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Funding liquidity regulation, ultra-expansionary monetary policy and European banks' profitability

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ABSTRACT

By reducing the asset-liability maturity mismatch, the Basel III Net Stable Funding Ratio (NSFR) might have a tremendous impact on banks' ability to make profits. We show that the joint effect of the adoption of ultra-expansionary measures of monetary policy and this liquidity requirement can seriously threaten banks' profitability in terms of their net interest margins. Based on a panel dataset of European banks observed over the 2011–2018 years, we find that the level and the dynamics of interest rates affect the relationship between NSFR and banks' profits. The impact of the NSFR is null during the years 2011–2012, when market rates firstly raise and then decline, which suggests that, when rates show a certain volatility, the decrease in the funding cost due to a lower exposure to funding liquidity risk more than offsets the drawback of lower interest earnings. This result does not hold for the years 2013–2018, when interest rates stay close to the zero level and, finally, become negative, but with a much more stable trend. We argue that the higher level of interest rates in the years 2011–2012 gives banks the room to negotiate more profitable conditions with the clientele following the changes in market rates observed during those years. The proximity to the zero level of the interest rates and their stability remove or significantly limit that possibility and can explain the negative impact of the NSFR on banks' net interest margins.

1. Introduction

The maturity mismatch between loans issued to finance long-term investment projects and deposits serving investors' liquidity needs significantly contributes to banks' profitability, when the yield curve is positively sloped, but also makes them exposed to funding liquidity risk (Entrop et al., 2015). During periods of financial turmoil, excessive maturity transformation and inadequate management practices of funding liquidity risk can jeopardize the stability of both individual banks and financial system. To address the funding weaknesses revealed by the global financial crisis (GFC), in 2010 the Basel Committee on Banking Supervision (BCBS) introduced two new quantitative standards: the Liquidity Coverage Ratio (LCR) and the Net Stable Funding Ratio (NSFR). The former ensures banks' ability to withstand liquidity stress in the short term, i.e., over a 30-day horizon, whereas the latter addresses funding

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liquidity risk and aims to increase banks' more stable and longer-term funding, i.e., over a one-year horizon (BCBS, 2010a). The banking industry raised concerns about the potentially adverse impact of these regulatory measures on banks' business models and profitability, which in essence would derive from the constraints they impose on the maturity transformation activity. Banks are expected to experience greater funding costs and/or lower earnings from their investments if they rely on excessive long-term funding and/or hold too liquid assets.

As a response to the GFC, the European Central Bank (ECB) adopted unconventional measures, such as the extremely low, or even negative, interest rates on deposit facility, aiming to increase banks' credit supply to the economy. This impressive monetary policy action has triggered a prolonged scenario of unprecedented low market rates, i.e., a formidable challenge for European banks' profitability (Genay and Podjasek, 2014). The compression in banks' interest margins caused by such a monetary stance might hinder monetary policy transmission itself (Claessens et al., 2018). By potentially posing a prudential limit on the margins from the maturity transformation, the liquidity regulation is expected to modify banks' targets in terms of asset mix and funding structure (Giordana and Schumacher, 2013), and ultimately to affect their ability to make profits (Dietrich et al., 2014). Therefore, we argue that policy makers should consider also the effects on banking activity of the introduction of the NSFR and LCR in assessing how the monetary policy transmission mechanism works under a prolonged scenario of extremely low/negative interest rates. The Basel III liquidity standards and the unprecedented scenario of interest rates have introduced structural changes in financial intermediation, able to reshape banking activity through their impact on profitability. To the best of our knowledge, this paper is the first study aiming to consider jointly their effects.

Estimating the trade-off between liquidity regulation and bank performance is still an important area of research, since both empirical literature on the relationship between maturity transformation and profitability and studies on the evaluation of policies related to banks' maturity mismatch are still very scant (King, 2013; Bologna, 2017; Roulet, 2018). The impact on banks' net interest margin (NIM) and overall profitability of a protracted scenario of extremely low interest rates deserves closer scrutiny as well (Claessens et al., 2018). Most empirical studies find that NIMs decline when interest rates are low because of banks' reluctancy to reduce deposit rates, due to the presence of an effective lower bound, below which depositors have incentives to switch to cash-forms of savings, and because of the opportunity cost to lose depositors to which banks might cross-sell other products. The impact of low interest rates on the overall profitability is not obvious and depends on the potential benefits that banks can exploit in terms of valuation gains on fixed-income securities and reduction in non-performing loans. In this paper, we examine the determinants of banks' NIM and overall profitability, with this latter measured by the Return on Assets (ROA) and Return on Equity (ROE) indices, by focusing on the impact of the NSFR during a period of never experienced before low and negative interest rates. We study the NSFR for two reasons. First, we expect it to foster major changes in banks' business models by forcing them to use longer-term funding sources; second, an estimation of the LCR would require details about the duration and composition of liquid assets and 30-day liabilities that are not provided by standard bank financial statements.

This research contributes to prior banking literature in three ways. First, we examine banks from 25 European countries over the 2011–2018 period, allowing us to investigate the dynamic impact of the NSFR on bank performance and test the trade-off hypothesis between liquidity regulation and profitability across different interest rate environments. Second, we account for both large, internationally active banks and small- and medium-sized, unlisted intermediaries, such as cooperative and savings banks, providing a more representative picture of the EU banking sector. Third, we use a proxy for the Basel III NSFR that comprehensively accounts for both asset and liability contributions to structural liquidity, adding evidence to the limited literature on banks' responses to prudential limits on funding liquidity risk (Dietrich et al., 2014) and complementing studies that focus on short-term liquidity measures like the LCR (Bonner and Eijffinger, 2016; De Haan and van den End, 2013).

The introduction of the NSFR produces incentives to collect longer-term and more stable sources of funds and/or to invest in more

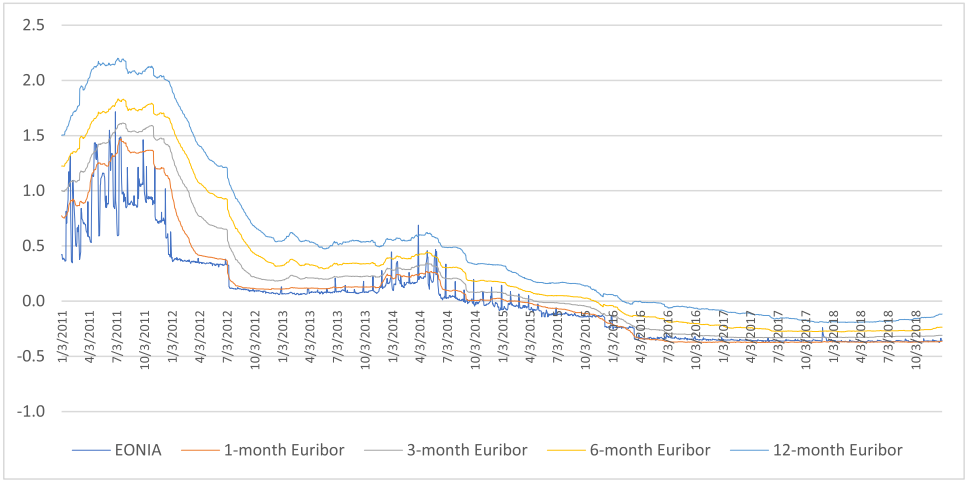

Fig. 1. EONIA and 1-, 3-, 6- and 12-month Euribor interest rates (2011–2018; data in %). Source: Datastream.

liquid and shorter-term assets, with a presumably negative impact on bank NIMs. On the other hand, thanks to a more balanced structure of asset and liability maturities, a bank could be perceived as less risky and benefit from a lower funding cost. If this latter effect offsets the reduction in the interest earnings, the NIM might positively react to the NSFR. We show that the relationship between NSFR and NIM and overall profitability depends on the level and the volatility of interest rates. Based on Fig. 1, we distinguish between the years 2011–2012 (first sub-period), when the EONIA rate and the 1-, 3-, 6- and 12-month Euribor rates first raised and then declined, showing a certain volatility, and the years 2013–2018 (second sub-period), when market rates stayed close to the zero level and, finally, became negative, but with a much less volatile trend than previous years.

During the period 2011–2012, when rates fluctuated, the benefits of reduced funding liquidity risk offset NIM reductions, resulting in no measurable NSFR impact on profitability. From 2013–2018, in a persistently low- and negative-rate environment, the NSFR negatively affected NIM but positively influenced ROA and ROE, as banks managed the trade-off between stability and profitability under extraordinary financial conditions. Because of the persistent scenario of extremely low or negative interest rates, the benefits of a lower exposure to funding liquidity risk no longer counterweights the compression of banks' NIMs, and the NSFR ends to negatively affect their ability to make profits from the traditional banking business of issuing loans and collecting deposits. In our view, the difference in the impact of the NSFR between the two sub-periods is also due to the changed interest rates environment. The higher level of interest rates in the years 2011–2012 gives banks more room to make good use of their bargaining power, by taking advantage of the changes in market rates observed during those years. In the following years, the proximity of interest rates to the zero level and their stability may have significantly limited, when not removed, that possibility. Anyway, as for ROA and ROE, banks have proved to be able to manage the negative consequences of a more balanced, and less profitable, asset-liability maturity structure, thus showing a positive relation between the NSFR and these two overall profitability ratios.

Given the still relatively recent introduction of the NSFR, which became a binding requirement only in June 2021, we believe our findings to be relevant and able to contribute to the debate about the possibility that the consequent limitation of banks' maturity transformation is excessive. To empirically investigate the impact of the NSFR, we estimate panel regressions with bank-specific fixed effects for our sample banks. Our dependent variables are NIM, ROA, and ROE, with the NSFR as the main explanatory variable. Bank-specific controls—credit risk, efficiency, solvency, and size—along with macroeconomic and financial market indicators—GDP growth, inflation, banking industry concentration, and the yield curve slope—allow us to capture both bank-level and country-level determinants of profitability. This methodology isolates the effects of liquidity regulation on performance while accounting for temporal adjustments in banks' behavior.

We add evidence to prior research that almost exclusively investigates the impact of the NSFR on banks' stability and lending activity, and show that, to promote sounder risk management practices and strengthen banks' liquidity position, regulators should consider the heterogeneous effect of the liquidity standard on banks' performance under different interest rates environments. Our results support the introduction of some flexibility into the liquidity regulatory framework, which might presumably reduce the potential unintended consequences of the NSFR on banking business sustainability. The rest of the paper is organized as follows. Section 2 describes the NSFR and how we calculate it. Section 3 presents a review of the main contributions of previous literature and develops the hypotheses tested in the empirical part of the paper. Section 4 describes the methodology in terms of empirical strategy and variables used. Section 5 presents the dataset, Section 6 discusses the results, and Section 7 shows the robustness checks. Finally, Section 8 provides concluding remarks.

