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Bank lending, liquidity regulation and unconventional monetary policies in the Eurozone

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ABSTRACT

We evaluate the joint impact of structural liquidity regulation and unconventional monetary policy on Eurozone banks' lending. Using an extensive bank-level quarterly dataset from 2008 to 2020, we study the introduction of the Net Stable Funding Ratio (NSFR) under Basel III and the European Central Bank's Longer-Term Refinancing Operations (LTROs) and Targeted LTROs (TLTROs). We find that while the NSFR had no effect on aggregate lending, it led to an increase in short-term lending and a reduction in long-term lending, consistent with lower maturity transformation. LTRO participation is associated with higher medium- and long-term lending, and our results indicate that this effect is conditional on banks' structural liquidity positions: banks with rising NSFRs were able to use LTRO and TLTRO funding to sustain long-term credit supply. These findings suggest that central bank liquidity interventions can mitigate the adjustment costs of tighter liquidity regulation during the transition period, enabling banks close to regulatory compliance to maintain longer-maturity lending.

1. Introduction

One of the main consequences of the 2008 Global Financial Crisis (GFC) on Eurozone banks was its long-lasting impact on the availability of credit to the real economy. Following a substantial decrease in 2008, the annual lending growth rate never returned to pre-crisis levels. The trend was compounded by the Sovereign Debt Crisis (2010-2013) and the Covid-19 pandemic (2020-2021), as illustrated in Fig. 1. The prolonged contraction in the money supply raised concerns among policy-makers. To address this issue, the European Central Bank (ECB) implemented several unconventional monetary policies, including the Longer-Term Refinancing Operations (LTROs) and the more recent Targeted Longer-Term Refinancing Operations (TLTROs), as part of its expansionary monetary policy stance. Unconventional monetary policies often entail generous liquidity support for banks and are thought to stimulate the lending supply via various channels. For example, they can reduce banks' cost of funding, thereby alleviating pressures on funding conditions, strengthening capitalisation, and boosting profitability (Dell'Arriccia et al., 2018; Albertazzi et al., 2021).

Eurozone banks also had to contend with widespread regulatory reforms. The 2010 Basel Accord (Basel III) significantly increased capital requirements and introduced new regulatory liquidity standards, the

Liquidity Coverage Ratio (LCR) and the Net Stable Funding Ratio (NSFR). These regulations are considered the most significant regulatory changes in the aftermath of the financial crisis and aim at increasing banks' resilience to shocks. Nevertheless, they also impose constraints on banks' activities, and their rapid implementation has highlighted the need for a sound understanding of their effects.

Liquidity requirements can have adverse effects on the real economy if banks satisfy such requirements at the expense of lending. As banks increase their holdings of liquid assets to comply with regulatory requirements, loans might be crowded out (Diamond and Kashyap, 2016). However, banks could comply by following different strategies: changing the composition of assets, raising capital, or altering the composition of liabilities. As such, it is unclear how liquidity regulation might affect loan supply, particularly in the longer term.

This paper contributes to the understanding of the implications of the Basel III liquidity requirements and the ECB's unconventional monetary policy on Eurozone bank lending, with particular attention to how these policies affect not only the overall volume of lending but also its maturity profile. Given the crucial role of the banking system in the transmission of monetary policy and its susceptibility to the introduction of liquidity regulation, it is important to examine the implications of these two concurrent sets of actions, including their interactions, on

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credit availability. While existing empirical research has investigated both policies separately, this study is the first, to our knowledge, to examine their joint effect. We extend our analysis from 2008Q1 (the beginning of the GFC in the Eurozone) to 2020Q1 (the last quarter before the outbreak of the Covid-19 pandemic) to allow banks to integrate the new regulations into their business decisions and balance sheet structures, enabling an evaluation of the policy from announcement to mandatory implementation.

The Eurozone provides an ideal laboratory to study the effect of unconventional monetary policies and regulatory changes on bank lending due to its unique structure: it is a monetary union with a common central bank, catering to economies whose banking sectors were exposed to the GFC and the Sovereign Debt Crisis to varying extents. Balance sheet data are from the SNL database (S&P Global - Market Intelligence); we collected data with quarterly frequency to capture intra-year variations in bank lending activity. Bank liquidity requirements are proxied by the estimation of the structural liquidity ratio introduced by Basel III, the NSFR. The NSFR was first introduced by a Basel Committee on Banking Supervision (BCBS) consultative document in 2009Q4 and became mandatory in 2021Q2. This regulatory liquidity ratio is explicitly designed to address structural funding risks and limit excessive maturity transformation. Our focus on the maturity structure of bank lending is a critical dimension of this study.

Our empirical strategy exploits the timing of the NSFR introduction and the heterogeneous exposure of Eurozone banks to the policy change. Although all banks were subject to the new regulation, they were impacted differently in terms of the balance sheet changes needed to address maturity mismatches. We capture this differential compliance constraints by calculating bank-level NSFR (based on the final revised 2014 BCBS document) for all banks in the sample from the beginning of the sample period (i.e. prior to the policy implementation) and capture the dynamic adjustments over the period.

Almost concurrently with the introduction of the NSFR, the ECB started its monetary easing: the first LTROs programme started in 2011 and ran for three years. It was followed by the TLTROs programme. We exploit the differences in banks' access to these refinancing operations, to disentangle the impact of unconventional monetary policies on bank lending of different maturities.

The identification of the impact of regulatory changes and unconventional monetary policy actions on bank lending is challenging, and endogeneity issues may arise. Three sources of endogeneity are potentially likely to bias our estimates: omitted variable bias, reverse causality, and self-selection. To address potential endogeneity issues caused by omitted variable bias, we use bank-level controls as well as bank, quarter and country fixed-effects that account for unobserved country-specific and business model-specific characteristics which may or may not remain constant over time and might be correlated with bank lending.

To alleviate concerns caused by the possibility of reverse causality - that is, bank lending strategies affecting the NSFR - we use a differences-

in-differences-in-differences (DDD) framework, conditional on capital (computed as equity to total assets, ETA). The argument is that, in reaction to Basel III, banks were increasing capitalisation levels at the same time as they were trying to become compliant with the new liquidity requirements, and an increase in equity mechanically increases the NSFR. In this context, we are interested in banks below the NSFR threshold that did not need to recapitalise. As an exogenous shock, we use the consultative document of the Basel III Accord published in December 2009, when the mechanism of the NSFR was spelt out for the first time. We consider a pre-shock period (2008Q1-2009Q4), that is, the period before the first consultative document on the new liquidity regulation, and post-shock period (2010Q1-2011Q3), to exclude the impact of the ECB unconventional monetary programmes.

Next, to account for possible self-selection issues deriving from the decision of banks to participate in the ECB liquidity programmes, we use a propensity score matching (PSM) model to match banks that participated in the LTRO and TLTRO programmes (treated group) to those that did not (control group) to isolate the impact of the participation in the ECB programmes on bank lending.

We find that the introduction of the NSFR had no effect on total lending. However, focusing on lending by maturity, we find a maturity swap effect that mainly took place via the substitution of long-term by short-term lending by the Eurozone banks. These results suggest that banks have decreased long-term illiquid assets, which is in line with the aim of the NSFR to reduce the maturity transformation risk but with potential consequences for corporate investment. Moreover, the expected mitigating effect of the ECB's interventions on credit supply appears to materialise. Our findings indicate that the unconventional liquidity measures were effective in halting the ongoing credit contraction, particularly through the LTROs, which led to an increase in medium- to long-term lending. We also find positive, though modest, effects from the TLTRO programme, but these are limited to total lending.

Focusing on the interaction between liquidity regulation and unconventional monetary policies, we find that the effects of LTROs and TLTROs vary with banks' liquidity characteristics. More specifically, banks that received liquidity through these unconventional facilities were able to increase their NSFR without reducing maturity transformation. This suggests that banks compliant with Basel III liquidity requirements used LTRO and TLTRO funding to support lending, rather than simply reducing balance sheet maturity mismatches. Unconventional monetary policy interventions helped ease banks' compliance constraints, enabling them to meet regulatory requirements without curtailing maturity transformation or restricting credit supply during the transition period.

The remainder of the paper is organised as follows. Section 2 provides background information, discusses the literature, and presents the testable hypotheses. Section 3 describes the empirical methodology, the sample and the variables used in the empirical analysis. Section 4 discusses the main results. The identification strategy is presented in

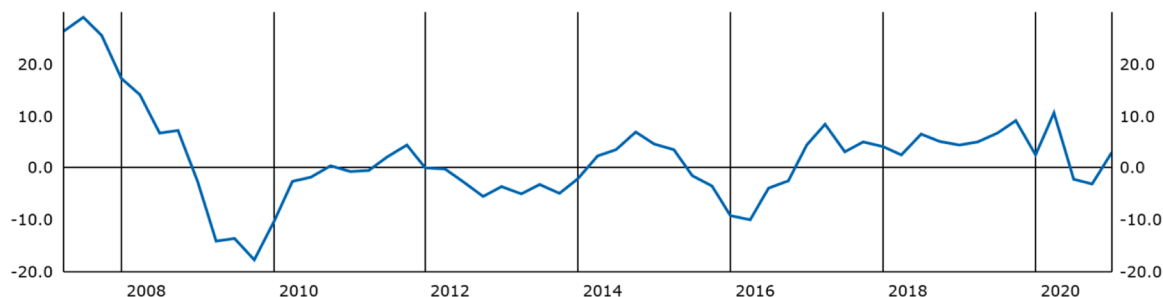


Fig. 1. Lending trend in the euro area.

The figure shows the annual growth rate of total bank loans (to unspecified counterpart sector) in the euro area. Source: Statistical Data Warehouse (<https://sdw.ecb.europa.eu>).

Section 5. Finally, Section 6 concludes and offers some policy implications.

2. Background, literature review and hypotheses development

2.1. Background

The Basel III framework introduced two complementary liquidity standards: the LCR and the NSFR. While the LCR aims to ensure that banks maintain sufficient high-quality liquid assets to survive a 30-day stress scenario, the NSFR targets a longer-term perspective by requiring banks to finance their activities with more stable sources of funding over a one-year horizon. As such, the LCR addresses short-term liquidity risks, whereas the NSFR seeks to promote a more resilient funding structure by limiting excessive reliance on short-term wholesale funding. These distinct objectives imply different adjustment strategies for banks and have different implications for lending behaviour. In addition, the NSFR directly targets banks' maturity transformation and long-term funding structures, making it particularly relevant for understanding the implications of liquidity regulation on credit supply.

The NSFR was first introduced by the BCBS in the consultative document of Basel III in December 2009 and was subsequently revised in the final Basel III document (BCBS, 2010) and the 2014 revision (BCBS, 2014). It became mandatory for Eurozone banks in June 2021, as illustrated in Fig. 2.

The NSFR is defined as the ratio of Available Stable Funding (ASF) to Required Stable Funding (RSF). For each bank, the ASF comprises weighted liabilities reflecting their contractual maturity and is defined as the portion of capital and liabilities expected to be a reliable source of funding over a one-year horizon. The RSF is a function of the liquidity characteristics and residual maturities of the various assets held by the institution. The ASF and RSF are calibrated to reflect the presumed degree of stability of a bank's liabilities and the liquidity of its assets. The introduction of the NSFR aimed to enhance financial stability by mitigating funding risks that could trigger distress at the individual bank level and pose systemic risks to the overall financial system.

Banks can implement different strategies to meet the NSFR requirements, which are likely to have different implications. For example, a bank could improve its NSFR by altering its balance sheet size or by modifying the composition of its assets or liabilities. While increasing liquidity resilience is generally considered beneficial, deleveraging or a shift towards less risky assets can have negative consequences for credit supply and the real economy. The multiple adjustment dimensions, combined with the scarcity of historical episodes evaluating the impact of structural liquidity regulation, have contributed to a wide range of views regarding the effects of Basel III liquidity standards on bank lending (Ananou et al., 2021; Crufman and Kandrak, 2022). In addition, the maturity structure of bank lending is a significant factor, with important implications for investment, financial stability, and monetary policy transmission. While a shift toward shorter-term lending may reduce maturity transformation and limit liquidity risk at the individual bank level, it can also constrain the supply of long-term credit to firms and households, thereby hindering capital formation and attenuating the effectiveness of policy interventions aimed at supporting long-term financing in the real economy.

2.2. Literature review and hypotheses development

Previous studies on the impact of liquidity regulation on bank lending have primarily focused on short-term liquidity requirements, such as the Dutch Liquidity Balance Rule (LBR) and the UK Individual Liquidity Guidance (ILG) regulation, implemented prior to Basel III. Some studies, including Bonner and Eijffinger (2016) and Banerjee and Mio (2018), found that the introduction of these short-term liquidity requirements did not have a significant effect on lending. However, Ananou et al. (2021) found that Dutch banks subject to the LBR

increased their lending compared to other Eurozone banks unaffected by the LBR. Curfman and Kandrak. (2022) focus on a de facto liquidity rule in the United States prior to the financial crisis. Their findings demonstrate that more stringent liquidity regulations have a negative impact on lending, especially on less liquid loan categories and align with the theoretical literature that suggests that banks tend to prioritise a more liquid asset composition in the presence of binding regulatory requirements (Diamond and Kashyap, 2016). The underlying rationale is that maintaining a higher proportion of liquid assets provides a cushion for banks during times of financial turbulence, contributing to overall financial stability but at the expense of lending. These findings are consistent with recent evidence on the impact of the LCR on bank lending. Roberts et al. (2023) show that U.S. banks subject to the LCR reduce lending and liquidity creation but become more resilient to liquidity shocks. Similarly, Sundaresan and Xiao (2024) show, both theoretically and empirically, that while quantity-based liquidity regulations lower banks' liquidity risks, they also crowd out bank lending and shift liquidity risks to institutions outside the regulatory perimeter. They find that banks more exposed to the LCR (measured by the gap between their pre-regulation liquidity levels and the mandated threshold) achieved greater liquidity improvements but suffered significantly lower lending growth.

Another strand of the literature involves simulations that suggest a significant negative impact of liquidity regulations on bank lending (Covas and Driscoll, 2014; De Nicolò et al., 2014; Papadamou et al., 2021). However, a weakness of this literature is that the findings are often driven by specific assumptions that may not accurately reflect the actual strategies pursued by banks in response to liquidity regulation.

While introduction of short-term liquidity requirements, including the LCR, has been extensively examined in the literature (Roberts et al., 2023; Sundaresan and Xiao, 2024), empirical research on structural liquidity requirements remains relatively limited.

We contribute to the growing empirical literature on liquidity requirements by providing new evidence on the impact of Basel III regulations on bank lending in the Eurozone. Specifically, we focus on the NSFR, which is designed to limit banks' maturity transformation over a longer horizon, and examine its effects on lending behaviour. Using a long sample period spanning both the pre-regulation and implementation phases of the NSFR, we track changes in banks' lending strategies over time. As a preliminary step, we assess the standalone effect of the NSFR by analysing not only total lending but also lending disaggregated by maturity. This benchmark allows us to establish whether the sensitivity of loan growth differs across maturities, with a more pronounced effect on long-term lending.

The identification of the impact of the NSFR on bank lending is potentially affected by the fact that, almost concurrently, the ECB began its monetary easing. The LTROs programme ran between 2011Q4 and 2015Q1, and the TLTROs programme ran between 2014Q3 and 2024Q4, including three different series of operations (TLTRO I: 2014Q3–2018Q3; TLTRO II: 2016Q2–2021Q1; and TLTRO III: 2019Q3–2024Q4), as illustrated in Fig. 2. The largest of these interventions were the three-year LTROs, which injected approximately one trillion euros into the Eurozone banking sector.¹ The main difference between LTROs and TLTROs is that the latter were specifically designed to support credit to the real economy, as the amount banks could borrow was linked to their lending to non-financial corporations and households.

