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The Transmission of Targeted Monetary Policy to Bank Credit Supply*

Matjaž Volk[†]

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Abstract

In this paper, I estimate the impact of Targeted Longer-Term Refinancing Operations (TLTROs) on the evolution of lending amounts and rates in Slovenia, with a specific focus on the distinct effects of TLTRO-I and -II. I use a combination of difference-in-differences and an instrumental variable approach, which together with detail credit register data enable the identification of the supply side effects of the TLTRO policy. The results show a supporting impact of targeted operations on bank loan supply, resulting in higher credit growth and lower rates. I find that TLTRO-I was supportive through both the quantity and price channels, whereas TLTRO-II only shows a significant impact on the credit amount. Further, I find that the transmission of TLTRO-I was higher through better capitalized banks, while both policy waves supported lending to safe and stable firms with higher credit ratings.

JEL Classification Codes: E52, E58, G21

Keywords: unconventional monetary policy, central bank liquidity, policy evaluation

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1 Introduction

In the aftermath of the global financial crisis, central banks across the globe responded with unconventional monetary policy measures to mitigate a credit crunch and invigorate aggregate demand. Among these measures, the Targeted Longer-Term Refinancing Operations (TLTROs), introduced by the European Central Bank (ECB) on June 5, 2014, emerged as one of pivotal tools in the unconventional toolkit.¹ While preceding operations, including various versions of Longer-Term Refinancing Operations (LTROs), were crafted to shore up the banking system during the peak of the European sovereign debt crisis, TLTROs were explicitly designed to target lending to the real economy. The primary objective of TLTROs was to amplify the effectiveness of monetary policy transmission through the bank lending channel. To date, there have been three TLTRO series, with the latest iteration, TLTRO-III, commencing March 2019.

This paper delves into the estimations of the impact of TLTROs on bank lending to corporate entities. The focus is on discerning how Slovenian banks adjusted their lending amounts and prices in response to TLTRO take-ups. Specifically, the paper explores the distinct effects of TLTRO-I and TLTRO-II on credit supply, considering a wide array of heterogeneous impacts contingent on bank, firm, and loan characteristics.

Estimating the impact of targeted monetary policy on bank lending confronts several challenges. Credit prices and quantities are shaped by both borrower demand and banks' incentives to supply credit to the real economy. To address potential biases, this study adopts the methodology of Khwaja and Mian (2008), examining how differently exposed banks adjust their loan supply to the same firm.² Additionally, the voluntary nature of TLTRO participation introduces a selection bias, which is mitigated using the borrowing allowance set by the ECB as an instrument, following Benetton and Fantino (2021). This instrument is predetermined, common across all banks, and exogenous to future lending decisions, providing a relevant solution to the selection problem.

The empirical results reveal a positive impact of targeted operations on bank lending, encompassing both credit quantity and price. TLTRO-I exhibited supportive effects through both the quantity and price channels, while TLTRO-II had a substantial impact primarily on the quantity of

¹Other non-standard measures adopted in the euro area include various programs of asset purchases, like corporate sector purchase programme (CSPP), public sector purchase programme (PSPP) and pandemic emergency purchase programme (PEPP), negative rate policy and forward guidance.

²This approach is widely employed in empirical banking to identify the supply-side impacts of liquidity shocks (Khwaja and Mian (2008) and Bonaccorsi di Patti and Sette (2016)), macroprudential policy (Jiménez et al. (2017) and Sivec and Volk (2023)), regulatory changes (Gropp et al. (2019) and Sivec and Volk (2021)), and monetary policy (Jiménez et al. (2012) and Jiménez et al. (2014)).

credit. A firm borrowing from a bank with a 1pp higher share of TLTRO funding in its balance sheet received 1.57pp more in credit and experienced a 17bp reduction in lending rates after TLTRO-I introduction. The impact of TLTRO-II on credit growth was more pronounced, at 3.02pp, although it did not show any impact on lending rates. Moreover, TLTRO-I continued to exert a supportive impact on lending rates even after 2016 when TLTRO-II was already in place.

The paper further identifies a heterogeneous impact of the TLTRO policy depending on bank, firm, and loan characteristics. The transmission is more pronounced in larger banks, and for TLTRO-I, it mainly worked through banks that were better capitalized and had higher funding costs. This suggests that ECB funding effectively reduced bank funding expenses and supported lending activity, particularly in banks with a robust capital position. Additionally, both TLTRO-I and II exhibited a more significant impact on lending to safe and stable firms with higher credit ratings. This outcome aligns with policymakers' goals, ensuring that increased lending benefits more productive firms. Lastly, the study finds that lending rates dropped more for loans with longer maturity, expected to be used for investment purposes and thus supporting economic activity.

This paper contributes to the literature on the transmission of unconventional monetary policy, focusing specifically on the impact of central bank liquidity provision. While existing studies have assessed the impact of LTROs in response to the sovereign debt crisis (see García-Posada and Marchetti (2016), Andrade et al. (2019), Crosignani et al. (2020) and Carpinelli and Crosignani (2021)) and targeted policies such as TLTROs (see Benetton and Fantino (2021), Andreeva and García-Posada (2021), Afonso and Sousa-Leite (2020) and Esposito et al. (2020)), this paper offers a comprehensive comparison of the impact of TLTRO-I and II. The comparison is conducted consistently, employing credit register data for the same economy. The analysis unveils distinct effects of the two policy waves on credit supply, indicating that TLTRO-I impacted both lending volume and rates, while TLTRO-II exhibited a substantial impact primarily on credit quality. This divergence may be partly attributed to the negative rate policy in place when TLTRO-II was introduced, which provided limited room for banks to cut rates. Furthermore, the findings underscore the significance of bank resilience for policy transmission, particularly in terms of solvency. During the TLTRO-I period, when banks were still recovering from the crisis and some had low capital levels, solvency emerged as a critical factor. In contrast, during the TLTRO-II timeframe, all Slovenian banks significantly bolstered their capitalization, diminishing the role of solvency in policy transmission during that period.