2. The net stable funding ratio

The 2007–2008 market turmoil emphasised the importance of liquidity to the functioning of financial markets and banking sector. The GFC showed how quickly banks could lose certain sources of funds and how severely funding liquidity risk can hit. As a response, BCBS (2008) set principles for sound practices of liquidity risk management, emphasised the importance of supervisors assessing the adequacy of a bank's liquidity position and risk management framework, and suggested steps that supervisors should take if these were deemed inadequate. Within the Basel III framework, which completed a series of reforms started in July 2009 to increase the resilience of the banking sector, the BCBS proposed the LCR and NSFR standards to address banks' funding weaknesses BCBS (2010a, 2010b).

Since it was first issued in December 2010, the NSFR went through substantial revisions to allow for the prompt identification of banks with excessive maturity mismatches and more fragile funding structures (BCBS, 2014). More recently, as concerns the implementation of the NSFR within the European Union, the revised Capital Requirements Directive (CRD 5, Directive EU 2019/878 of the European Parliament and of the Council) and Regulation (CRR 2, Regulation EU 2019/876 of the European Parliament and of the Council) have refined and continued to implement Basel III in the European Union. CRR 2 proposes a framework for the NSFR that introduces some adjustments to make the rule more proportionate for small and non-complex institutions, by allowing them to use a simplified and less granular version of the standard. The use of the simplified NSFR will be subject to supervisory approval by national competent authorities based on factors including the size of assets, trading book and derivative positions. Simplified NSFR approach would provide a relief to smaller banks in terms of meeting the funding cost and compliance challenges that the Basel III liquidity regime is expected to bring.

The objective of the NSFR is to promote bank resilience over a one-year time horizon by creating additional incentives for a bank to fund its activities with more stable sources of funding on an ongoing structural basis. BCBS (2014) issued the final version of the NSFR, which will become a binding requirement for European banks in June 2021 and is calculated as follows:

$$\text{NSFR} = \frac{\text{ASF (Available Amount of Stable Funding)}}{\text{RSF (Required Amount of Stable Funding)}} \geq 100\% \quad (1)$$

where:the Available Stable Funding (ASF) refers to the stable sources of funds, and is calculated through a weighting mechanism according to which greater weights are given to sources of funds that are least likely to disappear under stressed market conditions;the Required Stable Funding (RSF) is calculated by applying haircuts that depend on the liquidation value of a certain asset under stressed circumstances. The more liquid the asset, the lower the RSF haircut.

To calculate the NSFR in our empirical analysis, we make use of data from the financial statements available in the Moody's Analytics BankFocus database. Therefore, we do not have a fully detailed set of information about our banks' asset and liability structure and, since we must make some simplifying assumptions about the weighting scheme, our estimates of the NSFRs are proxies for the actual figures. BCBS (2014) establishes the components of each of the ASF categories and identifies the associated maximum weighting factor to be applied to calculate the numerator of the ratio, as well as the assets to be assigned to each RSF class and the respective weighting factor to obtain the denominator (see Appendix A). Following Scalia et al. (2013), the choice of the factors for each item of the available data is detailed in Table 1, together with the variation range of the regulatory weights referred to the granular sub-items.

3. Literature review and hypotheses development

This paper contributes to two main streams of empirical banking research: the former, which is wider and dates to the early '80 s, investigates the determinants of banks' profitability; the latter, which is more recent, refers to the impact on banking activity of the liquidity standards introduced by BCBS (2010). In Section 3.1 we provide a review of the major contributions in these two lines of studies and in Section 3.2 we present and discuss the hypotheses tested in the empirical section.

3.1. Literature review

3.1.1. Determinants of banks' profitability

Banking empirical literature generally measures profitability through interest margins and mainly rests on the dealership model

Table 1
Net Stable Funding Ratio weighting factors. It shows the weighting factors used to calculate the Available Stable Funding and the Required Stable Funding, i.e., the numerator and denominator of the Net Stable Funding Ratio, respectively.

Required Stable Funding (RSF)			Available Stable Funding (ASF)		
Assets	Factor		*Liabilities*	Factor	
	Basel	Applied		Basel	Applied
Residential mortgage loans	0.65–1	0.65	Customer deposits - current	0.5–0.9	0.85
Other mortgage loans	0.65–1	0.65	Customer deposits - savings	0.5–0.9	0.8
Other consumer/retail loans	0.65–1	0.85	Customer deposits - term	0.5–0.9	0.8
Corporate and commercial loans	0.65–1	0.85	Total customer deposits		
Other loans	0.65–1	0.85			
			Deposits from banks	0–0.5	0
Less: Reserves for impaired loans/NPLs		-1	Repos and cash collateral	0–0.5	0
Net loans			Other deposits and short-term borrowings	0–0.5	0
			Total deposits, money market and short-term fund		
Gross loans					
Loans and advances to banks	0–1	0.35	Senior debt maturing after 1 year	1	1
Reverse repos and cash collateral	0	0	Subordinated borrowing	1	1
Trading securities and at fair value through income	0.05–1	0.35	Other funding	-	1
Derivatives		0.25	Total long term funding		
Available for sale securities	0.05–1	0.35			
Held to maturity securities	0.05–1	1	Derivatives	0	0
At-equity investments in associates	0.05–1	1	Trading liabilities	0	0
Other securities	0.05–1	1	Total funding		
Total securities					
			Reserves for pensions and other	1	1
Investments in property	1	1	Other non interest	1	0
Insurance assets	1	1	Total liabilities		
Other earning assets	1	1			
Total earning assets			Pref. shares and hybrid capital accounted for as debt	1	1
			Pref. shares and hybrid capital accounted for as equity	1	1
Cash and due from banks	0	0	Non-controlling interest	-	-
Residual assets	-	1	Total equity	1	1
Total assets			Total liabilities and equity	-	-
			Central bank refinancing (3 years)	1	1
Liabilities					
Guarantees	0.05	0.05			
Committed credit lines	0.05	0.05			
Other contingent liabilities	0.05	0.05			

introduced by Ho and Saunders (1981), where the bank is a risk-averse dealer facing a cost due to the time mismatch of deposits supply and loans demand. To face the associated uncertainty, over the period 1976Q4–1979Q4 major US banks ask for a positive interest spread/margin that depends on the degree of managerial risk aversion, the size of the transactions undertaken by the bank, the market structure and the variance of interest rates. Several studies theoretically extend Ho and Saunders' model. McShane and Sharpe (1985) assume that uncertainty refers to the short-term money market rate rather than to the deposit and loan rates and find a stable non-linear relationship between NIMs and measures of market power, degree of absolute risk aversion and interest rate uncertainty for Australian trading banks over the years 1962–1982. Allen (1988) considers loans and deposits with different maturities and shows that interest spreads decrease since the interdependence of demands across bank services and products determines diversification benefits. By using Bank Call Report data for the years 1989–1993, Angbazo (1997) accounts for credit risk, interest rate risk and their interaction, and finds that NIMs are positively associated with core capital, non-interest bearing reserves, and management quality, and negatively related to a bank's liquidity position.

Demirgüç-Kunt and Huizinga (1999) make use of bank-level data for 80 countries in the period 1988–1995 and show that differences in profitability depend on bank-specific characteristics, macroeconomic conditions and regulatory and institutional factors, being positively related to capitalization, but negatively associated with reserve requirements. Examining a sample of 614 banks from six European countries and the US during the period 1988–1995, Saunders and Schumacher (2000) show that interest rate volatility has a significant impact on bank NIM and argue that policies aiming to diminish interest rate volatility could have a positive effect in reducing bank margins. Maudos and Fernández de Guevara (2004) observe that the fall in interest margins experienced by main European banking sectors in the period 1993–2000 is compatible with more relaxed competitive conditions, due to a reduction in credit risk, interest rate risk and operating costs. According to Carbó Valverde and Rodríguez-Fernàndez (2007), diversification in non-traditional activities causes an increase in market power and a spread decrease because of the effects of cross-subsidization banks from seven European countries during the years 1994–2001. Maudos and Solís (2009) study the Mexican banking system over the period 1993–2005 and find a positive relationship between the intermediation margin and Lerner index, operating cost and volatility of market interest rates, and a negative correlation with the quality of management and non-interest income.

More recently, researchers have increasingly focused on the interest rate risk, maturity transformation and monetary policy as determinants of bank profitability. Entrop et al. (2015) show that German commercial banks price their individual interest rate risk and corresponding expected excess holding period returns via the asset side into the NIM over the years 2000–2009, whereas only smaller institutions price interest rate risk exposure via the liability side. By analysing half-yearly individual bank level data from 1999H1 to 2008H1 in Italy, Bologna (2017) suggests that higher maturity transformation is typically associated with higher NIMs, particularly in the context of a steeper yield curve, but an excessive maturity transformation might result in higher risk exposure with no benefit in terms of NIM.

Borio et al. (2017) investigate how monetary policy affects profitability of 109 international banks headquartered in 14 major advanced economies for the period 1995–2012, and highlights that the level of short-term rates and the slope of the yield curve positively affect banks' ROA, particularly when the interest rate level is lower and the slope less steep. This would confirm that unusually low interest rates and an unusually flat term structure erode bank profitability. Differently, Altavilla et al. (2018) find no effect of a decrease in short-term interest rates on bank profitability for Euro area banks over the years 2000–2016, even if the monetary policy easing is prolonged over time. Using an international sample of 3385 banks during the 2005–2013 period, Claessens et al. (2018) observe that a one-percentage point decrease in interest rates implies an 8-bp reduction of NIM. The authors also show that this effect is greater (20 bps) if interest rates are low, and that, for each additional year of "low-for-long", interest margins and profitability fall by another 9 and 6 bps, respectively.

Omankhanlen et al. (2021) examine the period 2002–2019 and find that monetary policy instruments significantly influence banks' ability to achieve their profit objectives. A higher liquidity ratio and an expanded money supply are associated with increased bank profitability, while higher interest rates tend to reduce it. The study suggests that careful calibration of liquidity, interest rates, and money supply can support banks in meeting their profit targets. Tercero-Lucas (2023) investigates the impact of Eurosystem nonstandard monetary policies on the profitability of 54 Spanish banks over 2001–2017. Using panel data and controlling for bank-specific and macroeconomic factors, the analysis finds no significant effect of measures such as the ECB's total assets, excess reserves, or the slope of the yield curve on bank profitability, measured by ROA, pre-tax operating income, or net interest margins. This result holds across different econometric specifications and bank groups, suggesting that unconventional monetary policy may not directly influence bank profits in all contexts. Windsor et al. (2023) exploit a large cross-country dataset and show that the sensitivity of NIMs to falling interest rates is more modest than earlier estimates, suggesting that banks may have adapted to low-rate environments or that other profitability channels partially offset margin compression. Brkić (2025) observes that, following the ECB's policy shift in mid-2022, euro area banks experienced higher interest income and profitability, particularly supported by large excess liquidity and a high share of overnight deposits, which allowed them to maintain favorable net interest margins despite rising rates.