The primary objective of the ECB's refinancing operations is to provide liquidity to banks in order to support credit supply to the real economy. Although progress has been made in understanding the relationship between central bank liquidity support and credit provision,

¹ The ECB publishes details of the operations, including the allotted amount, the duration, and the number of bidders for each operation (see https://www.ecb.europa.eu/mopo/implement/omo/html/top_history.en.html).

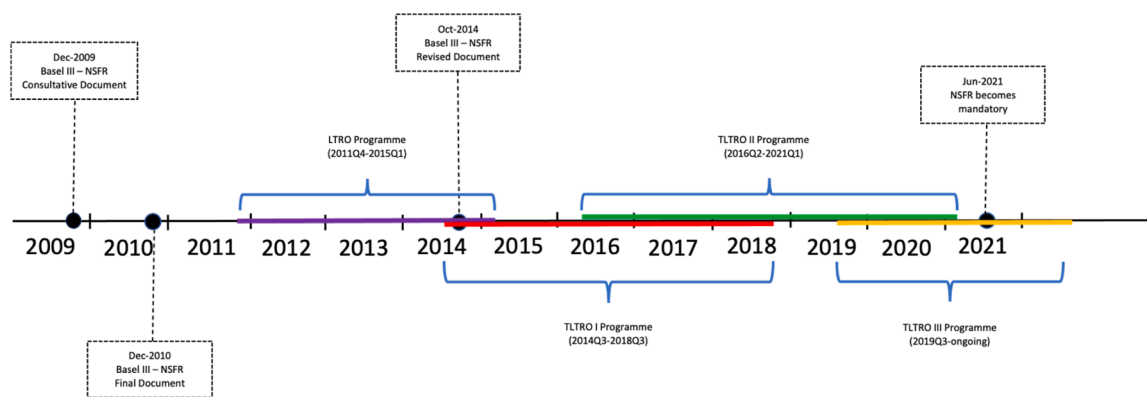


Fig. 2. Timeline of the implementation of the Basel III NSFR and ECB LTRO and TLTRO operations.

there remains limited evidence on how liquidity interventions should be optimally designed to enhance bank lending (Krishnamurthy et al., 2018; Carpinelli and Crosignani, 2021). A related stream of literature includes studies that consider the effects of government assistance on banks' activities. In this context, some studies suggest that the Troubled Assets Relief Program (TARP) in the U.S. increased lending (Li, 2013), particularly in the short term. Others argue that it may have also led to increased risk-taking by banks (Duchin and Sosyura, 2014). Berger et al. (2026) show that banks receiving TARP support disproportionately increased lending to riskier borrowers, consistent with greater moral hazard behaviour.

Existing empirical studies on the impact of the ECB's unconventional monetary policy operations also report mixed results. This stream of literature primarily focuses on banks' access to LTROs within individual European countries. García-Posada and Marchetti. (2016) and Andrade et al. (2019), focusing on the Spanish and French banking sectors, respectively, find that lending increases in response to the LTROs of 2011–2012. However, the effect is small in economic terms and relative to the amount of Spanish and French bank borrowing in the 3-year LTROs. Albertazzi et al. (2021), focusing on the Italian banking sector, do not find a significant effect on lending growth for the average bank-firm lending relationship. However, they find that the LTROs were more effective in improving lending supply to small-medium enterprises (compared to larger firms) for banks characterised by both a relatively large funding gap and a relatively favourable capitalisation. Crosignani et al. (2020) and Carpinelli and Crosignani (2021), focusing on Portuguese and Italian banking sectors, respectively, show that banks used some LTRO financing to buy domestic sovereign bonds. These results are supported by the work of Drechsler et al. (2016), Altavilla et al. (2017) and Von Ruden et al. (2023). Von Ruden et al. (2023) examine the effect of LTRO operations in the Eurozone and show a negative association with corporate investment. They find that riskier banks that received funds via the LTRO programme increased investments in sovereign bonds and decreased lending to corporates. Studies focussing on the effect of the more recent TLTROs on credit markets include Esposito et al. (2020) and Benetton and Fantino (2021). Using the Italian credit register data, they find positive effects on medium-long-term lending to firms and a decrease in interest rates, although these results depend on the firms' risk category and firms' size. These results are in line with Da Silva et al. (2021), who also find positive, albeit small, effects of the programmes on bank lending.

We contribute to this strand of the literature by examining the effects of both the LTRO and TLTRO programmes on Eurozone banks' lending. Our extended sample period allows us to account for changing macro-economic conditions across the Eurozone and to exploit cross-country differences in banks' participation in the various programmes. Furthermore, we analyse the impact of the ECB's unconventional monetary policies while explicitly accounting for the introduction of the NSFR, including the interaction between the two. In line with the extant

literature, we expect a positive impact of the ECB's refinancing operations on bank lending. In addition, we anticipate that access to central bank liquidity will mitigate the potentially negative effects of the NSFR on lending, with heterogeneous impacts across loans of different maturities.

Based on this discussion, we formulate the following testable hypotheses:

H1: The ECB's refinancing programmes (LTROs and TLTROs) have a positive impact on banks' lending activity.

H1a: The ECB's refinancing programmes (LTROs and TLTROs) mitigate the negative effect of the NSFR on bank lending, with heterogeneous impacts across loans of different maturities.

3. Data and empirical strategy

3.1. Data and main variables

We collect data from several datasets. At the bank-period (i, t) level, we collect balance sheet and financial statement data for banks headquartered in Eurozone countries from the SNL database (S&P Global – Market Intelligence). The calculation of the Basel III NSFR is data-demanding in terms of the granularity of the balance sheet items necessary for the calibration of the ratio, and data is only available at the highest level of consolidation. This significantly restricts the number of banks in our sample.² Our period-level (t) is quarters. The choice to use quarterly balance sheet data (rather than annual data) to measure the impact of the NSFR more accurately further contributed to restricting the number of banks for which data are available. For the purpose of our analysis, the NSFR is computed at the bank-quarter level following the regulatory guidelines in the October 2014 revision of the Basel III document. We summarise the definitions in Appendix 1 and Table A.2.

Fig. 3 shows the trend of the annual average of the NSFR for the full sample over the period 2008Q1–2021Q1 (the last quarter before it became mandatory). The average NSFR was below the threshold of 1 up to 2015; since then, most of the Eurozone banks have not only caught up with the Basel III liquidity ratio but substantially increased it. Note that while the Basel III requirements became binding in the Eurozone only in mid-2021, banks implemented them much earlier than expected due to increasing market pressure (Sugo and Vergote, 2020). The averages are, however, masking substantial differences in the liquidity position of our sample banks, as illustrated in Table A.3 in the Appendix. While the range decreases over time, and most banks reach the NSFR target of 1 or

² Several banks do not report to SNL (S&P Global – Market Intelligence) database with the required level of detail, simply because these measures were not mandatory before the new regulation proposed by the BCBS (2010). Missing values in the relevant accounting variables are present for banks in all categories, size, specialisation, ownership, etc.

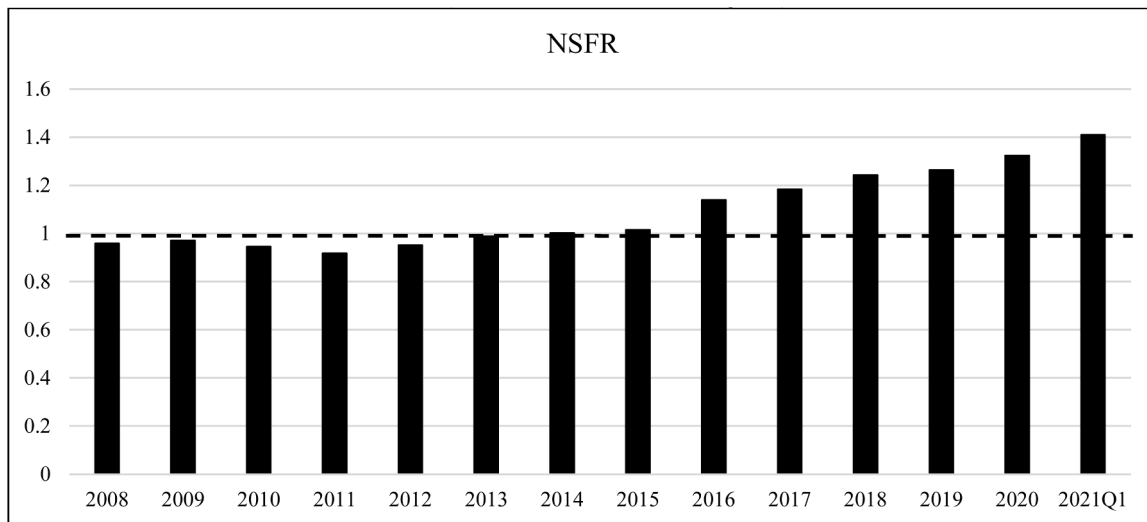


Fig. 3. Trend of the Net Stable Funding Ratio.

The figure shows the annual average values of the NSFR for our sample banks of 12 Eurozone countries over the period 2008Q1–2021Q1. To mitigate the effect of outliers, we winsorize observations in the outside 1% of each tail. The dotted line indicates the minimum threshold of the NSFR (equal to 1) required by Basel III and entered into force in mid-2021. Source: SNL (S&P Global – Market Intelligence) database, authors’ calculations.

above, the cost of the transition period, in terms of the balance sheet changes required, varies both across banks and within countries.

Second, we collect information about the ECB’s unconventional liquidity injections (LTROs as well as TLTROs programmes) at the bank-period (i,t) level from Bloomberg. This is not mandatory information, and banks do not have to disclose access to the ECB programmes. Nevertheless, many banks report this information and all those banks that report it are included in our sample.³

After matching the datasets, the final sample is composed of 153 banks from 12 Eurozone countries: Austria, Belgium, Cyprus, France, Germany, Greece, Ireland, Italy, Netherlands, Portugal, Slovenia, and Spain (see Table A.4). Despite the restrictions on data availability, our sample represents 87 percent of the total banking sector in terms of total assets, 78 percent in terms of LTRO uptake, and 70 percent in TLTRO uptake (in millions of euros).

followed by German banks. Our sample banks obtained 791,116 million euros under the LTRO programmes and 1,706 billion euros under all TLTRO programmes (up to 2021Q1), of which more than half of the latter (56 percent) is attributable to the amount introduced in the banking system through TLTRO III (960 million euros in March 2021), a programme that was adopted immediately before the Covid-19 crisis and that continued during all the pandemic period (see Table A.4).

3.2. Empirical strategy

To investigate the impact of the Basel III structural liquidity ratio (NSFR) as well as of the ECB’s unconventional monetary policies (LTROs and TLTROs) on Eurozone banks’ lending, we conduct the main analysis on our sample of 153 Eurozone banks and estimate the following specification:

$$LOANS\ GROWTH\ RATE_{i,t} = \beta_1(BASEL\ III\ STRUCTURAL\ LIQUIDITY\ RATIO)_{i,t-1} + \beta_2(ECB\ UNCONVENTIONAL\ LIQUIDITY\ INJECTIONS)_{i,t} + \beta_3(CONTROL\ VARIABLES)_{i,t-1} + \delta_i + \delta_t + \delta_c + \varepsilon_{i,t} \quad (1)$$

The number of banks in the sample is representative of the size and structure of each country’s banking sector. Indeed, German, Italian, and Spanish banks constitute the majority of banks in our sample. We also notice heterogeneity in banks’ participation in the ECB programmes, both among countries and within countries: overall, 45 percent of banks in our sample participate in the LTRO programme, decreasing to only 17 percent of banks participating in the TLTRO III programme. The literature has documented that the first LTRO operation was the most effective in terms of access to the programme (Carpinelli and Crosignani, 2021). Italian banks used the facilities the most, with 41 percent of banks in our sample accessing the LTRO programme and then progressively decreasing in participation, with only 27 percent of banks applying to the TLTRO III programme. French banks make the least use of the liquidity programmes,

where i refers to the bank, t indicates the quarter, c refers to the country, δ_i is bank fixed-effects (FE), δ_t is quarter FE and δ_c is country FE. $\varepsilon_{i,t}$ is the two-way standard errors clustered by bank and quarter.

Our dependent variable is the loans’ growth rate ($LOANS\ GROWTH\ RATE_{i,t}$). We compute the growth rate of loans to customers as the natural logarithm of total gross loans at time t over $t-1$ (the previous quarter). We consider loans at the aggregate level (LOG_GL total) and by the following maturities: *i*) short term: less than 3 months (LOG_GL < 3 months); *ii*) medium term: between 3 and 12 months (LOG_GL 3-12 months); between 1 and 5 years (LOG_GL 1-5 years); and *iii*) long term: greater than 5 years (LOG_GL > 5 years). It is important to note that lending is reported by contractual (nominal) maturity buckets, rather than by effective or behavioural maturity. In practice, borrowers may replicate longer-term financing needs through sequences of shorter-term loans or rollover arrangements, implying that nominal and effective maturities may diverge. Our analysis captures changes in the contractual maturity structure of bank lending, rather than the ultimate duration of

³ Bloomberg does not report any data on LTROs and TLTROs programmes for our sample banks headquartered in Malta, Luxembourg, and Slovakia (6 banks in total). For this reason, they were not included in our final sample.

borrowers' financing relationships.

Our target variables are the NSFR (*BASEL III STRUCTURAL LIQUIDITY RATIO*_{*i,t-1*}) and the ECB's unconventional refinancing operations LTROs and TLTROs (*ECB UNCONVENTIONAL LIQUIDITY INJECTIONS*_{*i,t*}). The NSFR is calculated for each bank in each quarter (as discussed in Appendix 1 and Table A.2 in the Appendix).

We construct two dummy variables to capture banks' participation in the ECB's liquidity programmes: D_LTROs and D_TLTROs, each introduced separately in the empirical model.⁴ D_LTROs equals 1 from the quarter in which a bank accesses liquidity through the LTROs programme until the end of the period considered, and 0 otherwise. The corresponding analysis is conducted over the period 2008Q1–2015Q1 (i.e., the maturity date of the LTROs programme), coinciding with the years during which the credit crisis impacted European banks.

Similarly, D_TLTROs equals 1 from the quarter in which a bank accesses liquidity through the TLTROs programme until the end of the sample period, for banks that had not previously received liquidity through the LTROs programme, and 0 otherwise.⁵ In this case, we focus on the period 2008Q1–2020Q1 (i.e., the last quarter before the outbreak of the Covid-19 pandemic).

The extended period allows for a policy evaluation that captures the integration of the NSFR into banks' strategic decision-making, rather than focusing solely on their initial reactions to the new regulation. We exclude the Covid-19 period to avoid unintended effects from liquidity injections linked to emergency health policies, which are outside the scope of this analysis.

A decline in lending activity may reflect not only a reduction in credit supply by banks, but also weaker credit demand from firms and households. To account for time-varying demand-side factors that affect all banks simultaneously, we include quarter fixed effects in all specifications.

To control for bank-specific credit supply factors, we include a set of time-varying accounting variables commonly used in the literature. These capture key dimensions of banks' balance sheet conditions that influence lending behaviour: size (log of total assets, SIZE), capitalisation (equity-to-assets, ETA), profitability (return on average assets, ROAA)⁶, cost efficiency (cost-to-income ratio, CIR), and asset quality (non-performing loans to gross loans, NPL_GL). These variables proxy banks' capacity and willingness to lend and help isolate the effect of regulatory and policy interventions from underlying supply-side constraints.

All the explanatory variables, except for the ECB's unconventional liquidity injections variables (D_LTROs and D_TLTROs), are lagged by one quarter to address potential endogeneity problems. Table A.1 in the Appendix provides brief definitions of all variables.

