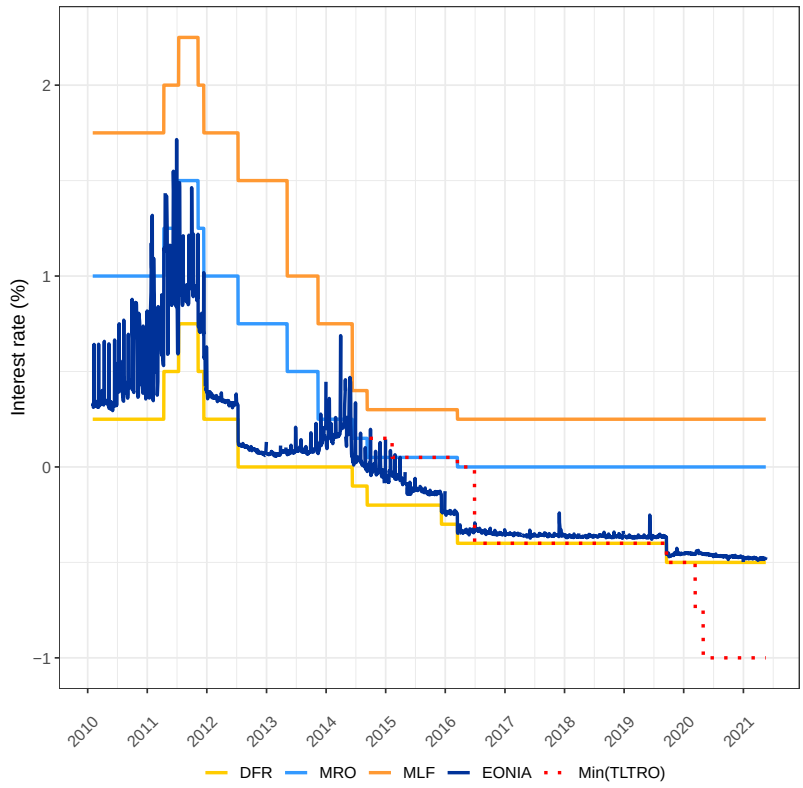


Source: Eurosystem proprietary market operations databases.

Note: "Others" contain MRO, 1 month-LTRO, 3 month-LTROs, 6 month-LTROs, 1Y-LTROs, Bridge LTROs, PELTROs, Fine tuning operations and marginal lending facility.

TLTRO parameters (interest rates, maximum borrowing allowance, etc.). Our model is able to take into account that TLTRO are central bank reserves lent directly to commercial banks. Banks may in turn increase the supply of loans to non-financial corporations and households, settled in commercial bank money (bank deposits). This institutional difference between the two types of monies being used is (to our knowledge) completely absent from existing models of funding-for-lending schemes. The main insight of our model is that TLTRO stimulate the supply of so-called "eligible" loans as long as banks have not reached their credit target. We call this channel the "targeted channel". Once banks have fulfilled the lending target set by the Eurosystem, TLTRO may still stimulate credit by increasing banks profits, a channel we

Figure 2: ECB policy rates and TLTRO minimum rate



Note: This graph shows the evolution of the the ECB key policy rates, the deposit facility rate (DFR), the rate of the main refinancing operation (MRO), the marginal lending facility rate (MLF), and the overnight unsecured interbank rate (EONIA), and the most favorable rate offered under the TLTRO (Min(TLTRO)).

call the "profitability" channel. This channel also affects the supply of "ineligible" loans.

The second, and most important contribution of our paper is to assess empirically the effectiveness of post-March 2020 TLTRO program on bank lending, and disentangle the two channels. In other words, we intend to provide the first estimates of the effects of a program that subsidies banks to lend. Such an assessment is all the more important that TLTRO have by definition a long maturity (3-year), and will be on the Eurosystem's balance sheet until at least end-2024, more than 10 years after the first TLTRO program started.

Evaluating such a program is empirically challenging due to reverse causality. Banks decide whether to participate or not to TLTRO operations. Reverse causality arises if banks participating to the TLTRO were doing so because they expected that their lending performance would be above the target set by the Eurosystem (and they would pay the most favorable interest rate, at -1%). In such a setting, TLTRO do not cause higher lending growth. It is the expectation of high lending growth that causes TLTRO participation.

To deal with this issue, the literature has used an instrumental variable approach (Benetton and Fantino (2021), Esposito, Fantino, and Sung (2020), Andreeva and García-Posada (2021)). The instrument used is the maximum amount that each bank is allowed to borrow at the TLTRO. It is set by the Eurosystem as a fixed percentage of banks' loan portfolio at the the start of the program. However, in our case banks were able to pick which entity of their banking group were included in the calculation of their loan portfolio. We show that banks strategically selected the entities that had the best lending prospects. Therefore, the size of the "borrowing allowance" (i.e. the maximum account banks could borrow) was affected by the expected performance of entities in the group, and cannot be considered exogenous.

A second empirical challenge, which is linked to the attractive pricing of the operations, is the large participation to the program (87% of banks), and only few small banks did not participate.[4] Banks that did not participate to TLTRO cannot be used as a control group for TLTRO III under such circumstances.

To overcome these issues, we use a simple feature of the program. By construction, credit performance of banks has to be measured over some time period, called the "reference period". For post-March 2020 TLTROs, the reference period was set from 1 March 2020 (right before the announcement) to 31 March 2021. Concretely, banks can borrow at -1 % if their "net lending" (new loans granted minus repayments) between 1 March 2020 and 31 March 2021 exceeds 0%. It means that after 12 March 2020 announcement, banks knew that any loan they granted that matured after the 31 March 2021 would count in their "lending performance". In contrast, banks did not expect loans that matured before 31 March 2021 to count in their lending performance (it is granted during the reference period but repayed before the end-date). This 31 March 2021 cut-off was set in June 2019, and never changed thereafter. It offers an exogenous change in the eligibility status of bank loans. We therefore test the effect of the eligibility status of a given bank loan on the size of the loan. We expect to find that eligible loans are ceteris paribus larger than non-eligible loans after TLTRO announcement. As we advance in the sample, mechanically, more loans may mature after 31 March 2021. We control for the average maturity of bank loans, using several sets of maturity fixed-effects.

This strategy allows to estimate the effect of TLTRO through its "targeted" channel. We

[4]Our figure of 87% is based on the minimum reserve requirements of all banks that could be found in the Centralised Securities Database (CSDB), which should contain all institutions that issued at least one debt security since 2018. The idea is to include only those banks that have alternative market sources for this calculation. We do not impose such restrictions in our regressions. If one considers all banks irrespective of whether they issued a bond, the participation was around 75 %

are however also interested in the "profitability" channel. To test for this second channel we exploit an exogenous variation of the amount banks could borrow - ie. their borrowing allowance. We use the December 2020 announcement, which unexpectedly increased the amount that banks could borrow from TLTRO by 10%. If we detect an impact of this increase on ineligible loans, or on all loans but by banks that already meet the lending performance at the time of announcement, we know for sure this does not come from the taregted chanel, but rather from a "profitability" channel. We show that this 10% increase is perfectly correlated with banks' actual borrowing at the following operation.[5] We use use this exogenous increase as an instrument for TLTRO borrowing at the March 2021 operation. Our results show an

We apply our strategies on the Euro-Area credit registry data, called Anacredit. Thanks to Anacredit, we are able to access loan-by-loan information on all credit granted to non-financial corporations by Euro-Area banks since the start of 2019. The information include notably the lender, the borrower, the date the loan was granted, the maturity of the loan and the guarantor, if any. This rich dataset allows us to control for other credit supply factors through bank-time fixed effects, and for credit demand factors through firm-time fixed effects. To our knowledge, this paper is the first to make use of Anacredit. We look at the volumes of new loans made by banks that participated to the post-March 2020 TLTROs to show the effect of the March 2020 announcements on origination volumes.

We find large, significant and robust effects of the "targeted" channel for the post-March 2020 TLTRO. Our most saturated regression suggests that loan origination for "eligible loans" (i.e. loans that matured after 31 March 2020) increased by 32% in the quarter immediately after the announcement of the subsidy, and by 19% in the following quarter. Moreover, our regressions on the profitability channel also show that loans that are not affected by the "targeted" channel of TLTRO systematically increase due to TLTRO borrowing. Within the same quarter, the targeted channel appears to be stronger than the profitability channel.

We make sure that our results are not driven by an increase in the supply of long-term loans vs. short term loans by running placebo tests. In these tests, we move the cut-off date by one period forward. The significance coefficients either diminishes markedly or disappears altogether, showing that there is a specific effect related to the 31 March 2021 deadline. We are not aware of any other regulation or program that creates a discontinuity at the 31 March

[5] In the case of the December 2020, we see that some banks try to affect the compositions of their groups, which could introduce some endogeneity. We therefore keep the composition of groups constant to avoid this issue.

2021, except the TLTROs.[6]

Our results using an instrumental variable approach confirm the positive effect of TLTROs on credit supply. They show that an exogenous increase in a bank's borrowing by 1% raise its credit between 5% and 7%. More importantly, this strategy allow us to uncover a profitability channel, i.e. "ineligible" are also affected by TLTRO and banks with strong credit performance too. The effect of TLTRO on these latter groups is however smaller than for "Eligible" loans, and for banks that are still fighting to reach their targets, as theory would predict.

Section 2 reviews the literature, section 3 details the institutional set-up, section 4 lays out our theoretical model, section 5 describes our data, section 6 explains our empirical strategies and our results. Section 7 concludes.

2 Literature review

The closest papers from ours are Benetton and Fantino (2021) and Esposito, Fantino, and Sung (2020), which study respectively the effects of TLTRO-I and TLTRO-II on credit supply in Italy, using loan-level data from the Italian credit registry. Other papers, using bank-by-bank data study the effect of TLTROs I and II: Andreeva and García-Posada (2021), Bats and Hudepohl (2019) and Laine (2019). While the TLTRO III were initially extremely close to the TLTRO II in terms of pricing and bidding limits, the changes that were made on 12 March 2020 significantly increased the size of the program compared to previous ones, and more importantly added an explicit subsidy component, which made this scheme a unique experiment. We contribute to this literature by looking for the first time at the effect of this subsidized "funding-for-lending" scheme for the whole Euro-Area.

We also make a methodological contribution to the literature on TLTROs. In principle, we could use the same instrumental variable as Benetton and Fantino (2021), Esposito, Fantino, and Sung (2020) Andreeva and García-Posada (2021). The instrument used is the maximum amount banks can borrow (the "borrowing allowance"), which itself depends on the size of banks' loan portfolio at the start of the program. However, we show that in our case, and possibly in previous TLTRO programs banks could strategically affect their allowance by including some entities of their banking group and exclude others from the "TLTRO group"

[6]Some countries have put in place state-guarantees for bank lending around March 2020, but we be control for all time-varying country events through our fixed effects. We also explicitly control for guarantees in our robustness section, and at last we run our results without French banks to check they are robust to the large loan-guaranteed scheme put in place in France.

they reported to the Eurosystem. We use different empirical strategies, notably based on the date of the end of the lending performance, which is the same for all banks and was never changed in 2019 or 2020 (despite the pandemic) ruling out any endogeneity.

We contribute also to the empirical banking literature, which disentangles supply and demand effect using loan-level data. This approach, pioneered by Khwaja and Mian (2008) looks at firms which borrows from two banks simultaneously and uses firm-time fixed effects to neutralize all time-varying variables that affect loan demand.[7] Thanks to our detailed dataset, we can observe new flows for loans (not only changes in outstanding amounts). Moreover, we are able control for the maturity of loan, a key parameter that most credit-registry data do not contain.

At last, our paper contributes to the larger literature on the empirical assessment of unconventional monetary policies, i.e. measures taken by central banks other than changing the level of short-term interest rates. While the profession has witnessed an explosion of contributions on forward guidance and central bank asset purchase, the literature on "funding for lending" schemes remains limited. In the euro area, for instance, Rostagno, Altavilla, Carboni, Lemke, Motto, Saint Guilhem, and Yiangou (2019) and Rostagno, Altavilla, Carboni, Lemke, Motto, and Saint Guilhem (2021) extensively study negative rates, asset purchases and forward guidance but not TLTRO. Outside the euro area, the empirical assessment of funding for lending schemes is also extremely sparse, set aside Havrylchyk (2016) and Churm, Joyce, Kapetanios, and Theodoridis (2021) for the UK experiment. This paper intends to fill the gap by studying the largest "funding-for-lending" scheme on record, which was put in place during an exceptional crisis.

3 Institutional environment

3.1 Untargeted refinancing operations

Since it started to conduct market operations in January 1999, the Euroystem has provided liquidity to Euro-Area banks through refinancing operations.[8] Initially Eurosytem lending took the form of "Main Refinancing Operations" (MRO) with one-week maturity and Longer-

[7] Other examples of papers using similar techniques include Jiménez, Ongena, Peydró, and Saurina (2014), Benetton and Fantino (2021) and Esposito, Fantino, and Sung (2020).

[8] Euro-Area banks needs for central bank liquidity was then higher than the liquidity provided by central bank outright purchases. This configuration is known in central bank parlance as "structural liquidity deficit" and implied that banks had to constantly roll-over their central bank refinancing to fulfill their liquidity needs.

Term Refinancing Operations (LTROs), which had maturities of maximum three months (Figure 1).[9] These relatively short term operations, together with the "corridor" enabled the Eurosystem to control money market rates.[10]

From 2007, in the face of deteriorating market conditions for long-term funding, the Eurosystem dramatically increased the maturity of its operations, with 6-month TLTRO conducted from April 2008 and 1-year LTROs from June 2009. This effort to extend the maturity of refinancing operations culminated with two 3-year LTROs in December 2011 and March 2012, nicknamed "Very Long-Term Refinancing Operations" (VLTROs).

By lengthening the maturity of its operations, the Eurosystem intended to lower long-term financing costs for banks to make sure they could provide credit to the non-financial sector at affordable conditions (Andrade, Cahn, Fraisse, and Mésonnier (2019)). Ceteris paribus, central bank refinancing translates into bank reserves piling up at the central bank, not necessarily bank loans.[11] Thus, these operations worked mainly through the pricing of banks' funding and probably much less through the quantities lent by the central bank.

