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Credit risk and Tunisian bank stability in the Covid-19 wave

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ABSTRACT

Banks are at the core of economic functioning in various countries and are the cause of their development in various fields. In a changing environment, they must deal with certain risks and maintain financial stability as the ultimate objective. The primary objective of this study is to examine the correlation between credit risk and bank stability within the Tunisian banking sector, with a specific focus on understanding the moderating impact of the COVID-19 pandemic. To achieve this, we employ several econometric techniques, including panel unit root and cointegration tests, panel Vector Error Correction Model (VECM), Fully Modified Ordinary Least Squares (FMOLS), and Dynamic Ordinary Least Squares (DOLS). Our empirical analysis relies on a panel dataset that encompasses a comprehensive sample of 8 Tunisian banks over 2000-2020. The results of our analysis unveil a significant negative relationship between credit risk and bank stability, indicating that higher levels of credit risk exert a detrimental effect on the overall stability of Tunisian banks. Furthermore, our study highlights that this adverse impact is further exacerbated during the COVID-19 pandemic, suggesting that the pandemic acts as a moderator. The findings of this study hold substantial implications for policymakers, regulators, and bank managers in Tunisia. They emphasize the critical importance of implementing robust risk management practices to mitigate credit risk and bolster bank stability. Additionally, the research underscores the need to consider the unique challenges introduced by external shocks, such as the COVID-19 pandemic, when assessing the overall stability of the banking system.

KEYWORDS

Bank stability; credit risk; Covid-19; Panel VECM; Fully Modified Ordinary Least Squares; Dynamic Ordinary Least Squares; moderating role

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1. Introduction

Financial stability is always a concern for central banks because healthy banks are essential to financial stability in any dynamic economy. The concept deepens economists' and policymakers' reflections on reducing financial instability so that financial stability appears as a full-fledged goal of economic policy (Betbèze et al., 2011).

The banking system is in charge of payments and the collection of cash and savings for loan distributions. It is also exposed to a variety of risks during the course of its operations, making banks vulnerable (Van Greuning and Iqbal, 2007; Van Greuning and Bratanovic, 2020), but credit risk remains the most serious risk of the conglomerate's massive debt. We, therefore, focus on the impact of credit risk on bank stability in the Tunisian context. Credit risk is an important factor in bank resilience. It enables effective risk management strategies by evaluating threats to a bank's financial system.

Global banking systems have been weakened by international and external shocks such as the sanitary crisis. The pandemic, which is wreaking havoc on Tunisia's economy, is causing a wave of macroeconomic deterioration and bank failures, said MAC SA's analysis and research (https://www.macsa.com). The effects of the Covid-19 crisis on the Tunisian banking sector have had a direct impact on the social accounts of banks through a deterioration in the quality of their asset portfolios (increase in bad debts) and a mechanical increase in the cost of risk (provisions) (Mansour and Ben Salem, 2020a). Furthermore, the effects can be observed in terms of yields and liquidity ratios.

According to the activity indicators as of June 30, 2020, of the Central Bank of Tunisia (CBT), the intermediation margin of listed banks decreased by 3% and the gross operating margin decreased by more than 12%.[1] In terms of liquidity ratios, the drop in deposits from economic operators affected by the crisis (tourism, transport, mechanical and electrical industry, textiles and clothing, etc.) and the deferment of maturities are causing a strong strain on the bank's cash flow, which affects their credit distribution. Mansour and Ben Salem (2020b) supplement these figures by observing a decrease in cash flows, level of funds, and deposits. In 2021, Tunisian banks experienced a decline in their asset-quality metrics. The impaired loans ratio for the largest banks stood at 13.8% by the end of the first half of 2021, compared to 13% in 2020. This deterioration intensifies in 2022 due to higher interest rates and inflation, which would further strain borrowers' ability to repay their debts. Moreover, the conclusion of Tunisia's pandemic-related loan deferral program in December 2021 limits potential support for borrowers. Consequently, an increase in impaired loans would have a significant impact on asset-quality metrics, particularly considering the anticipated slowdown in loan growth and the maturing of recent loans following a recent surge in lending.

To mitigate the economic and social fallout from the spread of the Covid-19 pandemic, the CBT has adopted several strategic measures, including cutting the key interest rate twice with a positive impact on aggregate demand and households' ability to repay their debts, greater flexibility in calculating banks' liquidity ratios (loans/deposits), and the introduction of refinancing programs with the CBT.