Table 1 reports the descriptive statistics relating to the control variables over the period 2008Q1–2021Q1. The data underlines that, on average, banks have a capitalisation (ETA) of 6.6 percent. However, looking at the minimum and the maximum values, there are some banks with a very high capitalisation ratio (26.1 percent) and banks with a very low capitalisation ratio (0.4 percent). In terms of profitability (ROAA), although the sample average is positive, there are some banks that show a negative return on average assets. On average, banks show good cost efficiency, with a cost-to-income ratio lower than 70 percent.

⁴ Although each ECB's unconventional programmes include several series of operations and auctions (2 for LTROs, 8 for TLTRO I, 4 for TLTRO II, and 10 for TLTRO III), we focus on each programme at the aggregate level (LTROs and TLTROs) and not on the impact of each single operation and auction. Details on the various auctions are available on the ECB website at https://www.ecb.europa.eu/mopo/implement/omo/html/top_history.en.html.

⁵ The number of banks in our sample that participated in the TLTROs programme but not in the previous LTROs programme is 40.

⁶ As a robustness test, we also use the Return on Average Equity (ROAE) and obtain very similar results (not reported, but available upon request).

Table 1

Summary statistics.

This table reports summary statistics of the dependent and independent variables for our sample banks of 12 Eurozone countries over the period 2008Q1–2021Q1. See Table A.1 in the Appendix for the description of these variables. All covariates based on accounting data are winsorised at the 1 per cent of each tail.

<i>Dependent variables</i>	Mean	Std. Dev.	Min. – Max.
LOG_GL total	0.004	0.188	-5.231 – 4.935
LOG_GL <3months	-0.007	0.176	-0.977 – 0.816
LOG_GL 3-12months	0.0008	0.131	-0.790 – 0.638
LOG_GL 1-5years	0.007	0.101	-0.713 – 0.612
LOG_GL >5years	0.007	0.078	-0.331 – 0.541
<i>Target variables</i>	Mean	Std. Dev.	Min. – Max.
NSFR	1.033	0.410	0.203 – 4.269
D_LTROs	0.234	0.423	0 – 1
D_TLTROs	0.178	0.383	0 – 1
<i>Control variables</i>	Mean	Std. Dev.	Min. – Max.
SIZE	17.487	1.613	13.187 – 21.454
ETA	0.066	0.032	0.004 – 0.261
ROAA	0.0003	0.012	-0.068 – 0.031
CIR	0.673	0.250	0.156 – 2.469
NPL_GL	0.042	0.049	-0.071 – 0.285

However, the CIR spans from 15.6 per cent to 246.9 percent, underling a wide variation. The quality of the credit portfolio, on average, shows a low level of non-performing loans (4.2 percent of NPL_GL), although there are some banks with a high level of problem loans in their balance sheet (28.5 percent of NPL_GL). This suggests that, although during the period observed, banks improved their credit portfolio quality, some banks continued to have high levels of NPLs.

4. Main results

4.1. Baseline regression

Table 2 presents the results of the baseline panel regressions for loans at both the aggregate level and disaggregated by maturity. For clarity of exposition, we estimate Eq. (1) using alternative proxies for unconventional monetary policies: Table 2, Panel A, reports results using the dummy variable D_LTROs over the period 2008Q1–2015Q1 (i.e., the maturity date of the LTROs programme), while Table 2, Panel B, reports results using the dummy variable D_TLTROs over the period 2008Q1–2020Q1 (i.e., the last quarter before the outbreak of the Covid-19 pandemic) for those sample of banks that never participated in the LTRO programme. All regressions include Bank, Quarter, and Country fixed effects.

The results in Table 2, Panel A, show that the NSFR is not significant for total lending (LOG_GL total). These findings suggest that overall lending does not appear to have been affected by the introduction of the NSFR. However, when focusing on lending by maturity, we find evidence of a maturity swap effect, mainly through the substitution of long-term with short-term lending by Eurozone banks. This result is consistent with one of the aims of the NSFR, namely, to incentivise banks to reduce their maturity mismatch. More specifically, the coefficient of the NSFR is positive and significant for short-term lending (LOG_GL<3months), but negative and significant for long-term lending (loans with maturities greater than five years). This indicates that while banks did not reduce overall lending to comply with Basel III liquidity requirements, they shifted the composition of their loan portfolios away from longer-term exposures, which are more penalising under the NSFR. This shift is economically meaningful: a 1 percent increase in the NSFR is associated with a 2.1 percent increase in short-term lending and a 1.2 percent decrease in long-term lending, with potential implications for household and corporate access to longer-term credit.

Regarding the ECB's unconventional liquidity injections, we find

Table 2

Baseline model: NSFR, LTROs and TLTROs programmes.

This table presents the results of the baseline panel regressions using alternative proxies for unconventional monetary policies: Panel A reports results using the dummy variable D_LTROs over the period 2008Q1–2015Q1 (i.e., the maturity date of the LTROs programme), while Panel B reports results using the dummy variable D_TLTROs over the period 2008Q1–2020Q1 (i.e., the last quarter before the outbreak of the Covid-19 pandemic) for those sample of banks that never participated in the LTRO programme.

The dependent variable is loans to customers, measured as the natural logarithm of the quarterly average growth rate of gross loans, considered both at the aggregate level (LOG_GL_total) and disaggregated by the following maturities: less than 3 months (LOG_GL<3months); between 3 and 12 months (LOG_GL3-12months); between 1 and 5 years (LOG_GL1-5years); and greater than 5 years (LOG_GL>5years).

Our target variables are the Basel III structural liquidity ratio (the NSFR), the dummy variables D_LTROs (equal to 1 from the quarter in which the bank takes liquidity through the LTROs programme, and 0 before) and D_TLTROs (equal to 1 from the quarter in which the bank takes liquidity through the TLTROs programme until the end of the sample period considered and that don't have received liquidity through the previous LTROs programme, and 0 before). As controls, we include variables based on accounting data (SIZE, ETA, ROAA, CIR, and NPL_GL); see Table A.1 in the Appendix for a full description of the variables. All explanatory variables based on accounting data are lagged by one quarter, except for D_LTROs and D_TLTROs. All covariates based on accounting data are winsorised at the 1st and 99th percentiles. Bank fixed effects (FE), Quarter FE, and Country FE are included in all models. Two-way clustered standard errors (at the bank and quarter level) are reported in parentheses. The superscripts ***, **, and * denote coefficients statistically different from zero at the 1%, 5%, and 10% levels, respectively, in two-tailed tests.

Panel A – NSFR and LTROs programme					
Variables	Total loans		Lending by maturity		
	LOG_GL_total	LOG_GL<3months	LOG_GL3-12months	LOG_GL1-5years	LOG_GL>5years
NSFR (-1)	0.002 (0.013)	0.021*** (0.006)	-0.011 (0.014)	-0.017* (0.010)	-0.012** (0.005)
D_LTROs	0.000 (0.016)	-0.001 (0.023)	0.010 (0.009)	0.017*** (0.006)	0.012** (0.005)
SIZE (-1)	-0.045 (0.042)	0.008 (0.024)	-0.018 (0.019)	-0.032 (0.024)	-0.039 (0.025)
ETA (-1)	0.180 (0.377)	-0.263 (0.335)	0.005 (0.329)	-0.158 (0.338)	0.150 (0.093)
ROAA (-1)	1.040 (1.163)	1.528** (0.692)	0.258 (0.585)	0.326 (0.445)	0.144 (0.444)
CIR (-1)	0.028 (0.047)	0.045 (0.037)	-0.001 (0.025)	-0.000 (0.019)	-0.001 (0.020)
NPL_GL (-1)	-0.044 (0.116)	-0.162 (0.175)	0.004 (0.058)	-0.005 (0.078)	-0.083 (0.076)
Bank FE	Yes	Yes	Yes	Yes	Yes
Quarter FE	Yes	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes	Yes
N. of obs.	2,660	2,585	2,528	2,558	2,553
R-squared	0.059	0.068	0.074	0.164	0.195
Panel B – NSFR and TLTROs programme					
Variables	Total loans		Lending by maturity		
	LOG_GL_total	LOG_GL1-3months	LOG_GL3-12months	LOG_GL1-5years	LOG_GL>5years
NSFR (-1)	0.009 (0.014)	0.033** (0.013)	0.002 (0.005)	0.001 (0.016)	-0.013* (0.008)
D_TLTROs	0.062* (0.033)	-0.001 (0.021)	-0.003 (0.020)	-0.008 (0.013)	0.013 (0.019)
SIZE (-1)	-0.001 (0.005)	0.003 (0.006)	0.007 (0.005)	-0.000 (0.005)	-0.005 (0.003)
ETA (-1)	0.207 (0.316)	-0.034 (0.228)	-0.049 (0.196)	-0.230 (0.258)	0.106 (0.133)
ROAA (-1)	0.243 (0.683)	0.944 (0.769)	-0.076 (0.532)	0.012 (0.526)	-0.259 (0.513)
CIR (-1)	0.004 (0.038)	0.038 (0.031)	-0.024 (0.019)	-0.024 (0.026)	-0.019 (0.023)
NPL_GL (-1)	-0.001 (0.095)	-0.169 (0.154)	0.091 (0.068)	0.033 (0.085)	-0.021 (0.052)
Bank FE	Yes	Yes	Yes	Yes	Yes
Quarter FE	Yes	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes	Yes
N. of obs.	2,707	2,690	2,656	2,629	2,627
R-squared	0.053	0.078	0.080	0.158	0.198

that the LTROs programme is positively associated with lending. Specifically, when significant, the dummy variable D_LTROs shows a positive relationship with bank lending, particularly at medium and long maturities. This result aligns with the findings of [Esposito et al. \(2020\)](#), [Benetton and Fantino \(2021\)](#), and [Da Silva et al. \(2021\)](#), who report positive effects of the ECB's interventions on banks' medium- and

long-term lending. Finally, among the control variables, ROAA is positive and significant, suggesting that more profitable banks lent more during the period observed.

Table 2, Panel B, presents the estimation results using the TLTROs programme. The maturity swap effect identified in Table 2, Panel A, is confirmed, and the magnitude of the coefficients is even stronger: a 1

percent increase in the NSFR is associated with a 3.3 percent increase in short-term lending and a 1.3 percent decrease in long-term lending. However, the impact of the ECB's liquidity injections differs from that observed for the LTROs. The coefficient on the dummy variable D_TLTROs is statistically significant only when the dependent variable is total lending (LOG_GL_total), and the relationship is weakly positive. A possible explanation for this limited effect is that banks may have used part of the TLTRO funds to repay liquidity obtained through earlier tranches, rather than expanding their lending activity.⁷ This behaviour may have diluted the intended stimulus effect of the TLTRO programme on bank credit supply.

4.2. The interaction between the NSFR and unconventional monetary policies

To investigate whether the potential effect of the ECB's unconventional liquidity programmes on bank lending is influenced by a bank's liquidity needs, we run a regression model that includes the interaction between NSFR and the dummy variables for the ECB programmes.

Our findings, reported in Table 3, present the coefficients of the interaction between NSFR and LTROs (Panel A) and between NSFR and TLTROs (Panel B). The NSFR variable remains negative and significant for long-term lending, consistent with our baseline results. In Panel A, the LTRO dummy, on its own, is statistically insignificant, suggesting that the programme did not exert a uniform effect on lending. However, the interaction $NSFR(-1)\#D_LTROs$ is positive and significant for loans over 5 years, indicating that LTRO funding helped sustain lending at the longest maturities. This suggests that the marginal effect of LTRO funding is conditional on the borrowing bank's liquidity position: the programme appears to alleviate the maturity-constraining effects of a high NSFR. In particular, for banks facing binding NSFR requirements, access to LTRO funding may have eased structural funding constraints, allowing them to extend longer-term credit. These results suggest that central bank liquidity support can offset some of the tightening in lending maturities associated with structural liquidity regulation, at least for a subset of banks.

In Panel B, the TLTRO dummy is insignificant, suggesting that the programme has no unconditional effect on lending across maturities. The interaction term $NSFR(-1)\#D_TLTROs$ is significant only for loans with maturities of 1–5 years, suggesting that TLTRO funding may have partially offset the tightening effect of structural liquidity regulation on medium-term credit supply, although this effect does not appear to extend to the longer end of the maturity spectrum.

Taken together, these results show that once the interaction terms are included, the standalone LTRO dummy becomes insignificant, while the interaction terms become positive and significant. This indicates that LTRO and TLTRO funding do not exert an independent positive effect on lending but instead mitigate the NSFR's constraining impact on banks' maturity structures. Their effect, therefore, appears to operate through their interaction with the NSFR: banks with rising NSFR values, being potentially on track to comply with Basel III rules, face fewer constraints and can use LTRO/TLTRO liquidity to support lending. This interpretation aligns with the findings of Papadamou et al. (2021) and may reflect the design and timing of the two programmes: LTROs, introduced during a period of acute market stress, provided longer-term funding to support lending, whereas TLTROs, introduced later with more targeted conditions linked to new lending, were more likely to support medium-term (1–5 years) credit exposures.

To further assess the robustness of our findings, we conduct two additional tests: (i) we account for banks' initial liquidity positions relative to pre-Basel III levels; and (ii) we replace programme dummies

with continuous measures of ECB liquidity uptake. The results of these regressions are reported in Tables A.5 and A.6, in Appendix 2. Overall, the estimates remain consistent with our baseline findings.

5. Identification strategy

The identification of the causal effects of regulatory reforms and unconventional monetary policy interventions on bank lending poses significant empirical challenges due to potential endogeneity. To mitigate these concerns, we implement a combination of empirical techniques. To address reverse causality, namely, that bank lending strategies may influence the NSFR, we implement a (DDD) framework, conditional on capitalisation (measured as equity-to-assets). To disentangle the effects of the different TLTRO stages (I, II, III), we implement a staggered Difference-in-Differences (S_DD) approach following Callaway and Sant'Anna (2021). To address self-selection into the ECB's liquidity programmes, we employ a PSM approach. The following subsections describe each component of our identification strategy in detail.

5.1. Difference-in-difference-in-difference analysis (DDD)

To alleviate the concern of reverse causality, that bank lending could affect the NSFR, we employ DDD regressions conditional on capital (computed as equity to total assets, ETA). The DDD is run on the sub-period from 2008Q1 to 2011Q3 (the last quarter before the beginning of the ECB's unconventional liquidity injections).⁸ We distinguish between the pre-shock period (2008Q1-2009Q4) and the post-shock period (2010Q1-2011Q3).

The argument is that banks were increasing capitalisation levels at the same time, and an increase in equity mechanically increases the NSFR. In this part of the analysis, we are interested in banks below the NSFR threshold (this is our dummy treated, $D_TREATED$) that did not need to re-capitalise (this is our dummy capital, $D_CAPITAL$). More specifically, $D_TREATED$ takes the value of 1 for banks with NSFR less than the median of NSFR in the quarter of the shock and 0 otherwise, while $D_CAPITAL$ takes the value of 1 for banks with ETA equal to or above the median of ETA in the quarter of the shock, and 0 otherwise. As exogenous shock (D_SHOCK), we use the consultative document of the Basel III Accord published in December 2009, when, for the first time, the mechanism of the NSFR was spelt out. Thus, our target variables in this model are D_SHOCK , its interaction with $D_TREATED$ and $D_CAPITAL$, respectively, and the interaction between these three variables.

