

Exploring the interplay of credit and liquidity risks: Impacts on banks' profitability



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ABSTRACT

This research delves into the intricate relationship between credit and liquidity risks and their far-reaching consequences on the overall profitability of banks. Leveraging a comprehensive dataset comprising 132 observations across twelve distinct financial institutions, spanning the period from 2009 to 2019, the analysis employs a sophisticated empirical framework grounded in simultaneous equations. By incorporating three meticulously chosen control variables, this approach adeptly disentangles the distinct effects of credit and liquidity risks on banks' financial performance. The methodological trajectory unfolds in a sequential manner, commencing with isolated scrutiny of the individual impacts of credit and liquidity risks on banks' profitability. This evaluation is gauged through robust metrics such as Returns on Assets and Economics. Subsequently, a nuanced exploration ensues, probing the intricate interplay between these two risks and their combined effect on banks' profitability. Eminent findings emerge from this investigation, underscoring the adverse consequences of escalated credit risk on bank liquidity, accompanied by a simultaneous elevation in overall risk exposure. This disturbing trend notably casts a substantial shadow over banks' profitability. Conclusively, this study consistently establishes the detrimental impact of the confluence of credit and liquidity risks on the financial well-being of banks. Evidently, this interaction exerts a negative influence on banks' profitability, a perspective persistently reinforced by the authors' analyses. The insights garnered from this study hold notable implications for the banking community and financial practitioners. By enhancing comprehension of the distinct attributes of credit and liquidity risks, this research contributes to a refined understanding of risk management dynamics. Moreover, it accentuates the urgency of fortifying the holistic management of liquidity-credit risks, a call to action that resonates deeply with both bankers and financiers seeking to navigate the intricate terrain of contemporary financial landscapes.

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1. Introduction

Ever since the inception of the Basel III reform, designed to fortify the foundations of the financial system and enhance the solidity of financial institutions through the implementation of solvency and liquidity benchmarks, international supervisory and regulatory entities have persistently engaged in

formulating directives that oversee the multifaceted hazards intrinsic to banking operations. Consequently, the resilience of bank profitability has encountered a heightened vulnerability, besieged by a convergence of credit and liquidity risks. These dual perils pose formidable trials for financial establishments, imperiling their profit margins in instances of deficit and casting a shadow of instability over the entirety of the banking domain.

However, this quest for stability remains an ongoing pursuit within a global context characterized by profound shifts and uninterrupted transformations. Over the passage of years, international bodies tasked with oversight and regulation have sustained their interventionist role

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to promulgate directives that govern the intricate array of risks endemic to the realm of banking. Of these hazards, credit and liquidity risks stand out as particularly pernicious to the vitality of the banking sector.

The Basel III reform is purposefully orchestrated to bolster the financial framework by instituting markers of solvency and liquidity. Simultaneously, this reform instates a leverage ratio that amplifies the prudential management of liquidity risk and fortifies the regulatory fabric governing the systemic risk entwined with banking institutions.

The literature on the effect of credit risk and bank profitability provided mixed results. Some studies supported a negative relationship (Cucinelli, 2015; Laryea et al., 2016), while few others found positive relationships (Abdelaziz et al., 2011). For instance, Noman et al. (2015) studied the effect of credit risk on bank profitability in Bangladesh in a sample of 18 banks during the 2003-2013 period. The authors found that credit risk significantly decreases bank profitability. Similarly, Laryea et al. (2016), focusing on an emerging market, examined a sample of 22 Ghanaian banks from 2005 to 2010 to study the effect of non-performing loans on bank profitability. Again, the results pointed to a negative relationship. Tabari et al. (2013) studied the association between liquidity risk and bank profitability based on a sample of Iranian commercial banks from 2003-2010. The same negative association was found for the Iranian example. The authors indicated that credit and liquidity risks negatively and significantly affect Iranian banks' profitability. Another study in Switzerland conducted by Mamatzakis and Bermpei (2014), based on a sample of 97 banks, reported that liquidity harmed banks' profitability. In other cases, some studies supported a positive relationship between bank profitability and credit risk. Flamini et al. (2009) examined a sample of 389 banks in 41 Sub-Saharan African countries from 1998 to 2006 and found a positive relationship between bank profitability and credit risk. This study measured credit risk by asset quality based on standard asset pricing. Abdelaziz et al. (2011) found the same result in a sample of nine Tunisian banks observed over the 1980-2009 period.