The subsequent sections of the paper are structured as follows. Section 2 presents the institutional background of TLTRO operations, while Section 3 provides more details on the participation of Slovenian banks in both waves, accompanied by a description of summary statistics and general bank behavior. Section 4 outlines the identification strategy. Results, together with robustness checks, are presented in Section 5. Finally, Section 6 concludes the paper and discusses policy implications.

2 Targeted longer-term refinancing operations

On June 5, 2014, the ECB announced TLTRO-I, a program spanning two years with a total of eight auctions. In the initial two auctions, banks were permitted to borrow up to 7% of their eligible loans as of April 30, 2014. Eligible loans encompassed those extended to firms and households, excluding loans for house purchases. An incentive scheme was implemented to encourage lending, with banks falling short of their benchmark (defined as the net lending flow in the 12 months leading up to April 30, 2014) were required to repay TLTRO borrowings before the September 2018 maturity. The subsequent six operations featured a different incentive structure, allowing banks to borrow up to three times the amount by which their net lending exceeded the benchmark.

The second wave, TLTRO-II, was introduced on June 10, 2016, consisting of four auctions from June 2016 to March 2017. It deviated from TLTRO-I in two key aspects. Firstly, the incentive structure was dropped, enabling banks to borrow up to 30% of their eligible loans outstanding as of January 31, 2016, excluding debt from the initial TLTRO-I operations. Secondly, banks surpassing their lending benchmarks received a reduced interest rate, as low as the deposit facility rate (-0.40%).

On March 7, 2019, the ECB announced TLTRO-III, the third series of operations, subject to recalibrations mainly due to the COVID-19 pandemic. Initially, seven operations were planned between September 2019 and March 2021. The borrowing allowance mirrored TLTRO-II, allowing banks to borrow up to 30% of eligible loans as of February 28, 2019. The TLTRO-III interest rate, initially set at 10 basis points above the average Main Refinancing Operations (MRO) rate for each operation's duration, underwent several changes. On September 12, 2019, the rate aligned with the average MRO rate and could be further reduced for banks meeting lending benchmark criteria. Responding to the pandemic on March 12, 2020, the rate decreased by 25 basis points, and the borrowing allowance increased to 50% of eligible loans. By the end of 2020, the rate further dropped to -1%, the borrowing allowance rose to 55%, and three additional auctions were

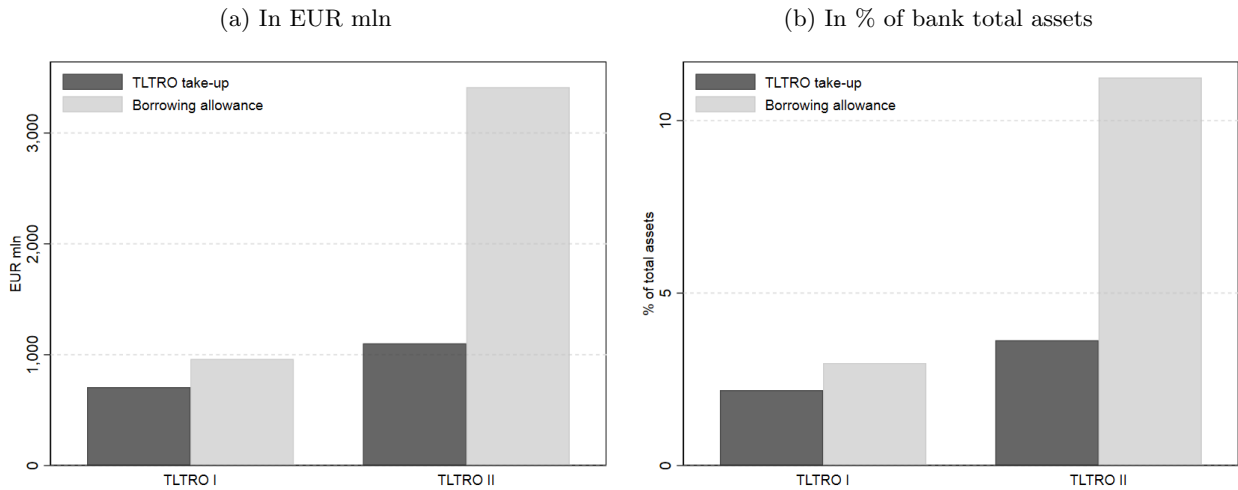
announced, scheduled between June and December 2021.

3 TLTRO participation and bank behaviour

Slovenian banks accessed a total of 706 million EUR through TLTRO-I and 1102 million EUR through TLTRO-II from the Eurosystem, as illustrated in Figure 1.³ Notably, banks exhibited a higher utilization rate of their borrowing allowance in TLTRO-I, with a take-up amount representing 73% of their allowance, compared to 32% in TLTRO-II.

Out of the 16 banks present in the Slovenian banking system in 2014, 13 participated in TLTRO-I, with an average borrowing amount equivalent to 2.26% of their total assets (Table 1). By the time TLTRO-II was introduced in 2016, the Slovenian banking system consisted of 14 banks, and 10 of them engaged in TLTRO operations,⁴ with an average amount of 5.67% of banks' total assets.

Figure 1: TLTRO take-up by Slovenian banks



Source: Bank of Slovenia, own calculations. TLTRO take-up amounts are reported for the first two TLTRO-I auctions (September and December 2014) and for all four TLTRO-II auctions (from June 2016 to March 2017).

The banking landscape underwent significant transformations during the periods of TLTRO-I and II. Slovenian banks grappled with a substantial burden of non-performing loans in the aftermath of the financial crisis. Despite a considerable transfer of defaulted assets to the Bank Assets Management Company (BAMC), the NPL ratio for an average bank remained high, hovering at

³The reported take-up amount of 706 million EUR in TLTRO-I corresponds to the first two auctions, as these are exclusively used for identification purposes in the analysis (see Section 4 for details). The overall borrowing across all eight TLTRO-I auctions amounts to 751 million EUR.