Fig. 4 (Panel A) plots the evolution of long-term lending (loans with maturities over five years) for treated and control banks before and after the publication of the Basel III consultative document in 2009Q4. In the pre-treatment period (prior to 2009Q4), the treated and control groups exhibit broadly similar trends in the natural logarithm of long-term lending, despite being at different levels. This visual evidence supports the parallel trends assumption, suggesting that in the absence of the shock, the two groups would have followed comparable trajectories. Following the shock, lending behaviour diverges, with the treated group displaying greater volatility. Fig. 4 (Panel B) presents the estimated quarterly differences in long-term lending between treated and control banks, with 95 percent confidence intervals. In the pre-treatment period, the differences are small and statistically indistinguishable from zero. By satisfying the parallel trends assumption, the observed post-shock divergence in lending behaviour can be more plausibly attributed to the regulatory announcement, rather than to pre-existing differences between the two groups.

The results for the triple interaction ($D_TREATED\#D_CAPITAL\#D_SHOCK$) are reported in Table 4 and are consistent with our main

⁷ Banks participating in the TLTRO III had the option to repay TLTROs early (a total of EUR 5048.86 million was repaid early). See: <https://www.ecb.europa.eu/mopo/implement/omo/html/communication.en.html>

⁸ We decided to stop the period of the DDD estimation in 2011Q3 (i.e. the last quarter before the beginning of the LTROs programme) to avoid the impact of the ECB's unconventional liquidity injections in this specification.

Table 3

Interaction between the NSFR and the ECB's unconventional liquidity programmes.

This table presents the results of our baseline model, run on the full sample of banks (from 12 Eurozone countries), including the interactions between our target variables (the NSFR and the liquidity injection dummy variables D_LTROs and D_TLTROs, respectively). The dependent variable is loans to customers, measured as the natural logarithm of the quarterly average growth rate of gross loans, considered both at the aggregate level (LOG_GL_total) and disaggregated by the following maturities: less than 3 months (LOG_GL<3months); between 3 and 12 months (LOG_GL3-12months); between 1 and 5 years (LOG_GL1-5years); and greater than 5 years (LOG_GL>5years). Our target variables are the Basel III structural liquidity ratio (the NSFR), the ECB's unconventional liquidity injection dummy variables (D_LTROs and D_TLTROs), and their interactions. In Panel A, we use the dummy variable D_LTROs (equal to 1 from the quarter in which the bank takes liquidity through the LTROs programme until the end of the period considered, and 0 before) and focus on the period 2008Q1–2015Q1 (i.e., the maturity date of the LTROs programme). In Panel B, we focus on banks that have not received liquidity through the previous LTROs programme and use the dummy variable D_TLTROs (equal to 1 from the quarter in which the bank takes liquidity through the TLTROs programme until the end of the sample period, and 0 before), over the period 2008Q1–2020Q1 (i.e., the last quarter before the outbreak of the Covid-19 pandemic). As controls, we include variables based on accounting data (SIZE, ETA, ROAA, CIR, and NPL_GL); see Table A.1 in the Appendix for a full description of the variables. All explanatory variables based on accounting data are lagged by one quarter, except for D_LTROs and D_TLTROs. All covariates based on accounting data are winsorised at the 1st and 99th percentiles. Bank fixed effects (FE), Quarter FE, and Country FE are included in all models. Two-way clustered standard errors (at the bank and quarter level) are reported in parentheses. The superscripts ***, **, and * denote coefficients statistically different from zero at the 1%, 5%, and 10% levels, respectively, in two-tailed tests.

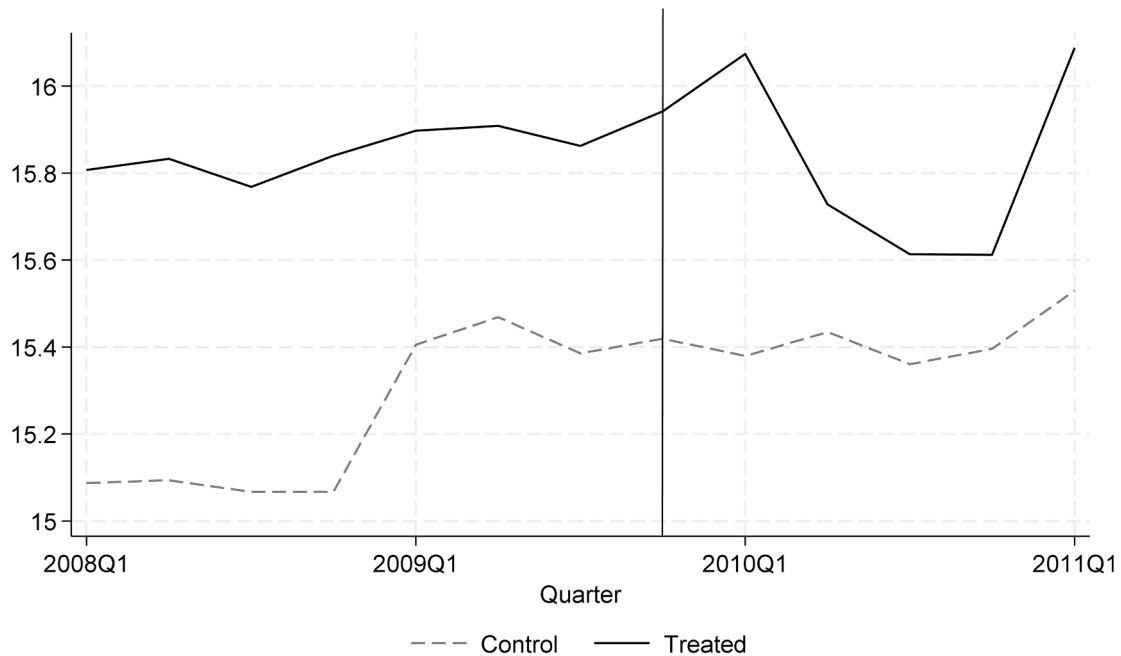
Panel A – NSFR, the dummy variable LTROs, and their interaction					
Variables	Total loans		Lending by maturity		
	LOG_GL_total	LOG_GL<3months	LOG_GL3-12months	LOG_GL1-5years	LOG_GL>5years
NSFR (-1)	0.000 (0.017)	0.017 (0.011)	-0.012 (0.008)	-0.018* (0.010)	-0.016** (0.008)
D_LTROs	-0.002 (0.013)	-0.010 (0.025)	0.007 (0.021)	0.015 (0.014)	0.003 (0.007)
NSFR(-1)#D_LTROs	0.003 (0.013)	0.010 (0.017)	0.003 (0.017)	0.002 (0.012)	0.010** (0.004)
SIZE (-1)	-0.045 (0.042)	0.007 (0.023)	-0.018 (0.019)	-0.033 (0.024)	-0.039 (0.025)
ETA (-1)	0.181 (0.377)	-0.259 (0.335)	0.006 (0.329)	-0.157 (0.338)	0.152* (0.089)
ROAA (-1)	1.038 (1.164)	1.524** (0.690)	0.257 (0.586)	0.325 (0.443)	0.139 (0.443)
CIR (-1)	0.028 (0.047)	0.045 (0.037)	-0.001 (0.025)	-0.000 (0.019)	-0.001 (0.020)
NPL_GL (-1)	-0.044 (0.115)	-0.160 (0.176)	0.005 (0.058)	-0.004 (0.077)	-0.082 (0.074)
Bank FE	Yes	Yes	Yes	Yes	Yes
Quarter FE	Yes	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes	Yes
N. of obs.	2,660	2,585	2,528	2,558	2,553
R-squared	0.059	0.068	0.074	0.164	0.195

Panel B – NSFR, the dummy variable TLTROs, and their interaction					
Variables	Total loans		Lending by maturity		
	LOG_GL_total	LOG_GL<3months	LOG_GL3-12months	LOG_GL1-5years	LOG_GL>5years
NSFR (-1)	0.008 (0.016)	0.033* (0.017)	-0.000 (0.001)	-0.004 (0.016)	-0.014* (0.008)
D_TLTROs	0.055 (0.039)	0.002 (0.041)	-0.015 (0.013)	-0.036 (0.023)	0.011 (0.019)
NSFR(-1)#D_TLTROs	0.008 (0.019)	-0.003 (0.036)	0.013 (0.008)	0.026* (0.015)	0.002 (0.008)
SIZE (-1)	-0.001 (0.005)	0.003 (0.006)	0.007 (0.005)	-0.000 (0.005)	-0.005 (0.003)
ETA (-1)	0.210 (0.314)	-0.035 (0.228)	-0.045 (0.193)	-0.234 (0.257)	0.106 (0.133)
ROAA (-1)	0.241 (0.682)	0.945 (0.772)	-0.079 (0.532)	-0.008 (0.525)	-0.261 (0.514)
CIR (-1)	0.004 (0.038)	0.038 (0.031)	-0.024 (0.019)	-0.024 (0.026)	-0.019 (0.023)
NPL_GL (-1)	-0.004 (0.095)	-0.169 (0.155)	0.087 (0.069)	0.024 (0.085)	-0.022 (0.052)
Bank FE	Yes	Yes	Yes	Yes	Yes
Quarter FE	Yes	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes	Yes
N. of obs.	2,707	2,690	2,656	2,629	2,627
R-squared	0.053	0.078	0.080	0.158	0.198

findings in Table 2. As we use a DDD approach, we verify the parallel trends assumption. Fig. 4 shows the parallel trend of quarterly gross loans to customers with a maturity of more than 5 years (GL > 5 years) - the loan maturity for which the triple interaction is significant - over the period 2008Q1–2011Q3 for both treated and control groups. The treated group consists of banks with an NSFR below the median and an ETA at or

above the median in the quarter of the shock, while the control group consists of banks with an NSFR at or above the median and an ETA at or above the median. Fig. 4 shows that, before the shock (i.e. the publication of the Basel III consultative document in 2009), changes in bank lending were similar for the two groups, whereas afterwards, control group banks increased their lending more than treated banks.

Panel A – Parallel trends of long-term lending



Panel B – Differences in long-term lending between the treated and control groups

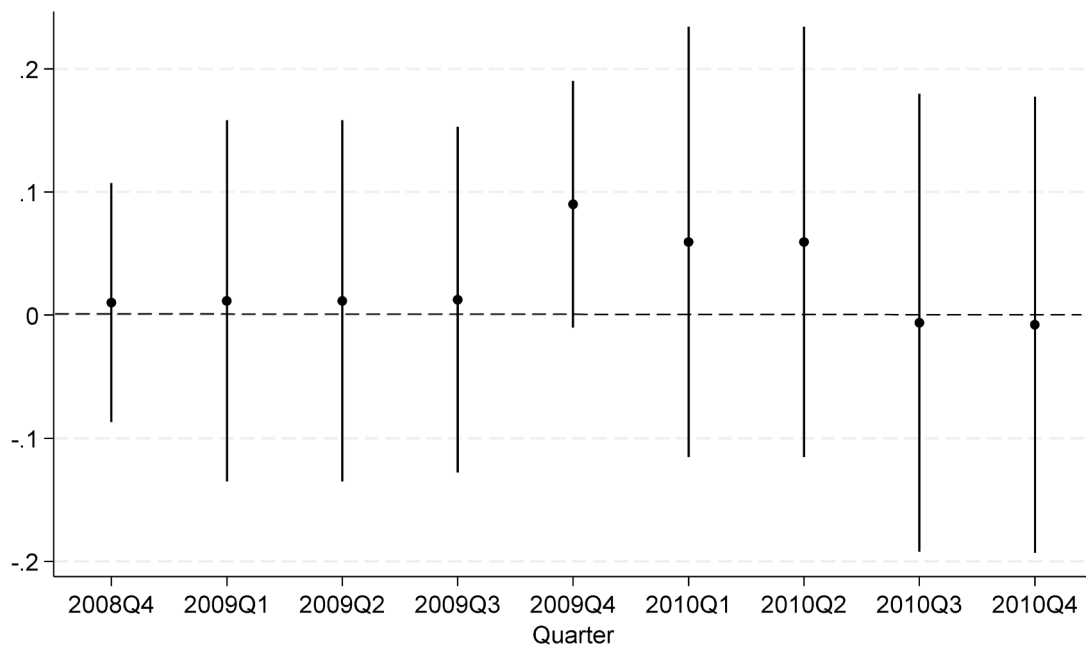


Fig. 4. Evolution of long-term lending for treated and control banks before and after the publication of the Basel III consultative document in 2009Q4. Panel A of this figure illustrates the behaviour of the natural logarithm of the quarterly loans to customers with a maturity of more than 5 years ($GL > 5$ years) before and after the shock or treatment (i.e. the publication of the consultative document of Basel III in December 2009) for both the treated and the control groups. The treated (control) group is relative to those banks with both a NSFR less than (equals to or above than) the median of NSFR in the quarter of the shock and an equity to total assets (ETA) equals to or above the median of ETA in the quarter of the shock. This classification allows us to isolate the behavioural response of banks that were less prepared in terms of structural liquidity, but sufficiently capitalised. Panel B of this figure presents the estimated quarterly differences of the natural logarithm of the long-term lending ($GL > 5$ years) between treated and control group, with 95 percent confidence intervals before and after the treatment.

Panel A – Parallel trends of long-term lending.

Panel B – Differences in long-term lending between the treated and control groups.

Table 4

Differences-in-differences-in-differences (DDD) estimation results.

This table presents the results of differences-in-differences-in-differences (DDD) estimations with bank and country fixed effects (FE) on the full sample of banks (from 12 Eurozone countries) over the period 2008Q1–2011Q3 (i.e., the last quarter before the beginning of the LTRO programme). The dependent variable is loans to customers, measured both at the aggregate level (Total loans) and disaggregated by maturity. The target variables are as follows: D_SHOCK, which takes the value of 0 for the years before the shock (i.e., the publication of the Basel III consultative document in December 2009) and 1 otherwise; D_TREATED#D_SHOCK, derived from the interaction between D_SHOCK and D_TREATED (which takes the value of 1 for banks with a NSFR lower than the median NSFR in the quarter of the shock, and 0 otherwise); D_CAPITAL#D_SHOCK, derived from the interaction between D_SHOCK and D_CAPITAL (which takes the value of 1 for banks with equity to total assets (ETA) equal to or above the median ETA in the quarter of the shock, and 0 otherwise); and D_TREATEDD_CAPITALD_SHOCK. All the control variables considered in the baseline model are included; see Table A.1 in the Appendix for a full description of the variables. All explanatory variables accounting-based are lagged by one quarter and winsorised at the 1st and 99th percentiles. Two-way clustered standard errors (at the bank and quarter level) are reported in parentheses. The superscripts ***, **, and * denote coefficients statistically different from zero at the 1%, 5%, and 10% levels, respectively, in two-tailed tests.