The introduction of longer-term refinancing operations, in particular 3-year LTROs, has generally been assessed as effective in avoiding a Euro Area credit crunch in 2011 (Andrade, Cahn, Fraisse, and Mésonnier (2019)). Some have argued however that these operations enabled banks to borrow from the Eurosystem to invest in higher yielding government securities ("carry-trade" effect) at the risk of reinforcing the sovereign-bank nexus (Crosignani, Faria-e Castro, and Fonseca (2020) and Acharya and Steffen (2015)).

3.2 Targeted Longer-Term Refinancing Operations (TLTROs)

To ensure that its refinancing operations stimulate bank lending to the "real economy", the Eurosystem made a significant change in 2014, and engaged into "Targeted Longer-Term Refinancing Operations" (TLTROs). Three programmes of TLTROs have been conducted as shown in Table 1: TLTROs I, TLTROs II and TLTROs III.

[9] From 1999 to 2004 MRO had two-week maturity, with one MRO conducted each week and two overlapping operations outstanding at all time. Prior to 2008, the Eurosystem allotted a limited amount of liquidity through a discriminatory price auction (Cassola, Hortacsu, and Kastl (2013)).

[10] For a model of the money market in the Euro-Area and the interaction with central refinancing operations and corridor, see (Vari (2020)).

[11] By identity, when loans increase on the asset side of the banking system consolidated balance sheet, deposits increase as well. Other liabilities toward non-banks may increase, such as bonds or shares, but this would require banks to actively issue securities. By default an increase in bank loans generates an increase in banks deposits.

Table 1: Summary of TLTRO parameters

Programme	Date	Maturity	Limit	Interest rate(s)
I (8 operations)	2014-16	2Y-4Y	7% of loans	DFR+0.35%
II (4 operations)	2016-17	4Y	30% of loans	DFR/DFR+0.5%
III 2019 (2 operations)	2019	3Y	30% of loans	DFR%/DFR+0.5%
III 2020 (4 operations)	2020	3Y	50% of loans	DFR-0.5%/DFR+0.5%
III 2021 (4 operations)	2021	3Y	55% of loans	DFR-0.5%/DFR+0.5%

Note: DFR stands for "deposit facility rate". It is the reference point used by the Eurosystem for the pricing of its operations and is a proxy for the risk-free overnight rate.

While the set-up varied for each programme, they shared two features :

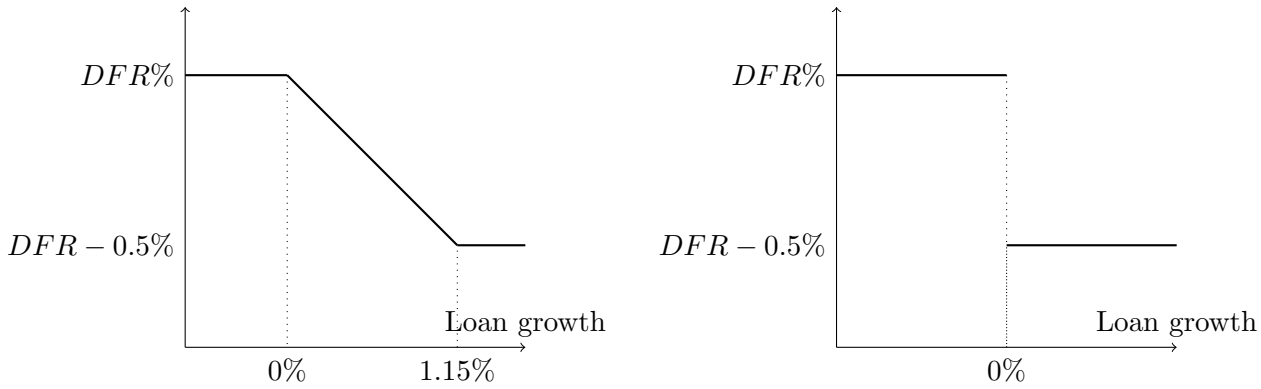
- The maximum amount that banks can borrow (the "borowing allowance") is a fraction of their loans to non-financial corporations and households, excluding home mortgages, net of funds already borrowed in previous TLTROs operations and still outstanding.
- The interest rate a given bank pays depends on its "lending performance", i.e. growth of its loans portfolio between the start and the end of a so-called "reference period". Under this scheme, banks pay more favorable interest rates if they reach a certain lending performance. As shown on diagram 1 certain operations had a progressive pricing structure, with interest rates decreasing linearly with the performance (e.g. TLTRO III operated in 2019), while operations conducted in 2020 have an interest rate structure which is binary, i.e. the interest rate paid drops from -0.5% to -1% when the bank exceeds the lending target by 1 euro.

Since their introduction, TLTROs parameters have become more generous, with higher borrowing allowance and lower interest rates (Table 1). A major change occurred on 12 March 2020, when the ECB Governing Council decided to lower the most favorable rate on TLTROs-III below the deposit facility rate.[12] It meant that banks could earn a risk-free profit of 50 bps per euro borrowed by participating to the TLTROs and placing the proceeds at the deposit facility.[13]

[12]Initially, the most favorable rate was set 25 bps below the deposit facility rate, and then lowered to 50 bps below the deposit facility rate on 30 April 2020.

[13]This interest rate schedule, when announced in March 2020, applied only between June 2020 and June 2021. In December 2020, the ECB Governing Council extended it to June 2022.

Diagram 1: TLTROs pricing, progressive vs. binary



Note: The first TLTRO III post-pandemic conducted in March 2020 offered interest rates of

$$DFR - / + 0.25\%$$

This pricing scheme is applicable during the (additional) special interest rate period (June 2020 to June 2022)

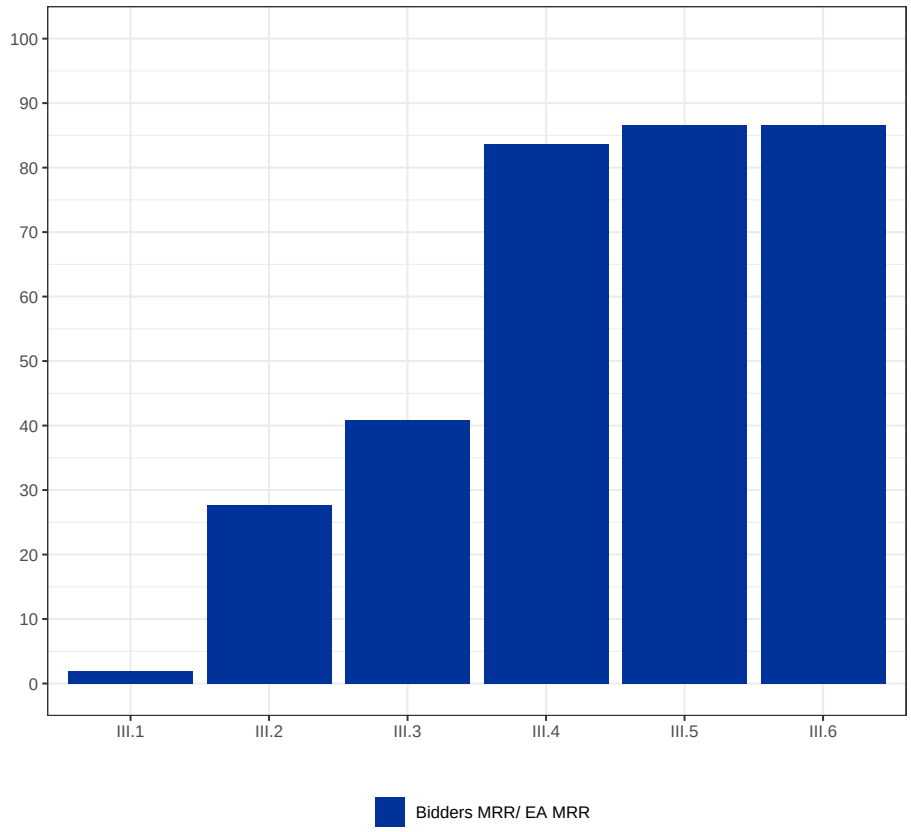
The participation of banks to the TLTRO III was subdued for the first two operations (Figure 3). Since March 2020, banks' participation has increased and by June 2020 has become almost systematic, with more than 87% of banks coming at one of the TLTRO III windows.[14] The remaining 13% were either very small credit institutions with operational constraints that did not allow them to enter this complex program, or banks specialized in home-mortgages, excluded from the TLTRO scheme (see below).

Similarly, the net take-up (bank's borrowing minus reimbursement of previous TLTROs) was actually negative for operations in 2019. Net borrowing became positive after parameters were changed in March 2020, and gross take-up surpassed EUR 1,300 bn in June 2020 (Figure 4), which was the largest central bank lending operation to be ever conducted. It was more than double the size of VLTROs operations in 2011, and 2012, which previously held that record (Crosignani, Faria-e Castro, and Fonseca (2020)).[15]

[14]Banks had to submit their application by 20 February 2020 to borrow at the March operation. Given that few banks participated to the program prior to that date, effectively, it meant that most banks were precluded from borrowing at the March 2020 operation, even if they wanted to. Moreover, at the time, the -1% interest rate applied only to the June 2020-June 2021 period, which made it more attractive to borrow from the June operation.

[15]We include in repayments, the scheduled repayments that occur at the maturity of any TLTRO, and anticipation repayments that banks have option to make after a certain time, depending on TLTRO programs.

Figure 3: Bank's participation to TLTRO III (% of bidders' size to all banks' size in terms of reserve requirements, in cumulative terms since TLTRO III.1)



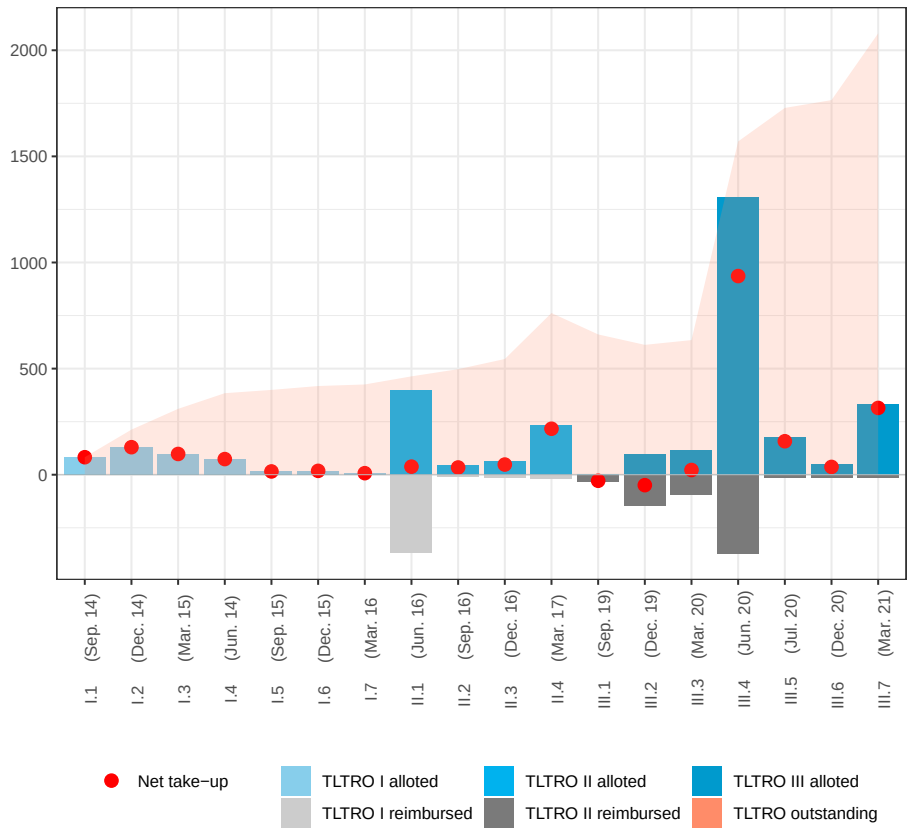
Source: Eurosystem proprietary market operations databases, CSDB, MPEC as of March 2021.

Note: This graph compares the total size of bidders to the total size of the banking system. Size is measured in terms of reserve requirements (MRR: minimum reserve requirements, a measure of size available to us for all banks in the Euro-Area), which reflects size in terms of deposits. We exclude from the calculations banks that are not allowed to borrow from the Eurosystem, and banks that did not issue bonds since 2018 (the start of our public bond database, CSDB).

3.3 How TLTROs stimulate credit

Contrary to pre-GFC refinancing operations, TLTROs were not expected to stimulate credit through a decline of money market rates (which would ultimately transmit to lending rates), or longer-term funding rates. TLTROs were conducted in a context of abundant excess liquidity and short term interest rates were already at the lower end of the central bank

Figure 4: TLTROs net take-up and amount outstanding (EUR billion)



Source: Eurosystem proprietary market operations databases.

corridor (Figure 2). In this context, additional excess liquidity has very limited effects on the overnight market interest rates. Even if banks can borrow reserves from the Eurosystem at a rate as low as -1%, by arbitrage banks have no incentive to lend unsecured funds at a rate below the ECB deposit facility rate, which remunerates bank reserves at -0.5%. TLTRO with their 3-year maturity and -1% interest rate are in principle an attractive option of long-term funding. However, there is no visible decline of bank' securities issuance since the start of TLTRO III (see figure 13 in appendix).[16] In the rest of this section we lay out the two channels through which TLTRO can stimulate credit.

As formally shown in our model, TLTRO may affect credit through two channels. We call

[16]Data show some moderate decline in issuance of securities with initial maturity below 1 year. This decline however starts before the TLTRO III were introduced.

the first channel, the "targeting channel". It arises from the incentive of banks to increase the supply of loans that count in their credit performance. We will call these loans "eligible loans". Increasing the size of their portfolio of "eligible loans" allows banks to reach the lending targets set under the TLTRO and benefit from a lower interest on their central bank borrowings. This channel should affect only the supply of eligible loans.

We call the second channel the "profitability channel". It works by allowing banks to conduct a risk-free arbitrage, by borrowing from the Eurosystem's TLTROs and leaving the proceeds on their central bank account at an interest rate 50 bps higher. This additional profits may incentive banks to lend more, which ceteris paribus reduces their profits. At the opposite, banks may chose to distribute additional profits to their shareholders by increasing dividends.

