IS UNCONVENTIONAL MONETARY POLICY MEDIATED BY BANKS' LIQUIDITY AND SOLVENCY RATIOS? EVIDENCE FROM THE EUROPEAN BANKING SECTOR

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Abstract

We try to answer the following research question: *Is unconventional monetary policy (UMP) mediated by European banks' liquidity and solvency ratios?* Starting from micro-prudential tools (unconventional monetary policy), this paper focuses on the micro-prudential perspective and contributes in different ways to the existing literature. First, using supervisory reporting data from European banks (European Central Bank (ECB), Statistical Data Warehouse), provides insights into the UMP (in terms of long term refinancing operation (LTRO)) during the first phase of the COVID-19 pandemic. Second, it empirically investigates the impacts of the LTRO on the liquidity and solvency of European banks, during the $Q_3$2016–$Q_2$2021 period. We argue that the impacts of UMP (in terms of LTRO) are strictly related to banks' solvency and liquidity, thus favouring the stability of the banking system. These results suggest that authorities may want to monitor the bank's capital ratio and the liquidity position of financial institutions, also to better understand the effects of unconventional monetary tools on lending volume. The topic of our paper is scarcely explored by similar studies; therefore, we believe that our work may fill this gap and significantly contribute to enriching the related empirical literature.

Keywords: Unconventional Monetary Policy, Liquidity, Solvency, European Banking System, COVID-19 Pandemic

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1. INTRODUCTION

Since the 2007 international financial crisis, European banks have strengthened their capital position, built up solid liquidity buffers and improved the quality of assets on their balance sheets. The COVID-19 pandemic caused a great shock in the economic and financial sectors around the world: there was a sudden stop in global economic activity and financial markets reacted sharply and violently to the shock.

In particular, in order not to block lending to retail and large corporate clients, central banks have introduced extraordinary measures aimed at injecting abundant liquidity into the financial system, activating a '*whatever it takes*' approach focused on market stabilization. The Federal Reserve (Fed), the Bank of Canada (BoC), the Reserve Bank of Australia (RBA), the Reserve Bank of New Zealand (RBNZ) and the Bank of England (BoE) have launched a range of macroeconomic tools, including unconventional ones, to face the social and economic emergency. Aggressive rate cuts to respective effective lower bounds (ELBs), asset purchase programmes (government/corporate bonds, commercial paper), standing facilities operations, lending support programmes (such as long-term refinancing operation (LTRO), targeted longer-term refinancing operations (TLTRO)), capital requirement flexibilities, such as reductions in the countercyclical capital buffer (CCyB) and other reductions in capital requirements (Basel framework), are the main policy measures that have allowed banks to support economic resilience.

In Europe, the European Central Bank (ECB) has kept key interest rates at historically low levels to ensure that the cost of borrowing remains low and thus facilitates lending. The official interest rates affect the cost of credit: if interest rates are low, theoretically it is easier for businesses to borrow funds, and this should support spending and investments.

Some central banks, such as the Fed, the BoC and the BoE, initially focused on buying government (and, in the case of the Fed, government agency) securities, with the main objective of alleviating dealers' balance sheet risk limits and easing market dislocations. In some cases, central banks have provided such credit through asset purchases, including purchases of commercial paper and corporate bonds (e.g., the ECB has purchased different types of assets). In addition, some central banks have purchased participation in loans originated by eligible lenders (e.g., the Fed's Main Street Lending Program) or have extended loans in foreign currency (e.g., the Riksbank and the Bank of Japan).

The 1,850-billion-euro Pandemic Emergency Purchase Programme (PEPP) aims to reduce financing costs and increase credit in the euro area. This programme complements the Asset Purchase Programmes that the ECB has adopted since 2014 (English, Forbes, & Ubide, 2021). When central banks aggressively intervened to stabilise markets in the spring of 2020, they quickly expanded the types of assets they were willing to purchase and the markets they were willing to support through liquidity and credit schemes. In this perspective, many central banks have gone beyond their role as "lenders of last resort" to become "buyers of last resort".

At the same time, central banks have activated credit support programmes already in the first phase of the pandemic crisis. In general, liquidity provision and credit support programmes, often implemented in conjunction with government policies, aim to support the bank's lending activity, to ensure that viable firms could survive the crisis and can ramp up production and support employment once the crisis has subsided. Many of these programmes are aimed at stimulating bank lending because it represents the main mitigation instrument in case of economic crisis. However, it should also be considered that the size of the lending activity depends not only on the liquidity available to the bank but also on the average riskiness of borrowers and the corresponding mandatory capital requirements.

In the Euro area, LTRO and TLTRO are fundamental operations in support of small and medium-sized enterprises, which account for around two-thirds of employment in the euro area, as due to their size they cannot have direct access to the capital market. However, the extent of the support is filtered by the Basel framework requirement (for credit risk, capital ratio, liquidity ratio) and by the bank's solvency and liquidity position.

Within the euro area, the conditions of the TLTRO III were revised in March 2020. The maximum amount obtainable through TLTRO III has been increased and the cost has been reduced to -1% for those banks that increase the loans granted, between June 2020 and June 2021, beyond a certain reference level. Furthermore, banks that reach certain (eligible) loan values granted, through complex calculation mechanisms, will be able to take advantage of possible reductions in interest rates.

The different responses of the ECB to COVID-19 were crucial in stabilizing economies and financial markets when countries were locked down. However, they raise numerous questions about monetary policy and the role of central banks in the future, also concerning the stability of the banking sector (Bartsch, Benassy-Quere, Corsetti, & Debrun, 2020; Bergant & Forbes, 2021; Bernanke, 2020). The ECB's responses are aimed at addressing three challenges: 1) stabilizing financial markets; 2) protecting the credit supply; and (counteracting the adverse impact of the pandemic on the expected inflation path. The credit supply was supported by the third series of targeted longer-term refinancing operations (the TLTRO III programme) and through high flexibility in the credit risk Basel framework.