⁴This decline in the number of banks is attributed to mergers within the industry.

almost 19% in 2014 prior to the commencement of TLTRO-I operations (see Table 1).⁵ By 2016, coinciding with the onset of TLTRO-II, the NPL ratio had halved, reaching 10%. Simultaneously, the capitalization, as gauged by the capital adequacy ratio, increased by an average of 2.4 percentage points between the two rounds of operations. The return on assets experienced a positive upturn, and the lending dynamic rebounded, reversing years of contraction. Conversely, bank funding costs decreased following an extended period of accommodative monetary policy. These marked differences observed among banks and across the two waves of operations underscore the importance of accounting for individual bank characteristics.

Table 1: Summary statistics

	TLTRO-I		TLTRO-II	
Total number of banks	16		14	
Number of banks with TLTRO > 0	13		10	
	Mean	St. dev.	Mean	St. dev.
TLTRO in % of total assets	2.26	1.43	5.67	5.00
Borrowing allowance in % total assets	2.84	1.40	10.32	4.96
Capital adequacy ratio in %	16.10	5.13	18.55	6.20
NPL ratio in %	18.88	12.05	9.78	5.58
Return on assets in %	0.07	1.42	1.18	1.16
Funding costs in %	1.27	0.48	0.54	0.30
Loan growth in %	-4.43	14.93	1.77	21.27

Source: Bank of Slovenia, own calculations.

Note: The table reports summary characteristics of banks present during the TLTRO-I and TLTRO-II operations. Threshold date for the calculation of summary statistics in one month before first round of operations, i.e. 2014m8 for TLTRO-I and 2016m5 for TLTRO-II. Defaulted exposure entering the calculation of the NPL ratio takes into account borrowers that are more than 90 days overdue in loan repayment or a bank assigns them a credit rating D or E (in five-grade rating scale from A to E). Funding costs are total weighted funding costs of a bank, across all the liability sources. Loan growth is reported for the non-banking sector.

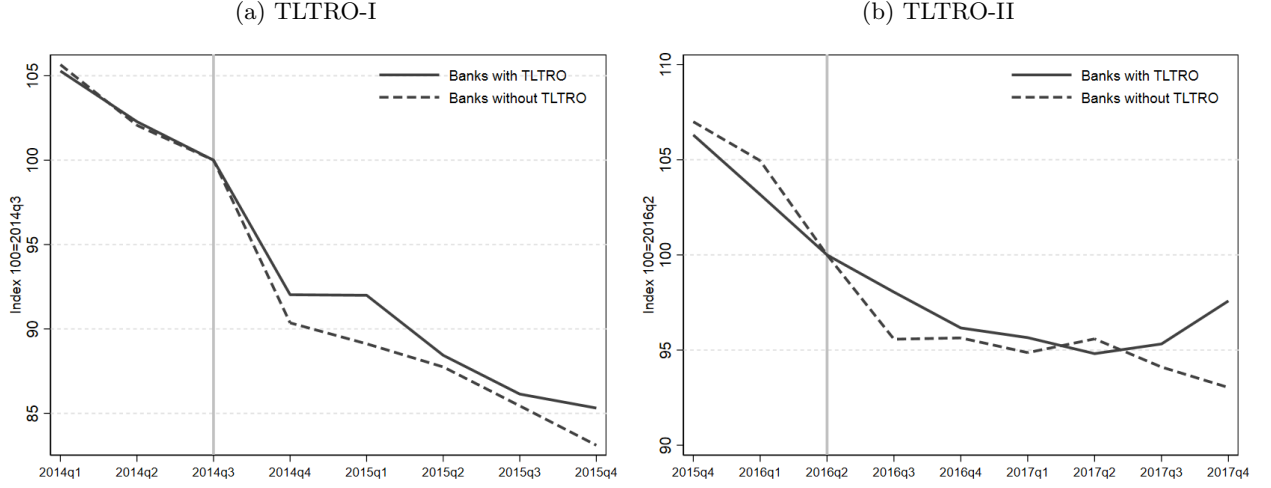
Figures 2 and 3 present the evolution of lending amount and rates around the two waves of operations. Each of the four figures shows two lines: the solid line is for banks that participated in the TLTRO, whereas the dashed line is for the once that did not.⁶ First, note that the evolution of lending and rate before the introduction of the policy (marked with grey lines in 2014q3 for TLTRO-I and in 2016q2 for TLTRO-II) was very similar for participating and non-participating banks. This is important for the identification with difference-in-differences setup that builds on the assumption of parallel trend in absence of policy. After the policy, banks with TLTRO-I funding

⁵The NPL ratio considers default exposure involving borrowers either more than 90 days overdue in loan repayment or assigned a credit rating of D or E (on a five-grade scale from A to E).

⁶Note that the number of banks that did not participate in TLTRO borrowing is low, 3 banks in TLTRO-I and 4 banks in TLTRO-II, but their share in total assets is non-negligible: 15% in TLTRO-I and 41% in TLTRO-II.

seem to have a bit higher evolution of lending and significantly lower rates. The evolution of lending is more positive also for banks participating in TLTRO-II (with exception of one period), whereas rate drops lower only at the end of horizon.