Noticeably, the literature needed to explore the effect of liquidity risk and bank profitability fully. Some studies reported that liquidity positively affects bank profitability (Adebayo et al., 2011). In contrast, many others have concluded that liquidity harms bank profitability because of the misallocation of resources. Similarly, Kim (2015) examined the effect of liquidity risk on the profitability of European banks during the 2001-2011 period and found that liquidity risk significantly decreases the profitability of these banks. Arif and Anees (2012) studied a sample of banks in the South African context over the 1998-2014 period. Bank profitability was measured by net interest margin. The results of the autoregressive distributed lag show that liquidity risk negatively affects bank profitability. More recently, the effect of liquidity risk

on bank profitability was studied by Hamdi and Hakimi (2019). The authors found that this relationship is nonlinear and that the impact of liquidity risk on bank profitability depends on some optimal thresholds. They examined a large sample of 127 countries observed over the 2005-2015 period. The piece was divided into 46 high-income and 81 low- and middle-income countries. The results of the transitional regression model indicate that an optimal level of liquidity and its effect on bank profitability differ across country groups.

Although Tunisia is known for its both high credit and liquidity risks, with a coverage rate of 58% and a classified debt rate of 15.8% in 2014, little research is devoted to investigating the relationship between credit risk, liquidity risk, and bank profitability in Tunisia (Ghenimi et al., 2017). Most empirical studies are focused on the American context (Imbierowicz and Rauch, 2014), the European context (Kim, 2015), and Asian countries (AlSagr et al., 2018). Moreover, international bodies, including the International Monetary Fund (IMF), the World Bank (WB), and rating agencies (SandP), indicate that the Tunisian banking sector needs to be more efficient to ensure control of these risks. As a result, the banking situation in Tunisia is fragile, requiring urgent and timely reforms to save banks' profitability and make the Tunisian banking sector more solid. In 2012, the Tunisian economy experienced a recovery following improving tourism, and foreign direct investment (FDI) flows. However, this recovery collapsed in 2013, 2014, and 2015 due to security, social and political difficulties. This social, economic, and political instability has negatively affected the activity of the banking sector in Tunisia. Consequently, the banking system has suffered the consequences of the national and international economic climate.

The effect of liquidity risk on bank profitability was explored by Hakimi and Zaghdoudi (2017). The authors examined a sample of 10 Tunisian banks from 1990-2013. The random-effects regression results show that liquidity risk significantly decreases the profitability of Tunisian banks. Using a sample of 123 banks over the 1999-2013 period, Adelopo et al. (2018) showed that liquidity risk significantly decreases banks' profitability before, during, and after the financial crisis.

By successfully taking account of studies previously, the effect of credit and liquidity risks on bank profitability is well documented in the literature since only a few studies have examined this question in Tunisia. So then, this paper aims first to study the effect of credit and liquidity risks on bank profitability separately and second to determine the effect of these risks' interaction on profitability in a sample of Tunisian banks. As a result, the paper offers a better understanding of marital difficulties faced by bank managers and stakeholders. Although our study focuses on the Tunisian banking sector, it explores the specificities of banks operating in developing countries. Therefore, our study's outcomes will be relevant for

owners and managers looking to improve their bank profitability. In addition, it provides information for other developing countries. It allows them to take the necessary measures to clean up their banking sectors and promote the stability of their financial systems.

In this study, however, we hypothesized the following. The first hypothesis (H1) is that credit risk decreases bank profitability. The second hypothesis (H2) considers that liquidity risk negatively affects bank profitability. Therefore, credit and liquidity risks are qualified as reciprocal risks. Finally, referring to H1 and H2, which oppose the negative effect of credit and liquidity risks on bank profitability, a third hypothesis (H3) assumes that interaction between credit risk and liquidity risk decreases bank profitability.

To this end, most previous works were undertaken without studies combining the effect of credit risk, liquidity risk, and the interaction effect between the two variables. More clarity in the literature motivated our study in the context of Tunisian banks. These two liquidity risks are considered reciprocal and recognized as the main determinants of a bank's sphere, given their importance in determining profitability.