In particular, in order not to worsen the mandatory capital requirements for banks too much and allow unconventional monetary policy (UMP) to flow and adequately support the real economy, the European Banking Authority (EBA) supports the measures taken and proposed by the national governments and EU bodies to address and mitigate the adverse systemic economic impact of COVID-19 on the EU banking sector (EBA, n.d).

Starting from macroprudential tools (unconventional monetary policy), this paper focuses on the micro-prudential perspective and contributes in different ways to the existing literature. First, using supervisory reporting data from European banks (ECB, Statistical Data Warehouse), provides insights into the UMP (in terms of LTRO) during the first phase of the COVID-19 pandemic. Second, it empirically investigates the impacts of the LTRO on the liquidity and solvency of European banks, during the $Q_3$2016–$Q_2$2021 period. In detail, we try to answer our research question, which is the following:

RQ1: Is UMP mediated by European banks' liquidity and solvency ratios?

The remainder of the paper is organized as follows. Section 2 presents the literature review on the impact of monetary policy on bank liquidity and solvency. Section 3 includes the models and data sources used, while Section 4 shows the empirical findings. In Section 5, we summarize the paper and propose some conclusions.

2. LITERATURE REVIEW

Monetary policies, conventional and unconventional, have played a crucial role in addressing weak macroeconomic performance and in supporting financial institutions, especially banks. It should be considered that these measures provide banks with abundant liquidity from the monetary authorities and lead to a reduction in the cost of debt, with positive consequences respectively for bank funding and the creditworthiness of borrowers, thus supporting bank capital, as well as the reduction of non-performing loans and the degree of loan-loss provisioning.

The liquidity and solvency of banks have been extensively analysed in the literature, especially concerning regulatory aspects. Here are some of the more recent works on the latter topic.

Theoretically, van den End and Kruidhof (2013) try to simulate the systemic implications of the liquidity coverage ratio (LCR) using a liquidity stress-testing model. Again, concerning bank liquidity, Roberts, Sarkar, and Shachar (2018) examine the creation of liquidity per unit of assets by banks subject to the LCR using the liquidity measures Liquidity Mismatch Index (LMI) (Bai, Krishnamurthy, & Weymuller, 2018) and BB measure (Berger & Bouwman, 2009). They find evidence of reduced liquidity creation by LCR banks compared to non-LCR banks. In particular, the authors argue that the reduction in liquidity creation occurs mainly on the asset side of the balance sheet, as there are more holdings of liquid assets and fewer holdings of illiquid assets by LCR banks. Similarly, Banerjee and Mio (2018) use the UK individual liquidity guidance (ILG) ratio to estimate the average treatment effect of tighter liquidity regulation on banks' balance sheets, finding that banks subject to the ILG have not adjusted the size of their balance sheets to meet tighter liquidity regulation, but have rather changed the composition of their assets and liabilities.

Part of the recent literature analyses the impact of liquidity regulation on bank performance and capital adequacy. Mashamba (2018) shows that the Basel III liquidity regulation, and in particular the LCR requirement, has positive effects on banks' profitability in emerging economies. The author's plausible explanation for this evidence is that banks manage their liquidity in a manner consistent with the LCR rule. Keqa (2021) argues that liquidity has statistically significant positive effects in determining the capital adequacy ratio of 103 commercial banks operating in the Western Balkan countries for the period between 2010 and 2018.

Other authors investigate the relationship between bank liquidity and solvency. On a theoretical level, Adrian and Boyarchenko (2018) study the welfare implications of liquidity and capital regulations, arguing that liquidity requirements are a preferable prudential policy tool over capital requirements, as tightening liquidity requirements reduces the likelihood of systemic distress without compromising consumption. Distinguin, Roulet, and Tarazi (2013) considering publicly traded banks in the US and Europe find empirical evidence that banks reduce their regulatory capital when they create more liquidity or when they face greater illiquidity as defined by the Basel III regulation. More recently, de Bandt, Lecarpentier, and Pouvelle (2021), analysing a large sample of French banks from 1993–2015, show that in times of crisis, banks tend to reduce the liquidity coefficient. However, while finding that the solvency ratio has a weakly significant effect on the liquidity ratio, their results do not allow to establish a causal relationship between the two variables.

Some authors, on the other hand, focus on the effects of monetary policy on the creation of bank liquidity. Berger and Bouwman (2017) show that, during normal times, monetary policy does not seem to have a significant impact on bank liquidity creation. The effects of monetary policy appear to be even weaker during financial crises. In addition, they find that high liquidity creation tends to be followed by financial crises. More recently, Kapoor and Peia (2021) study the effects of the US Federal Reserve's large-scale asset purchase programmes over the period 2008–2014 on bank liquidity creation. They find a strong effect on liquidity creation during the third round of quantitative easing (QE), showing a weaker impact on the real economy during the first two rounds, when the more exposed banks transformed the reserves created through the QE into less illiquid assets, such as real estate mortgages. Lastly, Dang and Huynh (2022), using a panel of Vietnamese banks from 2007–2019, show that banks may expand liquidity creation more aggressively as a result of official interest rate cuts or as a result of money injection into the market by the central bank. However, not all banks appear to respond equally to changes in monetary policy.

With reference, however, to the specific topic addressed in this paper, according to our knowledge, the empirical literature analysing the effects of UMP on banks' liquidity and solvency ratios is scarce. Hoerova, Mendicino, Nikolov, Schepens, and Van den Heuvel (2018) investigate whether liquidity and capital ratios contributed to the stability of European banks during the financial crisis, others analyse the role of central bank liquidity. They find that liquidity tools are beneficial, even though they cannot eliminate the need for central bank liquidity. Indeed, full compliance with the LCR and net stable funding ratio (NSFR) rules would have reduced banks' reliance on central bank liquidity during the financial crisis without eliminating this assistance.