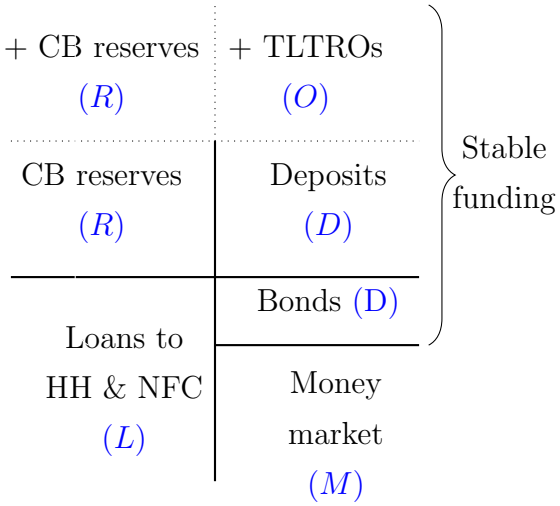
4 Theoretical model

4.1 General set-up

We consider a representative bank that holds loans and central bank reserves. The bank funds itself through money market borrowings, bonds, retail deposits, and central bank refinancing, as shown on Figure 5. The funding constraint for the representative bank therefore writes:

$$L + R = O + D + M \tag{1}$$

Figure 5: The representative bank's balance sheet



Where L is the stock of loans to households and non-financial corporations held by the bank, R is the amount of reserves held at the central bank. D is the stock of deposits, O is

the amount borrowed from the central bank, M is amount borrowed on the money market.[17] All balance sheet items should be thought as end-of-day stock variables averaged over one year, expressed in euros.

Moreover, for prudential reasons, banks are required to finance at least a fraction of their loan portfolio with "stable funding" (deposits or central bank financing). We call this exogenous fraction α.[18] Thus banks face an additional constraint:

$$O + D \geq \alpha L \tag{2}$$

Further, loans can be divided into: "Eligible" loans (L^E), which will be taken into account by the central bank to compute the lending performance of each bank and decide on the interest rate the bank pays on its TLTRO, and "Ineligible" loans (L^I), such that:

$$L = L^E + L^I \tag{3}$$

In the current set-up, we will consider that "Eligible" and "Ineligible" loans differ only with respect to their maturity date (before or after a cut-off date set by the central bank). Our model is sufficiently general to be applied to other situation, such as "green" vs. "brown" loans, for "green TLTRO", as discussed in van 't Klooster and van Tilburg (2020).

The profit function (Π) of the representative bank over a one year horizon writes

$$\Pi = r_E L^E + r_I L^I + r_R R - r_D D - r_O O - r_M M - C(L^E) - C(L^I) \tag{4}$$

r_E, r_I, r_R, r_D, r_O and r_M are nominal interest rates associated with each balance sheet item.

Banks act as price-taker on the loan market, and faces interest rate r_E and r_I. $C(L^i)$ is the cost to find new lending opportunities on the loan markets $i = \{I, E\}$. It captures search and screening costs. We use a quadratic cost function (as in Drechsler, Savov, and Schnabl (2017) for instance), with $C(L^i) = c\frac{(L^i)^2}{2}$ where $c > 0$.

Banks face a deposit supply function of the following form: $r_D = r_M + d_1$, where $d_1 > 0$ is a mark-up above the money market rate. It captures both the premium banks are ready to pay for locking-in long-term funds (see Bechtel, Ranaldo, and Wrampelmeyer (2019)) and the

[17] The banking system has a net liability on the money market due to non-bank actors (such as money market fund) who deposit funds for short period of time with banks.

[18] This constraint matches closely the Net Stable Funding Ratio (NSFR) set by the Basel Committee on Banking Supervision. We assume that it is set solely for prudential reasons without any monetary policy considerations. The disconnect between monetary and prudential regulation is documented in Monnet and Vari (2020).

fact that some deposits could be subject to zero lower bounds, while money market deposits are not.

We assume that the money market rate is equal to the deposit facility rate set by the central bank:

$$r_M = r_{DF} \tag{5}$$

where, r_{DF} is a policy rate directly controlled by the central bank.

This assumption reflects the situation of abundant excess liquidity created by asset purchase programs, which push money market rates close to the deposit facility rate, the bottom of the central bank corridor (Poole (1968), or Vari (2020)).

4.2 The targeted channel of TLTROs

We model targeted refinancing operations as loans offered by the central bank to banks for one year. The amount of the loan ranges between 0 and $\bar{O}$, where $\bar{O}$ is the borrowing allowance set by the central bank. Bank endogenously chose the amount they borrow within the $[0; \bar{O}]$ interval, depending on the level of the TLTRO interest rate they expect to pay r_O compared to the market interest rate on stable funding r_D, the money market rate r_M, and the amount of loan they grant (L).

The interest rate on the operation (r_O) depends on the size of the eligible loan portfolio at the end of the year (L^E). The level of interest rate changes depending on whether L^E exceeds or not some threshold $\underline{\mathrm{L}}^E$ set by the central bank, and a second threshold $\underline{\mathrm{L}}^E + g$, where $g > 0$ is also set by the central bank. We restrict ourselves to the following type of functions:

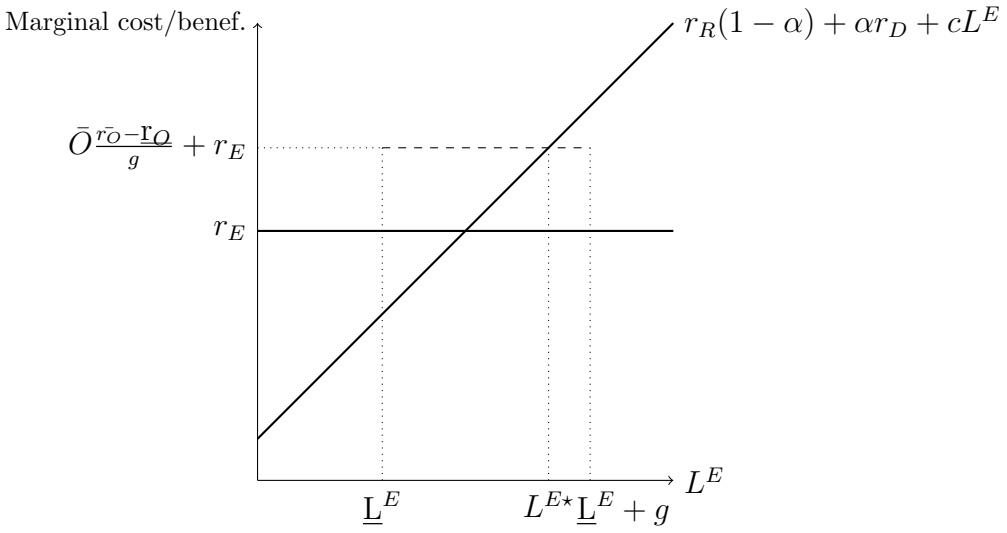
$$\begin{cases} r_O(L^E) = \bar{r_O} & \forall L < \underline{\mathrm{L}}^E \\ r_O(L^E) = \bar{r}_O + \underline{\mathrm{L}}^E \frac{\bar{r}_O - \underline{\mathrm{r}}_O}{g} - L^E \frac{\bar{r}_O - \underline{\mathrm{r}}_O}{g} & \forall L \in [\underline{\mathrm{L}}^E; \underline{\mathrm{L}}^E + g] \\ r_O(L^E) = \underline{\mathrm{r}}_O & \forall L > \underline{\mathrm{L}}^E + g \end{cases}$$

This type of functions fits all types of TLTROs. It corresponds exactly to TLTRO II and the pre-pandemic TLTROs III (see Table 1). When g tends to zero, the function fits the post pandemic TLTROs III. In order to keep the model as general as possible we explore here the case whenre $g > 0$, and keep the analysis of $g = 0$ for Appendix B.2.1.[19]

We also restrict the analysis to cases where the interest rates on TLTROs is always lower than the market for stable funding ($\bar{r}_O \leq r_D$), to fit the context of Eurosystem' s TLTROs. The model can easily be extended to a more general setting, as shown in Appendix B.2.2.

[19]Further, by setting the maximum rate $\bar{r_O}$ to r_D and the minimum rate to $DFR + 35bps$, the function replicates the payoff from the TLTROs I.

Figure 6: The bank's problem with TLTROs



The problem of the bank, can be written with the following Lagrangian:

$$\mathcal{L}=\Pi-\lambda(L+R-O-D-M)-\gamma(\alpha L-D-O)-\delta(O-\bar{O}) \tag{6}$$

Maximizing $\mathcal{L}$ with respect to the amount of loans (L) and deposits (D), interbank borrowing and (M) and central bank borrowings (O) and combining these equations yield the following conditions (Appendix B.2.1):

$$r_E-\bar{O}\frac{\partial r_O}{\partial L^E}=\frac{\partial C}{\partial L^E}+r_M(1-\alpha)+\alpha r_D \tag{7}$$

$$r_I=\frac{\partial C}{\partial L^I}+r_M(1-\alpha)+\alpha r_D \tag{8}$$

$$O=\bar{O} \tag{9}$$

The left-hand sides of equations (7) and (8) represent the marginal benefit of increasing loan supply, while the right-hand sides represents the marginal cost. In case of (7) the central bank scheme increases the marginal benefit through the following term: $\bar{O}\frac{\partial r_O}{\partial L^E}$.

Equation (7) is not continuous for all values of L^E, due to the fact that $\frac{\partial r_O}{\partial L^E}$ is null, except over $[\underline{L}^E;\underline{L}^E+g]$ where it is strictly negative. This dynamic is represented on Figure 6.

The amount of accommodation provided by the TLTROs can be found with (7) (8), using the functional forms of C^i, and r_O:

$$L^{I\star} = \frac{r_I - r_M(1-\alpha) - \alpha r_D}{c} \tag{10}$$

$$L^{E\star} = \frac{r_E - r_M(1-\alpha) - \alpha r_D}{c} + \bar{O}\frac{\bar{r_O} - \underline{r_O}}{gc} \tag{11}$$

Equation (10) shows the supply function of the bank for loans that are not eligible to be counted in the TLTRO lending performance. Supply is increasing in the price of loans r_I, and decreasing in the average cost of funding $r_M(1-\alpha)-\alpha r_D$, where the weight α corresponds to the share of stable funding a bank must raise to grant news loans. This basically means that conventional central bank policies that lower short-term rates (r_M) and longer term rates (r_D), stimulate loan supply in a way which is completely distinct from TLTROs. The supply of loans is also decreasing in c, the slope of the marginal cost function.

This intuitive supply function also applies to "Eligible" loans (first term of equation (11)). The second term of equation (11) gives the amount of additional lending resulting from the TLTROs. $\bar{O}$ is the amount of accommodation provided and $\frac{\bar{r_O}-\underline{r_O}}{gc}$ is the amount of accommodation per unit lent. It is equal to the the marginal decline in the interest rate on central bank lending per unit of additional loans granted by the bank, divided by the marginal cost per unit of TLTRO.

Let's keep in mind that this equilibrium applies to cases where parameters $\underline{L}^E$, g and c are such that the equilibrium amount of loans $L^{E\star}$ is in the interval $[\underline{L}^E; \underline{L}^E + g]$, meaning that central bank lending operation strictly increases loan supply to the real economy. Ceteris paribus, for lower values of c, the marginal cost function would be "too flat", and we would have $L^{E\star} > \underline{L}^E + g$. In this case TLTROs have no effects on lending, but banks still borrow from the operation. In this case TLTRO are a pure "boon".

4.3 The profitability channel

In addition to the targeted channel, the model shows another way through which TLTROs may stimulate loan supply. We call it the "profitability channel".

This second channel is effective if and only if banks borrow from the central operation, which happens only when $r_O \leq r_D$. In this case, we can use (4), and under the assumption that the banking sector is competitive, write the following equation:[20]

$$r_E L^E + r_I L^I + r_R R - \bar{O} r_O - r_D D - r_M M - C(L^E) - C(L^I) = 0 \tag{12}$$

[20]The following reasoning would also hold if banks were making positive but constant profit margins.

Using this equation together with identities that must hold at the level of the banking sector, Appendix B.2.3 shows that:

$$\frac{dL}{dr_O} = \frac{\bar{O}}{(1-\alpha)(r_M - r_D)} \tag{13}$$

This derivative is always negative ($\alpha < 1$ and $r_M < r_D$), implying that any decrease of the interest rate on TLTRO (r_O) may stimulate loan supply (eligible and non-eligible loans), even if the targeted channel is muted. The impact is proportional to the borrowing allowance ($\bar{O}$).

4.4 Main insights from the model

Our model allows us to make a series of predictions, that we will test in the data:

- TLTRO may stimulate the supply of eligible loans (only), through the "targeted channel".
- Whether the targeted channel is effective or not depends on bank unobservable (and possibly time-varying) characteristics such as marginal costs.
- The targeted channel is effective only for banks which loan supply is not "too high" relative to the lending target set by the central bank.
- Apart, from the targeted channel TLTRO may affect loan supply (for both types of loans) through a profitability channel.
- The effect of both channels on loans supply depend on the amount of TLTRO funding borrowed by the bank.

5 Data

Our data sources consist of confidential bank-by-bank information on borrowings of banks from the TLTROs, taken from the Eurosystem proprietary market operations database. We match these data with loan-level information from the AnaCredit database. We obtain a panel of bank loans at the quarterly frequency.[21]

[21] We could in principle use a higher frequency. However, TLTROs occur only once every quarter, which make quarterly frequency sufficient. Using this frequency makes our results immediately comparable with the literature, and it is more convenient as it reduces somehow the size of our dataset and avoids having too many coefficients.

5.1 Market Operations Database

The Eurosystem market operations database (MOPDB) consolidates confidential bank-by-bank information on all operations from the 19 euro-area national central banks. It contains end-of-day positions (deposits and borrowings) of all banks of the Euro-Area, as well as other related information (collateral use, borrowing limits, etc.). Each bank is identified via a unique a RIAD code, which also identifies institutions in Anacredit, and makes the merging of the two database immediate[22]. We take end-of-quarter TLTRO borrowings for all participating institutions.[23] TLTRO borrowing applies to a given "TLTRO group", i.e. a set of institutions from a given banking group that decide to participate together to the TLTRO. We therefore attribute the same participation status and the same borrowing amount to all the banks of a given "TLTRO group".