The remainder of this paper is structured as follows. Section 2 describes the data and outlines the methodology. Section 3 presents and discusses the main empirical results. Section 4 concludes.

2. Methodology and data

2.1. Modeling framework

Based on the assumption that credit and liquidity risks are considered reciprocal risks and admitted as the main determinants of bank profitability, Abdelaziz et al. (2022) devised an econometric approach using simultaneous equations. The SUR model is a system of multiple equations with a single dependent variable for each equation and k-independent or exogenous variables. The general specification of SUR simultaneous systems of equations can be represented as follows:

$$Y_m = X_m \beta_m + \varepsilon_m \tag{1}$$

where, Y_m is a vector of dependent variables, X_m is a vector of independent variables, β_m is a regression coefficient vector, and ε_m is the error term. Using the SUR method is again motivated by the estimation efficiency of combining information from different equations. In addition, the method can also test restrictions involving parameters in differential equations. The first step is to test the effect of credit risk and liquidity risk on bank profitability separately. In this case, bank profitability (PR) is the dependent variable whose equation is given by:

$$PR = \mathcal{F}(CR, LR, SIZE, CAP, GDP, INF) \tag{2}$$

Credit risk (CR) is the dependent variable written as follows:

$$CR = \mathcal{F}(PR, LR, SIZE, CAP, GDP, INF) \tag{3}$$

Liquidity risk LR is an endogenous variable written as follows:

$$LR = \mathcal{F}(PR, CR, SIZE, CAP, GDP, INF) \tag{4}$$

In the second phase, we investigate the interaction effect between credit and liquidity risks on bank profitability measured by ROA and ROE. The PR is the dependent variable taking the following equation:

$$PR_{it} = \alpha_{10} + \alpha_{11}CR_{it} * LR_{it} + \alpha_{12}SIZE_{it} + \alpha_{13}CAP_{it} + \alpha_{14}CR_{it} + \alpha_{15}GDP_{it} + \alpha_{16}INF_{it} + \varepsilon_1 \tag{5}$$

The interaction between the two risks CR×LR is considered as the endogenous variable whose equation is given by:

$$CR_{it} \times LR_{it} = \alpha_{20} + \alpha_{21}PR_{21} + \alpha_{22}SIZE_{22} + \alpha_{23}CAP_{23} + \alpha_{24}CR_{24} + \alpha_{25}GDP_{25} + \alpha_{26}INF_{26} + \varepsilon_1 \tag{6}$$

The dimensional variables in models 2–6 are given in Table 1.

2.2. Data

Our study's sample consists of 12 Tunisian banks observed over the 2009-2019 period yielding panel data of 132 observations. The data on financial banks were collected from the annual reports of the 12 banks, the financial market council, and the Tunisian stock exchange annual reports. The banks of our sample are reported in Table 2.

Table 1: Description of variables in models 2–6

Variables	Label	Measurement
PR	Bank profitability	ROA and ROE
CR	Credit risk	(%)
LR	Liquidity risk	(%)
CR×LR	Interaction term	Interaction between risks
SIZE	Bank size	Log of total assets (%)
CAP	Capital adequacy ratio	Bank capital to total assets (%)
GDP	Gross domestic product growth	Percentage Economic Growth (%)
INF	Inflation rate	Inflation rate measured by consumer prices (%)

Table 2: List of banks and acronyms

Banks	Acronyms
Société Tunisienne de Banque	STB
Banque Internationale Arabe de Tunisie	BIAT
Banque de l'Habitat	BH
AMEN Bank	A. Bank
AT. Bank	AT. Bank
Arab Tunisian Bank	ATB
Banque de Tunisie	BT
Banque Nationale Agricole	BNA
Banque de Tunisie et des Emirats	BTE
Union Bancaire de Commerce et d'Industrie	UBCI
Union International de Banque	UIB
Al Wifak International Bank	W. Bank

Table 3 traces the evolution of bank profitability between 2009 and 2019 in terms of ROA by the bank. From Table 3, it is easy to note that in 2009, bank profitability was low for STB, BIAT, BH, AMEN Bank, ATTIJARI, ATB, BNA, BTE, UBCI, and UIB. Then, the ROA of these banks was around 1% in 2009. This percentage is below the limits of the financial

standing of 2%. On the other hand, the two banks, BT and WIFAK Bank, had ROAs of 2.50% and 2.40%, respectively. BT Bank recorded ROA values of around 2% during 2009-2019. In 2019, ROA was around 2% (value close to prudential standards) for UIB, WIFAK Bank, ATTIJARI, and BIAT.