3.1.2. Basel III liquidity requirements and banking activity

NSFR and other liquidity-based requirements are macroprudential measures. Their effects on banks have been studied by vast literature. For example, Olszak et al. (2025) examine how such measures affect European banks' net interest margins using data for nearly 3000 banks across 28 EU countries from 1996 to 2019. They find that tighter liquidity regulations, such as higher liquidity buffers and limits on maturity mismatches, significantly compress NIMs, mainly by reducing interest income and increasing funding costs. The effect is stronger for smaller and less capitalized banks, highlighting the trade-off between enhanced financial stability and lower bank profitability under the post-Basel III regulatory framework. Typically adopting a retrospective approach, the research discussed in the present section use past balance sheet data to calculate these regulatory standards and to explore their potential

impact. We divide the reference literature into three main groups of studies. In the first one, we include papers examining the impact of the liquidity ratios on banks' profits, the second one contains works studying their effect in terms of balance sheet restructuring and lending incentives, while the studies comprised in the third group deal with the relation between the liquidity ratios, banks' riskiness and probability of failure.

Based on 2009 year-end data, King (2013) estimates the NSFR for the representative bank of 15 countries and shows that the most cost-effective strategies to meet the NSFR for banks below the minimum threshold are to increase holdings of higher-rated securities and to extend the maturity of wholesale funding. These strategies are not costless: they are expected to reduce NIMs by 70–88 bps on average. Dietrich et al. (2014) assess the effects of the NSFR on profit volatility of 921 banks in Western Europe between 1996 and 2010 and find that potential advantages in funding costs for low-NSFR banks do not seem to translate into higher profitability (as measured by ROA, ROE or NIM) and lower volatility of their results. According to Bonner and Eijffinger (2016), who analyse the impact of a requirement similar to the LCR on a sample of 18 Dutch banks from January 2004 to December 2011, banks do not pass on the increased funding costs in the interbank market to their private sector clients, thus experiencing a decrease in their interest margins.

More recently, Le et al. (2020) provide one of the first empirical examinations of the non-linear impact of the NSFR on profit (in) efficiency for US commercial banks and suggest that modest intensification in liquidity helps to reduce bank profit inefficiency but a too greater liquidity enlargement could increase it. Mashamba (2018) investigates the impact of the Basel III LCR on the profitability of 40 banks across 11 emerging markets from 2011 to 2016. Using a system GMM estimator, he finds that, contrary to theoretical expectations, compliance with the liquidity regulation does not reduce bank profitability. This is explained by the effective liquidity management practices of banks, suggesting that the LCR may not be detrimental to bank performance in emerging economies. Golubeva et al. (2019) analyze the impact of liquidity on the profitability of 45 European banks following Basel III implementation, using multiple liquidity measures such as the LCR, loan-to-deposit ratio, and financing gap. Employing ordinary and weighted least squares regressions for 2014–2018, they find that liquidity measures have a positive effect on some profitability proxies but an insignificant impact on others. In particular, the Basel III LCR does not significantly affect any profitability measure, suggesting that the influence of liquidity regulation on bank performance may vary depending on bank-specific characteristics and macroeconomic conditions.

Davis et al. (2022) show that liquidity measures such as the LCR and NSFR, as well as limits on loan-to-deposits ratios, are associated with statistically insignificant reductions in ROA and increases in ROE for a sample of 7250 global banks observed over the years ranging from 1990 to 2018. Adelopo et al. (2021) examine the effects of higher capital requirements and liquidity levels on the profitability of major European banks between 2010 and 2018. They find that liquidity is positively associated with bank profitability. The authors conclude that, although the Basel III framework is important for banking stability, its direct influence on profitability appears limited, highlighting a nuanced relationship between prudential regulation and bank performance.

As to the papers with a focus on the impact of the liquidity standards on the structure of banks' balance sheet and lending activity, Giordana and Schumacher (2013) study the effect of complying with the LCR and NSFR on the monetary policy transmission mechanism using highly detailed bank-level data from Luxembourg for the period 2003–2010. Based on their results, the bank-lending channel is likely to vanish as banks adhere to the new Basel III liquidity regulations; meeting the NSFR may reduce the reaction of the loan supply to monetary policy shocks more strongly than complying with the LCR. De Haan and van den End (2013) and Bonner and Eijffinger (2016) both investigate Dutch banks' behavior under a regulation very similar to the LCR from January 2004 to March 2010 and December 2011, respectively. The former argue that banks hold more liquid assets against liquid liabilities than strictly required, entailing that the adoption of the LCR would not lead to significant adjustments, whereas the NSFR would be binding since banks do not adjust their liquid assets to cash flows scheduled beyond one year. The latter show an increase in long-term borrowing and in the demand for long-term interbank loans.

Banerjee and Mio (2018) examine the casual impact of liquidity regulation on bank balance sheets, exploiting the heterogeneous introduction of tighter liquidity requirements by the UK Financial Services Authority in 2010. Their results show that banks responded by increasing holdings of high-quality liquid assets and non-financial deposits, while reducing short-term wholesale funding and intra-financial loans. However, they find no evidence that stricter liquidity regulation led to a contraction of overall balance sheets or a reduction in lending to the real economy. These findings suggest that liquidity regulation can strengthen balance sheet resilience without necessarily constraining credit supply. According to Roulet (2018), who study the context of deleveraging and "credit crunch" experienced in Europe over the years 2008–2015, more stringent capital adequacy rules create incentives for banks to replace retail-and-other loan assets with risk-free, more liquid government bond securities. The ratio of non-required amount of stable funding to total assets has a positive impact on banks' commercial lending growth, whereas it negatively affects the growth of retail and other lending. Roberts et al. (2023) examine the effects of the U.S. LCR on bank behavior, finding that LCR-regulated banks tighten lending standards and reduce liquidity creation mainly through lower lending relative to non-LCR banks. However, they also become more resilient, contributing less to fire-sale externalities. The net benefits of reduced fire-sale risk exceed the costs of foregone lending, particularly for large banks, with total benefits surpassing $50 billion between 2013 and 2017. Their findings indicate a trade-off between liquidity creation and resilience, emphasizing how liquidity regulation can enhance stability while shifting lending toward smaller, non-LCR banks.

Finally, some papers empirically explore the potential impact of the Basel III liquidity requirements on bank riskiness and distress probabilities. Based on a sample of 11,000 US and European banks from 2001 and 2009, Vazquez and Federico (2015) study the impact of the liquidity and leverage ratios on the probability of a bank failure during and after the GFC. They show that weak structural liquidity and a high leverage before the GFC made banks more vulnerable to subsequent failures. At the same time, smaller banks are more susceptible to failure because of liquidity problems, while large cross-border banking groups typically fail because of insufficient

capital buffers. Diamond and Kashyap (2016) extend the classic Diamond–Dybvig (1983) framework by introducing incomplete information among depositors and the possibility of liquidity-induced bank runs. Their analysis shows that banks may not always have sufficient incentives to hold adequate liquid assets to withstand such runs. Liquidity regulations akin to the Basel III LCR and NSFR can mitigate these risks by strengthening banks' incentives to maintain liquidity buffers, thereby enhancing financial stability. However, the authors note that optimal regulatory design would likely differ from the existing Basel III rules, suggesting room for refinement in current frameworks. Considering data from the GFC, Lallour and Mio (2016) suggest that the NSFR would have protected European and US banks against failure during the financial crisis, had banks complied with this regulatory ratio. This result is consistent with Chiaramonte and Casu (2017), who test the relevance of Basel III capital and structural liquidity ratios on the probability of default of banks active in the EU-28 member states during the period 2004–2013, and show that higher structural liquidity buffers are associated with lower probabilities of EU banks failures. Using an annual data sample of US bank holding companies from 1991 to 2002, Ly et al. (2017) find that the systemic risk becomes the lower the faster US banks respond to the new regime and increase their NSFR.

3.2. Developing hypotheses on the relation between the NSFR and banks' profitability

The objective of the NSFR is to make the maturity structure of banks' assets and liabilities more balanced, by creating incentives for banks to collect longer-term, more stable funds and/or to increase the share of shorter-term, more liquid assets. *Ceteris paribus*, this reduces banks' exposure to funding liquidity risk, but has also a negative impact on their NIMs, since this might imply an increase in the interest expenses and a decrease in the interest earnings. Nevertheless, should the lower funding costs potentially associated with a lower exposure to funding liquidity risk more than offset the possible decrease in interest earnings and/or the increase in funding costs, and should depositors, or other funds providers, be able to capture and reward the reduction in the risk exposure, the NSFR might induce an increase in bank NIM. However, due to the closer market scrutiny, we believe this to be something more likely to happen for large, listed banks rather than for the average European bank of our sample.

So, following King (2013), the first hypothesis we test in the empirical analysis, which refers to the 2011–2012 period of an ordinary interest rates environment, when market rates show an inverse-U-shaped trend, with a certain volatility, goes as follows:

Hypothesis 1. under an ordinary interest rates environment, bank NIM is negatively correlated with the NSFR.

By considering the 2011–2018 period, we can study the relation between the NSFR and NIM under different scenarios of interest rates. From 2013 to the end of our investigation period, interest rates have stayed at close-to-zero levels as the result of the ultra-expansionary monetary policies adopted in response to the worldwide financial crisis originated in 2007 in the United States and to the 2010 European sovereign debt crisis. Central banks nowadays not only control the shorter ends of the yield curve but, through a variety of unconventional monetary policies, such as quantitative easing, also influence the longer segments. This has not only lowered interest rates but has also led to a flattening of the yield curve. In the euro area, on June 2014, the ECB started a negative interest rates policy (NIRP) to complement and reinforce existing measures to encourage lending in a more effective way. The unprecedented levels of interest rates and the flattening of the yield curve for many of the main currencies have heightened the concern for an erosion of banks' profits.