5.2 AnaCredit

AnaCredit (*Analytical Credit Dataset*) is a ESCB proprietary database reporting loan-by-loan data on credit granted by all credit institutions resident in the euro area, to companies and other legal entities.[24] The database harmonizes and extends granular credit data collected by each euro area member states.[25] and provides a complete overview over credit instruments, debtors, creditors and other parties such as guarantors. The database contains 88 attributes based on harmonised definitions common to all participating countries. An extensive description of the AnaCredit methodology, reporting and attributes is available in the AnaCredit reporting manuals[26]

Data start is September 2018 and is updated on a monthly basis. A loan is uniquely identified by instrument, contract, debtor and creditor identifiers, which allows us to detect new loans. A loan can then be tracked with all its details (outstanding, etc) at a monthly frequency during its lifetime. In terms of coverage, Anacredit reports only loans to legal entities, (excluding households), with a minimum amount of Eur 25,000. Around 25 millions

[22] RIAD stands for Register of Institutions and Affiliates Data.

[23] TLTROs III operations occur once every quarter and are settled between the 27th and the 29th of the last month of the quarter, except in December when they settled on the 20th and the 21 of December 2019 and 2020. TLTRO repayments always take place on the settlement day of new operations.

[24] Foreign branches of credit institutions also report to AnaCredit, provided that these branches are resident in a euro area Member State

[25] The Governing Council of the ECB adopted Regulation (EU) 2016/867 on the collection of granular credit and credit risk data (ECB/2016/13) in May 2016

[26] https://www.ecb.europa.eu/stats/money_credit_banking/anacredit/html/index.en.html

individual loans are reported monthly, granted by around 7000 individual credit institutions to approximately 5 million of individual debtors.

Extensive consistency checks are performed using other data source (BSI, national credit registries) to ensure the data quality by the Eurosystem. On Figure 7, we simply provide a comparison of loan outstanding to NFC between the public BSI dataset (Balance sheet items dataset) and Anacredit.

We take all new loans granted from January 1st 2019 until December 31st 2020. We consider only "plain" loans, meaning we do not take credit card debt, credit lines and overdraft.[27] We restrict ourselves to loans to non-financial corporates (counterparty institutional sectors equal to 'S_11'), which is the only sector covered extensively by Anacredit. We first look only at "bullet" amortization structure loans, i.e. loans with a single reimbursement of the principal at the maturity of the loan.

By restricting the sample to bullets loans, we avoid the issue of loans that are partly amortized before 31 March 2021. Such loans would count only partially for banks lending performance (only the principal that remains outstanding as of 31 March 2021).

We run our regressions on all types of amortization structure in the robustness checks. Looking at the maturity structure of loans to NFCs (figure 8), we note that there are very few loans past 40 quarters, which leads us to drop all observations with maturity longer than 10 years. At last, we remove outliers (the top and bottom 0.5 % of the distribution in terms of amount outstanding).

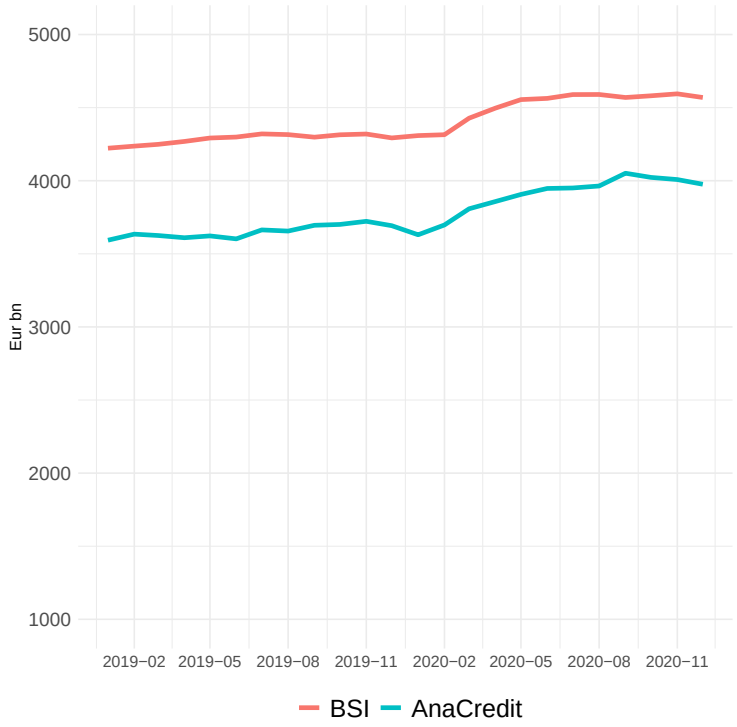
The descriptive statistics of our sample after cleaning can be seen on table 2. Summary statistics for our dataset before aggregation can be seen on table 3.

6 Empirical strategies and results

When evaluating the impact of TLTRO, researchers may face significant reverse causality issues. Typically, a bank that was planning to strongly expand credit (even in the absence of TLTROs), knows it would benefit from borrowing at the TLTROs, and could make a risk-free profit (see section 3). The specific credit dynamic of a bank may thus cause it to borrow at the TLTRO, as much as borrowing at the TLTRO may impact a particular bank's credit supply.

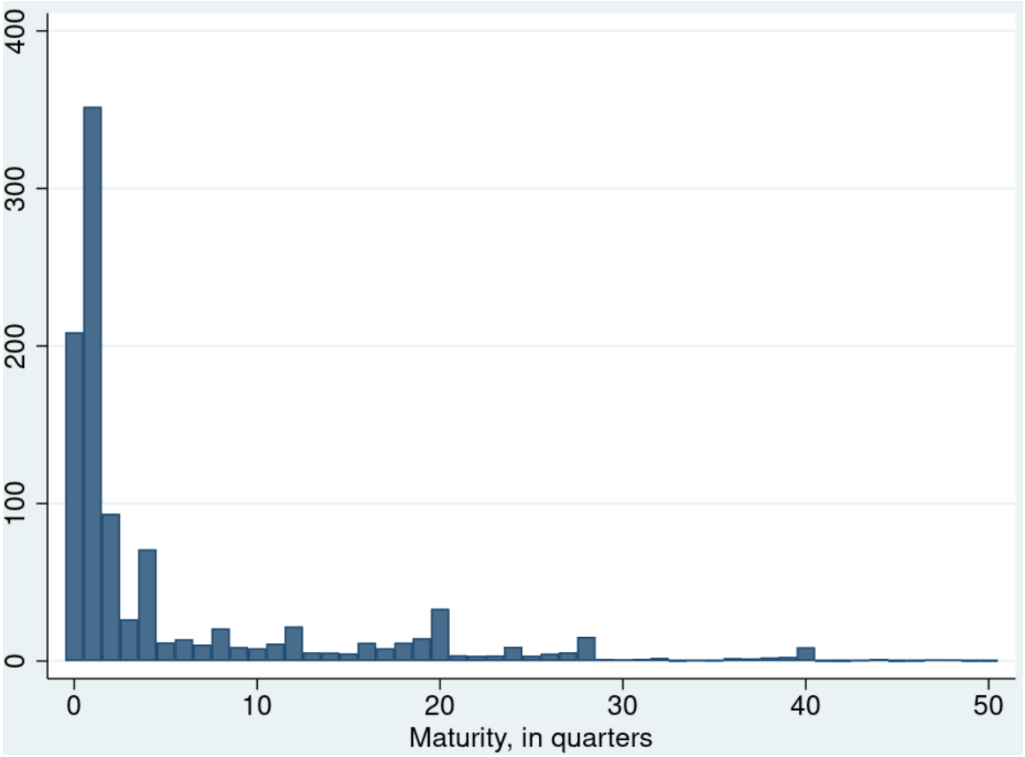
[27] To be precise, we select the instrument type "1004", which is described in the manual as "Loans other than overdrafts, convenience credit, extended credit, credit card credit, revolving credit other than credit card credit, reverse repurchase agreements, trade receivables and financial leases". We also exclude loans with purpose 12 (residential real estate purchase), 4 (Margin lending).

Figure 7: Comparison of reported credit to Non-financial corporations, BSI vs AnaCredit, Jan 2019 to Dec 2020



Note: This figure shows the comparison of credit amount outstanding granted by EA resident banks from two sources: public source (BSI serie 'ECB/BSI/M.U2.N.A.A20.A.1.U2.2240.EUR.E'), and Anacredit aggregated one from loan-level data. For both, we take the amount outstanding (stock) of credit to NFC denominated in Eur.

Figure 8: Maturity structure of bullet loans in Anacredit



Note: This figure shows the amount of "plain" bullets loans granted between January 2019 to December 2020, in billion of euros. Loans with a maturity of 0 quarters are those which maturity date is within the same calendar quarter as their settlement date.

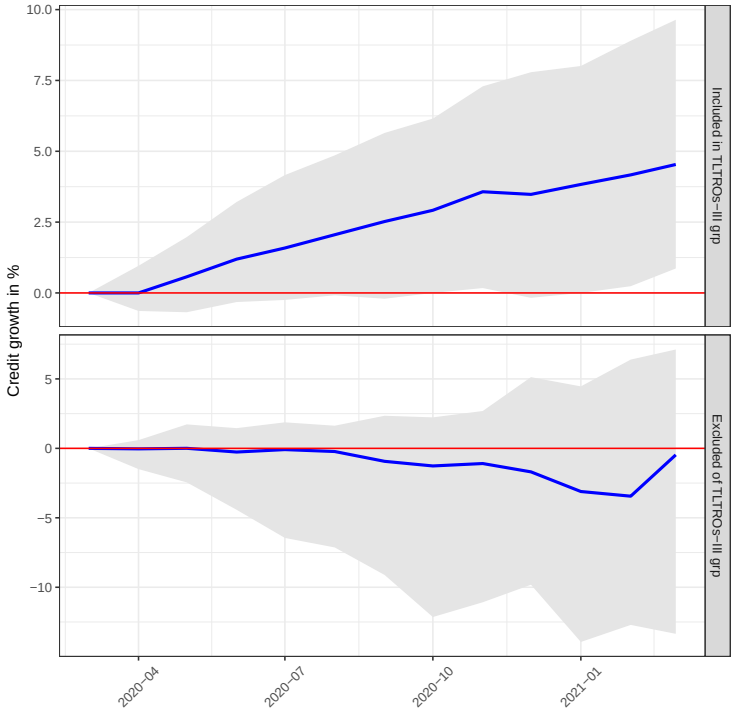
Up to now, the literature has dealt with this issue by using an instrumental variable approach (Benetton and Fantino (2021), Esposito, Fantino, and Sung (2020) and Andreeva and García-Posada (2021)). The instrument used is the maximum amount banks can borrow at the TLTRO (the borrowing "allowance"), which is equal to a fraction of the bank's loan portfolio at some date decided by the central bank.[28] We think this approach has shortcomings, because banks can strategically affect the size of their allowance. Indeed, the size of the loan portfolio depends on the composition of the group that the bank "declares" when it borrows at the TLTRO[29]. Banks do not have to include all the entities with which they have capitalistic links. It is up to the entity that bids to say which member of its banking group should be counted in its TLTRO group. We show on Figure 9 that banks tend to

[28]This date is always anterior to the announcement of of the TLTRO program to avoid that banks manipulate the reference point.

[29]The process through which banks can submit the composition of their TLTRO group, is explained in its 29 July 2014 press release.

include entities that perform well compared to the rest of the capitalistic group. The positive relationship found in these papers may reflect this selection bias in which types of entities are included to measure the performance of the group.[30]

Figure 9: Entities included in TLTRO groups vs. entities (voluntarily) excluded from TLTRO groups



Source: IBSI. Loans to Non-Financial Corporations and households (excluding home mortgages) between March 2020 and March 2021. Note: This figure compares the credit performance of entities that were included in a TLTRO groups vs. entities excluded from TLTRO groups (but belonging to the capitalistic group of entities that participated to TLTRO). Gray area are second and third quartiles of the distribution. Blue lines are the median of the distribution.

6.1 Testing for the targeted channel

We exploit an exogenous discontinuity created by the TLTRO programs. The credit performance of banks (used to compute ex-post the rate they will pay at the TLTRO) is measured by comparing their stock of credit at some final date with their stock of credit at some initial

[30]We believe this is why the literature has found larger effects in the IV regressions than in the OLS regressions. If the instrument really helped to alleviate the reverse causality issue, one would expect to find a smaller coefficient, not larger.

date. In the case of the TLTRO III, the final date was set as 31 March 2021. The initial date has changed during the life of the program, but it was always set at the date anterior to the announcement, to avoid that banks manipulate the reference point of the exercise.

The main advantage of using the end-date of the reference period, is that it represents a clear discontinuity, which is completely exogenous (banks cannot influence it in any way). It is one of the rare parameters of the TLTRO III that hasn't changed since the program was initially announced on 6 June 2019. Moreover, looking at loans that mature after March 31st 2020 vs. loans that mature before allows us to focus on the "targeted effet" of the TLTRO, i.e. we capture only the effect of TLTRO on the incentive of banks to meet the lending performance target. We avoid taking into account any positive or negative side-effect of TLTRO on profitability or other conventional effect such as lowering term funding rate, an effect that was already present in previous untargeted programs.

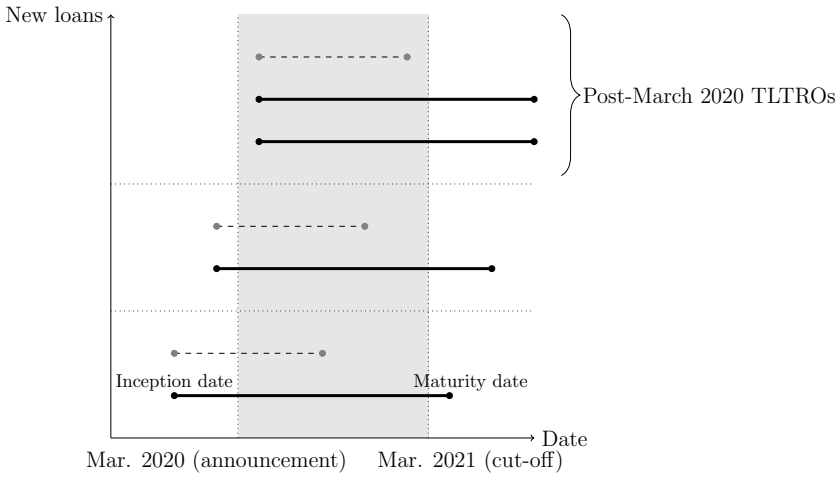
Concretely, we are going to estimate the effect of the TLTRO III announcement, on the growth of loans maturing after 31 March 2021, compared to loans maturing prior to 31 March 2021. We tag the loans maturing after 31 March 2021 as "eligible loans", because they will be eligible to count in the lending performance of banks, while loans maturing before 31 March 2021 are not eligible. We use a quarterly panel of bank loans, and we look at eligible vs. non-eligible loans at each period, expecting to see a change in their relative behavior around the TLTRO announcement, as shown on Figure 10.