Table 3: Evolution of bank profitability ROA and (ROE) between 2009 and 2019

Year	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
STB	0.006 (0.078)	0.002 (0.028)	0.002 (0.018)	-0.001 (-0.01)	-0.001 (1.014)	0.003 (-0.229)	0.004 (0.047)	0.004 (0.055)	0.004 (0.055)	0.006 (0.077)	0.014 (0.153)
BIAT	0.010 (0.122)	0.007 (0.094)	0.007 (0.093)	0.012 (0.163)	0.012 (0.176)	0.012 (0.153)	0.015 (0.196)	0.016 (0.213)	0.015 (0.206)	0.016 (0.208)	0.0203 (0.226)
BH	0.010 (0.130)	0.006 (0.076)	0.003 (0.032)	0.003 (0.039)	-0.030 (-0.703)	0.008 (0.181)	10.050 (0.153)	0.011 (0.167)	0.011 (0.152)	0.011 (0.157)	0.011 (0.144)
A. bank	0.011 (0.129)	0.013 (0.157)	0.012 (0.146)	0.009 (0.120)	0.014 (0.176)	0.011 (0.140)	0.007 (0.090)	0.010 (0.123)	0.013 (0.139)	0.013 (0.133)	0.0162 (0.143)
AT. bank	0.013 (0.192)	0.015 (0.199)	0.008 (0.091)	0.013 (0.139)	0.017 (0.213)	0.014 (0.181)	0.013 (0.207)	0.014 (0.219)	0.016 (0.241)	0.016 (0.228)	0.0187 (0.242)
ATB	0.012 (0.148)	0.013 (0.129)	0.008 (0.081)	0.011 (0.109)	0.009 (0.097)	0.011 (0.107)	0.010 (0.108)	0.008 (0.083)	0.008 (0.091)	0.001 (0.013)	0.001 (0.012)
BT	0.025 (0.149)	0.018 (0.119)	0.017 (0.122)	0.017 (0.119)	0.019 (0.127)	0.022 (0.139)	0.020 (0.134)	0.021 (0.139)	0.025 (0.169)	0.018 (0.132)	0.022 (0.147)
BNA	0.007 (0.075)	0.007 (0.079)	0.005 (0.063)	0.006 (0.076)	0.020 (0.026)	0.006 (0.083)	0.003 (0.039)	0.014 (0.180)	0.018 (0.203)	0.015 (0.152)	0.009 (0.081)
BTE	0.014 (0.054)	0.014 (0.056)	0.004 (0.018)	0.002 (0.010)	0.003 (0.016)	-0.013 (-0.086)	0.001 (0.012)	0.001 (0.007)	0.001 (0.006)	0.001 (0.007)	0.005 (0.043)
UBCI	0.013 (0.120)	0.012 (0.137)	0.009 (0.113)	0.005 (0.048)	0.007 (0.083)	0.011 (0.111)	0.010 (0.110)	0.009 (0.106)	0.010 (0.124)	0.012 (0.135)	0.016 (0.148)
UIB	0.003 (0.093)	0.007 (0.189)	0.008 (0.192)	0.005 (0.102)	0.009 (0.312)	0.014 (0.211)	0.015 (0.203)	0.016 (0.204)	0.016 (0.204)	0.018 (0.211)	0.019 (0.188)
W. bank	0.024 (0.115)	0.021 (0.139)	0.017 (0.113)	0.020 (0.170)	0.018 (0.106)	0.017 (0.097)	0.012 (0.027)	0.017 (0.029)	0.004 (0.009)	0.004 (0.016)	0.035 (0.138)

In addition, Table 3 traces the evolution of bank profitability between 2009 and 2019 in terms of ROE by the bank. It is noticeable that, in 2009, profitability measured by ROE for AT. Bank was attractive: 19.2% compared to that of STB (7.8%), BNA (7.5%), and UIB (9.3%). The general ROE trend of the 12 banks in our study has increased since 2009. Then, several banks, like BIAT (22.6%), AT. Bank (24.2%), and UIB (18.8%), have recorded ROE values close to 25% in 2019, which approximate those of European banks.