Our decision to split the entire 2011–2018 sample period in two sub-periods is based on the trend, level and volatility of market interest rates. As shown by Fig. 1, which specifically refers to the EONIA, 1-, 3-, 6- and 12-month Euribor interest rate, from January 2013 to January 2016 market interest rates stay very low, i.e., below 1 %, and stably close to the zero level. Finally, in the last part of our sample period, they become negative. In the second part of our investigation, we focus on this prolonged, extraordinary situation of extremely low or negative interest rates. Most of existing empirical studies show that NIMs are low when interest rates are low, mainly because banks are reluctant to lower the rates of many types of deposits and some other liabilities not to lose clientele (Borio et al., 2017). Claessens et al. (2018) argue that the effect of interest rates on bank NIM is likely to be larger in a low-yield environment if, *ceteris paribus*, the spreads on loans over deposit rates increase with the level of the rate, which can be expected when spreads compensate for default and other risks that are otherwise interest-insensitive. Therefore, we believe the adverse effect of the NSFR on bank NIM to be stronger under an interest rates environment, like the one experienced after the year 2012, in which interest rates stayed steadily close to zero or even below. Based on these arguments, our second hypothesis can be stated as follows:

Hypothesis 2. relative to an ordinary interest rates environment, bank NIM is more negatively correlated with the NSFR under a scenario of extremely low or negative interest rates.

The effects of low/negative interest rates on a bank's overall profitability, which we measure through ROA and ROE, are not so obvious, even if its NIM was to decline. Close-to-zero interest rates might produce some benefits in the short-run, both via valuation gains on fixed-income securities and a reduction in non-performing loans, as debt service becomes less burdensome for borrowers. According to Molyneaux (2022), very low interest rates might create incentives for banks to "search for yield" and to prefer high-yield long-term illiquid assets more than low-yield short-term liquid assets, possibly financed by cheap(er) central bank funding. Furthermore, low interest rates may also boost new lending activity to the economy and spur the provision of other financial services. Hence, making hypotheses about the impact of the NSFR on ROA and ROE is even less straightforward than for NIM. For example, since NIMs significantly contribute to their profits, small banks face more issues in generating an amount of non-interest income that can be sufficient to counterbalance the decrease in the interest-related margin. Therefore, countries with a large number of such intermediaries are hit to a greater degree by low interest rates, which implies that evidence referred to a cross-section of countries, like the one we provide in the empirical section, can help in identifying the effects of changes in interest rates on bank profitability (Claessens et al., 2018).

Empirical studies on the impact of extremely low/negative interest rates on the overall bank profitability have not reached conclusive and unanimous results. On one hand, some papers show negative effects (Genay and Podjasek, 2014; Busch and Memmel, 2015; Claessens et al., 2018; Borio and Gambacorta, 2017); on the other hand, other studies find a positive relation (Jobst and Lin, 2016; Madaschi and Nuevo, 2017; Basten and Mariathasan, 2018). We contribute to these studies by assessing the effects of the NSFR on banks' overall profitability when interest rates stay close to the zero level and finally become negative. Since ROA and ROE depend not only on the traditional activity of collecting deposits and issuing loans, but also on a bank's ability to find other sources of profits, its ability to properly manage operating costs and risk, we do not have a strong *a priori* about their relationship with the NSFR. Consequently, we do not to state any hypothesis. In this perspective, the results of our analysis referred to the years of very low or negative interest rates are of particular interest because they can be seen as a test of banks' ability to generate profits even in stressful situations and can provide interesting valuable insights for regulators and supervisors.

4. Methodology

4.1. The empirical model

To estimate the determinants of bank NIM, prior studies adopt either a two-stage process or a single-stage approach. As to the first method, in the first stage, the effect of the NIM explanatory variables not explicitly identified by the theoretical model is controlled to obtain an estimate of the "pure" margin. Then, the second stage analyses the relationship between this "pure" margin and the variables used in the theoretical model. The two-stage approach requires a time series long enough to be appropriately applied (Ho and Saunders, 1981; Saunders and Schumacher, 2000). In a single-stage approach, the empirical estimation includes both the variables of the theoretical model and the additional variables that reflect other aspects not incorporated into the modelling of the pure margin (McShane and Sharpe, 1985; Angbazo, 1997).

Table 2
List of variables. It presents description, predicted coefficients, reference studies and source of dependent variables, bank-specific variables, industry, macroeconomic and financial markets variables and additional variables.

Variable	Description	Predicted coefficient	Reference studies	Source
Dependent variables				
NIM	Net interest margin (as interest income minus interest expenses) to total assets	/	Ho and Saunders (1981); McShane and Sharpe (1985); Allen (1988); Angbazo (1997); Demirgüç-Kunt and Huizinga (1999); Saunders and Schumacher (2000); Maudos and Fernández de Guevara (2004); Carbó Valverde and Rodriguez-Fernàndez (2007); Maudos and Solís (2009); Entrop et al. (2015); Bologna (2017).	Moody's Analytics BankFocus
ROA	Net income to average total assets	/	Altavilla et al. (2018); Dietrich et al. (2014)	Moody's Analytics BankFocus
ROE	Net income to average total equity	/	Dietrich et al. (2014)	Moody's Analytics BankFocus
Bank-specific variables				
NSFR	Available stable funding to required stable funding	(-)	Not used up to now	Moody's Analytics BankFocus and authors' computation
Credit risk	Loan loss provisions to customer loans	(+)	Angbazo (1997); Maudos and Solís (2009)	Moody's Analytics BankFocus
Efficiency	Total operating expenses to operating income	(+)	Maudos and Fernández de Guevara (2004); Maudos and Solís (2009); Entrop et al. (2015); Bologna (2017)	Moody's Analytics BankFocus
Solvency	Equity to total assets	(+/-)	McShane and Sharpe (1985); Angbazo (1997); Saunders and Schumacher (2000); Maudos and Fernández de Guevara (2004); Maudos and Solís (2009)	Moody's Analytics BankFocus
Size	Natural logarithm of total assets	(+/-)	Bologna (2017)	Moody's Analytics BankFocus
Industry, macroeconomic and financial markets variables				
HHI	Herfindahl-Hirschman index	(+)	Maudos and Fernández de Guevara (2004); Carbó Valverde and Rodriguez-Fernàndez (2007); Bologna (2017)	Moody's Analytics BankFocus and authors' computation
GDPGR	Annual real GDP growth rate	(+/-)	Carbó Valverde and Rodriguez-Fernàndez (2007); Maudos and Solís (2009); Entrop et al. (2015); Bologna (2017)	World Bank
Inflation	Consumer price index annual growth rate	(+)	Maudos and Solís (2009); Entrop et al. (2015); Bologna (2017)	World Bank
Slope	Difference between the 10-year government bond and the Euribor 3-month	(+)	Bologna (2017)	Datastream

Following Köhler (2015), and based on the results of the Hausman test, we apply panel regressions with fixed effects to capture the influence of each bank-specific variable. Furthermore, the choice for fixed instead of random effect model has three reasons. First, if the individual effect represents omitted variables, it is highly likely that these bank-specific characteristics are correlated with the other regressors and therefore our fixed effects estimation helps us to partially eliminate endogeneity problems. Second, we want to analyse the adjustments of banks' behaviour in the time variation and not in the cross-sectional variation of the data. Third, our panel dataset includes very large to very small banks with great variations with respect to business models, which in turn implies that differences among banks are not random.

We estimate a regression model of banks' profits as a function of bank- and country-specific variables. The baseline equation takes the following form:

$$Y_{it+1} = c + \beta_1 NSFR_{it} + \sum_{j=1}^{J} \beta_j X_{it}^{J} + \sum_{k=1}^{K} \beta_k X_{mt}^{k} + \gamma_t + \alpha_i + \varepsilon_{it} \quad (2)$$

where c is a constant term; Y_{it+1} is the dependent variable for bank i at time $t + 1$, with $i = 1, \ldots, N$, and $t = 1, \ldots, T$ year. It alternatively measures the net interest margin, return on assets and return on equity. $NSFR_{it}$ is the Net Stable Funding Ratio, calculated using Eq. (1). We include two types of control variables in the regression: X_{it}^{j}, that are other bank-specific characteristics, measuring efficiency, credit risk exposure, solvency and size, and X_{mt}^{k}, which account for time varying common factors for country m at time t, with $m = 1, \ldots, M$ and $t = 1, \ldots, T$ year, such as controls for industry-specific, macroeconomic and financial markets conditions. Finally, γ_t is a year dummy and α_i a bank-specific fixed effect ε_{it} is the error term. Table 2 shows a brief description of the variables used in the empirical analysis, the expected sign of the relation of the independent variables with the dependent ones, their use in other studies and the respective source. All the variables are presented in details in the following Sections 4.2 and 4.3.

4.2. Profitability measures

To assess the effects of the NSFR on banks' ability to make profits, we employ three profitability-related, dependent variables, widely adopted by previous research: net interest margin, i.e., the difference between total interest income and total interest expenses, return on assets and return on equity. We divide the net interest margin by total assets to define our first dependent variable NIM (Ho and Saunders, 1981; Angbazo, 1997; Entrop et al., 2015). The return on assets (ROA) and return on equity (ROE) are two ratios where the numerator is in both cases the net income, which includes net interest margin and non-interest income and expenses, whereas the denominators are the average total asset and the average equity, respectively (Dietrich et al., 2014; Altavilla et al., 2018).

4.3. Other control variables influencing banks' profitability

4.3.1. Bank-specific control variables

As to the bank-specific variables, we control for credit risk, efficiency, solvency, and size. Following Angbazo (1997) and Maudos and Solís (2009), we estimate credit risk with the ratio of loan loss provisions to gross customer loans, which is higher when credit quality (credit risk) is lower (higher). Banks are expected to require higher interest margins to compensate for funding riskier projects and maintaining adequate loan loss reserves. We expect our measure of credit risk to be positively related with banks' profitability, even if Carbó Valverde and Rodriguez-Fernàndez (2007) warn that a bank might mitigate high credit risk by investing in low-return government securities, thus reducing its profits.

Bank efficiency is usually measured through the ratio of operating expenses to total assets (Entrop et al., 2015; Bologna, 2017) or through the cost-to-income ratio, i.e., the ratio of operating expenses to operating income (Maudos and Fernández de Guevara, 2004; Maudos and Solís, 2009), which is the variable we use. In line with Demirgüç-Kunt and Huizinga (1999), who claim that banks with high operational costs tend to transfer these costs to their customers, we expect that banks experiencing higher operating costs show higher NIM, ROA and ROE.

We measure our banks' solvency through the ratio of equity to total assets (McShane and Sharpe, 1985; Angbazo, 1997; Dietrich et al., 2014). High-capitalised banks are more solvent and face lower funding costs, which strengthens their margins and supports a positive impact of solvency on banks' profitability. On the other hand, less capitalised banks might have more incentives to take risk in order to increase capital via retained profits, thus justifying a negative sign for the correlation between solvency and profitability as well. As a result, we do not have any strong *a priori* about the impact of solvency on bank profits.