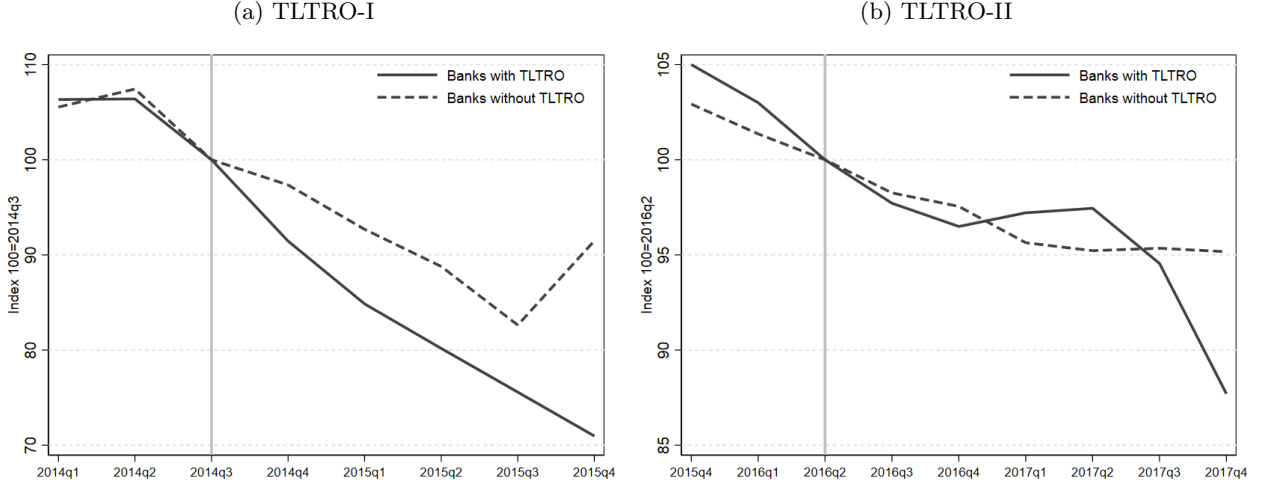
Figure 2: Evolution of lending amount and TLTRO participation



Source: Bank of Slovenia, own calculations. The two figures show the evolution of lending to corporates around TLTRO-I and TLTRO-II auctions.

Visual inspection in Figures 2 and 3 provides an initial insight into the disparities in the evolution of lending amounts and rates following the implementation of the policy. It is however not yet a proof, as there are numerous unaccounted factors in play. Firstly, as previously outlined, substantial variations among banks exist, and these discrepancies could significantly influence the results if they are correlated with TLTRO participation. Secondly, the observed changes in lending amounts and rates are influenced by a combination of demand and supply factors. The goal of my analysis is to estimate if banks with higher TLTRO funding adjusted their lending amount and rate differently, i.e., to identify the supply side. To achieve this, I employ a difference-in-differences approach with a set of fixed effects designed to absorb variations in loan demand (as discussed in the subsequent section). Additionally, it's crucial to note that the two figures only categorize banks as participating or non-participating. However, for the purpose of estimation, I utilize a continuous treatment model, enhancing clarity by allowing for identification based on the specific amount of TLTRO funding acquired by each bank.

Figure 3: Evolution of lending rates and TLTRO participation



Source: Bank of Slovenia, own calculations. The two figures show the evolution of rates for loans to corporates around TLTRO-I and TLTRO-II auctions.

4 Identification strategy

Estimating the impact of TLTRO on bank lending poses several empirical challenges. First, TLTROs were implemented by the policymakers as a reaction to macroeconomic conditions with a specific target to promote lending to the real economy. Therefore, macroeconomic shocks correlated to the policy may induce unobservable loan demand shifts that are contemporaneous to the ECB policy introduction, leading to simultaneity and omitted variable bias. Second, participation in the TLTRO was voluntary, which may result in a selection bias due to non-random assignment to treatment. The direction of the bias can be positive or negative, depending on characteristics of banks that took TLTRO funding and on their lending opportunities or planned expansion of loan supply.

To tackle the two issues above I use instrumental variable (IV) approach and make use of detailed credit register data to control for loan demand. In the first stage regression I instrument the treatment intensity with a maximum borrowing allowance within TLTRO-I and II. In particular, I estimate the following equation:

$$TLTRO_b = \phi Allowance_b + \Theta Controls_b + \epsilon_b \quad (1)$$

where $TLTRO_b$ is TLTRO take-up by bank b and $Allowance_b$ is borrowing allowance that determines maximum amount banks can borrow via TLTRO operations. The model is estimated separately for TLTRO-I and II. Both, the actual take-up and the allowance, are measured in percent of

bank total assets. Borrowing allowance is a valid instrument as it is correlated with actual TLTRO take-ups (the correlation coefficients equal to 0.748 and 0.457 for TLTRO-I and II, respectively) and is exogenous to banks' loan supply decisions during both operations.

The exogeneity of borrowing allowance stems from the institutional framework governing both operations. Maximum borrowing allowance is set by the ECB in a common way for all banks and is predetermined at the time of announcement of both operations. Specifically, as detailed in Section 2, during the initial two TLTRO-I auctions in September and December 2014, banks were permitted to borrow up to 7% of their outstanding amount of eligible loans as of April 30, 2014. In contrast, I exclude the amounts borrowed in the subsequent TLTRO-I auctions (between March 2015 and June 2016) because the additional borrowing allowances were contingent upon the evolution of banks' eligible lending activities exceeding bank-specific benchmarks. Notably, this incentive scheme was discontinued for TLTRO-II, and across the four TLTRO-II actions, banks had the opportunity to borrow up to 30% of their amount of eligible loans.

In addition to the borrowing allowance, the first stage regression (equation 1) incorporates controls for additional bank characteristics that may be relevant for explaining the observed bank take-ups during TLTRO auctions. Specifically, the set of controls ($Controls_b$) includes various variables, namely the capital adequacy ratio, NPL ratio, ROA, funding costs, log of total assets, and annual credit growth at a bank level. All these variables are measured one month prior to the initial take-ups in both TLTRO-I (August 2014) and TLTRO-II (May 2016) operations.