We expect an increase in the supply of loans that mature after the March 31st cut-off date. This is confirmed by looking at the evolution of the maturity of loans during the sample period (Figure 11). The average maturity structure is relatively stable in 2019 and early 2020. Right after the change in TLTRO III parameters is announced (at the end of Q1 2020), we see a sizeable increase in the amount of loans granted with maturities long enough to be eligible. Originations of eligible loans remain higher than usual afterward, even if the increase is less spectacular. Banks don't seem to lower their loan supply for shorter maturities in order to increase their supply of "eligible" loans, i.e. we do not see evidence of substitution. Figure 11 suggests that controlling for the maturity structure of loans portfolio is crucial. We do so in our regressions by using various maturity fixed-effects.

We run our regressions only on banks that participated to TLTRO III, because almost all banks participated, except few small banks that are arguably not comparable with the rest of the sample (see section 3). Our baseline regression looks as follows:

$$log(NewLoans)_{b,f,m,t} = \beta_t * Eligible_{b,f,m,t} + FE_{b,t} + FE_{f,t} + FE_{m,b} + \epsilon_{b,f,m,t} \tag{14}$$

Figure 10: Identification strategy



Note: This diagram represent the loan supply of a representative banks. Each line represents a loan from its inception to its maturity. Dotted lines represent loans that mature before 31 March 2021 (loans not eligible to count in the lending performance of the bank). Thick lines represent loan that mature after 31 March 2021. We look at loans origination at different dates (the inception date), reflecting our panel setting. Our identification assumption is that there should be more loans maturing after 31th 2021, after the announcement of the changes of the parameters of the TLTRO III, in March 2020, compared to before the announcement.

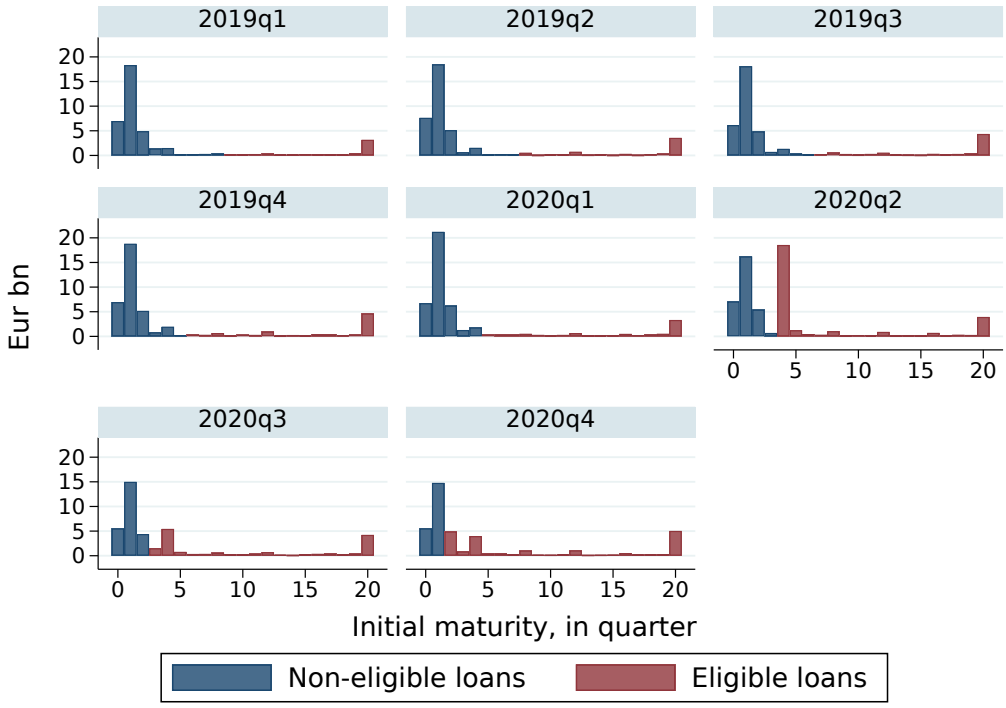
Where, $ln(NewLoans)_{b,f,m,t}$ is the logarithm of the total amount of new loans (in euros) granted by bank b, to firm f, with a maturity m at time t.[31] The β_t's are the coefficients of interest and measure the effect of being an "eligible" loans at each quarter. We expect them to be significant only after the announcements of the TLTROs in late March 2020. $FE_{b,t}$, $FE_{f,t}$, $FE_{m,b}$ are respectively bank-time, firm-time, and maturity-bank fixed effects. This last fixed effect intends to control for the maturity of loans granted by each bank, in order to take into account any deformation of the maturity structure of the loan portfolio of banks related to the TLTRO or other events. The maturity is defined as the quarter when the loan matures minus the quarter when the loan was settled. We cluster standard errors at the bank-time level.

We run placebo regressions resembling our baseline specification (equation 14) where we change the cut-off date for the variable "eligible", to confirm that the effect really comes from the parameters of TLTROs:

$$log(NewLoans)_{b,f,m,t} = \beta_t * Placebo_{b,f,m,t} + FE_{b,t} + FE_{f,t} + FE_{m,b} + \epsilon \tag{15}$$

[31] We aggregate loans when one given firm borrowed several times from the same bank, during the same quarter at the same maturity.

Figure 11: Maturity structure of new loans in the sample



Note: this figure shows the maturity structure at inception of new loans in our sample. The last bar (20 quarters) aggregates all loans of 20 quarters or more. Eligible loans refer to loans maturing after 31 March 2021 and therefore included in the lending growth computation.

The placebo tests consists in moving the cut-off one period (one quarter) forward, from March 31 2021 to June 30 2021.

This placebo tests come on top of our benchmark regressions where we include interaction between our eligibility variable and quarter dummies, for quarters before the announcements of TLTRO. One should expect these interactions to be insignificant. We will examine these interactions, thus performing another type of placebo test.

6.2 Results on the targeted channel

The results from our benchmark regressions are shown in table 4. The first three columns show our full sample (all banks that participated to the TLTRO III program), while the last three columns consider only banks that participated from March 2020 onward, in order to isolate better the effect of March 2020 announcements, and avoid mixing them up with those of TLTRO 2019 announcements. For each of these two samples, we try three ways to control

for the maturity structure, via different fixed effects.

We find a significant and robust effect of being an eligible loan on credit supply. This effect manifest itself right after the announcement of TLTRO parameters changes in March 2020 (start of Q2 2020), as expected. The effect in Q3 2020 is smaller but still large, significant and robust. Our preferred specification is in column 6 of table 4, because it takes the restricted sample, which is most likely to identify precisely the effect of 2020 announcements, and it uses maturity-bank fixed effects, the most rigorous set of fixed-effects to control for the maturity structure of bank loan portfolio.

We run placebo regressions corresponding to equations 15. Results are shown in table 5, It shows that moving the cut-off date from March 2021 to June 2021 makes nearly all coefficients insignificant. It means that we are unlikely to be capturing a "short term" loans vs. "long-term" loans supply effects. With this placebo test, we are now convinced that our methodology is appropriate to identify the "targeted" effect of TLTROs. We therefore make further refinements to our specifications to explore additional dimensions of the TLTROs.

We refine the baseline results outlined in table 4 by interacting the variable "Eligible" with several continuous variables.

First, we test whether there is any additional effect on credit as banks borrowed more from TLTRO (as opposed to just participating or not), by running equation 16. In order to evaluate the effect of borrowing more at the TLTRO, we run the following type of regressions:

$$log(NewLoans_{b,f,m,t}) = \beta_{1,t} * Eligible_{b,f,m,t} + \beta_{2,t} * Eligible_{b,f,m,t} * log(Takeup_b) + FE_{b,t} + FE_{f,t} + FE_{m,b} + \epsilon_{b,f,m,t} \quad (16)$$

Where "$Take - up_b$" is a continuous variable equal to the maximum amount borrowed by bank b at the TLTRO III).

Results are shown in table 6, and display significant additional effects of borrowing larger TLTRO amounts in Q3 and Q4 2020, suggesting that those banks that borrowed significant amount had long-lasting responses to the program.

6.3 Testing for the profitability channel

In order to test for the profitability channel we exploit an increase of the borrowing allowance announced by the Eurosystem in December 2020. The borrowing allowance was then increased from 50% to 55% of the eligible loans portfolio[32], effective from the March

[32]Observed as of February 2019

2021 TLTRO operation (III.7). Concretely, at the time of the announcement, banks learnt that they will be able to borrow 10% more than their initial allowance. As for the special reference period, banks may borrow at a rate as low as -1% if they meet a new lending performance criteria, based this time on their eligible net lending growth between 1st October 2020 and 31st December 2021. In particular, banks that would already know they meet the lending criterion in December 2020 also know that they will receive a pure subsidy.

This offers us an appropriate setup for testing the profitability channel: if we find an effect on credit supply on ineligible loans and/or on all loans granted by banks that already meet the lending performance at the time of announcement, we do isolate an effect that cannot be linked to the targeted channel, but only from the profitability channel as predicted by the model.

Our empirical strategy is as follows. Borrowing amounts at the March 2021 TLTRO are the decisions of banks, which are likely to be endogenous. We follow Benetton and Fantino (2021) in instrumenting the actual borrowing at this operation by the additional allowance announced in December 2020.

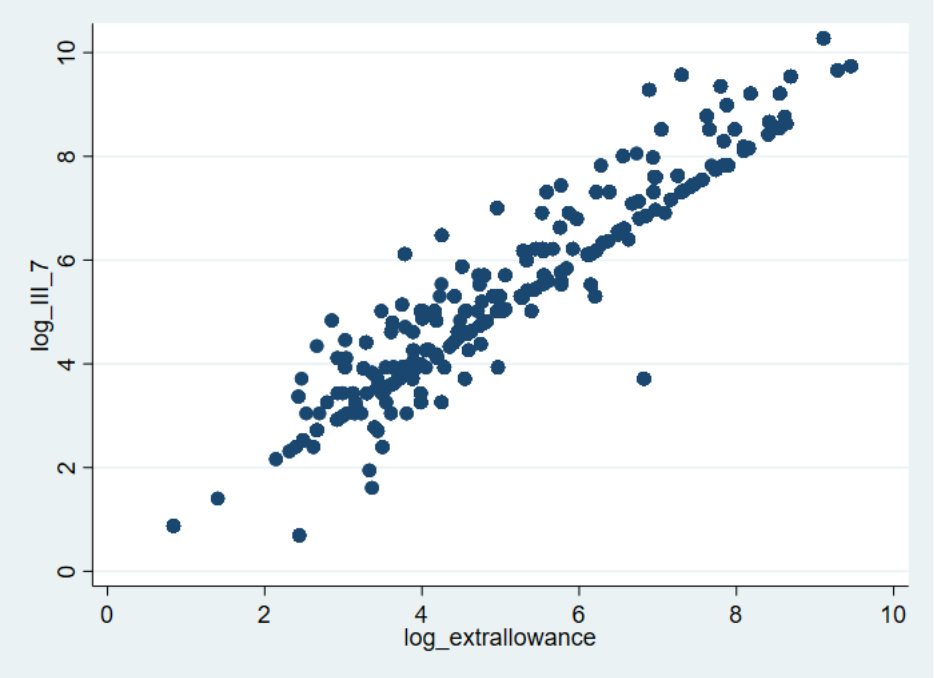
We plot on Figure 12 the relationship between the additional borrowing allowance (10% x stock of eligible loans) at the bank level, announced in December 2020 (x-axis), and how much they borrowed at the operation immediately after (y-axis). The cross section regression for this variable delivers a coefficient of 1.02, significant at the 1% level. The R-square is 0.92 and an F-stat of around 100,000 ruling out the possibility of a weak instrument.

Together with the allowance increase announced in December 2020, the Eurosytem offered to banks the possibility to change their group composition ahead of the March 2021 operation. To avoid that banks strategic changes in the size of their groups impacts our instrument, we computed the extra allowance based on the group composition prevailing before the announcement. Thanks to this workaround, we consider this extra-borrowing allowance as exogenous. Moreover, given the uncertainty over the size of the increase in the borrowing allowance, we are confident that the change was not expected by bank and that we capture most if not all the effect.

Also, by construction, the increase in the borrowing allowance should affect loan supply only through bank's borrowing at the March 2021 auction, suggesting that the exclusion restriction is satisfied.

However, this exercise entails one additional difficulty compared to previous ones: the quarter immediately after the December 2020 was subject to two distinct reference periods. Indeed, the reference periods announced in the original program was still running (it ended

Figure 12: Extra borrowing allowances and TLTRO III-7 take up



Source: Eurosystem proprietary market operations databases.

on 31 March 2021). At the same time, the December 2020 announcement provided that interest rates for all future operations would be determined based on a reference period that was running from 1st October 2020 to 31 December 2021.

To avoid mixing-up the effects of the two reference periods we take the last possible data available at the time of writing (Q1 2021), and conduct a cross-sectional exercise on that quarter. We may add subsequent quarters in future versions of the paper, when they become available.

Our benchmark regression for this exercise writes at follows:

$$NL_{i,f} = \beta_1 * \hat{O}_i + \beta_2 * Controls_i + FE_f + \epsilon_{i,f} \tag{17}$$

where $NL_{i,f}$ is the amount of new loans granted by bank i to firm f in the first quarter 2021. $\hat{O}_i$ is the take up of bank i at the March 2021 TLTRO operation (instrumented by the change in the borrowing allowance). We follow Benetton and Fantino (2021) for the choice of our bank-level control variables, and take all variables available in the Eurosystem IBSI database. FE_f control for demand.