Following Bologna (2017), we measure bank size as the natural logarithm of total assets. Ex-ante, the relationship between profitability and size is ambiguous. Based on the *too-big-to-fail* argument, larger institutions might behave in opportunistic terms and take high risk to achieve high returns, which supports a positive sign for the relationship between bank size and profitability. Furthermore, a positive sign could be expected also because larger banks might benefit from economies of scale and scope advantages. On the other hand, some studies argue that, just because of scale efficiencies they can benefit relative to the small banks, large intermediaries generally apply lower interest margins (Demirgüç-Kunt and Huizinga, 1999). Hence, the sign of the relationship between size and profitability might also be negative.

4.3.2. Industry, macroeconomic and financial markets variables

The banking literature suggests that the environment in which banks operate does have effects on their behaviour and performance: the structure of the banking industry, a country's economic development, as well as the conditions prevailing on the financial markets

can have a significant impact on their profitability. We consider the Herfindhal-Hirschman Index as a measure of banking industry concentration, the real GDP growth rate, the consumer price index and the yield curve slope to control for macroeconomic and financial markets conditions.

Previous studies assess banking market structure by calculating either the Herfindhal-Hirschman Index (HHI), to account for the concentration and the competitive structure, or the Lerner Index, in order to capture banks' ability to exercise market power (Maudos and Fernández de Guevara, 2004; Carbó Valverde and Rodriguez-Fernàndez, 2007; Bologna, 2017; Entrop et al., 2015). We use the HHI, which is calculated by squaring the market shares, in terms of total assets, of each competing bank on the market. HHI can take values between 0 and 10,000 or 0 and 1, depending on whether the market share is expressed as a decimal number or a percentage. In this paper, the range of 0–1 is used. If the ratio is 0, there is perfect competition, with an infinite number of banks in the market with the same amount of assets. The ratio is 1 in the case of monopoly. High market concentration reflects less competition and enables banks to have quasi-monopolistic power. As higher market concentration is likely to contribute to higher profitability, the estimated coefficient of the HHI variable in our model is expected to have a positive sign.

GDP growth rate directly affects the demand and supply of deposits and loans and consequently bank activity and performance. By reducing borrowers' riskiness, more benign economic conditions are likely to diminish banks' exposure to credit risk and the amount of loan loss provisions. *Ceteris paribus*, this determines an increase in bank profitability and suggests a positive sign for the coefficient of the GDP growth rate variable in our model. Nevertheless, in studying the importance of economic growth rate to determine bank interest margins Demirgüç-Kun and Huizinga (1999) find an inverse relationship. From this perspective, economic growth brings prosperity to the economy and banks can operate in a relatively ease environment, thus having incentives to charge little as interest margins.

Inflation is measured with the annual growth rate of consumer price index (Maudos and Solís, 2009; Entrop et al., 2015; Bologna, 2017). In a highly volatile economic environment, banks might charge higher interest margin for lending to cover the potential inflation risk and this would lead to a positive relationship between inflation and profitability. Furthermore, high inflation rates are generally associated with high interest rates and presumably higher interest margins. Interest rates may not reflect increased inflation in the short term, but in the medium and long term, banks will adjust their interest rates to compensate for the inflation premium and will increase the interest margins. Our hypothesis is that the inflation rate positively affects banks' profitability.

Yield curve slope is the difference between the 10-year and the 3-month rates (Bologna, 2017). Alessandri and Nelson (2015) argue that there is a need to control for the long-run and short-run effects of interest rates, through level and change terms, respectively. While in the long-run higher interest rates and steeper yield curves can be expected to have a positive effect on the NIM, a negative relationship might be found in the short-term as an interest rate increase (decrease) can have a negative (positive) effect on the NIM, due to non-negligible re-pricing frictions. To consider simultaneously both long-term and short-term interest rates, we use the yield curve slope and we expect a positive relation with banks' profitability.

5. Data and descriptive statistics

Following prior literature, to assess the potential effect of the NSRF, we adopt a retrospective approach and analyse how this ratio affects banks' performance based on past data (Dietrich et al., 2014, Köhler, 2015). We study 2023 banks operating in 25 European countries, including 16 Euro Area members,[2] over the years 2011–2018, for a total of 13,036 observations. We decided to stop our analysis in 2018 due to a major change in the institutional context of Italian cooperative banks, which, following the enactment of the Cooperative Credit Reform (Law 49/2016), joined newly formed Cooperative Banking Groups, substantially losing their independence. The frequency of our data is annual, and the analysis is conducted on individual basis. Data are taken from several sources. We collect data concerning the dependent variables and the bank-specific explanatory variables from the Moody's Analytics BankFocus database. Macroeconomic data are taken from two sources: data regarding interest rates are from Eikon Datastream; yearly data about the growth rate of gross domestic product (GDP) and the rate of inflation are from the World Bank database.

The initial sample has been filtered using three criteria. First, we consider data of European banks active for the entire sample period; second, based on the Moody's Analytics BankFocus classification, we limit our analysis to bank holdings and holding companies, commercial banks, cooperative banks, investment banks and savings banks; third, we use consolidated accounts, ensuring that each bank is included only once in the dataset. We winsorize our data at the 1st and 99th percentile level to ensure that outliers do not bias our estimates, and, to guarantee a sufficiently long presence in our database, we select only banks that have minimum four years of consecutive observations.

The number of banks included in the sample ranges from 570 in 2011–1903 in 2018. Furthermore, in terms of business model, cooperative banks represent more than half of our sample (9108 out of 13,036 observations). Table 3 reports some descriptive statistics for the variables included in our regression model for the years 2011–2018. For each variable, the total number of available observations, the mean, the standard deviation, the median, the minimum and the maximum values are shown. Our sample banks have an average NSFR of 1.06 over the entire investigation period, which means that, overall, banks meet the minimum liquidity requirement established by the Basel III framework.

The mean of each variable during the two sub-periods in which we split the entire sample period is presented in Table 4, which also displays that, during the first sub-period, banks have an average NSFR lower than during the years of extremely low or negative interest

[2] Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Italy, Latvia, Lithuania, Luxembourg, Malta, Poland, Portugal, Romania, Slovenia, Spain, Sweden, and the United Kingdom.

Table 3
Descriptive statistics (2011–2018). It presents the descriptive statistics of the dependent variables, bank-specific variables, industry, macroeconomic and financial markets variables in percentage points unless otherwise stated. All bank variables are winsorized at the 1- and 99-percentile level.

Variables	Obs.	Mean	Std. Dev.	Median	Min	Max
Dependent variables						
NIM	13,036	1.9843	0.8325	1.8995	-0.8506	20.2168
ROA	11,375	0.3583	0.5465	0.2769	-10.7523	9.9732
ROE	11,374	3.4843	5.6378	2.9241	-119.3837	80.1844
Bank-specific variables						
NSFR	13,036	106.0322	20.7933	101.7866	43.3317	198.3228
Credit risk	13,036	0.3429	1.2974	0.1710	-22.3381	52.7350
Efficiency	13,036	71.6185	17.2808	70.9841	6.4315	851.1973
Solvency	13,036	10.1101	3.5569	9.4351	1.0970	65.9530
Size (1)	13,036	20.0583	1.5218	19.9069	16.7116	26.9747
Industry, macroeconomic and financial markets variables						
HHI	13,036	20.8505	10.7893	17.1606	14.1335	100
GDPGR	13,036	1.5507	1.2949	1.7398	-9.1325	10.8182
Inflation	13,036	1.2208	0.8449	1.2265	-2.0970	5.7893
Slope	13,036	1.3559	0.5029	1.2211	0.6721	2.6477

(1) In nominal value. Table 2 gives the definitions of the variables.

rates. At the same time, European banks seem to show a decreasing profitability from the first to the second sub-period, which is common to both NIM, ROA and ROE. We use mean tests to investigate differences across the two sub-periods. These tests show that there is a certain, statistically significant difference between the two sub-periods in terms of NIM, but not with regard to ROA and ROE.

Table 5 provides pair-wise correlation coefficients of the key variables we use in our regression models. Overall, the low correlation coefficients suggest that multi-collinearity issues do not influence our empirical analysis over the entire sample period. This is confirmed even if we separately consider the two years 2011–2012 and the period 2013–2018 (results not shown).

6. Results

Tables 6 and 7 report the results of our analysis of the impact of the NSFR on banks' profitability for the years 2011 and 2012, and for those ranging from 2013 to 2018, respectively. Table 6 shows that, in line with our expectations, during the first sub-period, the correlation between our profitability measures and the NSFR is negative. Nevertheless, it is not statistically significant for neither the NIM, which does not provide support for our first hypothesis, nor for the ROA and ROE. During the years 2011–2012, irrespective of how it is measured, European banks' profitability does not seem to be affected by the structural regulatory limit on maturity transformation. As far as the NIM is concerned, as argued in the previous section, two potential effects might be at work: on the one hand, the negative impact induced by the lower interest earnings associated with more liquid assets and/or with the higher costs of fund caused by a more stable funding, and, on the other hand, the positive effect associated with banks' capacity to collect funds at a lower cost, due to the higher stability associated with a more balanced asset-liability structure. Based on the evidence reported in column (1) of Table 6, none of the two seems to prevail. Given the lack of statistical significance of the regression coefficients of the NSFR in columns (2) and (3) of Table 6, we do not have the possibility to identify a dominant mechanism, among those discussed above, based on which the NSFR might be able to extert a certain influence on banks' ROA and ROE.

The relation between the NSFR and profitability changes in the years of extremely low or negative interest rates and becomes statistically significant at the 1 % confidence level for all the three dependent variables. Particularly, Table 7 reports that the relation turns out to be negative for the NIM and positive for the ROA and ROE: banks with a lower exposure to funding liquidity risk (higher NSFRs) experience an erosion of the earnings coming from their lending/deposits taking business (NIM), but an increase of the overall profitability (ROA and ROE). Given the absence of a statistical significance of the regression coefficient of the NSFR in column (1) of Table 6, we can argue that our second hypothesis, stating a more negative effect of the NSFR on banks' NIM during the second sub-period, is supported. The persistent scenario of extremely low or negative interest rates determines a compression of banks' net interest margins that the benefits of a lower funding liquidity risk are not able to offset; therefore, the NSFR ends to negatively affect their ability to make profits in terms of net interest margin. In our view, the changed interest rates environment plays a significant role in explaining the difference between the two sub-periods. The higher level of interest rates in the years 2011–2012 gives banks the room to negotiate conditions that are more profitable with their clients, following the changes in market rates observed during those years, thus neutralizing the negative effect of the NSFR and producing a zero impact. The proximity to the zero level of the interest rates and their stability remove or significantly limit that possibility.