Therefore, considering that the topic of our paper is poorly explored by similar studies, we believe that our work may bridge this gap and contribute to enriching the related empirical literature.

3. RESEARCH METHODOLOGY

To study the relationship between UMP and banks' liquidity and solvency position during the $Q_3$2016–$Q_2$2021 period, we use an empirical model to investigate the impact of the UMP on banks' liquidity and solvency measures. The dataset is built using EBA Risk Dashboard (for liquidity and solvency ratios) and ECB Statistical Data Warehouse (for data on LTRO) as data sources. The specifications for our panel data regression models are explained below.

3.1. Model specifications

To investigate the relationship between UMP and liquidity risk, we performed the dynamic panel data model given by the following equation. We consider the LTRO as UMP.

$$Liq_{i,t} = \beta_0 + \beta_1 LTRO_t + \beta_2 LTRO_{t-1} + \beta_3 LTRO_{t-2} + u_{i,t} \quad (1)$$

with:

- i = 1, ..., 5;
- t = $Q_3$2016, …, $Q_2$2021;

where:

- i is the cross-section unit (bank);
- t is the quarters;
- β_0 is the intercept;
- β_1, β_2, and β_3 are the coefficient associated with the monetary variable at a time 't', at a time 't - 1' and at a time 't - 2';
- $u_{i,t}$ is the error term or specific disturbance of the i-th unit at a time 't';
- $Liq_{i,t}$ is the bank liquidity measured by $FND\_32_{i,t}$, $FND\_33_{i,t}$ and $LIQ\_17_{i,t}$ of the i-th unit at a time 't';
- $FND\_32_{i,t}$ is the Total loans and advances to non-financial corporations and households / Total deposits to non-financial corporations and households of the i-th unit at a time 't';
- $FND\_33_{i,t}$ is the Total encumbered assets and collateral / Total assets and collateral of the i-th unit at a time 't';
- $LIQ\_17_{i,t}$ is the Liquidity buffer / Net liquidity outflow of the i-th unit at a time 't';
- $LTRO_t$ is the growth rate of the volume of the longer-term refinancing operations at a time 't';
- $LTRO_{t-1}$ is the growth rate of the volume of the longer-term refinancing operations at a time 't - 1';
- $LTRO_{t-2}$ is the growth rate of the volume of the longer-term refinancing operations at a time 't - 2'.

In this model, $Liq_{i,t}$ is the transition variable. We use three variables to measure the bank's liquidity position: the *loan to deposit ratio* (Total loans and advances to non-financial corporations and households / Total deposits to non-financial corporations and households); the *asset encumbrance ratio* (Total encumbered assets and collateral / Total assets and collateral); the *short term liquidity ratio* (Liquidity buffer / Net liquidity outflow).

The *loan to deposit ratio* (*LDR*) is used to evaluate how the bank finances loans and is calculated by comparing a bank's total loans to its total deposits for the same period. If the ratio is less than one, the bank relies on its deposits to lend to its clients, without any external debt. On the other hand, if the ratio is greater than one, the bank has borrowed money that it has refinanced at higher rates, rather than relying entirely on its deposits. The *LDR* is a metric used to express the bank's liquidity position. It is evident that it represents a good representation of the financial intermediation formula: it expresses the funding tool of the lending activity (retail or wholesale funding).

The *asset encumbrance ratio* defines short-term liquidity risks. From a micro-prudential point of view, the lack of unencumbered assets means that a financial institution may have greater difficulties in obtaining funding, especially in times of financial distress, as too few assets (eligible collateral) remain available to obtain secured funding (lending of last resort), while unsecured funding may become too expensive or unavailable. In this perspective, the lack of unencumbered assets ultimately impacts the magnitude of the lending activity. From a macroprudential perspective, a banking system with a high level of encumbrance may be more sensitive to financial shocks, which can increase haircuts on collateral value. Gorton and Metrick (2012) identify drops in collateral values and increased haircuts — at the basis of the "run on repos" — as a trigger event of the global financial crisis. The reserve of high-quality unencumbered assets is needed to raise liquidity in times of financial distress. Therefore, banks with few high-quality assets are forced to keep them unencumbered. When financial institutions can no longer increase the level of encumbrance to sustain their funding need, they may be forced to sell their assets (liquidity buffer), thereby exacerbating the crisis.

The LTRO lag variables make it possible to verify the existence of the effect of monetary policy on liquidity variables after one or two quarters.

All variable definitions are provided in Table 1.

The econometric model used to measure the effects of the UMP variable on banks' solvency is as follows:

$$Sol_{i,t} = \beta_0 + \beta_1 LTRO_t + \beta_2 LTRO_{t-1} + \beta_3 LTRO_{t-2} + u_{i,t} \quad (2)$$

with:

- i = 1, ..., 5;
- t = $Q_3$2016, …, $Q_2$2021;

where:

- i is the cross-section unit (bank);
- t is the quarters;
- β_0 is the intercept;
- β_1, β_2, and β_3 are the coefficient associated with the monetary variable at a time 't', at a time 't - 1' and at a time 't - 2';
- $u_{i,t}$ is the error term or specific disturbance of the i-th unit at a time 't';
- $Sol_{i,t}$ is the bank solvency measured by $SVC\_1_{i,t}$, $SVC\_2_{i,t}$, $SVC\_3_{i,t}$, $SVC\_29_{i,t}$, $SVC\_13_{i,t}$, and $SVC\_12_{i,t}$ of the i-th unit at time 't';
- $SVC\_1_{i,t}$ is the Tier 1 capital / Total risk exposure amount of the i-th unit at a time 't';
- $SVC\_2_{i,t}$ is the Own funds / Total risk exposure amount of the i-th unit at a time 't';
- $SVC\_3_{i,t}$ is the Common equity Tier 1 capital / Total risk exposure amount of the i-th unit at a time 't';
- $SVC\_29_{i,t}$ is the Common equity Tier 1 capital / Total risk exposure amount with both, numerator and denominator, being adjusted for transitional effects of the i-th unit at a time 't';
- $SVC\_13_{i,t}$ is the Tier 1 capital — transitional definition / Total leverage ratio exposure — using

a transitional definition of Tier 1 capital of the *i*-th unit at a time '*t*';