The results from the second stage of this regression are shown in table 7, and point to a solid and significant relationship between TLTRO take up and loans supply (columns (1)

and (2)). According to our results, a 1% increase in the TLTRO take-up raises loan supply by by 5% to 7%. This results apply to all loans and are silent on the various channels.

To disentangle between the "targeted" and the "profitability" channel. We interact the variable take-up, with the dummy variables as follows:

$$NL_{i,f,m} = \beta_1 * \hat{O}_i * Eligible_m + \beta_2 * \hat{O}_i * (Ineligible_m) + \beta_3 * Controls_i + FE_f + \epsilon_{i,f} \quad (18)$$

where all notation are the same as in the previous equation, except"$Eligible_m$" and "$Ineligible_m$". Eligible is equal to 1 when the loan maturity date exceeds 31st December 2021 (the end of the reference period announced in December 2020) and 0 otherwise. Ineligible is equal to 1 minus eligible.

Ineligible loans should be unaffected by the targeted channel, and only by the "profitability" channel.

Results for this regressions are in columns (3) and (4) of table 7. They clearly show that "ineligible" loans are impacted by TLTRO, with a 1% increase in the take-up, raising the supply of ineligible loans by 5% to 6%, suggesting the existence of a profitability channel. Moreover, and as one would expect the effect on eligible loans is significantly stronger (14% to 16%) suggesting that this coefficient is able to capture the cumulative impact of both channels. Subtracting the coefficient associated with "Ineligible" from the one associated with "Eligible" suggests that the targeted channel is 1.5 to 2 time stronger.

To further test the profitability channel, we determine two groups of banks, depending on their lending performance at the time of announcement. We are especially interested to estimate the effect on loan supply of banks that know on December 2020 they already meet the lending performance, even without making additional effort. For that purpose, we create a dummy variable "$Achiever_i$" which is equal to 1 when bank i lending growth between 1st October 2020 (the start of the new reference period) and 31st December 2020 (when the announcement that this new period was introduced), exceeds 2% a level, comfortably above the 0% target set under this new program. We take this threshold to take into account the fact part of the eligible portfolio mature, and to reflect banks probably need to exceed the lending performance slightly before knowing for sure they will meet the lending performance in the future (eg. discounting possible prepayments, etc...)

We compute this lending performance from the IBSI data, observing the eligible portfolio for each bank, and reconstituting the TLTRO groups as just before the December 2020 annoucement. In theory, these banks know that they will meet the lending threshold even without changing their behavior, and thus should be unaffected by the targeted channel. We

also look at the interaction with "$Non - achiever_i$", which is equal to $1 - Achiever_i$. Our regressions look as follow:

$$NL_{i,f} = \beta_1 * O_i * Achiever_i + \beta_2 * O_i * (Non - Achiever_i) + \beta_3 * Controls_i + FE_f + \epsilon_{i,f} \quad (19)$$

The results from these regressions are displayed in columns (5) and (6) of table 7. In line with our theoretical insights that non-achievers are affected by two channels while achievers are just affected by the profitability channel, non-achievers exhibit a stronger response than achievers to the TLTROs.

6.4 Robustness

Other policy measures unrelated to TLTROs have been introduced in the wake of the pandemic. Our bank-time and firm-time fixed effects cover all country-specific time varying policies, and should control for most if not all such measures.

Still, during the pandemic, several European countries provided public guarantees for bank loans to NFCs. For the largest European countries, these guarantees stood between 60% to 90% of the loan amount[33]. Any aggregate supply effect should be effectively controlled by our set of fixed effects, in particular as schemes are country-specific. Similarly, effect from state-guarantee on firms' demand should be controlled for by the firm-time fixed effects. However, state-guarantees may still affect our identification strategy: for instance if state-guaranteed loans granted had a maturity that coincided with the way we define eligible loans under the TLTROs. To ensure our results are not affected these public schemes, we need first to identify state-guarantee loans in AnaCredit. As a general rule, we keep loans ultimately guaranteed by central governments (ESA sector S.1311) for a fraction larger than 60% of the principal amount, following Anderson, Papadia, and Véron (2020). When it is available, we also check the state-entity responsible for the state-guarantee scheme – e.g. for Germany, we also include loans guaranteed by KfW. On Fig. 14 we plot the amount state-guaranteed loans we find in AnaCredit. The amount we find are very close to aggregated figures provided by governments to the ECB (see for instance Falagiarda, Prapiestis, and Rancoita (2020)).

Equipped with a way to identify state-guaranteed loans, we are able to exclude those loans from our sample and re-run our benchmark regressions. Results are displayed on Table

[33]Details on these programmes can be found in Anderson, Papadia, and Véron (2020) and Falagiarda, Prapiestis, and Rancoita (2020)

8 and show that our results are preserved and robust to the exclusion of state-guaranteed loans.

We note that France had witnessed a loans growth that was particularly strong from March 2020 onward. This could be due to the large participation of French banks to the TLTRO program or to the significant state-guaranteed loans scheme put in place by the French Treasury. We therefore re-run our baseline regressions by taking out France, and check that results hold. Results from this exercise are displayed in table **??**, and show that the effect of TLTROs in Q2 2020 is still strong and significant, which is reassuring given that it was this quarter that saw such a strong growth in France.

In line with the literature, we have used firm-time fixed effects to control for loan demand. By construction, this excludes from the estimation firms that would contract a single type of loans (eg. "eligible") with a single bank, as we sum up eligible and ineligible loans at the quarter-firm-bank-level. Firms that contract both eligible and ineligible loans with a single bank are kept in the estimation, which theoretically may leave room for an omitted variable bias at the bank-firm relationship level. Therefore, along the lines of Khwaja and Mian (2008), we conduct a robustness check where we drop all firms that contract with only one bank, keeping effectively only "multi-bank" firms.

We run our baseline regressions on this restricted sample. Results are shown in Table 9 and are qualitatively identical to the benchmark regressions for the sample of banks that borrowed only from 2020 onward. Dropping single-bank firms weakens our results for Q3 2020.

At last, we run our regressions on all types of loans (not only bullets), to make sure our results can be generalized. Results are shown in Table 10. The coefficients of Q2 and Q3 2020 are positive and significant. While other quarters show significant coefficients, Q2 and Q3 2020 are the only ones that are statistically significant robust across all sets of fixed-effects.

7 Conclusion

In this paper we have used new loan-level data as well as a new empirical strategy, and shown that TLTROs as calibrated after March-2020 had a significant effect on credit supply.

The effect we find is comparable in size with those found in previous programs. These results bear interesting policy implications for the Eurosystem, notably, with respect to the exact calibration of parameters.

A Tables

A.1 Descriptive statistics: regression sample

Table 2: Summary statistics

Variable	Obs	Mean	Std. Dev.	P10	P25	P50	P75	P90
Panel A: Regression sample - New loans								
Loan amount outstanding	994622	355960.2	1313002	10000	24800	62495.97	200000	600000
log(outstanding)	994622	11.18	1.65	9.21	10.12	11.04	12.21	13.3
Residual mat. (qtr)	994622	2.73	4.77	0	1	1	4	4
Panel B: Eligible new loans								
Loan amount outstanding	232757	461587.8	1658062	15202.01	30000	70000	200000	741071.4
log(outstanding)	232757	11.39	1.58	9.63	10.31	11.16	12.21	13.52
Residual mat. (qtr)	232757	7.57	7.93	3	4	4	5	22
Panel C: Ineligible new loans								
Loan amount outstanding	761865	323690	1185884	8556.7	21219	60433.46	198974.4	573058.3
log(outstanding)	761865	11.11	1.66	9.05	9.96	11.01	12.2	13.26
Residual mat. (qtr)	761865	1.25	1.03	0	1	1	2	2
Panel D:Number of banks and firms across specifications								
Number of unique banks								1765
Number of unique banks - bidding post Mar 2020								986
Number of unique banks - bidding post Mar 2020 but not before								592
Number of unique firms								406,335
Number of unique firms, multi-banks								32,334

A.2 Additional descriptive statistics - Anacredit granular data, before collapsing by quarter, all amortization type (Type instrument "1004")

Table 3: Summary statistics - Anacredit full sample, loan-level

Variable	Obs	Mean	Std. Dev.	Min	Max	P10	P25	P50	P75	P90
Panel A: All new loans										
Loan amount outstanding	17618639	186066.1	3091927	10	2.32e+09	2490	8346	23200	50716	175748
log(outstanding)	17618639	9.99	1.72	2.3	21.56	7.82	9.03	10.05	10.83	12.08
original mat. (yrs)	17618639	2.23	3.62	0	94.64	.17	.25	.58	3.03	6
residual. mat.	17618639	2.18	5.74	0	979.15	.16	.25	.5	3	6
Panel B: Eligible new loans										
Loan amount outstanding	7026753	284429.5	3256834	10	1.62e+09	7893.09	18829.73	33830.17	100000	318225.7
log(outstanding)	7026753	10.67	1.58	2.3	21.21	8.97	9.84	10.43	11.51	12.67
original mat. (yrs)	7026753	4.86	4.58	0	94.64	.5	1.5	4.94	6	10
residual mat.	7026753	4.82	8.41	.08	97.91	.5	1.5	4.42	6	9.91
Panel C: Ineligible new loans										
Loan amount outstanding	10591886	120810.9	2975698	10	2.32e+09	1648.83	4960	15669	35261.8	91682.15
log(outstanding)	10591886	9.54	1.66	2.3	21.56	7.41	8.51	9.66	10.47	11.43
original mat. (yrs)	10591886	.48	.47	0	3.56	.13	.24	.3	.52	1
residual mat.	10591886	.42	.41	0	2.5	.08	.17	.25	.5	1

A.3 Results

Table 4: Time decomposition of the effect - baseline sample of bullet loans

This table reports the coefficients of equation 14. The dependent variable is the log amount of new loans. Independent variables are the interactions of a dummy taking one when the loan is "eligible", ie. maturing after 31 March 2021 and a quarter-dummy. All specifications include bank-time and firm-time fixed effects and vary with respect to maturity fixed effects. *Maturity* is a fixed effect for the initial maturity (in quarter), controlling for the average amount of loans of a given maturity. *Maturity* × *Country* and *Maturity* × *Bank* controls for possible heterogeneity in the maturity structure of loans between countries and banks. Columns 1-3 run these specifications for all banks that bid at least to one of the post Mar-2020 TLTRO operations, while columns 4-6 restrict the sample to banks that bid post Mar-2020 but not before.

	(1)	(2)	(3)	(4)	(5)	(6)
	All	All	All	No 2019 bid.	No 2019 bid.	No 2019 bid.
Eligible x Q1 2019	-0.104	0.0198	-0.0706	-0.294*	-0.128	-0.105
	(0.131)	(0.124)	(0.100)	(0.167)	(0.104)	(0.0885)
Eligible x Q2 2019	-0.271*	-0.130	-0.209**	-0.323	-0.203	-0.162
	(0.149)	(0.115)	(0.100)	(0.221)	(0.129)	(0.115)
Eligible x Q3 2019	-0.0534	0.0364	-0.0182	-0.167	-0.0930	-0.0160
	(0.119)	(0.109)	(0.0834)	(0.164)	(0.102)	(0.0991)
Eligible x Q4 2019	0.0532	0.161	0.00329	-0.126	-0.0582	-0.0245
	(0.142)	(0.158)	(0.115)	(0.175)	(0.168)	(0.159)
Eligible x Q1 2020	-0.179*	-0.103	-0.124	-0.0877	-0.0566	-0.0466
	(0.0987)	(0.0976)	(0.103)	(0.125)	(0.138)	(0.146)
Eligible x Q2 2020	0.299***	0.233***	0.216***	0.398***	0.256***	0.323***
	(0.0926)	(0.0653)	(0.0579)	(0.118)	(0.0758)	(0.0686)
Eligible x Q3 2020	0.174**	0.128*	0.0868*	0.280***	0.163***	0.189***
	(0.0767)	(0.0657)	(0.0527)	(0.0856)	(0.0633)	(0.0543)
Eligible x Q4 2020	0.0632	0.0567	0.0396*	0.0369	0.0197	0.0352
	(0.0584)	(0.0583)	(0.0238)	(0.0716)	(0.0674)	(0.0403)
Bank x Time	Yes	Yes	Yes	Yes	Yes	Yes
Firm x Time	Yes	Yes	Yes	Yes	Yes	Yes
Maturity	Yes	No	No	Yes	No	No
Maturity x Country	No	Yes	No	No	Yes	No
Maturity x Bank	No	No	Yes	No	No	Yes
R^2	0.778	0.782	0.786	0.824	0.829	0.830
Observations	521421	521362	518063	216394	216324	214061

Standard errors in parentheses

Note: SE clustered at the bank-time level

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 5: Placebo (using June 2021 instead of Mars-2021 as the cut-off)

This table is the analogue of table 4 and reports the results of a placebo regression in which we define the eligible loans as loans maturing after June 2021 instead of March 2021. The dependent variable is the log amount of new loans, and controls and fixed effects are unchanged.