Variables	Total loans		Lending by maturity		
	LOG_GL_total	LOG_GL<3months	LOG_GL3-12months	LOG_GL1-5years	LOG_GL>5years
D_SHOCK	0.025 (0.032)	0.013 (0.019)	0.004 (0.019)	-0.002 (0.016)	-0.009 (0.013)
D_TREATED	-1.407 (0.880)	-0.257 (0.777)	0.216 (0.151)	0.062 (0.129)	0.138 (0.101)
D_CAPITAL	-1.385 (0.875)	0.001 (0.019)	0.171 (0.145)	0.086 (0.456)	-0.061 (0.512)
D_TREATED#D_SHOCK	-0.039 (0.041)	0.022 (0.036)	-0.015 (0.039)	-0.014 (0.022)	0.009 (0.017)
D_CAPITAL#D_SHOCK	-0.012 (0.041)	0.009 (0.026)	0.007 (0.032)	-0.016 (0.015)	0.010** (0.004)
D_TREATED#D_CAPITAL	2.230 (2.700)	0.132 (0.302)	0.204 (0.150)	-0.019 (0.275)	0.290 (0.297)
D_TREATED#D_CAPITAL#D_SHOCK	0.000 (0.054)	-0.023 (0.035)	0.032 (0.067)	0.025 (0.029)	-0.017* (0.009)
Control variables (-1)	Yes	Yes	Yes	Yes	Yes
Bank FE	Yes	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes	Yes
N. of obs.	1,462	1,417	1,384	1,410	1,409
R-squared	0.114	0.089	0.117	0.130	0.135

The uninteracted NSFR term continues to show a negative association with long-term lending, while the negative and significant triple interaction indicates that this effect is stronger for treated banks with lower NSFR but stronger capital positions. This interpretation draws on the combined effect of the triple interaction and the relevant lower-order terms. The coefficient on the D_TREATED#D_SHOCK term is small and statistically insignificant, suggesting no average differential effect of the shock on treated banks. Similarly, the D_CAPITAL#D_SHOCK term is positive and marginally significant only for longer maturities, indicating that better-capitalised banks may have slightly mitigated the shock's impact. Taken together, the negative triple interaction implies that, among banks with stronger capital, those that were treated and had weaker NSFR positions reduced long-term lending more sharply than others did. This suggests that capital does not independently drive changes in long-term lending but conditions how banks respond to tighter liquidity requirements. These results could reflect distinct adjustment mechanisms: high-NSFR banks reduced long-term lending because the new liquidity requirements directly constrained their maturity transformation, whereas low-NSFR/high-capital banks appear to have done so strategically to preserve balance sheet flexibility and prevent further deterioration in their NSFR while relying on their capital buffers. Overall, these findings suggest that banks' responses to liquidity regulation could depend on the structure of their balance sheets, with different configurations shaping distinct adjustment behaviours.

5.2. Disentangling the effects of TLTRO stages

To take into consideration the different stages of the TLTRO programme, rather than capturing all of them within the same treatment dummy as in the baseline model of Table 2, we first use a Difference-in-Differences (DD) regression to analyse the effects of the TLTRO I and TLTRO II programmes on bank lending separately. While TLTRO III was also implemented, we exclude it from these analyses because no banks in

our sample accessed the TLTRO III programme as their initial intervention. All banks participating in TLTRO III had already taken part in at least one of the previous programmes. Moreover, banks that previously participated in the LTRO programme are excluded from the sample.

In Panel A of Table 5, we define D_TREATED_TLTRO I as a dummy equal to 1 if a bank participated only in the TLTRO I programme, and 0 otherwise. This analysis covers the period from 2008Q1 to 2016Q1, which corresponds to the quarter immediately preceding the introduction of the TLTRO II programme. The variable D_TIME I is defined as a dummy equal to 1 from 2014Q3 (the start of the TLTRO I programme) onwards, and 0 before. The regression also includes the interaction term D_TIME I#D_TREATED_TLTRO I to capture the treatment effect.

In Panel B of Table 5, we estimate the same DD model for the TLTRO II programme. We define D_TREATED_TLTRO II as a dummy equal to 1 if a bank participated only in the TLTRO II programme (and not in the earlier TLTRO I programme), and 0 otherwise. The variable D_TIME II is a time dummy equal to 1 from 2016Q2—i.e. the quarter in which TLTRO II was introduced—until the end of the sample period (2020Q1), and 0 before. Banks that participated in the TLTRO I programme are excluded. The regression includes the interaction term D_TIME II#D_TREATED_TLTRO II to capture the treatment effect.

Results show that the positive and significant effect on total lending of the overall TLTRO programme observed in the baseline model of Table 2 is driven by the TLTRO I programme (see the interaction term D_TIME I#D_TREATED_TLTRO I). Indeed, only those banks participating in the TLTRO I programme increased their lending activity. By contrast, the findings for the TLTRO II programme show no supportive effect on total lending activity and indicate a negative impact on both short- and long-term lending (see the interaction term D_TIME II#D_TREATED_TLTRO II).

Next, using a staggered Difference-in-Differences (S_DD) approach, we again take into consideration the different stages of the TLTRO programme (TLTRO I and TLTRO II), but within the same model rather than separately. This approach extends the traditional DD framework by

Table 5

Difference-in-Differences Estimates for TLTRO Programmes.

This table presents the results of Difference-in-Differences (DD) regression estimations on the TLTRO programmes considered separately. Banks that previously participated in the LTROs programme are excluded from the sample. In Panel A, we define treated banks (D_TREATED_TLTRO I) as those that participated only in the TLTRO I programme, and 0 otherwise. This analysis covers the period from 2008Q1 to 2016Q1, which corresponds to the quarter immediately preceding the introduction of the TLTRO II programme. The variable D_TIME I is defined as a dummy equal to 1 from 2014Q3 (the start of the TLTRO I programme) onward, and 0 before. The regression also includes the interaction term D_TIME I#D_TREATED_TLTRO I to capture the treatment effect.

In Panel B, we estimate the same DD model, but for the TLTRO II programme. We define D_TREATED_TLTRO II as a dummy variable equal to 1 if a bank participates only in the TLTRO II programme (and not in the previous TLTRO I programme), and 0 otherwise. The variable D_TIME II is a time dummy equal to 1 from 2016Q2 (i.e. the quarter in which TLTRO II was introduced) until the end of the sample period (2020Q1), and 0 before. The regression includes the interaction term D_TIME II#D_TREATED_TLTRO II to capture the treatment effect.

The dependent variable is loans to customers, measured as the natural logarithm of the quarterly average growth rate of gross loans, considered both at the aggregate level (LOG_GL_total) and disaggregated by the following maturities: less than 3 months (LOG_GL<3months); between 3 and 12 months (LOG_GL3-12months); between 1 and 5 years (LOG_GL1-5years); and greater than 5 years (LOG_GL>5years). Our target variables are the Basel III structural liquidity ratio (the NSFR), the dummy variables D_TREATED_TLTRO I, D_TREATED_TLTRO II, D_TIME I, D_TIME II, and the interaction terms D_TIME I#D_TREATED_TLTRO I and D_TIME II#D_TREATED_TLTRO II.

As controls, we include variables based on accounting data (SIZE, ETA, ROAA, CIR, and NPL_GL); see Table A.1 in the Appendix for a full description of the variables. All explanatory variables based on accounting data are lagged by one quarter and winsorised at the 1st and 99th percentiles. The superscripts ***, **, and * denote coefficients statistically different from zero at the 1%, 5%, and 10% levels, respectively, in two-tailed tests.

Panel A – DD regression on TLTRO I programme					
Variables	Total loans		Lending by maturity		
	LOG_GL_total	LOG_GL<3months	LOG_GL3-12months	LOG_GL1-5years	LOG_GL>5years
NSFR (-1)	0.005 (0.008)	0.004 (0.016)	0.008 (0.007)	0.009* (0.006)	0.011* (0.006)
D_TREATED_TLTRO I	0.001 (0.007)	0.007 (0.009)	0.009 (0.006)	0.008 (0.005)	0.010** (0.004)
D_TIME I	-0.014* (0.007)	0.006 (0.007)	-0.003 (0.006)	-0.011** (0.004)	-0.013*** (0.004)
D_TIME I# D_TREATED_TLTRO I	0.024* (0.013)	0.002 (0.011)	0.003 (0.009)	0.007 (0.007)	0.001 (0.006)
Control variables (-1)	Yes	Yes	Yes	Yes	Yes
Constant	0.069 (0.060)	-0.077 (0.058)	-0.007 (0.041)	0.073** (0.035)	0.066* (0.036)
N. of obs.	2,167	2,150	2,116	2,109	2,107
R-squared	0.007	0.005	0.009	0.020	0.024

Panel B – DD regression on TLTRO II programme					
Variables	Total lending		Lending by maturity		
	LOG_GL_total	LOG_GL<3months	LOG_GL3-12months	LOG_GL1-5years	LOG_GL>5years
NSFR (-1)	0.004 (0.007)	0.011 (0.015)	0.008 (0.008)	0.005 (0.006)	0.010 (0.006)
D_TREATED_TLTROII	0.004 (0.007)	0.000 (0.009)	0.008 (0.006)	0.006 (0.005)	0.011*** (0.004)
D_TIMEII	-0.011* (0.007)	0.008 (0.010)	-0.012* (0.006)	-0.013** (0.006)	-0.009** (0.004)
D_TIMEII# D_TREATED_TLTROII	-0.003 (0.011)	-0.082*** (0.013)	-0.006 (0.009)	0.012 (0.008)	-0.012* (0.006)
Control variables (-1)	Yes	Yes	Yes	Yes	Yes
Constant	0.070 (0.054)	-0.055 (0.053)	-0.005 (0.040)	0.066* (0.036)	0.064* (0.033)
N. of obs.	2,623	2,600	2,566	2,571	2,569
R-squared	0.006	0.005	0.010	0.019	0.019

accounting for variation in the timing of treatment adoption across observational units. Instead of relying on a single treatment date and a binary comparison between treated and untreated groups, S_DD leverages both cross-sectional and temporal variation in treatment exposure, enabling the estimation of dynamic treatment effects. This method is particularly suitable for contexts in which policies or interventions are implemented gradually, such as across regions, firms, or financial institutions.

In our study, we exploit the staggered rollout of the TLTRO programmes, which were introduced in different phases: (i) TLTRO I in 2014Q3 and (ii) TLTRO II in 2016Q2. While TLTRO III was also implemented (from 2019Q3 onwards), we exclude it from our analysis because no banks in our sample accessed the TLTRO III programme as their initial intervention. All banks participating in TLTRO III had already taken part in at least one of the previous programmes.

To implement the S_DD design, we define as treated (in the TLTRO I setting) all banks that accessed only the TLTRO I programme as their

first liquidity intervention, excluding those that had previously participated in the LTRO programme. The control group therefore includes banks that did not participate in any liquidity programme at that time or had not yet accessed TLTRO. For the TLTRO II setting, treated banks are defined as those that accessed only TLTRO II as their first liquidity programme, while untreated banks are those that never accessed any liquidity support programme during the period under observation.

We use the model proposed by Callaway and Sant'Anna (2021), which decomposes the average treatment effect into cohort-specific and time-varying components, enabling a more accurate identification of causal effects in staggered treatment settings. We calculate the pre- and post-average effects on two event windows: (-2; +2) and (-3; +3). In all cases, our results show no statistically significant effect of the two different TLTRO programmes on lending activity when included together in the same model. These results are shown in Table 6 and corroborate those observed in the PSM findings for the overall TLTRO programme, as discussed in Section 5.3.

Table 6

Staggered difference-in-differences results.

This table presents the results of a staggered Difference-in-Differences model with event windows ranging from -2 to +2 in Panel A and from -3 to +3 in Panel B. The analysis focuses on the sample of banks that never participated in the LTRO programme (from 12 Eurozone countries) over the period 2008Q1–2020Q1 (i.e. the last quarter before the outbreak of the Covid-19 pandemic). Treated banks are those that participated only in the TLTRO I or TLTRO II programmes, while untreated banks are those that never participated in liquidity programmes or had not yet participated.

The dependent variable is loans to customers, measured as the natural logarithm of the quarterly average growth rate of gross loans, considered both at the aggregate level (LOG_GL_total) and disaggregated by the following maturities: less than 3 months (LOG_GL<3months); between 3 and 12 months (LOG_GL3-12months); between 1 and 5 years (LOG_GL1-5years); and greater than 5 years (LOG_GL>5years). The target variables are the Basel III structural liquidity ratio (the NSFR) and the two TLTROs. The control variables are SIZE, ETA, ROAA, CIR, and NPL_GL. The reported coefficients are estimated as the average before the treatment (pre avg) and the average after the treatment (post avg). See Table A.1 in the Appendix for a full description of the variables. All explanatory variables based on accounting data are lagged by one quarter and winsorized at the 1st and 99th percentiles.

Panel A – Staggered Difference-in-Difference results with event window from -2 to +2							
	(-2;+2)	Coefficient	Std. err.	z	P>z	[95% conf.	interval]
LOG_GL_total	Pre_avg	0.001	0.019	0.070	0.942	-0.036	0.039
	Post_avg	-0.001	0.010	-0.090	0.926	-0.020	0.018
LOG_GL<3months	Pre_avg	-0.129	0.066	-1.970	0.049	-0.258	-0.001
	Post_avg	-0.022	0.015	-1.450	0.146	-0.051	0.008
LOG_GL3-12months	Pre_avg	0.029	0.027	1.090	0.277	-0.024	0.082
	Post_avg	0.022	0.036	0.600	0.549	-0.050	0.093
LOG_GL1-5years	Pre_avg	0.018	0.011	1.670	0.095	-0.003	0.040
	Post_avg	0.002	0.015	0.160	0.875	-0.027	0.031
LOG_GL>5years	Pre_avg	-0.009	0.006	-1.440	0.150	-0.022	0.003
	Post_avg	-0.013	0.009	-1.350	0.176	-0.031	0.006

Panel B – Staggered Difference-in-Difference results with event window from -3 to +3							
	(-3; +3)	Coefficient	Std. err.	z	P>z	[95% conf.	interval]
LOG_GL_total	Pre_avg	-0.003	0.013	-0.220	0.827	-0.027	0.022
	Post_avg	-0.001	0.007	-0.080	0.938	-0.015	0.014
LOG_GL<3months	Pre_avg	-0.094	0.046	-2.060	0.039	-0.184	-0.005
	Post_avg	-0.021	0.014	-1.470	0.142	-0.049	0.007
LOG_GL3-12months	Pre_avg	0.012	0.018	0.670	0.505	-0.023	0.046
	Post_avg	0.017	0.027	0.610	0.541	-0.037	0.070
LOG_GL1-5years	Pre_avg	0.011	0.008	1.330	0.184	-0.005	0.027
	Post_avg	0.002	0.011	0.180	0.859	-0.020	0.024
LOG_GL>5years	Pre_avg	-0.006	0.004	-1.400	0.161	-0.015	0.002
	Post_avg	-0.009	0.007	-1.300	0.193	-0.023	0.005

5.3. Propensity score matching

In our empirical framework, endogeneity concerns may arise also due to self-selection issues. Banks might choose to participate in the ECB programmes for many reasons, including constrained balance sheets and liquidity needs, as well as to expand lending and increase their customer base. To ensure that banks' self-selection into the LTROs and TLTROs programmes does not drive our results, we apply a propensity score matching analysis. In this respect, we match the propensity to participate in the liquidity programmes and build a control sample of banks that have ex-ante the same probability to borrow from the ECB but do not.

Propensity scores are estimated using a probit regression model of a dummy variable that takes a value of 1 if a bank has accessed ECB liquidity, and 0 otherwise. Following the matching literature, the model includes bank-level covariates and quarter fixed effects. Treated banks are defined as those that accessed liquidity through the LTRO or TLTRO programme during the respective intervention period, while control banks are those that did not participate in the corresponding programme. For the LTRO programme, treated and untreated banks are matched based on data from 2011Q3, that is the quarter before the start of the programme. For the analysis of the TLTRO programme, the sample is restricted to banks that did not participate in earlier LTROs to ensure a clean identification of the TLTRO treatment effect. Treated and untreated banks are matched based on data from 2014Q2, that is the quarter before the start of the TLTRO programme. The matching is performed using nearest-neighbour matching with two matches per

treated observation (PSM 2-neighbours).⁹ The objective of the matching procedure is to construct a set of comparable treated and untreated banks in order to isolate the causal effect of ECB liquidity support measures on bank lending behaviour. The results, presented in Table A.7 of the Appendix 3, indicate that larger banks with higher NSFRs were more likely to participate in both the LTRO and TLTRO programmes. These findings confirm the presence of systematic differences between participating and non-participating banks, underscoring the importance of addressing selection bias in the analysis. Fig. A.1 presents the density plots of the propensity scores for treated and control groups, before and after matching. Prior to matching, the distributions differ markedly, indicating substantial initial imbalance. Post-matching, the distributions exhibit significant overlap, suggesting that the matching procedure effectively improved comparability between the two groups based on observed characteristics.