Table 4 presents the descriptive statistics of our variables. Such statistics provide more details about the banking sector in Tunisia. In Table 4, the average bank profitability for the selected banks in Tunisia was 2.8%±18.2% for ROA and 12.1%±11% for ROE. ROA and ROE have a maximum of 206% and 34.6%, while their minimum was -3.7% and -70.4%, respectively. These statistics indicate that the Tunisian banking sector was considered a profitable

sector. Nevertheless, there are apparent differences in Tunisian banks' profitability. As for bank size, the average is 16.044±1.921, with a minimum and a maximum of 13.165 and 22.556, respectively. The average capital to total assets is 5.2%. However, fewer capitalized banks have a minimum of 1%, and better-capitalized banks with a maximum of 51.9%. The average is 7.9% for credit risk, with a minimum of 0.00 and a maximum of 37.2%. The average liquidity risk reached 610.8%, ranging from 54.8% to 128.403. Moreover, since Tunisian banks operate in a macroeconomic environment, we introduce two variables in our model: Economic growth (GDP) and inflation rate (INF). The highest growth recorded in Tunisia from 2009 to 2019 was 3.9%, while the lowest was -1.9%. Lastly, the descriptive statistics also indicate that average inflation was 5.1% during this period, with 7.3% being the maximum and 3.5% as the minimum.

Table 4: Summary statistics and correlations of the study's variables

Variable	Mean	Std. dev.	Min.	Max.	ROA	ROE	LR×CR	LR	CR	CAP	SIZE	GDP	INF
ROA	0.028	0.182	-0.037	2.060	1								
ROE	0.121	0.110	-0.704	0.346	0.661	1							
LR×CR	0.243	0.649	0.000	4.482	0.055	-0.159	1						
LR	6.108	20.848	0.548	128.403	0.096	-0.238	0.486	1					
CR	0.079	0.080	0.000	0.372	-0.125	-0.088	0.813	0.134	1				
CAP	0.052	0.072	0.010	0.519	0.145	-0.126	0.348	0.331	0.107	1			
SIZE	16.044	1.921	13.165	22.556	0.002	-0.065	-0.165	0.127	-0.375	-0.395	1		
GDP	0.020	0.016	-0.019	0.039	-0.063	0.011	0.039	-0.087	0.018	0.044	-0.145	1	
INF	0.051	0.012	0.035	0.073	0.056	0.083	-0.001	0.032	0.039	-0.130	0.216	0.070	1

3. Econometric results

Table 4 provides the correlation matrix for the variables. We chose Pearson correlation to check the

nature (positive or negative) and correlation level (high or low). Then, in Table 3, the correlation between all independent variables is very low. Therefore, we can conclude to no multi-collinearity

problem. The highest correlation is between CR and the interaction between credit and liquidity risks (LR×CR) because credit and liquidity risks highly correlate. Table 5 reports the results of the separate and interaction effect of credit and liquidity risks on bank profitability in Tunisia. CR, LR, and SIZE decrease banks' profitability. This result is significant for ROA and ROE. So then, credit risk

negatively and significantly correlates with banks' profitability in Tunisia. Such a trend decreases banks' profitability and could even lead to failure. As a result, banks become more rigid and restrictive in credit allocation when borrowers cannot meet their commitments. This can reduce banks' interest income; therefore, our first hypothesis (H1) is verified.