- $SVC\_12_{i,t}$ is the Tier 1 capital — fully phased-in definition / Total leverage ratio exposure — using a fully phased-in definition of Tier 1 capital of the *i*-th unit at a time '*t*';
- $LTRO_t$ is the growth rate of the volume of the longer-term refinancing operations at a time '*t*';
- $LTRO_{t-1}$ is the growth rate of the volume of the longer-term refinancing operations at a time 't - 1';
- $LTRO_{t-2}$ is the growth rate of the volume of the longer-term refinancing operations at a time 't - 2'.

The bank's solvency is usually measured by a set of capital ratios defined in the Basel framework in terms of *total risk exposure amount* (TREA) and *leverage ratio*. As known, TREA represents the total risk-weighted exposure amount for the credit risk, the counterparty credit risk and (multiplied by 12.5) the own funds' requirements for the Pillar I Risk (credit risk, market risk, operational risk). It is a regulatory indicator that expresses the size of the overall risk on the bank's balance sheet. The *leverage ratio* is a non-risk-based Basel requirement used to capture the amount of debt the bank has relative to its capital, specifically Tier 1 capital.

Table 1. Variable definitions

Variable type	***Variable name***	***Variable name extended***	***Description***
Unconventional monetary policy	*LTRO*	Longer-term refinancing operations	The growth rates of the volume of longer-term refinancing operations
Solvency	*SVC_1*	Tier 1 capital ratio	Tier 1 capital / Total risk exposure amount
	SVC_2	Total capital ratio	Own funds / Total risk exposure amount
	SVC_3	CET 1 capital ratio	Common equity Tier 1 capital / Total risk exposure amount
	SVC_29	CET 1 ratio (fully loaded)	Common equity Tier 1 capital / Total risk exposure amount (with both numerator and denominator being adjusted for transitional effects)
	SVC_13	Leverage ratio	Tier 1 capital — transitional definition / Total leverage ratio exposure — using a transitional definition of Tier 1 capital
	SVC_12	Leverage ratio (fully phased-in definition of Tier 1)	Tier 1 capital — fully phased-in definition / Total leverage ratio exposure — using a fully phased-in definition of Tier 1 capital
Funding and liquidity	*FND_32*	Loans and advances-to-deposits ratio for households and non-financial corporations	Total loans and advances to non-financial corporations and households / Total deposits to non-financial corporations and households
	FND_33	Asset encumbrance ratio	Total encumbered assets and collateral / Total assets and collateral *
	LIQ_17	Liquidity coverage ratio	Liquidity buffer / Net liquidity outflow

*Note: * Encumbered assets (recognised on the balance sheet) are considered at their carrying value, and collateral received is considered at fair value.*
The variable name, the variable name extended, and the description of the banks' solvency, funding and liquidity are the same as those used by the European Banking Authority in the EBA Risk Dashboard (www.eba.europa.eu/risk-analysis-and-data/risk-dashboard).
Source: Authors' elaboration.

3.2. Sample and data sources

The paper focuses on the period $Q_3$2016–$Q_2$2021, analysing the impact of the UMP (in terms of LTRO) adopted by the Euro system on banks' liquidity and solvency.

The liquidity and solvency variables come from the EBA Risk Dashboard[1], which summarises the main risks and vulnerabilities in the EU banking sector by examining the evolution of risk indicators in a sample of EU banks.

The time series of bank loans and LTRO, Euro area (changing composition) counterpart (millions of euros), is obtained from ECB's Statistical Data Warehouse. The analysis is from $Q_3$2016 since the first available data on LTRO date back to June 2016.

Statistical analysis of the data divides the full period into two sub-periods to understand if there was an impact caused by COVID-19. The period before the shock caused by COVID-19 (which begins with the launch date of the LTRO and ends with the first quarter of 2020) and the period of COVID-19, which begins in the second quarter of 2020.

Monthly Euro system data refer to the averages of daily positions over the corresponding maintenance periods.

Considering that the EBA Risk Dashboard data are quarterly, to make the data of the variables homogeneous, the monthly data of the LTRO have been translated into quarterly data considering the average data.

The dataset includes the top five-euro area countries in the $Q_3$2016–$Q_2$2021 period, in terms of LTRO amount (France, Germany, Italy, the Netherlands, Spain). This sample represents 86.51% (on average for the whole period) of the total amount of the LTRO.

Consequently, the observations of the full period were 100 for each variable, those of the pre-COVID-19 period was 75 and those of the COVID-19 period were 25.

Table 2 reports the descriptive statistics of the variables used in the estimation, concerning the entire period analysed. The sample of the analysis is a balanced panel. In fact, for the five countries considered, in the analysis period there are no omitted observations, as can be seen in Table 2 (bottom).

For each variable, Table 2 reports the descriptive statistics of the UMP variable, the liquidity variables and the solvency variables. The main descriptive statistics are the following: mean, median, range, measures of central tendency and some selected percentiles describing the frequency distribution of the data. Standard

[1] EBA Risk Dashboard website: www.eba.europa.eu/risk-analysis-and-data/-risk-dashboard.

deviation, coefficient of variation, skewness and kurtosis are available for each variable.

The data structure shows a substantially symmetrical distribution (the skewness indicator is close to zero) except for the *LTRO*, which shows a positive asymmetry (skewness equal to 4.9789) with a longer right tail.