We also examine the effect of ECB programme participation using propensity score-matched samples (see Table A.8 in Appendix 3). LTRO participation is associated with a significant increase in medium- and long-term lending, while no effects are found for shorter maturities or total lending. For TLTROs, no statistically significant effects are observed across maturities.

⁹ As a robustness check, we re-estimate the propensity score matching using four-nearest neighbours instead of two. In addition, we test the sensitivity of the results to alternative model specifications by using a different set of control variables to match treated and untreated banks. In both cases, the results remain consistent with our main findings, confirming the reliability of the estimated effects.

5.4. PSM-weighted fixed-effects estimation

We complement our analysis by estimating a fixed-effects panel model weighted by propensity scores. This approach leverages the advantages of both PSM and panel data methods: the matching step improves comparability between treated and untreated banks based on observed characteristics, while the fixed effects control for unobserved,

time-invariant heterogeneity at the bank level. By incorporating the estimated propensity score weights into the fixed effects regression, we correct for potential bias arising from non-random selection into the ECB's LTRO and TLTRO programmes. This method follows the framework proposed by [Abadie and Imbens \(2006\)](#) and applied in recent banking literature ([Beccalli et al., 2023](#)).

The PSM is implemented separately for the LTRO and TLTRO

Table 7

PSM and fixed effect regression – LTRO and TLTRO programmes.

Panel A presents the results from fixed effects panel regressions estimated on the full matched sample of banks from 12 Eurozone countries, covering the period 2008Q1 to 2015Q1, which corresponds to the maturity horizon of the LTRO programme. Treated and untreated banks are matched using propensity score matching (PSM) based on data from 2011Q3 (i.e. the quarter immediately preceding the launch of the LTRO programme). Panel B presents the results of panel regression estimations on the full sample of banks (from 12 Eurozone countries) over the period 2008Q1–2020Q1 (i.e., the last quarter before the outbreak of the Covid-19 pandemic). To match treated and untreated banks, the PSM is performed at 2014Q2 (i.e. the quarter immediately preceding the launch of the TLTRO programme). The resulting weights from the PSM procedure are used in the estimation to correct for potential selection bias. The dependent variable is bank lending to customers, measured as the natural logarithm of the quarterly average growth rate of gross loans. Lending is analysed at the aggregate level (LOG_GL_total) and disaggregated by maturity: less than 3 months (LOG_GL<3months), between 3 and 12 months (LOG_GL3–12months), between 1 and 5 years (LOG_GL1–5years), and greater than 5 years (LOG_GL>5years). The key explanatory variables are the NSFR, the LTRO participation dummy (D_LTROs), which equals 1 from the quarter in which the bank receives LTRO funding, and 0 before, and the TLTRO participation dummy (D_TLTROs), which equals 1 from the quarter in which the bank takes liquidity through the TLTROs programme until the end of the sample period considered and that don't have received liquidity through the previous LTROs programme, and 0 before). Control variables include bank-level accounting measures: SIZE, capitalisation (ETA), profitability (ROAA), cost efficiency (CIR), and asset quality (NPL_GL). All accounting-based covariates are lagged by one quarter, except for D_LTROs and D_TLTROs, and winsorised at the 1st and 99th percentiles to reduce the influence of outliers.

All regressions include bank fixed effects, quarter fixed effects, and country fixed effects. Standard errors are two-way clustered at the bank and quarter levels and reported in parentheses. The superscripts ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively, based on two-tailed tests.

Panel A – LTROs programme					
Variables	Total loans		Lending by maturity		
	LOG_GL_total	LOG_GL<3months	LOG_GL3-12months	LOG_GL1-5years	LOG_GL>5years
NSFR (-1)	0.002 (0.013)	0.021*** (0.006)	-0.011 (0.014)	-0.017* (0.010)	-0.012** (0.005)
D_LTROs	0.000 (0.016)	-0.001 (0.023)	0.010 (0.009)	0.017*** (0.006)	0.012** (0.005)
SIZE (-1)	-0.045 (0.042)	0.008 (0.024)	-0.018 (0.019)	-0.032 (0.024)	-0.039 (0.025)
ETA (-1)	0.180 (0.377)	-0.263 (0.335)	0.005 (0.329)	-0.158 (0.338)	0.150 (0.093)
ROAA (-1)	1.040 (1.163)	1.528** (0.692)	0.258 (0.585)	0.326 (0.445)	0.144 (0.444)
CIR (-1)	0.028 (0.047)	0.045 (0.037)	-0.001 (0.025)	-0.000 (0.019)	-0.001 (0.020)
NPL_GL (-1)	-0.044 (0.116)	-0.162 (0.175)	0.004 (0.058)	-0.005 (0.078)	-0.083 (0.076)
PSM_weights	Yes	Yes	Yes	Yes	Yes
Bank FE	Yes	Yes	Yes	Yes	Yes
Quarter FE	Yes	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes	Yes
N. of obs.	2,660	2,585	2,528	2,558	2,553
R-squared	0.059	0.068	0.074	0.164	0.195
Panel B – TLTROs programme					
Variables	Total loans		Lending by maturity		
	LOG_GL_total	LOG_GL<3months	LOG_GL3-12months	LOG_GL1-5years	LOG_GL>5years
NSFR (-1)	0.015 (0.010)	0.033*** (0.013)	0.005*** (0.001)	0.002 (0.017)	-0.012* (0.007)
D_TLTROs	0.072* (0.041)	0.010 (0.023)	0.018 (0.021)	0.003 (0.016)	0.001 (0.015)
SIZE (-1)	-0.004 (0.006)	-0.001 (0.005)	0.004 (0.004)	0.001 (0.006)	-0.003 (0.002)
ETA (-1)	-0.178 (0.280)	-0.080 (0.263)	-0.102 (0.207)	-0.116 (0.273)	0.116 (0.134)
ROAA (-1)	0.045 (0.640)	0.790 (0.815)	-0.289 (0.644)	-0.129 (0.607)	-0.431 (0.610)
CIR (-1)	0.029 (0.039)	0.043 (0.032)	-0.022 (0.021)	-0.016 (0.026)	-0.012 (0.024)
NPL_GL (-1)	-0.047 (0.134)	-0.343** (0.175)	0.127 (0.100)	0.027 (0.130)	-0.015 (0.069)
PSM_weights	Yes	Yes	Yes	Yes	Yes
Bank FE	Yes	Yes	Yes	Yes	Yes
Quarter FE	Yes	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes	Yes
N. of obs.	2,301	2,298	2,272	2,238	2,233
R-squared	0.056	0.098	0.106	0.136	0.159

programmes, with treated and untreated banks defined as in the previous matching procedure. The analysis proceeds in two steps. First, we estimate propensity scores by matching treated and untreated banks based on their balance sheet characteristics observed in the quarter immediately preceding the launch of the respective liquidity programme: 2011Q3 for the LTROs and 2014Q2 for the TLTROs. This step yields both the propensity scores and the associated weights used in the subsequent analysis.

In the second step, we re-estimate the fixed-effects panel regression model specified in Eq. (1) by incorporating the matching weights derived from the PSM. This weighted specification adjusts for potential selection bias (Abadie and Imbens, 2006). The results, presented in Table 7, provide strong confirmation of our main findings and further reinforce the robustness of the baseline estimates.

6. Conclusions

Eurozone banks' lending declined sharply in 2008 and never fully recovered. This paper investigates the impact of the concurrent introduction of the NSFR, under the Basel III liquidity framework, and the ECB's unconventional monetary policy interventions (specifically, the LTRO and TLTRO programmes) on Eurozone banks' lending behaviour. Our analysis spans from 2008Q1, when the global financial crisis began to affect European banks, to 2020Q1, just before the onset of the COVID-19 pandemic. This extended timeframe allows us to assess how banks integrated the NSFR into their strategic decisions over time, beyond their initial adjustments to the regulation.

The NSFR was designed to encourage banks to fund liquid assets with more stable and longer-term sources, thereby reducing maturity transformation risk. Although the NSFR only became legally binding in the Eurozone in 2021, our findings demonstrate that banks began adjusting their balance sheet structures in anticipation of the requirement well before its formal implementation.

A key challenge in isolating the effect of liquidity regulation is the concurrent implementation of the ECB's unconventional liquidity injections. To address this, we contribute to two strands of literature: one examining the effects of liquidity regulation, and the other analysing the impact of unconventional monetary policy. To the best of our knowledge, this is the first study to explore the joint effects of these two policy regimes on bank lending.

Our empirical findings indicate that aggregate lending was not significantly affected by the introduction of the NSFR. This suggests that banks were able to meet the new regulatory requirements through strategies that did not involve reducing overall credit supply. However,

when we disaggregate by loan maturity, we find that a higher NSFR is associated with increased short-term lending and reduced long-term lending. This indicates a shift in maturity structure, consistent with a reduced appetite for maturity transformation under the new regulatory framework.

We also find that the ECB's unconventional liquidity measures, particularly the LTROs, had a positive effect on medium- and long-term lending, while the TLTROs had more limited but still positive effects, primarily on total lending. Despite their funding-for-lending design, the TLTROs were also used in part to refinance or repay earlier tranches of the same programme.

Finally, we examine the interaction between liquidity regulation and central bank interventions. Our results show that banks receiving LTRO or TLTRO liquidity were able to improve their NSFR without reducing maturity transformation, suggesting that those already close to compliance with Basel III were able to use the liquidity injections to support, rather than decrease, lending activity. These findings underscore the importance of taking into account banks' structural liquidity positions when designing policy measures aimed at sustaining credit supply during periods of financial distress.

CRediT authorship contribution statement

Barbara Casu: Writing – review & editing, Writing – original draft, Methodology, Investigation, Formal analysis, Conceptualization. **Laura Chiaramonte:** Writing – review & editing, Writing – original draft, Methodology, Formal analysis, Data curation, Conceptualization. **Doriana Cucinelli:** Writing – review & editing, Methodology, Investigation, Formal analysis, Data curation.

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Appendix

Table A.1

Variable definitions.

This table describes all the variables used in our analyses and the source of data used to collect them.

Variables	Label	Definition	Source
DEPENDENT VARIABLES			
Total loans	LOG_GL total	The natural logarithm of total gross loans (GL) at time t over $t-1$ (i.e. the previous quarter).	SNL
Loans by maturity	LOG_GL <3months	The natural logarithm of gross loans (GL) with a maturity of less than 3 months at time t over $t-1$ (i.e. the previous quarter).	(S&P Global – Market Intelligence) database (Authors' calculations)
	LOG_GL 3-12months	The natural logarithm of gross loans (GL) with a maturity of more than 3 months, but less than 1 year at time t over $t-1$ (i.e. the previous quarter).	
	LOG_GL 1-5years	The natural logarithm of gross loans (GL) with a maturity of more than 1 year, but less than 5 years at time t over $t-1$ (i.e. the previous quarter).	

(continued on next page)

Table A.1 (continued)

Variables	Label	Definition	Source
	LOG_GL >5years	The natural logarithm of gross loans (GL) with a maturity of more than 5 years at time t over t-1 (i.e. the previous quarter).	
TARGET VARIABLES			
Basel III structural liquidity ratio	NSFR	The Net Stable Funding Ratio (NSFR) is computed as the ratio of available stable funding (ASF) to required stable funding (RSF), see Table A.2 in the Appendix.	SNL (S&P Global – Market Intelligence) database (Authors' calculations)
Bank participation in the ECB's unconventional liquidity injections	D_LTROs	Equals 1 from the quarter in which the bank takes liquidity through the LTROs programme; and 0 before.	Bloomberg database (Authors' calculations)
	D_TLTROs	Equals 1 from the quarter in which the bank takes liquidity through the TLTROs programme until the end of the sample period considered and that don't have received liquidity through the previous LTROs programme; and 0 before).	
Interactions between NSFR and each ECB's unconventional liquidity programme	NSFR#D_LTROs	Interaction between NSFR and the dummy variable D_LTROs.	Authors' calculations
	NSFR#D_TLTROs	Interaction between NSFR and the dummy variable D_TLTROs.	
CONTROL VARIABLES			
	SIZE	The natural logarithm of total assets.	SNL (S&P Global – Market Intelligence) database (Authors' calculations)
	ETA	The ratio of equity to total assets.	
	ROAA	The ratio of net income to average total assets.	
	CIR	The ratio of overheads to the sum of net interest income (defined as the difference between gross interest & dividend income and total interest expense) and other operating income.	
	NPL_GL	The ratio of non-performing loans to gross loans.	
ALTERNATIVE TARGET VARIABLES used in additional and robustness tests			
Standardised NSFR	NSFR_NSFR2008	The ratio of NSFR of the bank to the sample average value of NSFR in 2008 (i.e. the first year of our analysis).	SNL (S&P Global – Market Intelligence) database (Authors' calculation)
Bank uptake of ECB's unconventional liquidity injections	AM_LTROs	The amount borrowed with the LTROs programme (AM_LTROs).	Bloomberg database (Authors' calculation)
	AM_TLTROs	The amount borrowed with the TLTROs programme (AM_TLTROs).	SNL (S&P Global – Market Intelligence) database (Authors' calculations)
Target variables used in DDD model	D_SHOCK	Equals 1 for the period after the shock (i.e. the publication of the consultative document of Basel III in December 2009); and 0 otherwise.	
	D_TREATED	Equals 1 for banks with a Net Stable Funding Ratio (NSFR) lower than the median in the quarter of the shock (the publication of the consultative document of Basel III in December 2009); and 0 otherwise.	
	D_CAPITAL	Equals 1 for banks with an equity to total assets (ETA) equal to or above the median in the quarter of the shock (the publication of the consultative document of Basel III in December 2009); and 0 otherwise.	
	D_TREATED#D_SHOCK	Interaction between D_TREATED and D_SHOCK.	
	D_CAPITAL#D_SHOCK	Interaction between D_CAPITAL and D_SHOCK.	
	D_TREATED#D_CAPITAL	Interaction between D_TREATED and D_CAPITAL.	
	D_TREATED#D_CAPITAL#D_SHOCK	Triple interaction between D_TREATED, D_CAPITAL and D_SHOCK.	

Appendix 1 – The Net Stable Funding Ratio (NSFR) of Basel III

The NSFR, our variable of interest, is the ratio between the amount of Available Stable Funding (ASF) relative to the amount of Required Stable Funding (RSF):

$$NSFR = \frac{ASF}{RSF} \quad (A.1)$$

The ASF comprises weighted liabilities reflecting their contractual maturity and is defined as the portion of capital and liabilities expected to be a reliable source of funding over a one-year time horizon. The RSF of a specific bank is a function of the liquidity characteristics and residual maturities of the various assets held by that institution. The ASF and RSF are calibrated to reflect the presumed degree of stability of a bank's liabilities and liquidity of a bank's assets. The weights for assets and liabilities range from 0% to 100%; these are primarily the result of internationally agreed definitions and calibrations (see BCBS, 2014). In this way, on the one hand, ASF categories are biased to a greater extent by more stable funding and to a lesser extent by less stable funding. On the other hand, assets that are more liquid and more readily available to act as a source of extended liquidity in the stressed environment receive lower RSF factors (and require less stable funding) than assets considered less liquid in such circumstances and, therefore, require more stable funding. Hence, more liquid assets (even in conditions of stress) are weighted by a lower RSF factor; in fact, asset components are weighted inversely to their degree of liquidity. While the level of detail necessary to estimate the NSFR is not publicly available, we can approximate the ratio consistently with the BCBS guidelines (see Eq. (A.2)). Table A.2 illustrates the calibrations we used, following the final 2014 document, and the relevant balance sheet items considered for the estimation of the NSFR.