Table 5: Separate and interaction effects of credit and liquidity risks on ROA and (ROE) in Tunisia

Model	Variable	Separate effect		Model	Variable	Interaction effect	
		Coef.	Z			Coef.	Z
(2)	LR	-0.0006 (0.0018)	-0.7400 (3.8000)	(5)	CAP	0.0127 (-0.2680)	0.0600 (-2.1000)
	CR	-0.6585 (-0.4319)	-3.2000 (-3.7700)		SIZE	-0.0061 (-0.0161)	-0.7400 (-3.3700)
	CAP	0.1908 (-0.4014)	0.7800 (-2.9400)		GDP	1.0717 (0.0576)	1.0300 (0.1000)
	SIZE	-0.0138 (-0.0287)	-1.5000 (-5.5800)		INF	-2.1824 (-0.1201)	-1.6000 (-0.1500)
	GDP	1.3931 (-0.0406)	1.3400 (-0.0700)		α_{10}	0.2165 (0.3984)	1.4900 (4.8000)
	INF	-2.2170 (0.4241)	-1.6200 (0.5500)				
	β_{10}	0.3815 (0.6047)	2.4000 (6.8000)				
	PR	-6.3140 (55.0497)	-0.7400 (3.8000)		CAP	5.3025 (5.3025)	8.9100 (8.9100)
	CR	-43.748 (-19.5766)	-2.1600 (-0.9700)		SIZE	0.0699 (0.0699)	3.1400 (3.1400)
	CAP	115.667 (126.4477)	5.3100 (5.8200)		GDP	3.3652 (3.3652)	1.2100 (1.2100)
(3)	SIZE	2.5976 (3.8858)	3.0000 (4.3400)	(6)	INF	-5.5142 (-5.5142)	-1.5200 (-1.5200)
	GDP	156.259 (137.7863)	1.5400 (1.3900)		α_{20}	-0.9419 (-0.9419)	-2.4400 (-2.4400)
	INF	-251.12 (-235.4440)	-1.8900 (-1.8100)				
	β_{20}	-28.323 (-58.7183)	-1.8400 (-3.5700)				
	PR	-0.1135 (-0.2346)	-3.2000 (-3.7700)				
	LR	-0.0007 (-0.0036)	-2.1600 (-0.9700)				
	CAP	0.24850 (0.1374)	2.4900 (1.3400)				
	SIZE	-0.0130 (-0.0175)	-3.5900 (-4.6000)				
	GDP	0.5808 (0.4149)	1.3400 (0.9700)				
	INF	-0.2470 (0.0782)	-0.4300 (0.1400)				
(4)	β_{30}	0.2842 (0.3714)	4.5800 (5.5200)				
	Obs.	RMSE	Prob.				
	ROA	0.1784 (0.1014)	0.0288 (0.0000)	ROA	0.1784 (0.1023)	0.4720 (0.0005)	
	LR	17.3236 (17.2040)	0.0000 (0.0000)	LR*CR	0.47650 (0.4765)	0.0000 (0.0000)	
	CR	0.0743 (0.0739)	0.0000 (0.0000)				

On the other hand, liquidity risk significantly reduces bank profitability. Since liquidity has been recognized as a necessary pillar of banking, less liquid banks tend to have lower profitability. Thus, insufficient liquidity is one factor that negatively affects credit activity income, consequently reducing banks' profitability and customer trust. This result aligns with Hakimi and Zaghdoudi (2017), confirming our second hypothesis (H2). Table 5 also showed that an increase in bank size significantly decreases banks' profitability, measured by ROA or ROE. It implies that bank size negatively and substantially correlates with bank profitability. In

addition, large banks have the advantage of economies of scale, leading to lower costs. As a result, they can engage in more diversified activities. However, this type of bank faces high conflicts of interest, governance problems, and asymmetric information with higher information costs.

The model 2 results show that increased banks' profitability significantly decreases liquidity risk. However, it was also found that liquidity risk increases as credit risk and bank size increase. The most profitable banks are the least exposed to liquidity risk. By reaching a specific profitability level, banks become more capitalized and strengthen

their capital base to improve customer trust and reduce exposure to liquidity risk. We also found that the inflation rate significantly negatively impacts liquidity risk. Economically, inflation leads to a redistribution of income favoring borrowers rather than lenders. As a result, banks become more rigid and restrict their lending activities in an inflationary environment.

Moreover, an increase in bank profitability significantly decreases the credit risk level. Therefore, with a satisfactory profitability level, banks can improve credit risk management. In addition, banks are motivated to strengthen their experience and skills in credit risk management to hedge this risk and reduce the probability of exposure. Therefore, banks can finance and improve the credit risk management process with high profitability.