In the second stage I estimate the impact of TLTRO take-ups on credit growth and lending rates for new loans. The impacts are estimated for non-financial corporates using detailed credit register data that enable to control for loan demand and other unobserved firm characteristics with a series of fixed effects. The underlying assumption here is that loan demand is the same across all the banks a firm borrows from and does not depend on bank characteristics.⁷ Whereas both, credit growth and lending rate equation are based on Khwaja and Mian (2008) methodology, they differ slightly in their setup.⁸

TLTRO impacts on the evolution of lending amount is estimated for one-year window be-

⁷Altavilla et al. (2021) highlight the significance of bank resilience in the decision-making process of firms when choosing a lender. This consideration is particularly relevant to the concept of "strategic withdrawal" observed in firms avoiding banks with balance sheet issues due to concerns about potential insolvency. Notably, my estimates include the post-banking crisis period in Slovenia, characterized by robust capitalization across all banks. Hence, the apprehension regarding strategic withdrawal should be mitigated during this timeframe.

⁸Khwaja and Mian (2008) approach is widely used in empirical banking. For other examples of its application see Behn et al. (2016), Jiménez et al. (2017) and Benetton and Fantino (2021).

fore/after the introduction of each TLTRO series. In particular, I estimate the following model:

$$\Delta L_{fb} = \beta \times \widehat{TLTRO}_b + \Theta Controls_b + D_f + \epsilon_{fb} \quad (2)$$

where ΔL_{fb} is log change of firm f loan amount in bank b in period between 2014m8 and 2015m8 for TLTRO-I and between 2016m5 and 2017m5 for TLTRO-II. $\widehat{TLTRO}_b$ are the fitted values from the first stage regression in equation 1. D_f are fixed effects that capture loan demand and other unobserved firm characteristics. The identification assumption is that loan demand is not bank specific.

To uncover the TLTRO impacts on lending rate I make use of reported monthly rates and estimate the following difference-in-differences model:

$$LR_{fbt} = \beta \times I(t \geq T) \times \widehat{TLTRO}_b + \Theta Controls_{bt} + D_{fy} + D_b + \epsilon_{fbt} \quad (3)$$

where LR_{fbt} is lending rate for a new loan, taken by firm f in bank b in month t . D_{fy} are firm-year fixed effects, that capture loan demand and other firm characteristics.⁹ D_b captures bank effects that are constant over time. The time frame for the estimation is 2013m1-2015m12 for TLTRO-I and 2015m1-2017m12 for TLTRO-II. The coefficient of interest, β , captures the differential effect of the policy between treated and control banks after each of the two TLTRO series became effective ($t \geq T$). More specifically, $T = 2014m9$ for TLTRO-I and $T = 2016m2$ for TLTRO-II. In addition to the control variables described above, I also control for loan-specific characteristics like loan maturity, credit rating, collateral and interest rate fixation.

When assessing the impact of TLTRO-II, I take into account the remaining TLTRO-I funds on banks' balance sheets. The final TLTRO-I auction took place in June 2016, coinciding with the initiation of TLTRO-II. Given that the maturity of TLTRO-I borrowings was scheduled for September 2018,¹⁰ there exists an overlap in ECB funding between the two operations. This overlapping period may influence the estimated effects of TLTRO-II. Consequently, I incorporate controls for TLTRO-I amounts and investigate the interaction between the two TLTRO series to assess their combined impact on credit growth and lending rates.

⁹I use firm-year instead of firm-month fixed effects as it only requires that the same firm takes a loan from at least two different banks in the same year. I also checked a more restrictive specification with firm-month fixed effects and it does not change the conclusions. The results are available upon the request.

¹⁰Unless banks, not meeting the lending benchmark, had to repay their TLTRO borrowings earlier.

5 Results

This section presents the findings regarding the impact of TLTRO policy on the evolution of lending amounts and rates. The primary results are initially summarized, and subsequently, a more detailed exploration is conducted, examining the heterogeneous impact based on bank, firm, and loan characteristics. A separate subsection follows, presenting the outcomes of two robustness checks that validate the main results.

Table 2 presents the main set of results for the impact of TLTRO-I and II on credit growth and lending rates for new businesses. The displayed impacts represent β coefficients from second-stage regressions in equations 2 and 3. The corresponding first-stage results are detailed in the Appendix in Table A. Both TLTRO-I and II exhibit a positive and statistically significant impact on credit growth. Specifically, the same firm is expected to experience approximately a 1.6pp higher growth in loans in a bank with a one percentage point higher share of TLTRO-I funding on its balance sheet. For TLTRO-II, this impact doubles, reaching 3pp. Given the mean individual-firm credit growth of -3% and 1% around the TLTRO-I and TLTRO-II periods, respectively, these impacts are not only statistically significant but also economically meaningful.

Moreover, TLTRO-I exerts a supportive influence on lending rates. In a bank with a 1pp higher share of TLTRO-I funding, the same firm is expected to receive a new loan with a 0.167pp lower lending rate. The significance of this impact is underscored by the fact that, around the introduction of TLTRO-I, the mean lending rate stood at 5%. Conversely, TLTRO-II does not exhibit any impact through the price channel, indicating that its effects were solely manifested through adjustments in lending quantities.

Next, I delve into the dynamic interplay between TLTRO-I and II. Following June 2016, banks held in their balance sheets funding from the Eurosystem obtained through two distinct operations: TLTRO-I and II. This prompts an inquiry into the potential interactions between these two phases. The results presented in Columns (1) and (3) of Table 3 mirror those reported for TLTRO-II in Table 2, just that they display also the coefficient on the impact of TLTRO-I. The findings reveal that TLTRO-I continued to exert a supportive influence on lending rates (with a coefficient of -0.089, highly statistically significant) even beyond 2016. Moving on, in Columns (2) and (4), I assess the impact of the interaction between TLTRO-I and II amounts. A statistically significant impact (at 10% level) is found only for rates, though it is economically quite weak as the average value of the interaction ($\text{TLTRO-II} \times \text{TLTRO-I}$) is less than 0.1%, as opposed to average TLTRO-II funds that

Table 2: TLTRO impact on credit growth and lending rates

	Credit growth		Lending rate	
	TLTRO-I	TLTRO-II	TLTRO-I	TLTRO-II
TLTRO	1.574**	3.022***	-0.167***	-0.019
Level of estimation	Firm-bank	Firm-Bank	Firm-bank-month	Firm-bank-month
Firm controls	Firm FE	Firm FE	Firm-year FE	Firm-year FE
Bank fixed effects	No	No	Yes	Yes
Number of observations	11,558	9,606	27,398	36,844
R-square	0.507	0.599	0.857	0.880

Source: Bank of Slovenia, AJPES, own estimates.