The Basel III liquidity standards have undergone substantial revisions since they were first issued in December 2010. For example, with respect to the NSFR, the overall aim of the changes in October 2014 was to ensure that the indicator reflected a bank's structural liquidity risk rather than it being calculated for stress testing purposes only. These changes include greater differentiation in terms of maturity, to allow for the prompt identification of banks with excessive maturity mismatches and more fragile funding structures (BCBS, 2014).

$$NSFR = \frac{\text{Equity} + \text{Total Long Term Funding} + \left(\frac{\text{Total Time Deposits and Savings Accounts}}{\text{Government Securities}} \right) * 0.95 + (\text{Current Accounts}) * 0.9 + \left(\frac{\text{Other Deposits and Short Term Borrowings}}{\text{Other Securities} + \text{Net Loans to Banks}} \right) * 0.5}{\left(\frac{\text{Mortgage Loans}}{\text{Retail and Corporate Loans}} \right) * 0.65 + \left(\frac{\text{Retail and Corporate Loans}}{\text{Other Assets}} \right) * 0.85 + \text{Other Assets}} \quad (A.2)$$

Table A.2

NSFR calculation.

This table summarises the weights for each asset and liability item used to compute the final version of the NSFR of October 2014. NSFR is computed as the ratio of Available Stable Funding (ASF) to Required Stable Funding (RSF). We calculate NSFR using the data available in SNL (S&P Global – Market Intelligence) database.

ASF factor 2014	SNL Liability & Equity Items
100%	Total equity
	Total long-term funding
95%	Savings accounts
	Total time deposits
90%	Current accounts
50%	Other deposits and short-term borrowings
0%	Deposits from banks
RSF factor 2014	SNL Asset Items
0%	Cash and due from banks
5%	Debt issued or guaranteed by National or Supranational Government
50%	Other securities (= Total Securities – Debt issued or guaranteed by National or Supranational Government – at-equity investments in associates) Net loans to banks
65%	Mortgage loans
85%	Retail and corporate loans plus other retail loans
100%	Reserve for impaired loans/NPLs Non-earning assets (=Total assets – Total earning assets – Cash and due from banks)
	Fixed assets
	Insurance assets
	Net investments properties
	At-equity investments in associates

Table A.3

Net stable funding ratio by year and by country.

This table shows the descriptive statistics of the NSFR for our sample banks by year and by country. To mitigate the effect of outliers, we winsorize observations in the outside 1% of each tail. Source: SNL (S&P Global – Market Intelligence) database, authors' calculations.

Year/Country		Austria	Belgium	Cyprus	France	Germany	Greece	Ireland	Italy	Netherlands	Portugal	Slovenia	Spain
2008	Mean	1.007	0.857	1.353	1.115	0.918	0.978	0.774	0.937	1.200	0.960	1.388	0.917
	(Std. Dev.)	(0.212)	(0.196)	(0.194)	(0.564)	(0.350)	(0.240)	(0.371)	(0.382)	(0.649)	(0.206)	(0.080)	(0.1789)
	Min. – Max.	0.591 – 1.439	0.536 – 1.191	1.097 – 1.656	0.699 – 2.052	0.203 – 2.464	0.203 – 1.377	0.203 – 1.220	0.367 – 2.464	0.611 – 2.464	0.715 – 1.424	1.289 – 1.486	0.576 – 1.377
2009	Mean	0.920	0.892	1.319	1.046	0.897	0.990	0.953	1.009	0.968	1.023	1.434	0.968
	(Std. Dev.)	(0.258)	(0.217)	(0.187)	(0.531)	(0.334)	(0.206)	(0.374)	(0.403)	(0.519)	(0.155)	(0.028)	80.1929
	Min. – Max.	0.742 – 1.423	0.620 – 1.224	1.092 – 1.613	0.667 – 2.182	0.203 – 2.064	0.677 – 1.349	0.412 – 1.642	0.373 – 2.464	0.582 – 2.464	0.790 – 1.362	1.395 – 1.462	0.606 – 1.469
2010	Mean	1.009	1.048	1.352	1.029	0.913	0.894	0.666	0.904	1.066	0.955	1.446	0.957
	(Std. Dev.)	(0.245)	(0.514)	(0.236)	(0.480)	(0.292)	(0.224)	(0.460)	(0.288)	(0.501)	(0.180)	(0.047)	(0.245)
	Min. – Max.	0.699 – 1.428	0.691 – 2.464	1.116 – 1.746	0.652 – 2.061	0.203 – 1.857	0.463 – 1.320	0.203 – 1.703	0.393 – 2.464	0.606 – 2.464	0.733 – 1.348	1.407 – 1.506	0.603 – 1.533
2011	Mean	0.986	0.820	1.225	1.013	0.901	0.764	0.618	0.922	1.106	0.975	-	0.906
	(Std. Dev.)	(0.256)	(0.312)	(0.274)	(0.432)	(0.276)	(0.206)	(0.213)	(0.331)	(0.490)	(0.169)	-	(0.2649)
	Min. – Max.	0.513 – 1.448	0.342 – 1.303	0.955 – 1.621	0.609 – 1.905	0.203 – 1.742	0.436 – 1.310	0.332 – 0.875	0.396 – 2.464	0.539 – 2.464	0.742 – 1.322	-	0.213 – 1.544
2012	Mean	1.059	0.672	1.246	1.017	0.930	0.695	0.812	0.978	0.999	0.983	1.365	0.991
	(Std. Dev.)	(0.223)	(0.260)	(0.264)	(0.387)	(0.297)	(0.166)	(0.173)	(0.395)	(0.484)	(0.182)	(0.082)	(0.3929)
	Min. – Max.	0.738 – 1.529	0.283 – 1.072	1.002 – 1.616	0.668 – 1.824	0.203 – 1.880	0.462 – 0.989	0.568 – 0.974	0.486 – 2.464	0.474 – 2.314	0.728 – 1.323	1.271 – 1.442	0.203 – 1.938
2013	Mean	1.074	0.793	1.098	1.057	0.976	0.850	0.858	1.021	1.142	0.969	1.558	0.983
	(Std. Dev.)	(0.243)	(0.276)	(0.447)	(0.371)	(0.293)	(0.162)	(0.158)	(0.405)	(0.397)	(0.221)	(0.035)	(0.245)
	Min. – Max.	0.655 – 1.457	0.391 – 1.257	0.654 – 1.520	0.681 – 1.739	0.449 – 1.969	0.557 – 1.119	0.635 – 1.006	0.574 – 2.464	0.657 – 2.464	0.680 – 1.423	1.519 – 1.591	0.220 – 1.459
2014	Mean	1.147	0.833	1.289	1.074	0.987	0.940	0.920	1.006	1.335	0.986	1.460	0.889
	(Std. Dev.)	(0.230)	(0.271)	(0.517)	(0.283)	(0.305)	(0.118)	(0.190)	(0.393)	(0.565)	(0.224)	(0.092)	(0.252)
	Min. – Max.	0.824 – 1.551	0.408 – 1.198	0.625 – 2.151	0.771 – 1.639	0.445 – 2.054	0.788 – 1.110	0.662 – 1.091	0.492 – 2.464	0.560 – 2.464	0.681 – 1.521	1.392 – 1.588	0.203 – 1.237

(continued on next page)

Table A.3 (continued)

Year/Country		Austria	Belgium	Cyprus	France	Germany	Greece	Ireland	Italy	Netherlands	Portugal	Slovenia	Spain
2015	Mean	1.123	0.736	1.183	0.975	1.075	0.646	0.937	0.902	1.396	1.002	1.645 (0)	1.005
	(Std. Dev)	(0.332)	(0.205)	(0.643)	(0.248)	(0.427)	(0.168)	(0.220)	(0.400)	(0.4859)	(0.283)		(0.185)
	Min. –	0.738 –	0.509 –	0.642 –	0.701 –	0.555 –	0.480 –	0.645 –	0.568 –	0.885 –	0.655 –	1.645 –	0.729 –
	Max.	1.571	0.980	2.271	1.599	2.464	0.945	1.164	2.464	2.464	1.510	1.645	1.461
2016	Mean	1.290	0.778	2.427	1.166	1.074	0.649	1.318	1.086	1.386	1.130	1.537	1.003
	(Std. Dev)	(0.283)	(0.229)	(0.058)	(0.270)	(0.324)	(0.091)	(0.358)	(0.594)	(0.221)	(0.297)	(0.145)	(0.205)
	Min. –	0.767 –	0.552 –	2.351 –	0.732 –	0.552 –	0.552 –	0.956 –	0.570 –	1.075 –	0.766 –	1.415 –	0.552 –
	Max.	1.700	1.067	2.479	1.629	2.070	0.804	1.738	4.269	1.777	1.556	1.743	1.844
2017	Mean	1.319	0.898	2.183	1.181	1.157	0.716	1.393	1.067	1.427	1.217	1.681	1.017
	(Std. Dev)	(0.285)	(0.266)	(1.153)	(0.251)	(0.445)	(0.134)	(0.405)	(0.548)	(0.280)	(0.297)	(0.107)	(0.226)
	Min. –	0.834 –	0.611 –	0.966 –	0.786 –	0.552 –	0.552 –	0.996 –	0.552 –	1.023 –	0.790 –	1.597 –	0.552 –
	Max.	1.914	1.207	3.502	1.550	2.973	0.906	1.812	3.370	1.933	1.676	1.837	1.844
2018	Mean	1.306	1.104	2.534	1.200	1.328	1.010	1.213	1.022	1.425	1.304	2.161	1.075
	(Std. Dev)	(0.299)	(0.224)	(1.220)	(0.428)	(0.567)	(0.111)	(0.183)	(0.388)	(0.277)	(0.310)	(0.283)	(0.141)
	Min. –	0.847 –	0.705 –	1.162 –	0.593 –	0.647 –	0.871 –	1.024 –	0.613 –	1.098 –	0.836 –	1.787 –	0.810 –
	Max.	1.939	1.236	4.269	1.999	2.975	1.233	1.415	2.391	2.017	1.750	2.454	1.472
2019	Mean	1.327	1.183	3.002	1.222	1.171	1.215	1.303	0.993	1.620	1.224	2.430	1.127
	(Std. Dev)	(0.302)	(0.015)	(1.357)	(0.502)	(0.378)	(0.113)	(0.260)	(0.314)	(0.379)	(0.221)	(0.232)	(0.178)
	Min. –	0.886 –	1.168 –	1.580 –	0.593 –	0.708 –	1.072 –	1.035 –	0.603 –	1.162 –	0.868 –	2.299 –	0.552 –
	Max.	2.080	1.201	4.269	2.291	2.402	1.381	1.656	2.017	2.449	1.624	2.778	1.465
2020	Mean	1.458	1.348	2.956	1.067	1.274	1.370	1.600	1.004	1.606	1.362	3.297	1.130
	(Std. Dev)	(0.443)	(0.135)	(0.941)	(0.311)	(0.400)	(0.093)	(0.586)	(0.2879)	(0.522)	(0.289)	(0.458)	(0.279)
	Min. –	0.911 –	1.168 –	1.857 –	0.637 –	0.696 –	1.199 –	1.082 –	0.630 –	0.769 –	1.008 –	2.613 –	0.552 –
	Max.	2.814	1.457	4.269	2.158	2.204	1.539	2.644	1.828	2.883	2.016	3.573	2.021
2021Q1	Mean	1.517	1.323	3.098	1.065	1.485	1.471	1.802	1.160	1.466	1.870	3.243 (0)	1.046
	(Std. Dev)	(0.416)	(0.190)	(1.090)	(0.223)	(0.701)	(0.123)	(1.423)	(0.8019)	(0.552)	(0.655)		(0.229)
	Min. –	0.922 –	1.188 –	2.327 –	0.684 –	0.621 –	1.384 –	0.552 –	0.663 –	0.817 –	1.029 –	3.243 –	0.609 –
	Max.	2.274	1.457	3.869	1.269	2.796	1.559	3.352	4.269	2.142	2.599	3.243	1.354
Total	Mean	1.186	0.880	1.675	1.087	0.981	0.894	0.946	0.986	1.235	1.077	1.824	0.969
	(Std. Dev)	(0.330)	(0.318)	(0.899)	(0.398)	(0.353)	(0.244)	(0.457)	(0.409)	(0.512)	(0.291)	(0.629)	(0.243)
	Min. –	0.513 –	0.283 –	0.625 –	0.593 –	0.203 –	0.203 –	0.203 –	0.367 –	0.474 –	0.655 –	1.271 –	0.203 –
	Max.	2.814	2.464	4.269	2.291	2.975	1.559	3.352	4.269	2.883	2.599	3.573	2.021

Table A.4

Summary statistics of sample Eurozone banks LTRO and TLTRO uptake.

This table reports the distribution of our sample banks headquartered in 12 Eurozone countries collected by the SNL (S&P Global – Market Intelligence) database and their representativeness as a share of total assets over the period 2008Q1–2021Q1 (see first two columns). The grey area shows the participation in the ECB's programmes (by country) for those banks with data available in the Bloomberg database.

Country (n. of banks in our sample)	Representativeness of our sample (as a share of total assets)	Banks that applied for each programme - by country - available on the Bloomberg database							
		LTROs programme (2011Q4-2015Q1)		TLTRO I programme (2014Q3-2021Q1)		TLTRO II programme (2016Q2-2021Q1; 4 tranches)		TLTRO III programme (2019Q3-2021Q1; 7 tranches)	
		N. of participating banks by programme	Uptake of liquidity injections (euros)	N. of participating banks by programme	Uptake of liquidity injections (euros)	N. of participating banks by programme (N. of participating banks by tranche)	Uptake of liquidity injections (euros)	N. of participating banks by programme (N. of participating banks by tranche)	Uptake of liquidity injections (euros)
Austria (13)	85.01%	4	10,825,777,500.00	3	3,348,309,600.00	2 (2)	3,426,421,300.00	2 (4)	27,246,674,000.00
Belgium (3)	89.15%	3	88,991,600,000.00	2	5,539,832,000.00	2 (3)	6,957,837,000.00	1 (3)	27,363,429,000.00
Cyprus (2)	95.65%	1	4,634,095,000.00	2	911,706,879.08	1 (2)	886,068,700.00	-	-
France (6)	95.61%	1	6,150,948,750.00	3	27,959,900,900.00	1 (2)	1,376,697,000.00	1 (4)	147,645,646,000.00
Germany (21)	90.29%	5	37,363,889,200.00	2	-	1 (2)	10,505,505.000	2 (6)	87,336,372,000.00
Greece (4)	99.97%	-	-	4	9,866,259,200.00	3 (7)	11,003,491,500.00	-	-
Ireland (7)	73.43%	3	37,658,053,500.00	2	4,313,409,000.00	2 (2)	5,877,560,000	2 (2)	17,536,596,000.00
Italy (36)	88.57%	28	294,302,197,651.29	16	119,440,577,246.80	14 (39)	234,521,738,121.00	7 (25)	358,876,330,000.00
Netherlands (10)	67.29%	3	3,928,426,500.00	3	12,112,279,730.00	3 (5)	31,476,430,000.00	2 (4)	110,120,655,000.00
Portugal (5)	93.92%	6	46,067,199,750.00	3	3,524,428,542.00	2 (3)	6,774,875.000	1 (2)	4,964,599,000.00
Slovenia (3)	79.03%	3	2,220,620,600.00	2	257,645,440.00	-	-	-	-

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Table A.4 (continued)

Country (n. of banks in our sample)	Representativeness of our sample (as a share of total assets)	Banks that applied for each programme - by country - available on the Bloomberg database							
		LTROs programme (2011Q4-2015Q1)		TLTRO I programme (2014Q3-2021Q1)		TLTRO II programme (2016Q2-2021Q1; 4 tranches)		TLTRO III programme (2019Q3-2021Q1; 7 tranches)	
		N. of participating banks by programme	Uptake of liquidity injections (euros)	N. of participating banks by programme	Uptake of liquidity injections (euros)	N. of participating banks by programme (N. of participating banks by tranche)	Uptake of liquidity injections (euros)	N. of participating banks by programme (N. of participating banks by tranche)	Uptake of liquidity injections (euros)
Spain (43)	89.97%	12	258,974,147,952.00	11	108,485,456,683.40	7 (14)	136,937,258,967.30	8 (19)	179,413,518,390.00
Total (153)	Mean value (87.32%)	69	791,116,956,403.29 77.65% of ECB LTROs (1,018,722,000,000)	51	295,759,805,221.28 69.54% of ECB TLTRO I (425,273,500,000)	38 (81)	449,969,942,588.30 60.76% of ECB TLTRO II (740,193,200,000)	26 (69)	960,503,819,390.00 46.18% of ECB TLTRO III (2,079,905,080,000)

Appendix 2 – Additional analyses

2.1 Standardised NSFR

In our first robustness tests, we construct a new NSFR variable, taking into account the NSFR position of the bank in quarter t over the sample's average liquidity position at the beginning of the period considered (i.e. the sample average value of NSFR in 2008), thus before the mechanism of the NSFR became known through the consultative document of the Basel III Accord published in December 2009. For each bank, we calculate:

$$NSFR_NSFR2008 = NSFR_{i,t} / NSFR_{2008} \text{ (A.3)}$$

In 2008, banks' liquidity positions were endogenously determined, as they were not yet subject to Basel III requirements. We therefore test whether differences in banks' initial 'readiness' for the new regulatory liquidity ratio influenced their subsequent lending behaviour. The results, presented in Table 6, confirm the robustness of our main findings. Importantly, once we control for banks' initial liquidity positions, the estimated economic impact of the introduction of the NSFR on lending becomes stronger. Specifically, a 1 percent increase in the NSFR is associated with a 9.5 percent and 15 percent increase in short-term lending, and with a 5.3 percent and 6.1 percent decrease in long-term lending, in Panels A and B of Table A.5, respectively.