As regards the size of the tails, the excess kurtosis indicator equal to kurtosis minus 3 was considered.

The *LTRO* variable shows a departure from the distributive normality, showing a greater elongation (leptokurtic distribution). The excess kurtosis indicator is approximately 30.47.

The correlation matrices between all the variables considered in the three periods analysed (Tables 3, 4 and 5) provide interesting information that will be further investigated in the subsequent statistical analysis.

Indeed, while the correlation matrices of the full period and the pre-COVID-19 period do not seem to show significant correlations between the *LTRO* variable and the banks' solvency and liquidity variables, the correlation matrix of the COVID-19 period shows a significant and negative correlation between the *LTRO* variable and the *LIQ_17*, *SVC_12* and *SVC_13* variables, and a positive correlation with the *FND_32* variable. This latest information suggests insights that were developed using the following linear regression analysis.

Table 2. Descriptive statistics — Full period ($Q_3$2016–$Q_2$2021)

Variable	***Mean***	***Median***	***Minimum***	***Maximum***
LTRO	0.0402	0.0000	-0.0422	0.9018
FND_32	1.1884	1.1721	0.9402	1.4546
FND_33	0.2631	0.2655	0.1495	0.3647
LIQ_17	1.5311	1.5313	1.2317	2.0534
SVC_1	0.1561	0.1550	0.1110	0.1923
SVC_12	0.0505	0.0506	0.0386	0.0631
SVC_13	0.0526	0.0518	0.0424	0.0657
SVC_2	0.1841	0.1806	0.1370	0.2335
SVC_29	0.1394	0.1422	0.0987	0.1722
SVC_3	0.1427	0.1436	0.1042	0.1723
Variable	***Std. dev.***	***C.V.***	***Skewness***	***Ex. kurtosis***
LTRO	0.1164	2.8925	4.9789	30.468
FND_32	0.1047	0.0881	0.1175	-0.3558
FND_33	0.0505	0.1918	-0.5937	-0.3044
LIQ_17	0.1923	0.1256	0.7910	0.2977
SVC_1	0.0193	0.1237	-0.0032	-0.8125
SVC_12	0.0049	0.0981	0.0136	-0.6536
SVC_13	0.0052	0.0998	0.2573	-0.8384
SVC_2	0.0259	0.1404	0.3893	-0.7517
SVC_29	0.0184	0.1317	-0.2366	-1.0446
SVC_3	0.0162	0.1136	-0.2243	-0.9583
Variable	***5% perc.***	***95% perc.***	***IQ range***	***Missing obs.***
LTRO	-0.0262	0.2143	0.0370	0
FND_32	1.0326	1.3554	0.1488	0
FND_33	0.1659	0.3311	0.0635	0
LIQ_17	1.2762	1.9475	0.2622	0
SVC_1	0.1259	0.1884	0.0278	0
SVC_12	0.0431	0.0582	0.0085	0
SVC_13	0.0453	0.0611	0.0082	0
SVC_2	0.1485	0.2319	0.0315	0
SVC_29	0.1108	0.1658	0.0320	0
SVC_3	0.1168	0.1661	0.0272	0

Note: Variables are defined as follows: longer-term refinancing operations (LTRO), loans and advances-to-deposits ratio for households and non-financial corporations (FND_32), asset encumbrance ratio (FND_33), liquidity coverage ratio (LIQ_17), Tier 1 capital ratio (SVC_1), leverage ratio (fully phased-in definition of Tier 1) (SVC_12), leverage ratio (SVC_13), total capital ratio (SVC_2), CET 1 ratio (fully loaded) (SVC_29), CET 1 capital ratio (SVC_3).
Source: Authors' calculations.

Table 3. Correlation matrix over the full period ($Q_3$2016–$Q_2$2021)

	LTRO	***FND_32***	***FND_33***	***LIQ_17***	***SVC_1***
LTRO	1.0000	0.0333	-0.0188	0.0056	0.1639
FND_32		1.0000	0.0039	-0.5088	0.1538
FND_33			1.0000	0.4470	-0.3722
LIQ_17				1.0000	-0.1980
SVC_1					1.0000
	SVC_12	***SVC_13***	***SVC_2***	***SVC_29***	***SVC_3***
LTRO	-0.2024	-0.2263	0.1757	0.1605	0.1553
FND_32	-0.7344	-0.6871	0.2234	0.2021	0.1684
FND_33	0.3569	0.3648	-0.4991	-0.2608	-0.2361
LIQ_17	0.6530	0.6600	-0.2912	-0.2461	-0.1934
SVC_1	-0.3768	-0.4240	0.9768	0.9728	0.9781
SVC_12	1.0000	0.9688	-0.4798	-0.3951	-0.3378
SVC_13		1.0000	-0.5130	-0.4747	-0.3880
SVC_2			1.0000	0.9338	0.9317
SVC_29				1.0000	0.9830
SVC_3					1.0000

Note: 5% critical value (for two tails) = 0.1966 for n = 100.
Source: Authors' calculations.

Table 4. Correlation matrix over the pre-COVID-19 period ($Q_3$2016–$Q_1$2020)

	LTRO	*FND_32*	*FND_33*	*LIQ_17*	*SVC_1*
LTRO	1.0000	0.1178	-0.0249	-0.1153	0.0536
FND_32		1.0000	0.1234	-0.0773	0.4224
FND_33			1.0000	0.5869	-0.5467
LIQ_17				1.0000	-0.5619
SVC_1					1.0000
	SVC_12	***SVC_13***	***SVC_2***	***SVC_29***	***SVC_3***
LTRO	-0.2225	-0.2052	0.0918	0.0530	0.0483
FND_32	-0.6858	-0.6211	0.4264	0.4455	0.4650
FND_33	0.3470	0.3766	-0.6433	-0.4263	-0.4115
LIQ_17	0.5604	0.6040	-0.5943	-0.5598	-0.5439
SVC_1	-0.7002	-0.7147	0.9787	0.9744	0.9768
SVC_12	1.0000	0.9676	-0.7415	-0.6957	-0.6741
SVC_13		1.0000	-0.7441	-0.7435	-0.6876
SVC_2			1.0000	0.9325	0.9324
SVC_29				1.0000	0.9819
SVC_3					1.0000

Note: 5% critical value (two-tailed) = 0.2272 for n = 75.
Source: Authors' calculations.