Note: The table reports the estimated coefficients of the impact of TLTRO-I and II on credit growth and lending rates to corporates. The impact on credit growth is estimated on a bank-firm level, using only firms with multiple relations with banks (Khwaja and Mian (2008)), where the dependent variable is change in log credit amounts between 2014m8 and 2015m8 for TLTRO-I and between 2016m5 and 2017m5 for TLTRO-II. The impact on lending rate is estimated on firm-bank-time level, using only firms that take loans from multiple banks in a given year. TLTRO are fitted values from first-stage regression, where TLTRO amounts (in % of total assets) are explained with borrowing allowance and bank controls (equation 1). The same set of controls is included also in the second stage and include: capital adequacy ratio, leverage ratio, NPL ratio, ROA, funding costs, log of total assets and annual credit growth at the bank level. Estimates for lending rates also control for loan characteristics: maturity, credit rating, collateral and interest rate fixation. In addition, TLTRO-II estimates control also for the still existing TLTRO-I amounts in time of TLTRO-II take-ups. Significance: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Standard errors are clustered at bank level.

equal to about 5% of total assets.

Table 3: Interaction between TLTRO-I and TLTRO-II impact

	Credit growth		Lending rate	
	(1)	(2)	(3)	(4)
TLTRO-II	3.022**	3.052***	-0.019	0.013
TLTRO-I	0.361		-0.089***	
TLTRO-II $\times$ TLTRO-I		3.196		-0.717*

Source: Bank of Slovenia, AJPES, own estimates.

Note: The table reports the impact of TLTRO-II on credit growth and lending rate, when considering its interaction with TLTRO-I. TLTRO-I is the existing amount of TLTRO funding in banks' balance sheet (in % of total assets) in time frame when TLTRO-II operations were already taking place. When estimating the impact on credit growth, TLTRO-I equals to its average amount in period 2016m5 - 2017m5, at the bank level. For estimating the impact on lending rate, the exact bank-time values are used. Significance: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Standard errors are clustered at bank level.

Table 4 presents the results of the heterogeneous impact of TLTROs on bank lending, depending on bank characteristics. To investigate this, I employ interaction terms by combining TLTRO take-ups with indicator variables representing bank total assets, capital adequacy, profitability (ROA), funding costs, and bank credit growth. Specifically, the indicator takes on a value of one when a bank-specific variable surpasses the median. Notably, the statistically significant heterogeneous

impact is observed for total assets (column (1)), suggesting that the influence of targeted monetary policy on bank lending is more pronounced for larger banks. Other interactions show a more mixed picture.

The analysis reveals that the effect of TLTRO on lending is more substantial for well-capitalized banks, although this significance is apparent only for TLTRO-I (column (2) in Table 4). This outcome implies that the monetary policy intervention in the form of TLTRO-I had a limited impact on the real economy through banks with weaker capital positions. Subsequently, during the TLTRO-II wave, the capital positions of banks strengthened, potentially explaining the non-significant effect of bank capitalization on the transmission of TLTRO-II. Similarly, bank funding costs play a role in the transmission of the policy only during TLTRO-I, where the impact of the policy is more substantial for banks with higher funding costs (column (4) in Table 4). The elevated funding costs of banks can act as a significant obstacle to the supply of bank loans, and this result suggests that the TLTRO policy alleviates this issue. During TLTRO-II, banks could raise funds inexpensively from the market due to accommodative monetary policy, likely contributing to the less relevant role of funding costs in the transmission of TLTRO-II. Lastly, the analysis indicates that the impact of TLTRO-II was more pronounced for more profitable banks and those with higher credit growth.

Table 4: TLTRO impact on credit growth - bank heterogeneity

	(1)	(2)	(3)	(4)	(5)
TLTRO-I					
TLTRO	0.992	0.754	2.038**	2.329***	1.557**
TLTRO $\times$ I(Assets)	1.705**				
TLTRO $\times$ I(Capital adeq. ratio)		2.741***			
TLTRO $\times$ I(ROA)			-0.347		
TLTRO $\times$ I(Funding costs)				4.727***	
TLTRO $\times$ I(Credit growth)					0.284
TLTRO-II					
TLTRO	2.447***	2.847***	1.718*	3.391***	2.709***
TLTRO $\times$ I(Assets)	3.571***				
TLTRO $\times$ I(Capital adeq. ratio)		2.684			
TLTRO $\times$ I(ROA)			3.744**		
TLTRO $\times$ I(Funding costs)				-0.454	
TLTRO $\times$ I(Credit growth)					2.095***

Source: Bank of Slovenia, AJPES, own estimates.

Note: The table reports the estimated coefficients of the impact of TLTRO-I and II on credit growth, exploring bank heterogeneity. $I()$ denotes indicator variables that equal one when a bank-specific value for the variable in brackets is above the median. Significance: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Standard errors are clustered at bank level.

I now turn into the examination of heterogeneity in the impact of TLTRO across different firm characteristics. In Table 5, Column (1) illustrates the interaction between TLTRO funding and a firm's riskiness, as indicated by a credit rating of A or B assigned by a bank.¹¹ The positive coefficient indicates that the increased lending from both TLTRO waves was predominantly directed towards financially stable and secure firms. This outcome aligns with the desired objective of policymakers and is further reinforced by a more substantial impact observed for larger, more profitable, and less indebted firms, as presented in Columns (2)-(4). Notably, these impacts are statistically significant only for TLTRO-II.