The severe macro-financial shock caused by the pandemic continues to disrupt the global economy, putting both banks and borrowers under pressure (see Duan et al., 2021; Berger and Demirgüç-Kunt, 2021; Shabir et al., 2023). To meet unprecedented challenges, regulators must act decisively to ensure that banking systems continue to serve the real economy while preserving financial stability. Based on these facts, we feel compelled to assess the outcome of Covid-19 and how it might alter (or not) the credit risk-bank stability relationship in the Tunisian case. As far as we are aware, we are the first to carry out such a research question.

The outline of the paper is as follows. In Section 2, we review the theory and papers related to the determinants of bank stability with a focus on the effect of credit risk. The method and material will be given in Section 3. We expose the main findings in Section 4, and Section 5 concludes with the key policy implications.

[1] https://www.ilboursa.com/docs/TV%20indicateurs.pdf.

2. Literature review

2.1. Theories of credit risk

In a competitive domain, banks seek to engage in new activities and deals that capture the attention and interest of customers. However, a harsh environment is not without risk. Risk exposure is alarming in the absence of tools to manage it, leading to bank failures. Credit risk is one of the most important financial risks and is considered an important source of bank profitability. The reduction of credit risk is made possible by a sound credit policy (Van Greuning and Bratanovic, 2009). In general, credit risk is the potential loss that banks incur when lending money to customers or professionals. Various definitions of credit risk are proposed in the literature. Desmicht (2004) defines credit risk as the risk of a shortfall (loss) if the borrower defaults. This is the risk of non-payment or the risk of default. For Camara (2006), credit risk is the probability that credit will not be paid by a customer or a member of the microfinance institution for any reason. Anderson et al. (2002) join Desmicht (2004) and Camara (2006) in these definitions and argue that credit risk is the probability that debt service will exceed the capacity of the borrower. According to Gouriéroux and Tiomo (2007), credit risk is the risk of loss inherent in a borrower's inability to repay its debts (bonds, bank loans, trade receivables, etc.). This risk can be divided into default risk, which occurs when a borrower defaults on paying principal and/or interest on its debt, default recovery risk, and risk of deterioration in debt quality.

Credit risk assessment undergoes stochastic methods to assess credit quality. The standard theory dates back to Merton (1974) who proposes a structural approach to risk modeling. The Merton model is a mathematical formula used by stock market analysts and commercial credit brokers to assess a company's credit risk by modeling equity as a call option on its assets. The structural approach to credit risk is particularly well rooted in the foundations of financial theory. It provides an intuitive link between the default event and the value of the company's assets (Moraux and Renault, 2002, p.19).

Mitigating the effect of credit risk comes from providing information on upcoming borrowers. Lenders should develop a scoring approach to assess the repayment capacity of borrowers and analyze the value of the loan request (Owojori et al., 2011). Banks require mortgage insurance as collateral and the interest rate is automatically linked to the level of risk (Al-Husainy and Jadah, 2021). Credit risk refers not only to the probability of default, but also to collection risk, which relates to the amount that the creditor will recover in the event of default, or to the risk of deterioration in credit quality, which may lead, for example, to the rating of a bond issuer being downgraded, ultimately causing its bonds to fall in the market.