As for ROA and ROE, it is likely that the reduction of loan loss provisions and/or the asset revaluation effect are able to more than offset the reduction in the net interest margins, thus finally resulting in an increase in banks' net income and in their overall profitability. The results referred to the years of low and negative interest rates are not in line with Dietrich et al. (2014), who find no stastistically significant evidence about the impact of NSFR on individual bank profitability, but are consistent with studies finding a negative impact on bank performance, such as King (2013).

Not in line with the existing literature, during the years 2011–2012, we find a negative and statistically significant at 1 % confidence level relationship between NIM and the variable "Credit risk". This relation is confirmed also in the years 2013–2018, even if its

Table 4
Difference in means between the sub-periods 2011–2012 and 2013–2018. It presents the means and the differences in means of the dependent variables, bank-specific variables, industry, macroeconomic and financial markets variables. Standard errors are reported in parentheses.

Variables	2011–2012	2013–2018	Difference in means
Dependent variables			
NIM	0.0218	0.0196	0.0022***
	(0.0002)	(0.0001)	(0.0002)
ROA	0.0039	0.0036	0.0004*
	(0.0002)	(0.0001)	(0.0002)
ROE	0.0383	0.0346	0.0037
	(0.0029)	(0.0005)	(0.0030)
Bank-specific variables			
NSFR	1.0597	1.0604	-0.0007
	(0.0051)	(0.0019)	(0.0055)
Credit risk	0.0058	0.0031	0.0027***
	(0.0005)	(0.0001)	(0.0005)
Efficiency	0.7106	0.7169	-0.0062
	(0.0076)	(0.0014)	(0.0078)
Solvency	0.1003	0.1012	-0.0010
	(0.0011)	(0.0003)	(0.0012)
Size	19.9018	20.0775	-0.1757***
	(0.0452)	(0.0139)	(0.0473)
Industry, macroeconomic and financial markets variables			
HHI	0.2882	0.1987	0.0894***
	(0.0033)	(0.0009)	(0.0034)
GDPGR	0.0059	0.0167	-0.0108***
	(0.0005)	(0.0001)	(0.0005)
Inflation	0.0268	0.0104	0.0163***
	(0.0001)	(0.0001)	(0.0002)
Slope	0.0206	0.0127	0.0079***
	(0.0001)	(0.0000)	(0.0001)

***, ** and * are statistical significances at 0.01, 0.05 and 0.10 level, respectively. Table 2 gives the definitions of the variables.

intensity is weakened. Our result does not support the theory that the greater is the credit risk faced by banks (the lower is their credit portfolio quality), the higher is their NIM, which might suggest that our sample banks do not apply a proper risk-adjusted pricing to their loans. Contrary to NIM results, in the ROA and ROE regressions the coefficients of "Credit risk" are not statistically significant, with the only exception of column (2) in Table 7, where the coefficient is marginally significant at the 10 % confidence level.

Consistently with a number of studies and with our expectations, during the first sub-period, the correlation between NIM and our variable "Efficiency" is positive and statistically significant at 1 % confidence level. We find support to the hypothesis according to which banks with high operational costs (higher values for the "Efficiency" variable) tend to transfer these costs to their customers and experience high net interest margins. The positive relation between efficiency and profitability is not confirmed after 2012, when less efficient banks seem also to be characterized by lower NIMs, with an even smaller-size coefficient, in comparison with the years 2011–2012. The signs of the regression coefficients for the variable "Efficiency" when using ROA and ROE as dependent variables are negative in the first sub-period and positive in the second one, respectively, being anyway in no case statistically significant.

The relationship between NIM and "Solvency" is negative in both sub-periods, and statistically significant at 1 % confidence level, with the only exception of the NIM variable for the years 2011 and 2012. Since less capitalised banks might have more incentives to take more risk, they might be characterized by higher interest margins, probably because of their attempts to achieve higher returns and increase their capital via retained earnings. This would finally result also in higher ROAs and ROEs.

During the first sub-period, for all the three profitability measures we consider, bank size has a positive relation, even if statistically significant, at 1 % confidence level, only for the NIM. The relation becomes negative and statistically significant for all the dependent variables at the 1 % confidence level over the years 2013–2018. As far as this period of low and negative interest rates is concerned, this negative sign is against most of previous studies, but in line with Maudos and Fernández de Guevara (2004). Theoretically, the larger the size of a bank's operations, the higher the risk of failure. For a given value of credit risk, an operation of greater size would mean a greater potential loss, so the bank should tend to increase its profitability. Our finding does support neither this risk-related theory nor the *too-big-to-fail* argument, but is in line with Demirgüç-Kunt and Huizinga (1999), according to which, due to scale efficiencies, large banks tend to apply lower interest margins.

The coefficient of the Herfindahl-Hirchman Index is positive and statistically significant at 1 % confidence level for all our regressions, in both sub-periods, with regression coefficients that are smaller in columns (1), (2) and (3) of Table 5 referred to the 2013–2018 years. Therefore, we support the intuition that high market concentration reflects less competition and enables banks to have more market power, thus achieving higher net interest margins, returns on assets and returns on equity. As far as the macroeconomicomic variables are concerned, the regression coefficient of the GDP growth rate in the NIM regression is negative and statistically significant at 1 % confidence level over the second sub-period, consistent with Demirgüç-Kun and Huizinga (1999). It means that if the economy grows, banks experience a reduction in their NIMs since they can expand their business in terms of lending volumes and thus can charge less on their customers. We also argue that this might be the consequence of the reduction in the cost of funding

Table 5
Pair-wise correlation coefficients (2011–2018). It presents the pair-wise correlation coefficients referred to the dependent variables, bank-specific variables, industry, macroeconomic and financial markets variables.

	NIM	ROA	ROE	NSFR	Credit risk	Efficiency	Solvency	Size	HHI	GDPGR	Inflation	Slope
NIM	1.0000											
ROA	0.2489***	1.0000										
ROE	0.1627***	0.8864***	1.0000									
NSFR	0.0311***	0.1608***	0.0542***	1.0000								
Credit risk	0.2198***	-0.1039***	-0.1838***	0.1408***	1.0000							
Efficiency	-0.1272***	-0.4426***	-0.3806***	-0.0278***	-0.1886***	1.0000						
Solvency	0.1796***	0.3033***	0.0495***	0.3798***	0.1478***	-0.0489***	1.0000					
Size	-0.1786***	-0.0845***	-0.0324***	-0.1900***	0.0374***	-0.0631***	-0.2458***	1.0000				
HHI	0.2630***	0.1670***	0.1031***	0.3134***	0.2010***	-0.0953***	0.1024***	0.0657***	1.0000			
GDPRG	0.0162*	0.1305***	0.1297***	-0.0478***	-0.1300***	0.0770***	-0.0014	-0.0086	0.0706***	1.0000		
Inflation	-0.0367***	0.0316***	0.0306***	-0.1071***	-0.0569***	0.0507***	-0.0115	-0.0629***	0.0139	-0.2094***	1.0000	
Slope	0.0799***	-0.0040	-0.0047	-0.0186**	0.0316***	-0.0049	-0.0225**	-0.0336***	0.1460***	-0.3370***	0.5034***	1.0000

***, ** and * are statistical significances at 0.01, 0.05 and 0.10 level, respectively. Table 2 gives the definitions of the variables.

Table 6
The NSFR and European banks' profitability: baseline results. It shows the results of the regression model of Eq. (1) for our sample banks over the years 2011–2012. In columns (1), (2) and (3), the dependent variables are NIM, ROA and ROE, respectively. Regressions involve panel data and are estimated with bank-specific fixed effects. Note that we winsorize all bank variables at the 1- and 99-percentile level to mitigate the impact of outliers. Standard errors are reported in parentheses. We cluster standard errors at the bank-level.

	(1)	(2)	(3)
Variables	$NIM_{i,t+1}$	$ROA_{i,t+1}$	$ROE_{i,t+1}$
$NSFR_{i,t}$	-0.003	-0.004	-0.064
	(0.002)	(0.004)	(0.048)
Credit $risk_{i,t}$	-0.054***	-0.017	0.287
	(0.012)	(0.021)	(0.247)
$Efficiency_{i,t}$	0.002**	-0.001	-0.047
	(0.001)	(0.001)	(0.055)
$Solvency_{i,t}$	-0.004	-0.062***	-0.919***
	(0.011)	(0.018)	(0.212)
$Size_{i,t}$	0.006***	0.001	0.009
	(0.001)	(0.002)	(0.023)
$HHI_{m,t}$	0.058***	0.064***	0.616***
	(0.011)	(0.019)	(0.220)
$GDPGR_{m,t}$	0.084***	0.045***	1.504***
	(0.022)	(0.008)	(0.444)
$Inflation_{m,t}$	-0.138***	-0.265***	-0.828***
	(0.039)	(0.066)	(0.276)
$Slope_{m,t}$	-0.063	0.029	-0.430
	(0.075)	(0.126)	(0.784)
Constant	-0.065***	0.029	0.234
	(0.024)	(0.041)	(0.482)
Bank fixed effects	YES	YES	YES
Observations	1425	1425	1425
R-squared	0.2538	0.1253	0.1195

***, ** and * are statistical significances at 0.01, 0.05 and 0.10 level, respectively. Table 2 gives the definitions of the variables.

Table 7
The NSFR and European banks' profitability: baseline results. It shows the results of the regression model of Eq. (1) for our sample banks over the years 2013–2018. In columns (1), (2) and (3), the dependent variables are NIM, ROA and ROE, respectively. Regressions involve panel data and are estimated with bank-specific fixed effects. Note that we winsorize all bank variables at the 1- and 99-percentile level to mitigate the impact of outliers. Standard errors are reported in parentheses. We cluster standard errors at the bank-level.