Table 5. Correlation matrix over the COVID-19 period ($Q_2$2020–$Q_2$2021)

	LTRO	*FND_32*	*FND_33*	*LIQ_17*	*SVC_1*
LTRO	1.0000	0.1178	-0.0249	-0.1153	0.0536
FND_32		1.0000	0.1234	-0.0773	0.4224
FND_33			1.0000	0.5869	-0.5467
LIQ_17				1.0000	-0.5619
SVC_1					1.0000
	SVC_12	***SVC_13***	***SVC_2***	***SVC_29***	***SVC_3***
LTRO	-0.2225	-0.2052	0.0918	0.0530	0.0483
FND_32	-0.6858	-0.6211	0.4264	0.4455	0.4650
FND_33	0.3470	0.3766	-0.6433	-0.4263	-0.4115
LIQ_17	0.5604	0.6040	-0.5943	-0.5598	-0.5439
SVC_1	-0.7002	-0.7147	0.9787	0.9744	0.9768
SVC_12	1.0000	0.9676	-0.7415	-0.6957	-0.6741
SVC_13		1.0000	-0.7441	-0.7435	-0.6876
SVC_2			1.0000	0.9325	0.9324
SVC_29				1.0000	0.9819
SVC_3					1.0000

Note: 5% critical value (two-tailed) = 0.3961 for n = 25.
Source: Authors' calculations.

4. RESULTS AND DISCUSSION

This section focuses on the empirical results to understand the effects of UMP on banks' liquidity and solvency, which are vital factors in preventing financial crises and, therefore, for financial stability. Table 6 presents the output of the *LTRO* regressions on three bank liquidity variables.

In columns A we perform *LTRO* regressions with two lags on the bank liquidity measures *FND_32*, *FND_33* and *LIQ_17* for the entire period. Regression of *LTRO* on *LIQ_17* shows that the coefficient of *LTRO_2* is positive and statistically significant at the 10% level. This finding suggests that banks' LCR increases in response to the *LTRO* measure with a time lag of two (two quarters). The regressions of the pre-COVID-19 and COVID-19 subperiods, indicated in columns B and C, show a relevant impact of the *LTRO_1* variable on the *FND_33* variable. This means that the *LTRO* variable expects an increase:

- related especially to *high-quality liquidity assets* also about the fact that the greater liquidity available (in the presence of UMP) allows banks to purchase additional government bonds (which financed government manoeuvrers for the COVID-19 crisis in many European countries) which, as is well known, represents an important part of the LCR denominator;
- in the *asset encumbrance ratio*, thus providing information to the public and creditors of an increase in the bank's ability to use guaranteed funds to remain liquid even in case of a contingency cash flow back up.

In this perspective, we can underline that the *LTRO* tool has a positive impact on funding and liquidity measures to promote the monetary and financial balance of banking intermediaries, with the awareness that the proper functioning of the banking system is one of the *sines qua non-drivers* for a smooth reallocation of resources between sectors and firms, ensuring that the transmission of monetary policy remains effective. However, the magnitude of the impact depends on the dimension of the liquidity ratio analysed.

The liquidity position is not the only driver, other elements must be taken into consideration: the solvency of the banks and the ability of the credit risk Basel framework not to create entry barriers (relating to lending activity) that are excessively pro-cyclical during the COVID-19 crisis. In this sense, the European Regulators have deemed it appropriate to introduce areas of regulatory flexibility, to address and mitigate the adverse systemic economic impact of COVID-19 on the EU banking sector, to mitigate credit risk and therefore support lending to the real economy. The EBA has extended the deadline for the application of its guidelines on payment moratoria (EBA/GL/2020/02, Guidelines on moratoria), to avoid the automatic classification of loans as unlikely to pay or non-performing loans (NPLs), by sterilizing the capital requirements pro-tempore (especially for credit risk), improving the solvency of banks and, therefore, the possibility of granting new credit. In this perspective, in our theoretical approach, the UMP, intermediated by the Basel framework flexibility, could be positively correlated with the solvency of banks. With the subsequent analysis, we try to test our hypothesis.

Table 6. Impact of *LTRO* on bank liquidity

	FND_32			*FND_33*			*LIQ_17*		
	(A)	*(B)*	*(C)*	*(A)*	*(B)*	*(C)*	*(A)*	*(B)*	*(C)*
Constant	1.1825*** (0.0414)	1.2046*** (0.0391)	0.9880*** (0.0435)	0.2645*** (0.0221)	0.2260*** (0.0238)	0.2384*** (0.0169)	1.5322*** (0.0697)	1.4775*** (0.0590)	1.9418*** (0.1067)
LTRO	0.0165 (0.0448)	0.0552 (0.1381)	1.5372 (1.1654)	−0.0035 (0.0235)	0.0114 (0.0157)	0.9506 (0.4656)	0.0071 (0.0629)	−0.1746 (0.1163)	−2.9160 (2.0569)
LTRO_1	−0.0421 (0.0248)	0.1957 (0.1384)	1.0210 (1.1466)	0.0026 (0.0209)	−0.1314* (0.0612)	0.9869* (0.4276)	0.1618 (0.0918)	0.0036 (0.2668)	−1.9304 (2.1524)
LTRO_2	−0.0448 (0.0386)	0.2562 (0.1536)	0.1285 0.0962	0.0029 (0.0271)	−0.0770 (0.0697)	−0.0583 (0.0368)	0.1457* (0.0619)	−0.2848 (0.2810)	−0.2554 (0.1830)
R^2	0.0068	0.0493	0.2442	0.0002	0.0285	0.3152	0.0215	0.0164	0.2240
Adjusted R^2	-0.0279	0.0026	0.0381	-0.0347	-0.0193	0.1284	-0.0127	-0.0320	0.0124
No. obs.	90	65	15	90	65	15	90	65	15