2.2. The empirical view of the credit risk-bank stability relationship

There is abundant empirical literature on the determinants of banking performance in several countries and regions. Secondary data and panel techniques are generally used to provide insights into these determinants. Researchers primarily identify bank-specific factors such as non-performing loans, capital adequacy ratio, cost-to-income ratio, diversification, overheads, or bank-industry factors such as bank size and concentration, or macroeconomic determinants such as inflation and GDP in Tunisia. Ben Naceur and Goaied (2008), Ameur and Mhiri (2013), and Nessibi (2016) share the view that capitalization, efficiency, and private ownership contribute positively to bank profitability and that macroeconomic variables have no significant effect. Pasiouras et al. (2022) disagree and suggest that economic growth leads to higher profitability. Studies including Rachdi (2013), Béjaoui and Bouzgarrou (2014), Chouikh and Blagui (2017), and Derbali (2022) focus on the determinants of bank performance while accounting for special events such as Global financial crisis or the 2011 revolution. Ltaifa (2018) claim that financial development is a driver of net interest margin. Alouane et al. (2022) find that the relationship between diversification and bank performance is influenced by the concentration levels within the banking sector. Studies of the determinants of bank performance include other regions and countries and results may depend on income level as indicated by Dietrich and Wanzenried (2011). Capitalization is consistently associated with higher profitability (Ramadan et al., 2011; Rahman et al., 2015; Djalilov and Piesse, 2016; Batten and Vo, 2019; Hasan et al., 2020; Isayas, 2022). Tahraoui and Achibane (2012) focus on the impact of operational risk in Morocco and show that this effect is sensitive to the measurement used. It should be noted that competition has been identified as a favorable factor for bank profitability (Le and Ngo, 2020; Grubišić et al., 2022).[2] Others have attempted to link bank performance to institutional factors (e.g., Bougatef, 2017) or to the macroprudential policy (e.g., Adelopo et al., 2022). However, mixed results have been observed, especially when different measures of bank profitability are employed (Adelopo et al., 2018).

The coverage of this subsection will be the effect of credit risk on bank stability. When talking about credit risk, one would expect a more vulnerable banking system to be accompanied by higher levels of this type of risk.

Studies including Ben Khedhiri and Ben Khedhiri (2011), Bougatef (2017), Hamdi et al. (2017), Ghenimi et al. (2017), Zaghdoudi (2019), Abdelaziz et al. (2022) and Ahmed et al. (2022) advocate this negative effect. Credit risk as a threat to the health of banks induces fragility. Emergency corrective actions by regulators and risk management tools are mandatory. In this context, the Comité de Bâle sur le Contrôle Bancaire (2015) provides guidelines for the recovery of vulnerable banks. The quality of governance and management is probably the single most important determinant of a financial institution's effectiveness. Therefore, regular assessment of a bank's corporate governance practices is an essential component of the supervisory review process, including the quality of board and management oversight and the effectiveness of internal risk management and control functions (including internal audit, credit risk monitoring, and compliance). This process seems to be fruitful for the Tunisian case as underlined by Boussaada and Labaronne (2015).

However, banks could resist an upsurge of credit risk when they are sufficiently profitable and/or have developed a strong defense system against precedent shocks. Such a positive correlation is found by Boahene et al. (2012) and Afriyie et al. (2012) for the case of rural banks in Ghana, Flamini et al. (2009) for commercial banks in Sub-Saharan Africa and Sufian and Habibullah (2009) for China. The findings of those works confirm the tradeoff between risk and return. The concept was developed by Markowitz in the Modern Portfolio Theory, which postulates a monotonic relationship between risk and return. Return in particular is an increasing function of risk (see Curak et al., 2012).

For Tunisia, two studies make an exception regarding the nature of the relationship between credit risk and bank stability. While Hakimi and Zaghdoudi (2017) claim a positive but insignificant effect of credit risk on bank profitability, Djebali and Zaghdoudi (2020) argue that credit risk is detrimental to bank performance beyond a certain threshold, hence a nonlinear relationship. Ghenimi et al. (2017) examine the interplay between credit risk and liquidity risk and their impact on bank profitability in the Middle East and North Africa (MENA). They point out that when liquidity risk is higher, credit risk leads to bankruptcy.

Our work builds upon and enhances the groundbreaking research conducted by Bekri et al. (2020), focusing on the critical relationship between credit risk and bank stability. While we share a similar objective, our study introduces different measures, variables, and controls to provide a more comprehensive analysis. One notable limitation of Bekri et al.'s (2020) paper is the absence of an assessment regarding the direction and magnitude of the impact of credit risk on long-term bank stability. We bridge this gap by employing advanced econometric techniques, specifically Fully Modified Least Squares (FMOLS) and Dynamic Least Squares (DOLS) methods, to precisely quantify these effects. However, what truly sets our research apart is our consideration of the sanitary crisis and its moderating role in shaping the connection between credit risk and bank stability. By incorporating

[2] We refer readers to Rasiah (2010) for a succinct review of earlier papers.

this vital contextual factor into our analysis, we provide a deeper understanding of the intricate dynamics at play during times of economic upheaval. Finally, we provide a series of robustness checks to enhance the validity and reliability of the results.