	(1)	(2)	(3)
Variables	$NIM_{i,t+1}$	$ROA_{i,t+1}$	$ROE_{i,t+1}$
$NSFR_{i,t}$	-0.002***	0.002***	0.020***
	(0.000)	(0.001)	(0.007)
Credit $risk_{i,t}$	-0.010***	-0.009*	-0.071
	(0.003)	(0.005)	(0.054)
$Efficiency_{i,t}$	-0.001***	0.000	0.005
	(0.000)	(0.000)	(0.004)
$Solvency_{i,t}$	-0.048***	-0.021***	-0.466***
	(0.003)	(0.004)	(0.044)
$Size_{i,t}$	-0.005***	-0.003***	-0.033***
	(0.000)	(0.000)	(0.004)
$HHI_{m,t}$	0.016***	0.014***	0.131***
	(0.002)	(0.002)	(0.024)
$GDPGR_{m,t}$	-0.052***	-0.001	-0.060
	(0.003)	(0.005)	(0.054)
$Inflation_{m,t}$	0.004	-0.007	0.044
	(0.005)	(0.007)	(0.073)
$Slope_{m,t}$	-0.011	0.019*	0.172
	(0.007)	(0.010)	(0.105)
Constant	0.130***	0.060***	0.740***
	(0.005)	(0.007)	(0.076)
Bank fixed effects	YES	YES	YES
Observations	9588	9586	9586
R-squared	0.2626	0.0146	0.0237

***, ** and * are statistical significances at 0.01, 0.05 and 0.10 level, respectively. Table 2 gives the definitions of the variables.

that European banks experienced during those years thanks to the effect of the (targeted) long-term refinancing operations launched by the ECB in late 2010 and early 2011, which were able to affect banks' interest expenses with a certain lag, in our second sub-period. We do not observe any statistically significant impact of the GDP growth rate on the ROA and ROE over those years. Things are different in the years 2011–2012, where the regression coefficients are all positive and statistically significant at the 1 % confidence level. Lower loan loss provisions associated with better economic conditions might explain the positive impact of GDP growth on the overall profitability measures, whereas, as for the NIM, the expansion of new loans when the economy grows might have occurred by charging higher interest rates on their customers.

Conversely to our hypothesis, inflation is negatively related to our banks' profitability measures in the years 2011 and 2012: regression coefficients are all statistically significant at the 1 % confidence level. The relation between inflation and bank profitability is not significant during the 2013–2018 years. Contrary to our expectations and the related literature, there is no statistically significant relationship between the slope of the yield curve and our sample banks' profitability measures, with the only exception of the ROA variable in the second sub-period, even if the regression coefficient, which is positive, is only marginally significant at the 10 % confidence level.

7. Robustness checks

To check the robustness of our results, we perform some sensitivity analyses in this section. For brevity, in Tables 8–10, we report the results for the NSFR variable only. First, from a methodological perspective, we detect whether the assumptions underlying the estimates of the NSFR affect our main results. So, within the NSFR calculation, we change the weighting factors applied to loans and deposits to test if our results are driven by the assumptions adopted to treat two of the most important items of a bank's balance-sheet. We stress our NSFR proxy by applying the lowest (highest) value in the range of the regulatory weights for all kinds of loans and the highest (lowest) value in the range of the regulatory weights for all kinds of deposits. In columns (1) of Table 8 we apply the 0.65 weighting coefficient for loans and the 0.90 weighting coefficient for deposits, whereas in columns (2) we use the 1 weighting coefficient for loans and the 0.50 weighting coefficient for deposits. Panel A and Panel B refer to the years 2011–2012 and 2013-2018, respectively. The impact of the NSFR on our three measures of profitability remains the same discussed in the main results section above.

German banks are about half of our dataset. To exclude that their behaviour drives our results, we re-estimate our regression model on a sample that does not include these credit institutions. Panels A and B of Table 9 refer to the years 2011–2012 and 2013–2018, respectively, and show that, even after removing German banks, the NSFR reduces banks' NIM during the extremely low or negative interest rates environment, whereas it is positively associated with ROA and ROE.

Cooperative and savings banks represent more than half of our dataset. So, as a third robustness check, in Table 10 we detect whether our main findings are referred to their particular business model by dropping them from the sample. Again, Panels A and B refer to the two sub-periods in which we have split our investigation horizon. Main results discussed in the previous section are still confirmed.

The relation between the NSFR and banks' profitability might depend on the level of this latter. Therefore, as a fourth robustness

Table 8
The NSFR and European banks' profitability: different NSFR calculation approaches. It shows the results of the regression model of Eq. (1) for our sample banks, where the dependent variables are NIM, ROA and ROE, respectively. In column (1), the NSFR is calculated by applying the 0.65 weighting coefficient for loans and the 0.90 weighting coefficient for deposits; in column (2), the NSFR is calculated by applying the 1 weighting coefficient for loans and the 0.50 weighting coefficient for deposits. Regressions involve panel data and are estimated with bank-specific fixed effects. Note that we winsorize all bank variables at the 1- and 99-percentile level to mitigate the impact of outliers. Standard errors are reported in parentheses. We cluster standard errors at the bank-level. Panels A and B refer to the years 2011–2012 and to the years 2013-2018, respectively.

Panel A: years 2011–2012						
Variables	$NIM_{i,t+1}$		$ROA_{i,t+1}$		$ROE_{i,t+1}$	
	(1)	(2)	(1)	(2)	(1)	(2)
$NSFR_{i,t}$	-0.000	-0.004	-0.003	-0.003	-0.046	-0.060
	(0.002)	(0.004)	(0.003)	(0.006)	(0.036)	(0.072)
Bank fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1425	1425	1425	1425	1425	1425
R-squared	0.2517	0.2531	0.1255	0.1243	0.1193	0.1178
Number of banks	855	855	855	855	855	855
Panel B: years 2013–2018						
Variables	$NIM_{i,t+1}$		$ROA_{i,t+1}$		$ROE_{i,t+1}$	
	(1)	(2)	(1)	(2)	(1)	(2)
$NSFR_{i,t}$	-0.001***	-0.006***	0.002***	0.003***	0.017***	0.029***
	(0.000)	(0.001)	(0.001)	(0.001)	(0.005)	(0.011)
Bank fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	9588	9588	9588	9588	9588	9588
R-squared	0.2610	0.2664	0.0147	0.0142	0.024	0.024
Number of banks	2203	2203	2203	2203	2203	2203

***, ** and * are statistical significances at 0.01, 0.05 and 0.10 level, respectively. Table 2 gives the definitions of the variables.

Table 9
The NSFR and European banks' profitability: no German banks. It shows the results of the regression model of Eq. (1) for our sample banks, without German banks, where the dependent variables are NIM, ROA and ROE, respectively. Regressions involve panel data and are estimated with bank-specific fixed effects. Note that we winsorize all bank variables at the 1- and 99-percentile level to mitigate the impact of outliers. Standard errors are reported in parentheses. We cluster standard errors at the bank-level. Panels A and B refer to the years 2011–2012 and to the years 2013-2018, respectively.

Panel A: years 2011–2012			
Variables	$NIM_{i,t+1}$	$ROA_{i,t+1}$	$ROE_{i,t+1}$
$NSFR_{i,t}$	-0.002	-0.004	-0.076
	(0.002)	(0.004)	(0.053)
Bank fixed effects	Yes	Yes	Yes
Observations	1057	1057	1057
R-squared	0.3243	0.1155	0.1263
Number of banks	547	547	547
Panel B: years 2013–2018			
Variables	$NIM_{i,t+1}$	$ROA_{i,t+1}$	$ROE_{i,t+1}$
$NSFR_{i,t}$	-0.002***	0.003**	0.024**
	(0.000)	(0.001)	(0.010)
Bank fixed effects	Yes	Yes	Yes
Observations	4283	4281	4281
R-squared	0.1222	0.0118	0.0182
Number of banks	937	937	206

***, ** and * are statistical significances at 0.01, 0.05 and 0.10 level, respectively. Table 2 gives the definitions of the variables.

Table 10
The NSFR and European banks' profitability: no cooperative banks. It shows the results of the regression model of Eq. (1) for our sample banks, without cooperative banks, where the dependent variables are NIM, ROA and ROE, respectively. Regressions involve panel data and are estimated with bank-specific fixed effects. Note that we winsorize all bank variables at the 1- and 99-percentile level to mitigate the impact of outliers. Standard errors are reported in parentheses. We cluster standard errors at the bank-level. Panels A and B refer to the years 2011–2012 and to the years 2013-2018, respectively.

Panel A: years 2011–2012			
Variables	$NIM_{i,t+1}$	$ROA_{i,t+1}$	$ROE_{i,t+1}$
$NSFR_{i,t}$			
	-0.018	-0.012	-0.1558
	(0.160)	(0.011)	(0.139)
Bank fixed effects	Yes	Yes	Yes
Observations	318	318	318
R-squared	0.2534	0.1876	0.1634
Number of banks	201	201	201
Panel B: years 2013–2018			
Variables	$NIM_{i,t+1}$	$ROA_{i,t+1}$	$ROE_{i,t+1}$
$NSFR_{i,t}$			
	-0.003***	0.002**	0.0169**
	(0.000)	(0.001)	(0.006)
Bank fixed effects	Yes	Yes	Yes
Observations	2974	2973	2973
R-squared	0.1636	0.0146	0.0156
Number of banks	636	636	636

***, ** and * are statistical significances at 0.01, 0.05 and 0.10 level, respectively. Table 2 gives the definitions of the variables.

check, we split our overall sample in two sub-samples including banks belonging, respectively, to the 1st quartile (less profitable banks) and to the 4th quartile (more profitable banks) of the distribution of each of the profitability variables we consider (NIM, ROA and ROE). Table 11 shows that, even by accounting for different levels of profitability, our main results are confirmed, since we find that regression coefficients for the NSFR variable are not statistically significant for the years 2011–2012 (see Panel A), whereas they are not only significant at the ordinary confidence levels, but also have the same sign of the coefficients observed in Table 7.

To investigate whether the level of bank liquidity affects our results, the relation between the NSFR and profitability is separately tested on two sub-samples that are identified on the basis of their liquidity position in terms of funding gap, i.e., the ratio of the difference between gross loans and customer deposits to gross loans. Table 12 shows the estimates referred respectively to the banks of the 1st quartile (more liquid banks) and of the 4th quartile (less liquid banks) of the funding gap distribution. Our main results remain confirmed in both cases for both the first and second sub-period.

Table 11
The NSFR and European banks' profitability: less profitable vs. more profitable banks. It shows the results of the regression model of Eq. (1) for banks belonging to the 1st and 4th quartile of the distributions of the NIM, ROA and ROE, respectively, where the dependent variables are NIM, ROA and ROE. Regressions involve panel data and are estimated with bank-specific fixed effects. Note that we winsorize all bank variables at the 1- and 99-percentile level to mitigate the impact of outliers. Standard errors are reported in parentheses. We cluster standard errors at the bank-level. Panels A and B refer to the years 2011–2012 and to the years 2013-2018, respectively.