Table 5: TLTRO impact on credit growth - firm heterogeneity

	(1)	(2)	(3)	(4)
TLTRO-I				
TLTRO	0.643	1.229	1.169	1.172
TLTRO $\times$ I(Rating A/B)	1.131*			
TLTRO $\times$ I(Assets)		0.776		
TLTRO $\times$ I(EBITDA margin)			1.036	
TLTRO $\times$ I(Debt-to-equity)				0.445
TLTRO-II				
TLTRO	2.164**	2.326**	2.632***	3.878***
TLTRO $\times$ I(Rating A/B)	1.114*			
TLTRO $\times$ I(Assets)		2.100***		
TLTRO $\times$ I(EBITDA margin)			1.161*	
TLTRO $\times$ I(Debt-to-equity)				-1.198*

Source: Bank of Slovenia, AJPES, own estimates.

Note: The table reports the estimated coefficients of the impact of TLTRO-I and II on credit growth, exploring firm heterogeneity. $I()$ denotes indicator variables that equal one when a firm-specific value for the variable in brackets is above the median, except for Rating A/B where it equals one when a firm is assigned rating A or B. Significance: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Standard errors are clustered at bank level.

Last, I analyse the variability in the impact of TLTRO on lending rates, taking into account various loan characteristics. Specifically, I investigate the differences across loan maturity, interest rate fixation, and credit ratings assigned at the time of loan approval.

Starting with loan maturity, TLTRO-I demonstrates a more pronounced effect for longer maturities. Banks with a one-percentage-point higher share of TLTRO-I funding experience an average reduction of 17 basis points in lending rates (refer to Table 2). Notably, the impact exceeds 20 basis points for loans with an original maturity exceeding 3 years (Table 6). This trend is favourable, as longer-term loans are more likely to be directed towards financing investments, thereby contribut-

¹¹Banks assess the credit risk of firms using ratings ranging from A to E.

ing to economic growth. In contrast, TLTRO-II exhibits a minimal and statistically non-significant average impact (refer to Table 2). However, there is a discernible effect for loans with shorter maturities (below 1 year), where banks with a one-percentage-point higher TLTRO-II funding experience a reduction of approximately 5-7 basis points. While relatively modest, this suggests that TLTRO-II had a somewhat more supportive role for loans intended for regular operational purposes.

Table 6: TLTRO impact on lending rates - loan heterogeneity

	TLTRO-I	TLTRO-II
Heterogeneity across loan maturity classes		
Up to 3 months	-0.053	-0.058**
3 months to 1 year	-0.196***	-0.072**
1 year to 3 years	0.076	-0.001
3 years to 10 years	-0.207**	0.0132
Above 10 years	-0.218***	0.019
Heterogeneity across interest rate fixation		
Fixed interest rate	-0.164***	0.005
Floating interest rate	-0.224**	-0.029
Heterogeneity across credit ratings		
Rating A	-0.119**	0.026
Rating B	-0.250***	-0.022
Rating C	-0.134**	-0.083
Rating D	-0.159**	-0.095*
Rating E	-0.043	-0.029

Source: Bank of Slovenia, AJPES, own estimates.

Note: The table reports the estimated coefficients of the impact of TLTRO-I and II on lending rates for new businesses, exploring loan heterogeneity. Significance: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Standard errors are clustered at bank level.

Looking at interest rate fixation, TLTRO-I shows a supportive impact for both, loans with fixed and floating interest rate. The impact is larger for floating interest rate, though it is not statistically different from the coefficient for fixed interest rate.¹² Finally, in response to the TLTRO-I introduction, rates dropped across all the credit ratings, with the highest impact for rating B, where they were lower by 25bp. TLTRO-II, on the other hand, shows the largest impact for rating D. This outcome is not desirable as in this way the policy was more supportive for firms close to bankruptcy. However, the impact is small and the share of D-rated loans is less than 3%.

¹²Running a test of equality between coefficient for fixed and floating interest rate returns a p-value of 0.467.

5.1 Robustness checks

This section introduces two comprehensive sets of robustness checks to validate the findings. Firstly, a placebo test is conducted, simulating a hypothetical introduction of the TLTRO policy one year earlier. This test aims to eliminate the possibility that the results are influenced by specific confounding factors. Secondly, the sample is expanded by incorporating single-bank relation firms, thereby enhancing the external validity of the results. These robustness checks are applied to the main estimate of the TLTRO's impact on the evolution of lending amounts and rates, as initially presented in Table 2.

In the placebo test, I assume that the the first auction within the TLTRO-I and TLTRO-II occurred in September 2013 and June 2015, respectively. This check aims to assess whether any observed treatment effects existed prior to the formal introduction of the policy. Should this hypothesis hold true, it would suggest that my findings may be influenced by confounding variables associated with subsequent TLTRO funding uptake by banks. The results of this analysis are presented in Table 7. Notably, the coefficients reflecting the impact of TLTRO are both statistically insignificant and exhibit reduced magnitudes for both the evolution of credit amounts and lending rates. Based on these outcomes, I draw the conclusion that it is unlikely for a correlated confounder to be driving the observed results.

Table 7: Placebo test - hypothetical introduction of TLTROs one year earlier

	Credit growth		Lending rate	
	TLTRO-I	TLTRO-II	TLTRO-I	TLTRO-II
TLTRO	0.011	1.406	-0.025	0.029
Level of estimation	Firm-bank	Firm-Bank	Firm-bank-month	Firm-bank-month
Firm controls	Firm FE	Firm FE	Firm-year FE	Firm-year FE
Bank fixed effects	No	No	Yes	Yes
Number of observations	13,351	9,673	30,353	37,745
R-square	0.527	0.513	0.845	0.872

Source: Bank of Slovenia, AJPES, own estimates.