*Note: The regressions allow for three period: (A) $Q_3$2016–$Q_2$2021 (full period), (B) $Q_3$2016–$Q_1$2020 (pre-COVID-19 period), (C) $Q_2$2020–$Q_2$2021(COVID-19 period). The standard errors used in calculating significance levels are clustered at the bank organization level and are shown in parentheses. ***, **, and * indicate 1%, 5%, and 10% significance, respectively.*
Source: Authors' calculations.

Concerning the statistical analysis of the impact of the UMP variable on the solvency of EU banks, Table 7 shows interesting levels of significance of the variables *SVC_1*, *SVC_2* and *SVC_3*. We, therefore, find a significant statistical relationship between the UMP variable and the ratios that represent the bank's solvency (Tier 1 capital ratio, total capital ratio, and CET ratio). Over the entire analysis period, the regression results reported in columns A show an impact of *LTRO* with one- and two-lag times on all three bank solvency variables with a significance level of 5% and a significance level of 10% on the variables *SVC_1* and *SVC_2* without quarterly time lag. The UMP variable seems to be moderately and positively correlated with the bank's capital ratio and therefore with solvency. As is well known, bank capital adequacy is largely explained by the bank's credit risk (and therefore by the lending activity) but is also related to other risks (market, operational, counterparty, and other Pillar 2 risks (country risk, interest rate risk of the banking book, residual risk, strategic risk, reputational risk, misconduct risk, compliance risk, etc.)). This means that, although the areas of regulatory flexibility on credit risk have allowed pro tempore to contain this and the related capital requirements, the COVID-19 crisis has nevertheless impacted the bank's overall own funds.

It is interesting to note how the significance of the impact of *LTRO* on dependent variables changes if we examine the data of the two subperiods examined. In fact, in the pre-COVID-19 period, the regression coefficients indicated in columns B do not show significance except for the variable *SVC_2* which has a significant level of only 10%.

The COVID-19 period, as indicated by the coefficients of the columns C, confirms the impact of the UMP variable with two lags on the *SVC_1* variable, the impact on the *SVC_1* variable with a higher level of significance, and the impact on the *SVC_3* variable with a level of significantly lower than that of the entire period. From this perspective, the bank's capital adequacy (solvency) appears to be positively correlated with the UMP variable included in the analysis. However, in our view, this is a pro-tempore effect linked to the end of regulatory flexibility.

Table 7. Impact of *LTRO* on bank solvency (*SVC_1*, *SVC_2*, *SVC_3*)

	SVC_1			*SVC_2*			*SVC_3*		
	(A)	*(B)*	*(C)*	*(A)*	*(B)*	*(C)*	*(A)*	*(B)*	*(C)*
Constant	0.1538*** (0.0085)	0.1528*** (0.0092)	0.1482*** (0.0145)	0.1804*** (0.0117)	0.1794*** (0.0124)	0.1697*** (0.0163)	0.1406*** (0.0074)	0.1396*** (0.0078)	0.1329*** (0.0149)
LTRO	0.0232* (0.0106)	0.0054 (0.0162)	0.3301 (0.2156)	0.0331* (0.0144)	0.0182 0.0214	0.4166 (0.2490)	0.0191 (0.0099)	0.0055 (0.0170)	0.3506 (0.2145)
LTRO_1	0.0261** (0.0078)	0.0155 (0.0231)	0.2860 (0.1746)	0.0356** (0.0111)	0.0564 (0.0360)	0.3386 (0.1986)	0.0224** (0.0071)	0.0071 (0.0183)	0.3068 (0.1771)
LTRO_2	0.0365** (0.0118)	0.0518 (0.0297)	0.0181** (0.0047)	0.0477** (0.0147)	0.0970* (0.0449)	0.0292*** (0.0046)	0.0325** (0.0115)	0.0491 (0.0314)	0.0132* (0.0061)
R^2	0.1213	0.0244	0.3723	0.1219	0.0601	0.4055	0.1242	0.0276	0.4053
Adjusted R^2	0.0907	-0.0236	0.2011	0.0913	0.0138	0.2433	0.0936	-0.0203	0.2431
No. obs.	90	65	15	90	65	15	90	65	15

*Note: The regressions allow for three period: (A) $Q_3$2016–$Q_2$2021 (full period), (B) $Q_3$2016–$Q_1$2020 (pre-COVID-19 period), (C) $Q_2$2020–$Q_2$2021(COVID-19 period). The standard errors used in calculating significance levels are clustered at the bank organization level and are shown in parentheses. ***, **, and * indicate 1%, 5%, and 10% significance, respectively.*
Source: Authors' calculations.

The regressions shown in Table 8 also indicate the existence of a significant impact of the UMP variable on the other bank solvency variables analysed (*SVC_29*, *SVC_13* and *SVC_12*) over the entire period (columns A). The positive impact of the UMP variable on the leverage ratio is because they increase the total asset (liquidity buffer) and make it possible to increase the total loans. In this way, the UMP variable stabilizes the numerator of the leverage ratio and increases its denominator.

However, the analysis of the data in the subperiods provides indications of the impact of *LTRO* on these solvency variables which have a different relevance between the COVID-19 period (columns C) and the previous one (columns B).

These solvency variables were affected by *LTRO* with two lags in the COVID-19 period, although the *SVC_13* variable was also affected by *LTRO* in the same quarter.