Panel A: years 2011–2012						
	1tst quartile			4th quartile		
	(1)	(2)	(3)	(1)	(2)	(3)
Variables	NIM $_{i,t+1}$	ROA $_{i,t+1}$	ROE $_{i,t+1}$	NIM $_{i,t+1}$	ROA $_{i,t+1}$	ROE $_{i,t+1}$
$NSFR_{i,t}$	-0.008	-0.113	0.120	-0.005	0.003	0.019
	(0.005)	(0.070)	(0.929)	(0.005)	(0.003)	(0.045)
Bank fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	248	131	123	574	908	903
R-squared	0.6830	0.9137	0.9125	0.2641	0.3258	0.2683
Number of banks	161	111	103	392	716	725
Panel B: years 2013–2018						
	1tst quartile			4th quartile		
	(1)	(2)	(3)	(1)	(2)	(3)
Variables	NIM $_{i,t+1}$	ROA $_{i,t+1}$	ROE $_{i,t+1}$	NIM $_{i,t+1}$	ROA $_{i,t+1}$	ROE $_{i,t+1}$
$NSFR_{i,t}$	-0.002***	0.005**	0.063**	-0.06***	0.003**	0.002**
	(0.000)	(0.002)	(0.025)	(0.001)	(0.001)	(0.001)
Bank fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	2190	2113	2086	2452	3141	3154
R-squared	0.0824	0.0450	0.0491	0.1859	0.0362	0.0456
Number of banks	780	755	778	893	1534	1540

***, ** and * are statistical significances at 0.01, 0.05 and 0.10 level, respectively. Table 2 gives the definitions of the variables.

Table 12
The NSFR and European banks' profitability: less liquid vs. more liquid banks. It shows the results of the regression model of Eq. (1) for banks belonging to the 1st and 4th quartile of the distribution of the funding gap (the ratio of the difference between customer loans and deposits to customer loans). Regressions involve panel data and are estimated with bank-specific fixed effects. Note that we winsorize all bank variables at the 1- and 99-percentile level to mitigate the impact of outliers. Standard errors are reported in parentheses. We cluster standard errors at the bank-level. Panels A and B refer to the years 2011–2012 and to the years 2013-2018, respectively.

Panel A: years 2011–2012						
	1tst quartile			4th quartile		
	(1)	(2)	(3)	(1)	(2)	(3)
Variables	NIM $_{i,t+1}$	ROA $_{i,t+1}$	ROE $_{i,t+1}$	NIM $_{i,t+1}$	ROA $_{i,t+1}$	ROE $_{i,t+1}$
$NSFR_{i,t}$	0.001	0.006	-0.006	0.011	0.001	-0.034
	(0.003)	(0.006)	(0.055)	(0.032)	(0.009)	(0.112)
Bank fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	325	325	325	539	539	539
R-squared	0.7444	0.6035	0.2235	0.4619	0.2178	0.2194
Number of banks	221	221	221	317	317	317
Panel B: years 2013–2018						
	1tst quartile			4th quartile		
	(1)	(2)	(3)	(1)	(2)	(3)
Variables	NIM $_{i,t+1}$	ROA $_{i,t+1}$	ROE $_{i,t+1}$	NIM $_{i,t+1}$	ROA $_{i,t+1}$	ROE $_{i,t+1}$
$NSFR_{i,t}$	-0.005**	0.001**	0.015**	-0.006***	0.004**	0.057**
	(0.002)	(0.000)	(0.007)	(0.001)	(0.002)	(0.022)
Bank fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	2421	2420	2420	2221	2220	2220
R-squared	0.4579	0.0692	0.083	0.1262	0.0560	0.0463
Number of banks	678	678	678	600	600	600

***, ** and * are statistical significances at 0.01, 0.05 and 0.10 level, respectively. Table 2 gives the definitions of the variables.

8. Conclusions

This paper analyses how European banks' ability to make profits has reacted to the introduction of the NSFR by examining data referred to the 2011–2018 period. The study is motivated by a gap in the literature regarding the combined effects of liquidity regulation and macroeconomic conditions, specifically, those stemming from the unconventional, ultra-expansionary monetary

policies adopted by the ECB after the GFC. Particularly, we investigate the impact of the Basel III funding liquidity requirement under varying interest rate environments. To capture potential differences, we divide the period into two sub-periods: 2011–2012, characterized by moderate interest rate volatility, and 2013–2018, when rates remained near zero and eventually turned steadily negative. Therefore, our research extends the literature about the determinants of net interest margin and overall bank profitability to detect the joint effect on banks' behaviour of the introduction of the NSFR and of the extremely low or negative interest rates.

Based on a large set of panel data referred to 25 European countries, we find that the relationship between the NSFR and banks' profitability changes with the level and the volatility of the interest rates. The impact of the NSFR on banks' profits is null during the years 2011–2012. This does not hold in the second part of our sample period, when interest rates fell to unprecedented low levels and the impact of the NSFR on banks' NIM becomes negative, whereas it turns out to be positive for ROA and ROE. These findings suggest that the interaction between regulatory liquidity requirements and an ultra low-interest rate environment can influence different aspects of bank profitability in contrasting ways: while net interest margins may be compressed, overall profitability as measured by ROA and ROE may still increase, potentially due to effects such as lower loan loss provisions or asset revaluation. We acknowledge that our results are most directly applicable to European banks during periods of low or negative interest rates and may not fully generalize to other banking systems or macroeconomic environments.

It appears that the joint effect of the adoption of ultra-expansionary measures of monetary policy and the Basel III liquidity requirement can jeopardize banks' ability to make profits, at least in terms of net interest margins, which can be an issue in the financial stability perspective. In particular, in an environment of historically low interest rates, banks face greater difficulties in negotiating more favorable terms with clients, as deposit and lending rates are already compressed. This limits their ability to expand net interest margins through traditional channels, highlighting why liquidity requirements such as the NSFR can have a more pronounced negative effect on NIM under these conditions. From a policy standpoint, our research shows that, with the adoption of the ultra-expansionary measures of monetary policy that drove interest rates to unprecedented low levels, meeting the Basel III NSFR constraint might have a negative impact on banks' profits associated with the traditional loans issuing and deposits collecting business.

Overall, our results are relevant for regulators and policymakers because they demonstrate the importance of considering profitability measures when designing monetary and prudential policies. These findings support the idea of introducing some flexibility into the liquidity regulatory framework, which could reduce potential unintended consequences of the NSFR on banking business sustainability. Future research could extend the analysis beyond 2018 to examine the post-pandemic and monetary policy normalization phases, and to assess whether the relationships identified here hold under these new conditions. Extending the sample would also make it possible to study the implications of the 2019 reform of the Italian cooperative banking sector, which led to a sharp decline in the number of independent cooperative banks and potentially altered the competitive and structural dynamics of the European banking landscape.

Author statement

On behalf of my coauthors, I confirm that:

- this manuscript is original, has not been published previously, and is not currently under consideration for publication elsewhere;
- all authors have read and approved the revised version of the manuscript and agree to re-submit it to *Research in International Business and Finance*;
- all the authors declare that they have no conflicts of interest.

CRediT authorship contribution statement

Giuseppe Galloppo: Validation, Supervision, Data curation, Conceptualization. **Domenico Curcio:** Writing – review & editing, Writing – original draft, Methodology, Investigation, Data curation, Conceptualization. **Erika Bragaglia:** Writing – original draft, Software, Methodology, Investigation, Data curation, Conceptualization. **Roberto Guida:** Validation, Supervision, Investigation, Conceptualization.

Declaration of Competing Interest

We declare that we have no financial and personal relationships with other people or organizations that can inappropriately influence our work, there is no professional or other personal interest of any nature or kind in any product, service and/or company that could be construed as influencing the position presented in, or the review of, the manuscript entitled.

Appendix A

According to BCBS (2014), the components of each of the ASF categories and the associated maximum ASF factor to be applied in calculating its total amount are:

ASF factor	Components of ASF category
100 %	• Total regulatory capital (excluding Tier 2 instruments with residual maturity of less than one year) • Other capital instruments and liabilities with effective residual maturity of one year or more
95 %	• Stable non-maturity (demand) deposits and term deposits with residual maturity of less than one year provided by retail and small business customers
90 %	• Less stable non-maturity deposits and term deposits with residual maturity of less than one year provided by retail and small business customers
50 %	• Funding with residual maturity of less than one year provided by non-financial corporate customers • Operational deposits • Funding with residual maturity of less than one year from sovereigns, PSEs, and multilateral and national development banks • Other funding with residual maturity between six months and less than one year not included in the above categories, including funding provided by central banks and financial institutions
0 %	• All other liabilities and equity not included in the above categories, including liabilities without a stated maturity (with a specific treatment for deferred tax liabilities and minority interests) • NSFR derivative liabilities net of NSFR derivative assets if NSFR derivative liabilities are greater than NSFR derivative assets • "Trade date" payables arising from purchases of financial instruments, foreign currencies and commodities

As far as the RSF is concerned, the specific types of assets to be assigned to each asset category and their associated RSF factor are:

RSF factor	Components of RSF category
0 %	• Coins and banknotes • All central bank reserves • All claims on central banks with residual maturities of less than six months • "Trade date" receivables arising from sales of financial instruments, foreign currencies and commodities
5 %	• Unencumbered Level 1 assets, excluding coins, banknotes and central bank reserves
10 %	• Unencumbered loans to financial institutions with residual maturities of less than six months, where the loan is secured against Level 1 assets as defined in LCR paragraph 50, and where the bank has the ability to freely rehypothecate the received collateral for the life of the loan
15 %	• All other unencumbered loans to financial institutions with residual maturities of less than six months not included in the above categories • Unencumbered Level 2 A assets
50 %	• Unencumbered Level 2B assets • HQLA encumbered for a period of six months or more and less than one year • Loans to financial institutions and central banks with residual maturities between six months and less than one year • Deposits held at other financial institutions for operational purposes All other assets not included in the above categories with residual maturity of less than one year, including loans to non-financial corporate clients, loans to retail and small business customers, and loans to sovereigns and PSEs
65 %	• Unencumbered residential mortgages with a residual maturity of one year or more and with a risk weight of less than or equal to 35 % under the Standardised Approach Other unencumbered loans not included in the above categories, excluding loans to financial institutions, with a residual maturity of one year or more and with a risk weight of less than or equal to 35 % under the standardised approach
85 %	• Cash, securities or other assets posted as initial margin for derivative contracts and cash or other assets provided to contribute to the default fund of a CCP • Other unencumbered performing loans with risk weights greater than 35 % under the standardised approach and residual maturities of one year or more, excluding loans to financial institutions • Unencumbered securities that are not in default and do not qualify as HQLA with a remaining maturity of one year or more and exchange-traded equities • Physical traded commodities, including gold
100 %	• All assets that are encumbered for a period of one year or more • NSFR derivative assets net of NSFR derivative liabilities if NSFR derivative assets are greater than NSFR derivative liabilities • 20 % of derivative liabilities as calculated according to paragraph 19 • All other assets not included in the above categories, including non-performing loans, loans to financial institutions with a residual maturity of one year or more, non-exchange-traded equities, fixed assets, items deducted from regulatory capital, retained interest, insurance assets, subsidiary interests and defaulted securities

Data availability

The authors do not have permission to share data.

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