	(1)	(2)	(3)	(4)	(5)	(6)
	All	All	All	No 2019 bid.	No 2019 bid.	No 2019 bid.
Eligible x Q1 2019	-0.121	0.000885	-0.132	-0.400**	-0.233*	-0.236**
	(0.135)	(0.131)	(0.105)	(0.173)	(0.122)	(0.109)
Eligible x Q2 2019	-0.362**	-0.221*	-0.324***	-0.446**	-0.327**	-0.326***
	(0.167)	(0.126)	(0.114)	(0.226)	(0.145)	(0.121)
Eligible x Q3 2019	-0.0994	-0.0177	-0.0927	-0.292*	-0.230**	-0.182
	(0.120)	(0.113)	(0.0893)	(0.153)	(0.113)	(0.112)
Eligible x Q4 2019	-0.0177	0.0964	-0.0857	-0.279*	-0.211	-0.192
	(0.144)	(0.167)	(0.119)	(0.151)	(0.171)	(0.168)
Eligible x Q1 2020	-0.238**	-0.129	-0.202*	-0.225*	-0.193	-0.225
	(0.106)	(0.113)	(0.122)	(0.124)	(0.159)	(0.158)
Eligible x Q2 2020	0.197*	0.110	0.127	0.191	0.0532	0.0857
	(0.114)	(0.0924)	(0.0905)	(0.122)	(0.104)	(0.108)
Eligible x Q3 2020	0.0638	0.0384	-0.0182	0.0266	-0.0451	-0.0526
	(0.0776)	(0.0706)	(0.0584)	(0.0933)	(0.0924)	(0.0830)
Eligible x Q4 2020	0.0909	0.0676	-0.00660	-0.0941	-0.172	-0.182
	(0.107)	(0.107)	(0.0857)	(0.100)	(0.106)	(0.124)
Bank x Time	Yes	Yes	Yes	Yes	Yes	Yes
Firm x Time	Yes	Yes	Yes	Yes	Yes	Yes
Maturity	Yes	No	No	Yes	No	No
Maturity x Country	No	Yes	No	No	Yes	No
Maturity x Bank	No	No	Yes	No	No	Yes
R^2	0.778	0.782	0.786	0.824	0.829	0.830
Observations	521421	521362	518063	216394	216324	214061

Standard errors in parentheses

Note: SE clustered at the bank-time level

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 6: Intensive margin of TLTRO borrowing

This table reports the coefficients of equation 16. The dependent variable is the log amount of new loans. Independent variables are the triple interactions of a dummy taking one when the loan is "eligible", ie. maturing after 31 March 2021, the log amount of cumulative net take-up at TLTRO III operations and a quarter-dummy. Coefficients of the simple interactions of the each terms not shown.

	(1)	(2)	(3)
	No 2019 bid.	No 2019 bid.	No 2019 bid.
Eligible x take-up x Q1 2019	0.0405	0.136**	0.126
	(0.110)	(0.0602)	(0.0910)
Eligible x take-up x Q2 2019	-0.0490	-0.0736	-0.0757
	(0.0787)	(0.0567)	(0.103)
Eligible x take-up x Q3 2019	0.0705	0.0577	0.131
	(0.0652)	(0.0637)	(0.107)
Eligible x take-up x Q4 2019	-0.0138	-0.0485	-0.0182
	(0.0664)	(0.0676)	(0.0936)
Eligible x take-up x Q1 2020	-0.00158	-0.00482	0.0704
	(0.0737)	(0.0749)	(0.0869)
Eligible x take-up x Q2 2020	0.0156	0.0532	0.151**
	(0.0844)	(0.0563)	(0.0636)
Eligible x take-up x Q3 2020	0.152***	0.163***	0.148***
	(0.0445)	(0.0469)	(0.0416)
Eligible x take-up x Q4 2020	0.0824***	0.0585**	0.0531***
	(0.0239)	(0.0265)	(0.0185)
Eligible x Time controls	Yes	Yes	Yes
Bank x Time	Yes	Yes	Yes
Firm x Time	Yes	Yes	Yes
Maturity	Yes	No	No
Maturity x Country	No	Yes	No
Maturity x Bank	No	No	Yes
R^2	0.824	0.829	0.830
Observations	216394	216324	214061

Standard errors in parentheses

Note: SE clustered at the bank-time level

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 7

In this table we restrict our sample to banks that participated in the March 2021 TLTRO opertaion. The variables "Achiever" and "Non-achiever" are constructed with IBSI data which explains the smaller number of observations in columns (5) and (6).

	(1)	(2)	(3)	(4)	(5)	(6)
Take-up	0.0662***	0.0544***				
	(0.00703)	(0.0131)				
Take-up x Eligible			0.143***	0.156***		
			(0.0288)	(0.0318)		
Take-up x Ineligible			0.0631***	0.0460***		
			(0.00711)	(0.0132)		
Take-up x Non-achiever					0.104***	0.0905***
					(0.0162)	(0.0345)
Take-up x Achiever					0.0680***	0.0845**
					(0.0186)	(0.0386)
Bank controls	No	Yes	No	Yes	No	Yes
Maturity x Country FE	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	43142	34838	43142	34838	15529	8754

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 8: Time decomposition of the effect - excl. state guaranteed loans

	(1)	(2)	(3)	(4)	(5)	(6)
	All	All	All	No 2019 bid.	No 2019 bid.	No 2019 bid.
Eligible x Q1 2019	-0.105	0.0164	-0.0714	-0.298*	-0.131	-0.106
	(0.131)	(0.125)	(0.101)	(0.167)	(0.104)	(0.0885)
Eligible x Q2 2019	-0.274*	-0.135	-0.218**	-0.328	-0.211	-0.168
	(0.149)	(0.115)	(0.101)	(0.221)	(0.129)	(0.116)
Eligible x Q3 2019	-0.0576	0.0290	-0.0270	-0.170	-0.0959	-0.0175
	(0.119)	(0.109)	(0.0833)	(0.164)	(0.102)	(0.0991)
Eligible x Q4 2019	0.0554	0.160	0.00358	-0.128	-0.0585	-0.0262
	(0.142)	(0.159)	(0.116)	(0.174)	(0.169)	(0.160)
Eligible x Q1 2020	-0.178*	-0.104	-0.128	-0.0918	-0.0590	-0.0522
	(0.0986)	(0.0977)	(0.103)	(0.124)	(0.138)	(0.144)
Eligible x Q2 2020	0.303***	0.239***	0.214***	0.391***	0.250***	0.320***
	(0.0928)	(0.0658)	(0.0585)	(0.119)	(0.0769)	(0.0694)
Eligible x Q3 2020	0.169**	0.125*	0.0824	0.274***	0.157**	0.187***
	(0.0757)	(0.0652)	(0.0523)	(0.0830)	(0.0635)	(0.0538)
Eligible x Q4 2020	0.0639	0.0573	0.0390	0.0406	0.0231	0.0392
	(0.0593)	(0.0592)	(0.0242)	(0.0720)	(0.0677)	(0.0399)
Bank x Time	Yes	Yes	Yes	Yes	Yes	Yes
Firm x Time	Yes	Yes	Yes	Yes	Yes	Yes
Maturity	Yes	No	No	Yes	No	No
Maturity x Country	No	Yes	No	No	Yes	No
Maturity x Bank	No	No	Yes	No	No	Yes
R^2	0.778	0.782	0.786	0.824	0.829	0.830
Observations	519263	519204	515915	215533	215463	213207

Standard errors in parentheses

Note: SE clustered at the bank-time level

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 9: Robustness - Time decomposition of the effect (multibanks only)

This table is the analogue of table 4 and reports the results when we restrict to firms with new loans granted by at least two different banks, in the spirit of Khwaja and Mian (2008). The dependent variable is the log amount of new loans, and controls and fixed effects are unchanged.

	(1)	(2)	(3)	(4)	(5)	(6)
	All	All	All	No 2019 bid.	No 2019 bid.	No 2019 bid.
Eligible x Q1 2019	-0.207	-0.0624	-0.0245	-0.238	0.208	0.283
	(0.241)	(0.176)	(0.198)	(0.342)	(0.185)	(0.242)
Eligible x Q2 2019	-0.164	-0.00696	0.0183	-0.0639	0.189	0.404
	(0.211)	(0.185)	(0.245)	(0.340)	(0.266)	(0.298)
Eligible x Q3 2019	0.0652	0.0671	-0.104	0.0340	0.0685	0.0280
	(0.145)	(0.132)	(0.150)	(0.239)	(0.172)	(0.216)
Eligible x Q4 2019	0.0202	0.0289	-0.141	0.0663	0.0476	-0.0466
	(0.149)	(0.153)	(0.145)	(0.208)	(0.222)	(0.227)
Eligible x Q1 2020	-0.0268	0.0670	-0.0516	0.154	0.175	0.0717
	(0.128)	(0.128)	(0.156)	(0.195)	(0.180)	(0.240)
Eligible x Q2 2020	0.231**	0.177**	0.224***	0.455***	0.312***	0.340***
	(0.0983)	(0.0848)	(0.0677)	(0.143)	(0.110)	(0.108)
Eligible x Q3 2020	0.0736	0.0702	0.0793	0.320***	0.249**	0.273**
	(0.0916)	(0.0946)	(0.0821)	(0.119)	(0.116)	(0.111)
Eligible x Q4 2020	0.0649	0.0629	0.0637**	0.0475	0.0460	0.0695
	(0.0410)	(0.0412)	(0.0255)	(0.0835)	(0.0780)	(0.0481)
Bank x Time	Yes	Yes	Yes	Yes	Yes	Yes
Firm x Time	Yes	Yes	Yes	Yes	Yes	Yes
Maturity	Yes	No	No	Yes	No	No
Maturity x Country	No	Yes	No	No	Yes	No
Maturity x Bank	No	No	Yes	No	No	Yes
R^2	0.710	0.712	0.712	0.767	0.770	0.768
Observations	325073	325022	322561	128960	128889	127214

Standard errors in parentheses

Note: SE clustered at the bank-time level

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 10: Robustness - Time decomposition of the effect (all types of amortization)

This table is the analogue of table 4, extending our sample of loans to all types of amortization. The dependent variable is the log amount of new loans, and controls and fixed effects are unchanged.

	(1)	(2)	(3)	(4)	(5)	(6)
	All	All	All	No 2019 bid.	No 2019 bid.	No 2019 bid.
Eligible x Q1 2019	0.244*	0.150	0.0492*	0.488**	0.235**	0.194***
	(0.131)	(0.0957)	(0.0295)	(0.231)	(0.105)	(0.0516)
Eligible x Q2 2019	0.208**	0.133*	0.0537*	0.337*	0.117	0.102*
	(0.0944)	(0.0797)	(0.0276)	(0.196)	(0.106)	(0.0617)
Eligible x Q3 2019	0.210**	0.138*	0.0737**	0.297	0.0799	0.102
	(0.0952)	(0.0787)	(0.0313)	(0.202)	(0.116)	(0.0640)
Eligible x Q4 2019	0.162*	0.0841	0.0189	0.314	0.0768	0.0807
	(0.0934)	(0.0754)	(0.0266)	(0.191)	(0.109)	(0.0623)
Eligible x Q1 2020	0.222**	0.128	0.0494	0.456**	0.218*	0.197***
	(0.105)	(0.0911)	(0.0346)	(0.215)	(0.131)	(0.0640)
Eligible x Q2 2020	0.539*	0.375**	0.180***	0.944**	0.421***	0.290***
	(0.289)	(0.170)	(0.0360)	(0.432)	(0.133)	(0.0752)
Eligible x Q3 2020	0.263***	0.214***	0.134***	0.427***	0.288***	0.238**
	(0.0817)	(0.0579)	(0.0462)	(0.143)	(0.0817)	(0.0952)
Eligible x Q4 2020	0.130**	0.100**	0.0721***	0.154	0.0988*	0.101***
	(0.0532)	(0.0433)	(0.0194)	(0.0968)	(0.0592)	(0.0316)
Bank x Time	Yes	Yes	Yes	Yes	Yes	Yes
Firm x Time	Yes	Yes	Yes	Yes	Yes	Yes
Maturity	Yes	No	No	Yes	No	No
Maturity x Country	No	Yes	No	No	Yes	No
Maturity x Bank	No	No	Yes	No	No	Yes
R^2	0.795	0.800	0.811	0.808	0.815	0.824
Observations	2215189	2215106	2204725	861454	861372	854691

Standard errors in parentheses

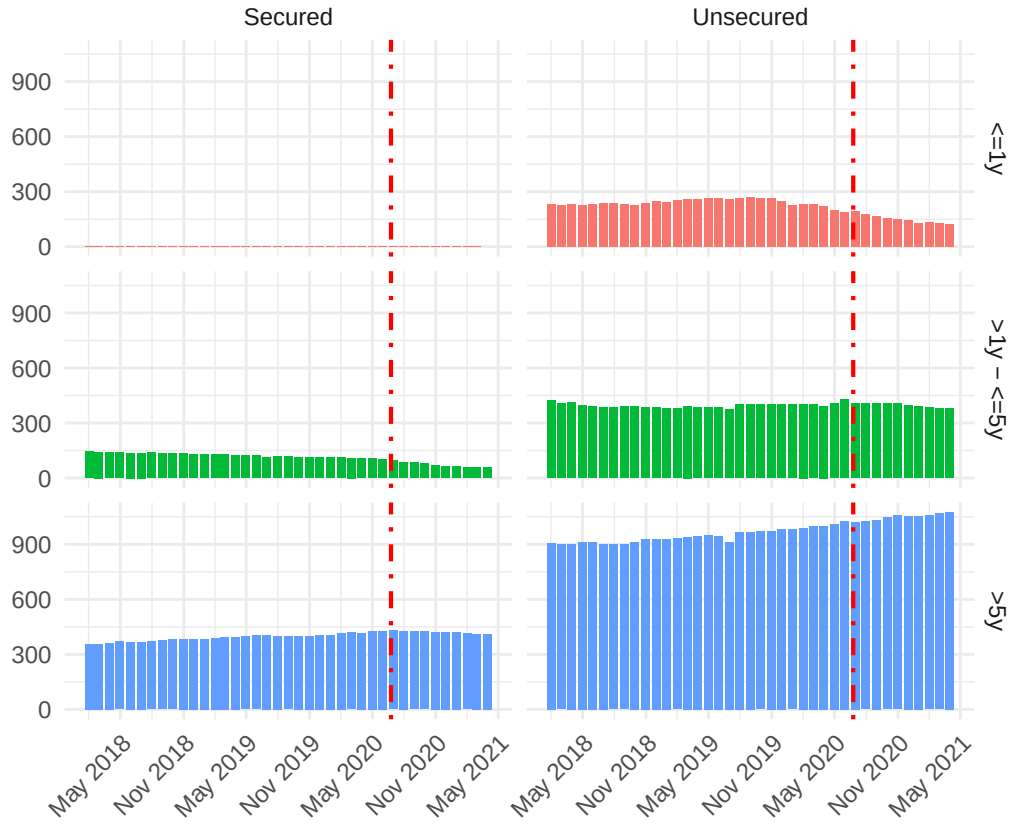
Note: SE clustered at the bank-time level