Given the reciprocal relationship between credit and liquidity risks, the results indicate that an increase in credit risk drives up bank liquidity and increases liquidity risk. As a result, it reduces bank

liquidity, leading to interest losses, and exposes banks to a liquidity problem. Another significant result is shown in Table 5 based on model 3, which implies that bank profitability, liquidity risk, bank size, and inflation are negatively and significantly correlated with credit risk. In contrast, GDP growth and CAP increase significantly.

We are now turning to the effect of credit risk and liquidity on bank profitability in Tunisia. The results are presented in Table 5. However, before analyzing the outcomes of model 6, we propose to check the correlation of the residuals, which should be different from zero (Table 6). Table 6 shows the residuals correlation matrix. We notice that the correlation of the residuals in the PR and LR×CR equations is different from zero. Therefore, the residuals of the equations are correlated. Moreover, the result of the Breusch-Pagan test indicates a correlation between residuals. The probabilities of this test are 0.6732 and 0.0580 for ROA and ROE, respectively, yielding the correlation between the residuals.

Table 6: Correlation matrix of residuals

Profitability is ROA			Profitability is ROE		
	PR	LR×CR		PR	LR×CR
PR	1		PR	1	
LR×CR	-0.0367	1	LR×CR	0.1650	1
Breusch-Pagan test		0.6732	Breusch-Pagan test		0.0580

In the second stage, we aim to test the interaction effect of credit and liquidity risks LR×CR on banks' profitability in Tunisia. Table 5 shows that in model 4, bank size and inflation negatively and significantly correlate with banks' profitability in Tunisia. Among others, bank size and inflation significantly decrease banks' profitability for both ROA and ROE. However, when ROA measures profitability, CAP and GDP growth increase slightly. Then, an increase in the profitability of banks in Tunisia, measured by ROA, decreases CR and LR. Model 5 proves that only inflation negatively correlates with LR*CR. In addition, the results indicate that the interaction between CR and LR is positive and significant with GDP and CAP. Lastly, bearing on the above results, one might support the negative effect of the interaction of credit and liquidity risks on bank profitability, thus confirming our hypothesis (H3).

4. Conclusion

The empirical analysis of this study is based on two steps. The first step is to test the effect of credit and liquidity risks on bank profitability separately as measured by ROA and ROE. The second step investigates the effect of the interaction between the two risks on bank profitability. Accordingly, this article examined the relationship between credit and liquidity risks on the one hand and bank profitability on the other in Tunisia. In addition, this article was also interested in studying the impact of the interaction between credit and liquidity risks on bank profitability in Tunisia. Following the methodology of Abdelaziz et al. (2022), our

empirical findings indicate that an increase in credit risk drives up bank liquidity and increases liquidity risk. Besides, the profitability of Tunisian banks is negatively and significantly sensitive to an increase in credit and liquidity risks. This negative effect is confirmed either when we test the impact of these two risks in models (3) and (4) separately or jointly in model 6. Therefore, one might support that credit risk (H1) and liquidity risk (H2) affect banks' profitability in Tunisia. In addition, our study supported the hypothesis (H3) that the interaction between credit and liquidity risks decreases banks' profitability in Tunisia.

Qualified as reciprocal risks, an increase in credit risk leads to increased liquidity risk for Tunisian banks and vice versa. Moreover, we found that banks' profitability decreases significantly with the level of credit and liquidity risks. Therefore, this negative effect is confirmed by the different or interaction effects of these two risks. A comparative study with some Maghreb countries, notably Morocco, would be interesting. In recent years, Morocco has been able to reduce its non-performing loans and align itself with international standards. The study of the factors that may have influenced the risk management of Moroccan banks will allow us to identify the shortcomings of the Tunisian banking sector and provide the appropriate solutions.

List of symbols

PR	Performance
ROA	Return on Assets
ROE	Return on Economics

LR	Liquidity Ratio
CR	Credit
CAP	Capitalization
SIZE	Bank SIZE
GDP	Gross Domestic Product
INF	Inflation

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Compliance with ethical standards

Conflict of interest

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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