2.2 Amounts borrowed

We conduct an additional robustness analysis by replacing the dummy variables for the LTRO and TLTRO programmes with continuous variables that capture the actual amount of liquidity obtained by each bank. This approach allows us to account for heterogeneity in the intensity of exposure to ECB liquidity operations, rather than assuming a uniform effect across all participating banks. Specifically, we construct two variables, AM_LTROs and AM_TLTROs, measured as the natural logarithm of one plus the euro amount received under each programme. The results of this analysis, reported in Table A.6, confirm our baseline findings: there is a positive relationship between LTRO participation and medium- and long-term lending, as well as between TLTRO participation and total lending.

Table A.5

Standardised NSFR.

This table presents the results of our baseline model, run on the full sample of banks (from 12 Eurozone countries), where the target variable is the NSFR of the bank scaled by the sample average value of the NSFR in 2008 (i.e., the first year of our analysis). The dependent variable is loans to customers, measured both at the aggregate level (Total loans) and disaggregated by maturity. Our target variables are the Basel III structural liquidity ratio (the NSFR) scaled by its average value in 2008 and the ECB's unconventional liquidity injection variables (LTROs and TLTROs). In Panel A, we use the amount borrowed through the LTROs programme (AM_LTROs) and focus on the period 2008Q1–2015Q1 (i.e., the maturity date of the LTROs programme). In Panel B, we focus on banks that have not received liquidity through the previous LTROs programme and use the amount borrowed through the TLTROs programme (AM_TLTROs), over the period 2008Q1–2020Q1 (i.e., the last quarter before the outbreak of the Covid-19 pandemic). All the control variables considered in the baseline model are included; see Table A.1 in the Appendix for a full description of the variables. All explanatory variables are lagged by one quarter, except for the ECB's unconventional liquidity injection variables, and are winsorised at the 1st and 99th percentiles. Bank fixed effects (FE), Quarter FE, and Country FE are included in all models. Two-way clustered standard errors (at the bank and quarter level) are reported in parentheses. The superscripts ***, **, and * denote coefficients statistically different from zero at the 1%, 5%, and 10% levels, respectively, in two-tailed tests.

Panel A – Standardized NSFR and the dummy LTROs.

Variables	Total loans		Lending by maturity		
	LOG_GL_total	LOG_GL<3months	LOG_GL3-12months	LOG_GL1-5years	LOG_GL>5years
NSFR_NSFR2008 (-1)	0.007 (0.060)	0.095*** (0.028)	-0.050 (0.062)	-0.078* (0.045)	-0.053** (0.022)
D_LTROs	0.000 (0.016)	-0.001 (0.023)	0.010 (0.009)	0.017*** (0.006)	0.012** (0.005)
Control variables (-1)	Yes	Yes	Yes	Yes	Yes
Bank FE	Yes	Yes	Yes	Yes	Yes
Quarter FE	Yes	Yes	Yes	Yes	Yes

(continued on next page)

Table A.5 (continued)

Variables	Total loans		Lending by maturity		
	LOG_GL_total	LOG_GL<3months	LOG_GL3-12months	LOG_GL1-5years	LOG_GL>5years
Country FE	Yes	Yes	Yes	Yes	Yes
N. of obs.	2,660	2,585	2,528	2,558	2,553
R-squared	0.059	0.068	0.074	0.164	0.195
Panel B – Standardized NSFR and the dummy TLTROs					
Variables	Total loans		Lending by maturity		
	LOG_GL_total	LOG_GL<3months	LOG_GL3-12months	LOG_GL1-5years	LOG_GL>5years
NSFR_NSFR2008 (-1)	0.042 (0.063)	0.150** (0.062)	0.012 (0.022)	0.003 (0.075)	-0.061* (0.035)
D_TLTROs	0.062* (0.033)	0.001 (0.021)	-0.004 (0.020)	-0.009 (0.014)	0.015 (0.020)
Control variables (-1)	Yes	Yes	Yes	Yes	Yes
Bank FE	Yes	Yes	Yes	Yes	Yes
Quarter FE	Yes	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes	Yes
N. of obs.	2,707	2,652	2,618	2,593	2,591
R-squared	0.053	0.079	0.080	0.158	0.199

Table A.6

Baseline model considering the amount borrowed with the ECB's unconventional liquidity programmes.

This table presents the results of panel regression estimations on the full sample of banks (from 12 Eurozone countries), using the amount borrowed, computed as the logarithm of one plus the amount of euros obtained by banks from the ECB for each programme (LTROs and TLTROs). In Panel A, we use the amount borrowed through the LTROs programme (AM_LTROs) and focus on the period 2008Q1–2015Q1 (i.e., the maturity date of the LTROs programme). In Panel B, we focus on banks that have not received liquidity through the previous LTROs programme and use the amount borrowed through the TLTROs programme (AM_TLTROs), over the period 2008Q1–2020Q1 (i.e., the last quarter before the outbreak of the Covid-19 pandemic). The dependent variable is loans to customers, measured as the natural logarithm of the quarterly average growth rate of gross loans, considered both at the aggregate level (LOG_GL_total) and disaggregated by the following maturities: less than 3 months (LOG_GL<3months); between 3 and 12 months (LOG_GL3-12months); between 1 and 5 years (LOG_GL1-5years); and greater than 5 years (LOG_GL>5years). Our target variables are the Basel III structural liquidity ratio (the NSFR) and the amount borrowed (AM_LTROs in Panel A and AM_TLTROs in Panel B). All the control variables considered in the baseline model are included; see Table A.1 in the Appendix for a full description of the variables. All explanatory variables based on accounting data are lagged by one quarter, except for AM_LTROs and AM_TLTROs, and are winsorised at the 1st and 99th percentiles. Bank fixed effects (FE), Quarter FE, and Country FE are included in all models. Two-way clustered standard errors (at the bank and quarter level) are reported in parentheses. The superscripts ***, **, and * denote coefficients statistically different from zero at the 1%, 5%, and 10% levels, respectively, in two-tailed tests.

Panel A – NSFR and the amount borrowed with the LTROs programme.

Variables	Total loans		Lending by maturity		
	LOG_GL_total	LOG_GL<3months	LOG_GL3-12months	LOG_GL1-5years	LOG_GL>5years
NSFR (-1)	0.002 (0.013)	0.021*** (0.006)	-0.011 (0.014)	-0.017* (0.010)	-0.011** (0.005)
AM_LTROs	-0.000 (0.002)	-0.001 (0.002)	0.001 (0.001)	0.002*** (0.001)	0.001*** (0.001)
Control variables (-1)	Yes	Yes	Yes	Yes	Yes
Bank FE	Yes	Yes	Yes	Yes	Yes
Quarter FE	Yes	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes	Yes
N. of obs.	2,660	2,585	2,528	2,558	2,553
R-squared	0.059	0.068	0.074	0.164	0.195
Panel B – NSFR and the amount borrowed with the TLTROs programme					
Variables	Total loans		Lending by maturity		
	LOG_GL_total	LOG_GL<3months	LOG_GL3-12months	LOG_GL1-5years	LOG_GL>5years
NSFR (-1)	0.010 (0.014)	0.033** (0.013)	0.002 (0.005)	0.001 (0.016)	-0.013* (0.008)
AM_TLTROs (1)	0.010** (0.005)	0.002 (0.002)	0.002 (0.002)	-0.000 (0.001)	0.001 (0.002)
Control variables (-1)	Yes	Yes	Yes	Yes	Yes
Bank FE	Yes	Yes	Yes	Yes	Yes
Quarter FE	Yes	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes	Yes
N. of obs.	2,707	2,690	2,656	2,629	2,627
R-squared	0.055	0.078	0.080	0.158	0.198

Appendix 3 – Propensity score matching

Table A.7

- Probit regression to match treated and untreated banks.

This table presents the results of Probit regression to estimate the propensity score to access EBC liquidity programmes. In Model (1), the dependent variable is the LTRO dummy variable, which equals 1 if a bank participated in the LTRO programme, and 0 otherwise; this model covers the period from 2011Q4 to 2015Q1. In Model (2), the dependent variable is the TLTRO dummy variable, equal to 1 if a bank accessed TLTRO funding, and 0 otherwise. Model (2) focuses on the period 2014Q3 to 2020Q1, excluding banks that had previously participated in the LTRO programme. All control variables used in the baseline model are included, along with an additional variable capturing the loan loss provisions to gross loans ratio (LLP_GL). See Table A.1 in the Appendix for a full description of all variables. The matching is performed using nearest-neighbour matching with two matches per treated observation (PSM 2-neighbours). All explanatory variables are lagged by one quarter and winsorised at the 1st and 99th percentiles. The superscripts ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively, based on two-tailed tests.

Variables	(1) D_LTROs	(2) D_TLTROs
NSFR (-1)	0.236*** (0.0908)	0.502*** (0.146)
SIZE (-1)	0.164*** (0.0245)	0.337*** (0.0410)
ETA (-1)	4.791*** (1.213)	0.521 (2.062)
ROAA (-1)	5.991** (2.711)	-4.513 (5.887)
CIR (-1)	-0.197 (0.143)	-1.379*** (0.348)
NPL_GL (-1)	1.763 (1.367)	-4.193 (3.274)
LLP_GL (-1)	3.895** (1.704)	13.82*** (3.548)
Constant	-3.787*** (0.529)	-7.125*** (0.915)
Quarter FE	Yes	Yes
N. of obs.	1,485	936
Pseudo R-squared	0.052	0.249

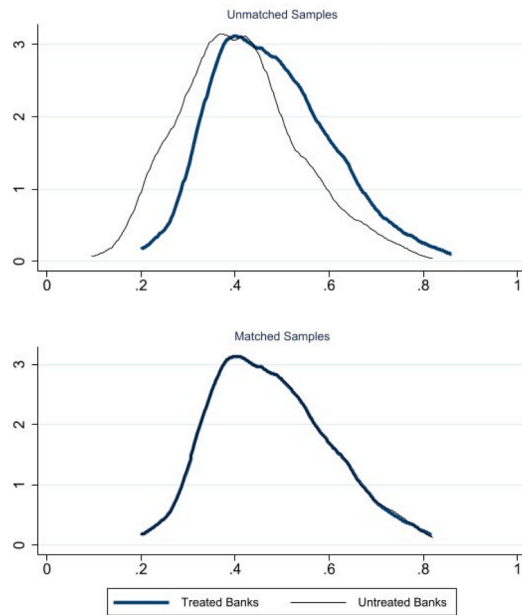
Table A.8

Propensity score matching.

This table presents the results of the propensity score matching analysis conducted on a matched sample of banks from 12 Eurozone countries. The period considered for LTRO programmes spans from 2011Q3 to 2015Q1, while the period considered spans from TLTRO programmes 2014Q2 to 2020Q1. The dependent variable is loans to customers, measured both at the aggregate level (Total loans) and disaggregated by maturity. All control variables considered in the baseline model are included; see Table A.1 in the Appendix for a full description of the variables. All explanatory variables are lagged by one quarter and winsorised at the 1st and 99th percentiles. The superscripts ***, **, and * denote coefficients statistically different from zero at the 1%, 5%, and 10% levels, respectively, in two-tailed tests.

	Coeff.	Std.err.	Z	P> z	[95% conf.	Interval]
D LTROs						
LOG_GL total	0.103	0.015	0.670	0.506	-0.020	0.040
LOG_GL <3months	0.008	0.012	0.640	0.052	-0.016	0.031
LOG_GL 3-12months	0.003	0.008	0.370	0.712	-0.013	0.019
LOG_GL 1-5years	0.021	0.008	2.700	0.007**	0.006	0.037
LOG_GL >5years	0.010	0.006	1.680	0.094**	0.002	0.022
D TLTROs						
LOG_GL total	0.027	0.026	1.050	0.295	0.023	0.077
LOG_GL < 3months	-0.017	0.017	-1.020	0.308	-0.049	0.015
LOG_GL 3-12months	-0.003	0.019	-0.190	0.851	-0.040	0.033
LOG_GL 1-5years	0.004	0.013	0.280	0.780	0.022	0.029
LOG_GL >5years	-0.002	0.008	-0.210	0.837	0.018	0.014

Panel A) LTRO



Panel B) TLTRO

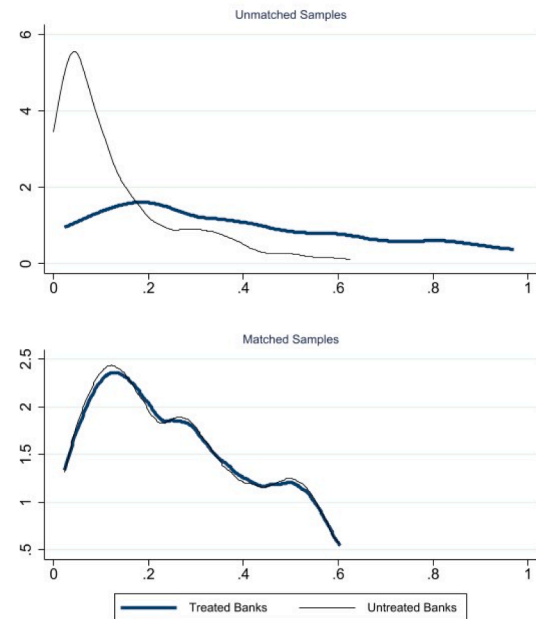


Fig. A.1. Quality of matching procedure.

This figure displays the density plots of the estimated propensity scores for treated and untreated banks, both before and after matching. Panel A corresponds to the LTRO programme, while Panel B refers to the TLTRO programme. In both panels, the distributions of the propensity scores are visibly more aligned after matching, indicating improved covariate balance between the treated and control groups and supporting the validity of the matching procedure.

Data availability

We will share the data and code

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