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

B Appendix

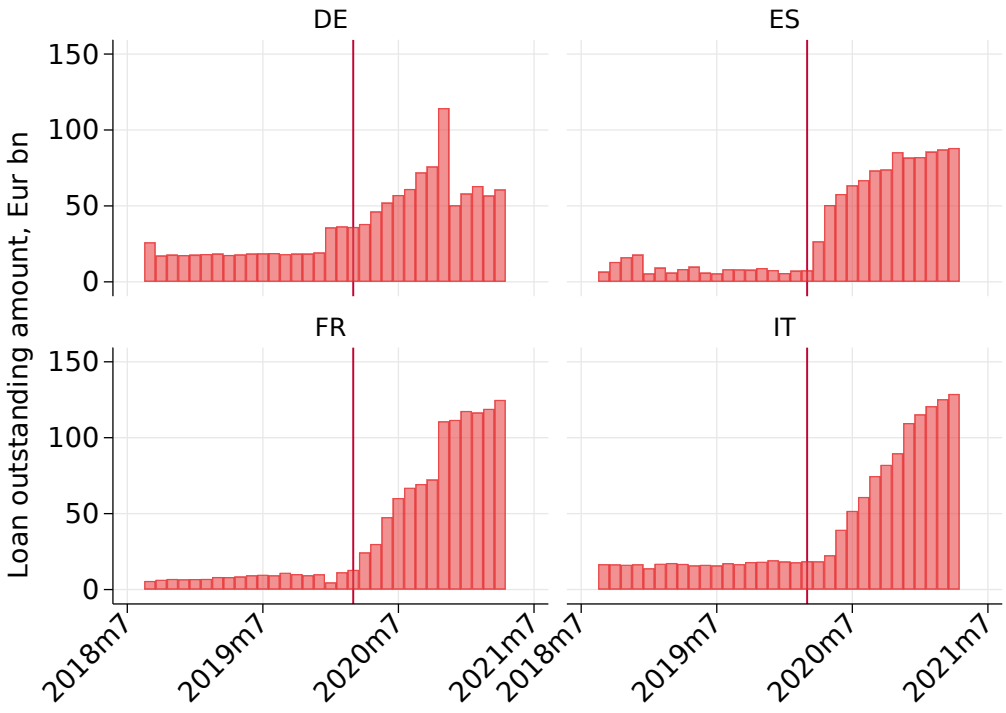
B.1 Additional graphs

Figure 13: Outstanding amount of bank debt, by initial maturity bucket and type (secured/unsecured), in Eur billion



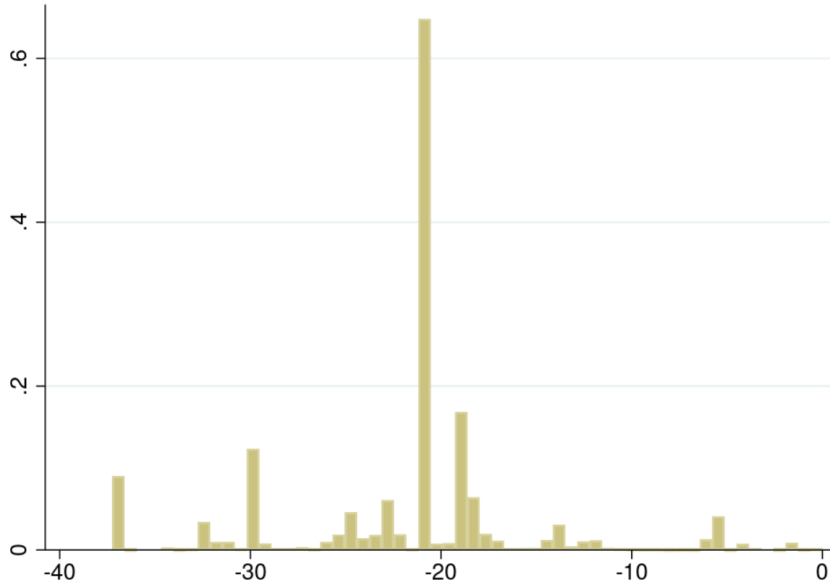
Note: This figure shows the nominal amount outstanding of TLTRO III participating banks debts, secured and unsecured.Vertical red dotted line corresponds to the June 2020 takeup.

Figure 14: State-guaranteed loans, selected countries



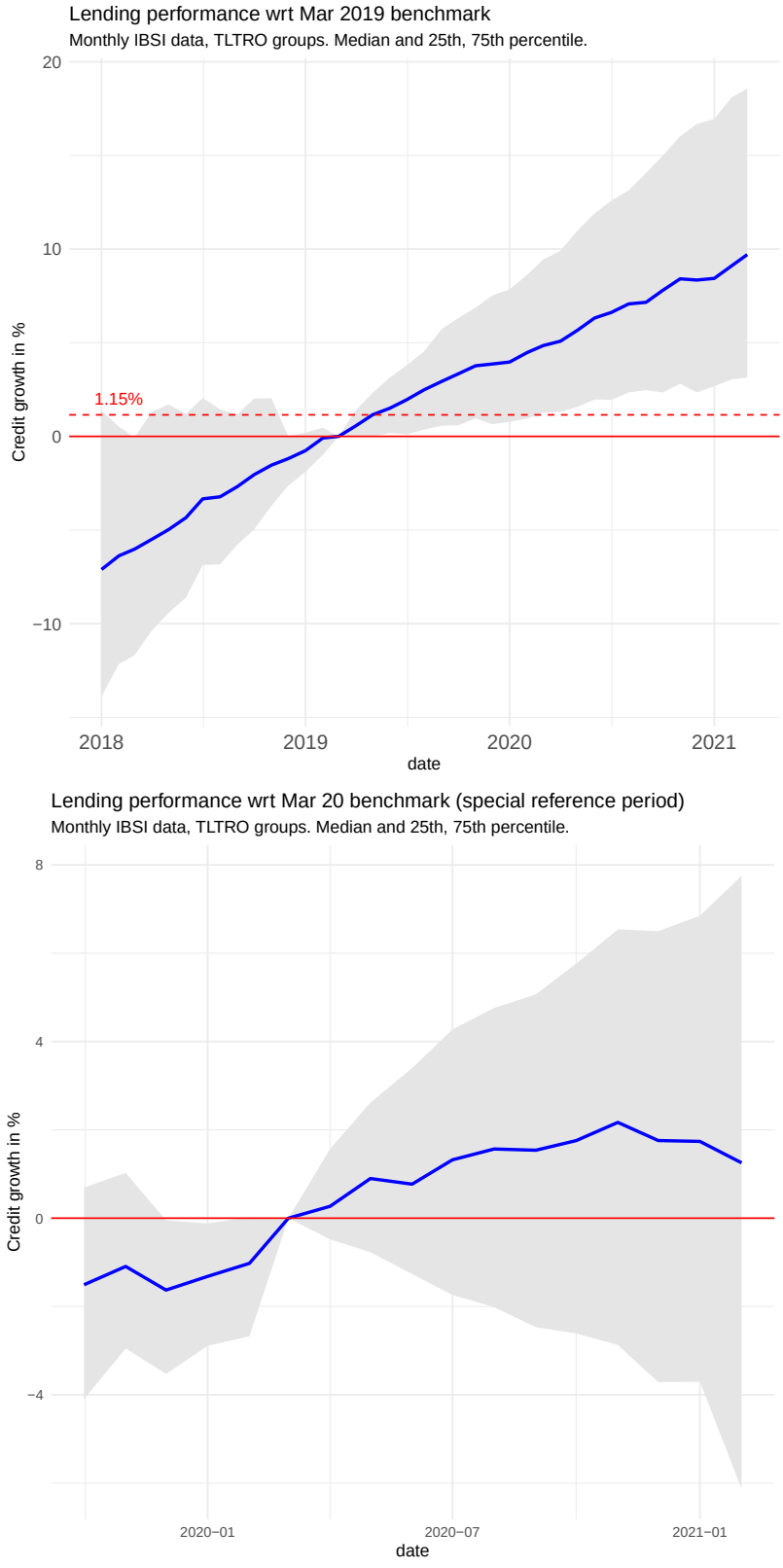
Source: AnaCredit. This figure shows the loan amount outstanding that we identify as covid-crisis related state guaranteed loans. As a general rule, we keep loans ultimately guaranteed by the central government (ESA sector S_1311) for a fraction superior to 60% of the principal, following Anderson, Papadia, and Véron (2020). For Italy, we keep loans guaranteed by Fondo di Garanzia. Our figures are consistent with those of ECB (Falagiarda, Prapiestis, and Rancoita, 2020).

Figure 15: Distribution of projected loan portfolio decrease among TLTRO participating banks



Source: AnaCredit. This distribution shows the projected decline of the loans to non-financial corporations, in %, as of March 2020.

Figure 16: Lending performance proxy, according to IBSI data



B.2 Proofs of section 4

B.2.1 Case where g=0

If $g = 0$, the function $r_O(L^E)$ is never differrentiable, and we cannot use the Lagrangian to solve for L^E

Let's first look at the case where the supply of eligible loan exceeds the lending target, set by the central bank, i.e.:

$$\frac{r_E - r_M(1-\alpha) - \alpha r_D}{c} \equiv L^{E\prime} \geq \underline{\mathrm{L}} \tag{20}$$

Then the bank is not enticed to change it behavior and the solution is by:

$$\begin{cases} L^{I\star} = \frac{r_I - r_M(1-\alpha) - \alpha r_D}{c} \\ L^{E\star} = \frac{r_E - r_M(1-\alpha) - \alpha r_D}{c} \\ O^* = \bar{O} \\ D^* = \alpha(L^{E\star} + L^{I\star}) - \bar{O} \end{cases}$$

The solution remains unchanged if $L^{E\prime} < \underline{\mathrm{L}}$ and $\Pi(L^{E\prime}) > \Pi(\underline{\mathrm{L}})$ If $L^{E\prime} < \underline{\mathrm{L}}$ and $\Pi(L^{E\prime}) < \Pi(\underline{\mathrm{L}^E})$, the solution becomes:

$$\begin{cases} L^{I\star} = \frac{r_I - r_M(1-\alpha) - \alpha r_D}{c} \\ L^{E\star} = \underline{\mathrm{L}^E} \\ O^* = \bar{O} \\ D^* = \alpha(L^{E\prime} + L^{I\star}) - \bar{O} \end{cases}$$

Using the profit function one can derive the condition under which $\Pi(L^{E\prime}) < \Pi(\underline{\mathrm{L}})$:

$$\bar{O}(\bar{r_O} - \underline{\mathrm{r}_O}) > (\underline{\mathrm{L}^E} - L^{E\prime})^2 \tag{21}$$

This condition has a straightforward interpretation: in the case of a binary pricing structure ($g = 0$), and if the lending target set by the central bank is higher than the loans the bank would have supplied anyway ($\underline{\mathrm{L}^E} > L^{E\prime}$), lending is stimulated if the borrowing allowance $\bar{O}$ and the spread between the most favorable and the least favorable rate ($\bar{r_O} - \underline{\mathrm{r}_O}$) are large compared to the distance between the target set by the central bank and amount the bank would have lent in the absence of TLTRO $(\underline{\mathrm{L}^E} - L^{E\prime})^2$

B.2.2 Demand for central bank refinancing

First order conditions (FOCs) associated with equation (6) are as follows:

$$\begin{cases} L^E : r_E - O\frac{\partial r_O}{L^E} - \frac{C(L^E)}{L^E} = \lambda + \alpha\gamma \\ L^I : r_I - \frac{C(L^I)}{L^I} = \lambda + \alpha\gamma \\ M : \lambda = r_M \\ D : \lambda + \gamma = r_D \\ O : \lambda = r_O - \gamma + \delta \end{cases}$$

Combining the first FOC with the third and the fourth allows to derive equation (7). Combining the second FOC with the third and the fourth allows to derive equation (8). Combining the last three FOC, allows to derive the following condition:

$$r_D - r_O = \delta \tag{22}$$

From this condition, we can infer that:

$$r_D > r_O \iff \delta > 0 \iff O = \bar{O} \tag{23}$$

In words: as long as the interest rate from the central bank refinancing operation is larger than the interest on deposits, banks saturate their constraint.

The third and the fourth FOCs can be used similarly to show that:

$$r_D > r_M \iff \gamma > 0 \iff D + O = \alpha L \tag{24}$$

Given that $d_1 > 0$, equation (24) is always verified.

In the particular case when $r_D = r_O(L^{E\star})$, then the solution to the bank's problem is given by:

$$\begin{cases} L^{I\star} = \frac{r_I - r_M(1-\alpha) - \alpha r_D}{c} \\ L^{E\star} = r_O^{-1}(r_D) \\ O^* = \frac{gc}{r_{\bar{O}} - r_{\underline{O}}}(r_O^{-1}(r_D) - \frac{r_E - r_M(1-\alpha) - \alpha r_D}{c}) \\ D^* = \alpha(L^{E\star} + L^{I\star}) - O^* \end{cases}$$

When $r_D < r_O(L^{E\star})$, the demand for central bank refinancing drops to zero.

B.2.3 Profitability channel

Under the assumption that banks are competitive, an additional channel may kick in, that we call the profitability channel.

To see it, let's recall a couple of identities that may hold in our model. First, if we assume that all central bank asset purchase are conducted with non-banks, that in turn deposit their

liquidity with commercial banks, it must be the case that: $R = M + \bar{O}$.[34] Moreover, loans granted to the non-financial sector are settled in bank money, i.e. bank deposit, meaning that the sum of loans must equal the sum of deposits on aggregate (L=D).

The aggregate profit of the banking sector then writes:

$$r_E L^E + r_I L^I + r_R(M + O) - \bar{O} r_O - r_D L - C(L^E) - C(L^I) = 0 \tag{25}$$

Taking the total derivative of equation (27), and using the fact that R, M and are set by the central bank allows to see how the banking sector adjusts to a decrease of r_O:

$$(r_E - r_D - cL^E)dL^E + (r_I - r_D - cL^I)dL^I = \bar{O} dr_O \tag{26}$$

Using the equilibrium values of L^E and L^I, and $dL^E + dL^I = dL$ yields:

$$\frac{dL}{dr_O} = \frac{\bar{O}}{(1-\alpha)(r_M - r_D)} \tag{27}$$

[34] To lighten notations, we neglect here the role of banknotes, coins and other "autonomous factor" that impact the amount of reserves R. The model can easily be extended to include them.

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