Note: The table reports the estimated coefficients for a hypothetical introduction of TLTRO-I and II in 2013m9 and 2015m6, respectively. Significance: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Standard errors are clustered at bank level.

The identification strategy, as proposed by Khwaja and Mian (2008), hinges on the analysis of firms with multiple bank relationships. This approach allows for the control of demand-side factors and other firm characteristics through the incorporation of firm fixed effects. However, a potential drawback to this estimation lies in the substantial exclusion of observations, raising concerns about

the representativeness of the resulting sample.

To mitigate this concern, I adopt the methodology advocated by Degryse et al. (2019). Instead of relying on firm fixed effects, this approach introduces control for loan demand using industry-location-size (ILS) fixed effects, or industry-location-size-time fixed effects in the case of lending rate equations. This methodology assumes a constant loan demand within each ILS cluster, representing a milder assumption than the original Khwaja and Mian (2008) framework. Notably, the ILS estimation allows for the inclusion of firms with single bank relations, as long as they belong to an ILS cluster comprising firms borrowing from more than one bank. In my analysis, I define ILS clusters based on 22 industries, 13 location districts, and 7 size classes. For the lending rate equation, which also incorporates a temporal dimension, I introduce 3 time clusters represented by years.

The findings, presented in Table 8, affirm the robustness of the results. The estimated coefficients closely mirror those in the main analysis (Table 2). Notably, the impact on credit growth remains statistically significant for both TLTRO-I and II. However, the magnitudes differ slightly, registering at 1.062 and 2.678, respectively, in contrast to 1.574 and 3.022 under the Khwaja and Mian (2008) framework. Regarding lending rates, there is a marginally higher responsiveness to TLTRO-I introduction compared to the estimates on the restricted sample, while no discernible reaction is observed for TLTRO-II. In summary, the results remain robust to sample extension and the adoption of an alternative methodological approach.

Table 8: TLTRO impacts with sample expansion

	Credit growth		Lending rate	
	TLTRO-I	TLTRO-II	TLTRO-I	TLTRO-II
TLTRO	1.062***	2.678**	-0.182***	-0.035
Level of estimation	Firm-bank	Firm-Bank	Firm-bank-month	Firm-bank-month
Firm controls	ILS	ILS	ILSY	ILSY
Bank fixed effects	No	No	Yes	Yes
Number of observations	33,630	26,017	48,491	59,609
R-square	0.044	0.045	0.628	0.614

Source: Bank of Slovenia, AJPES, own estimates.

Note: The table reports the estimated coefficients of the impact of TLTRO-I and II using the whole sample of firms. Loan demand and other firm characteristics are controlled for with industry-location-size (ILS) fixed effects in case of estimates for credit growth and with industry-location-size-year (ILSY) fixed effects for lending rates. Significance: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Standard errors are clustered at bank level.

6 Conclusion

The ECB introduced TLTRO policy as a strategic component to enhance the effectiveness of accommodative monetary policy, specifically through the bank lending channel. These operations, constituting a subset of non-standard monetary policy tools alongside asset purchases, negative rates, and forward guidance, have been implemented in three series (announced in 2014, 2016, and 2019). The latest iteration, TLTRO-III, was particularly extensive, designed as a response to the economic shocks induced by the global pandemic.

Across all TLTRO series, a common characteristic has been the provision of a low borrowing rate, thereby reducing the overall funding costs for participating banks. This cost reduction is subsequently transmitted to borrowers in the form of lower lending rates for both firms and households. Importantly, there is a positive externality for banks not directly engaged in the TLTRO program. As participant banks tend to delay or cancel bond issuance, the resulting decrease in bond supply leads to a reduction in external funding costs, even for non-participating banks.

This research focuses on assessing the impact of the first two TLTRO series, namely TLTRO-I and II, on bank lending to corporates. The investigation delves into how banks adjust both the quantity and price of credit in response to these targeted monetary policy interventions. To identify supply-side effects, the study examines how differently affected banks adjust their lending amounts and rates to the same firm. Recognizing the potential selection bias arising from voluntary bank participation in TLTRO auctions, an IV approach is adopted, leveraging the exogenous ECB allocation rule.

The empirical results underscore the supportive impact of targeted operations on bank loan supply, manifesting in increased credit growth and reduced interest rates. Specifically, TLTRO-I exhibits a supportive influence through both quantity and price channels, while TLTRO-II primarily impacts the quantity of credit.

The implications of these findings for policymakers are noteworthy, particularly in the realm of unconventional monetary policy measures. The study demonstrates that firms benefiting from TLTRO operations are predominantly stable and less risky, characteristics associated with long-term productivity. Moreover, the effects of TLTROs are more pronounced for loans with longer maturities, indicative of their utilization for financing investments that contribute to overall economic activity. The study also underscores the importance of a stable banking environment, as the transmission of monetary policy stimulus is more effective through better-capitalized banks. This effect

is particularly pronounced around the introduction of TLTRO-I when banks were in the process of fortifying their capital base. By the time of TLTRO-II, the increased capitalization of the Slovenian banking system played a diminished role in the propagation of targeted monetary policy.

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Appendix: First stage regressions

Table A: First stage regressions

	TLTRO-I	TLTRO-II
Borrowing allowance	0.751*	0.415
Capital adequacy ratio	0.016	0.128
NPL ratio	-0.007	0.261
ROA	0.072	2.298
Funding costs	1.210	17.132
ln(Total assets)	-0.000	-0.038
Credit growth	-0.005	0.002
Constant	-0.013	0.137
Number of observations	16	14
R-square	0.586	0.645

Source: Bank of Slovenia, AJ PES, own estimates.

Note: The table reports first stage regression coefficients, where the TLTRO amounts (in % of bank total assets) are explained with borrowing allowance (in % of bank total assets) and other bank characteristics. All the controls are measured one month before the initial take-ups within the TLTRO-I and II operations. Significance: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.