In the pre-COVID-19 period (columns B), there was no impact of the UMP variable on *SVC_29* on the one hand. On the other hand, a significant effect of the independent variable was recorded both on the *SVC_13* variable and above all on the *SVC_12* variable.

Finally, to test the robustness of the empirical results, we performed several tests. First, we estimated our results by considering the same variables with 3-quarters lag and 4-quarters lag, respectively without any temporal lag. This test allows us to understand that for greater temporal lags the analysis does not have sufficient significance. Second, we analysed alternatively fixed and time-effect regression models following the Hausman test. The results of this test provide no further additional information. Third, we also considered country-specific control variables. This test allowed us to understand the existence of bias for the omitted variables. Fourthly, we considered a specific control of the robustness of the results using alternative liquidity and solvency ratios (e.g., interbank ratio, net loans to total assets, equity to net loans, equity to assets).

Table 8. Impact of *LTRO* on bank solvency (*SVC_29*, *SVC_13*, *SVC_12*)

	SVC_29			*SVC_13*			*SVC_12*		
	(A)	*(B)*	*(C)*	*(A)*	*(B)*	*(C)*	*(A)*	*(B)*	*(C)*
Constant	0.1374*** (0.0087)	0.1366*** (0.0091)	0.1264*** (0.0143)	0.0532*** (0.0023)	0.0523*** (0.0024)	0.0608*** (0.0028)	0.0511*** (0.0020)	0.0502*** (0.0020)	0.0590*** 0.0020
LTRO	0.0225 (0.0115)	0.0097 (0.0193)	0.4109 (0.2054)	−0.0090** (0.0031)	−0.0123* (0.0046)	−0.0848 (0.0457)	−0.0073* (0.0026)	−0.0112** (0.0039)	−0.0635 0.03828
LTRO_1	0.0241** (0.0080)	0.0074 (0.01780)	0.3534 (0.1717)	−0.0037 (0.0025)	−0.0133 (0.0068)	0.0032 (0.0523)	−0.0027 (0.0022)	−0.0165** (0.0055)	0.0134 0.0466
LTRO_2	0.0354* (0.0129)	0.0508 (0.0317)	0.0166* (0.0076)	0.0004 (0.0031)	−0.0140* (0.0059)	−0.0097* (0.0037)	0.0019 (0.0027)	−0.0149* (0.0056)	−0.0086* 0.0035
R^2	0.1196	0.0235	0.4522	0.0580	0.0844	0.2809	0.0461	0.1140	0.3118
Adjusted R^2	0.0889	-0.0246	0.3028	0.0252	0.0394	0.0847	0.0129	0.0704	0.1241
No. obs.	90	65	15	90	65	15	90	65	15

*Note: The regressions allow for three period: (A) $Q_3$2016–$Q_2$2021 (full period), (B) $Q_3$2016–$Q_1$2020 (pre-COVID-19 period), (C) $Q_2$2020–$Q_2$2021(COVID-19 period). The standard errors used in calculating significance levels are clustered at the bank organization level and are shown in parentheses. ***, **, and * indicate 1%, 5%, and 10% significance, respectively.*
Source: Authors' calculations.

5. CONCLUSION

This study aims to examine the effects of UMP (in terms of LTRO) on the liquidity and solvency of European banks, comparing data from the pre-COVID-19 crisis and the COVID-19 crisis period.

First, our empirical results show a positive correlation between the UMP variable and the banks' capital ratio and therefore with solvency. As is well known, the bank's capital adequacy is largely explained by the bank's credit risk (and therefore by the lending activity) but is also related to other risks (market, operational, counterparty, and other Pillar 2 risks). Second, we find a positive impact of the LTRO measure on the LCR and asset encumbrance ratio, suggesting that banks' liquidity tends to increase in response to the LTRO measures and that this liquidity adjustment occurs with a short time lag. In this perspective, we can underline that the LTRO tool has a positive impact on bank funding and liquidity, thus favouring the monetary and financial balance of banking intermediaries, in the awareness that the proper functioning of the banking system is one of the *sines qua non* drivers for a smooth reallocation of resources between sectors and firms, as well as to ensure that monetary policy transmission remains effective. However, the magnitude of the impact depends on the dimension of the liquidity ratio analysed.

The liquidity position is not the only driver. Other elements must be taken into consideration: the solvency of the banks and the ability of the credit risk Basel framework not to create entry barriers (relating to lending activity), which are excessively pro-cyclical in the COVID-19 era. Although the areas of regulatory flexibility on credit risk have *pro tempore* made it possible to contain this and the related capital requirements, the COVID-19 crisis has nevertheless affected the capital solidity banks. These results are robust against alternative econometric specifications. They suggest that authorities may want to monitor the bank's capital ratio and the liquidity position of financial institutions, to better understand the effects of unconventional monetary tools on lending volume. Our findings confirm that monetary policy transmission is also mediated by Basel framework requirements.

Our analysis allows us to underline that the rapid and sizeable reaction of central banks, and in particular the ECB, has been effective in preventing the collapse of the financial market, thus minimizing the negative implications for the real economy. With low-interest rates before the crisis, central banks had to increasingly rely on unconventional measures to stimulate the economy. Credit flows were sustained thanks to the policy-induced easing of financial conditions, combined with prudential support (flexibility on the credit risk framework). This made it possible to increase the banks' liquidity buffer and position, sterilizing the effect of the COVID-19 shock on the credit risk capital requirement, on the capital ratio and therefore on capital adequacy, thus increasing the lending activity.

Looking ahead, achieving inflation targets in a sustainable way, including microeconomic activity related to the bank's solvency and liquidity, is highly desirable to support the economic and financial sector and avoid a systemic crisis.

This research could be considered as a basis for future research, for example, it would be interesting to verify whether the results obtained by analysing the data at an aggregate level can be confirmed using data at the individual bank level.

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