Based on theory and practice, we put forward the following hypotheses:

H1: Credit risk is negatively associated with bank stability.

H2: The emergence of the Covid-19 crisis leads to bank instability.

H3: The effect of credit risk on bank stability will be amplified during the Covid-19 pandemic.

3. Material and method

3.1. Data

We gather yearly data on 8 listed Tunisian banks over the period 2000-2020. The panel is unbalanced.[3]

We use two measures of bank stability: Return on assets (ROA), which is the ratio of net income to total assets, and Risk-adjusted return on assets (RAROA), which is ROA divided by its standard deviation. Although ROA is considered an indicator of bank performance or profitability, we believe that RAROA is the appropriate metric for bank stability and it is employed in our empirical analysis to test robustness.[4] The literature documents different measures of credit risk. Bekri et al. (2020) and Ahmed et al. (2022) portray the latter as the share of gross non-performing loans to total assets. Others specify the credit risk of the loan growth (e.g., Ben Khedhiri and Ben Khedhiri, 2011; Bahrini, 2011; Ltaifa, 2018; Hakimi and Zaghdoudi, 2017; Hamdi et al., 2017; Bel Haj Salah, 2020). Bougatef (2017) chooses rather quantify credit risk with the ratio of loan loss provision to total assets, while Hamdi and Hassen (2021) focus on doubtful credits to total credits as a potential metric. We map the credit risk (RCRED) by the average loan loss provisions according to the availability of data. Financial leverage (FINLEV) and bank concentration (CONC) are added as control variables. FINLEV is defined as the ratio of total liabilities to total assets, while CONC represents assets held by the three largest banks to total commercial bank assets of all Tunisian banks. As specified by the World Bank in the glossary, "Total assets include total earning assets, cash and due from banks, foreclosed real estate, fixed assets, goodwill, other intangibles, current tax assets, deferred tax assets, discontinued operations, and other assets."[5] All variables are taken from the Eikon database, except CONC which is retrieved from the World Bank's Global Financial Development Database.[6]

Descriptive statistics and the correlation matrix are shown in Tables 1 and 2, respectively. Loan loss provisions scaled by average loans have a mean equal to 1.68%. This can be seen as a risk management measure to mitigate potential credit losses. The average rate of return on assets is 0.9%, but when accounting for associated risk, the 8 banks can generate higher returns on their assets (mean=1.96). Financial leverage is on average 88%, meaning that a significant part of assets is financed by liabilities. Bank concentration is moderate, with the three largest banks holding on average 57% of total assets. Yet, evidence suggests that competitive pressure is medium. The bank stability measures and the credit risk fluctuate between negative and positive values. The probability associated

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[3] The list of banks is Amen Bank (AB), Arab Tunisian Bank (ATB), Bank of Tunisia (BT), Tunisia and Emirates Bank (BTE), Arab International Bank of Tunisia (BIAT), National Agricultural Bank (BNA), Bank of Housing (BH), International Banking Union (UIB). AB, ATB, BIAT, BT, and UIB are private, while the others are public. BIAT holds the largest market share among all the eight banks (44%).

[4] Studies such as Adusei (2015), Ali et al. (2018), Chand et al. (2021) utilize RAROA as a measure of bank stability.

[5] We collect data on many variables documented to be potential factors of bank stability. However, we only retained those with satisfactory results in terms of the unit root test and the existence of the long run cointegrating relationship between those variables. The same applies to the measures of bank stability such as Bank Z-score, Return on Equity, and Risk-adjusted Return on Equity.

[6]Access to data was not direct because they are provided at a cost. We are indebted to Abdelaziz Hakimi for material support.

with the Jarque-Bera test is less than 0.05. This suggests a non-normal distribution of the series. Skewness provides information about the symmetry of data. ROA, RCRED, and FINLEV are highly skewed (>1 or <-1), while RAROA and CONC are moderately skewed (between 0.5 and 1). The distribution of all the variables except CONC is leptokurtic since the Kurtosis measure is greater than 3. We note that CONC is the only variable whose kurtosis is less than 3, which suggests a platykurtic distribution, but it is highly dispersed around the mean according to the standard deviation.

Table 1. Descriptive statistics.

	ROA	RAROA	RCRED	FINLEV	CONC
Mean	0.008844	1.958393	0.016857	0.879332	57.09244
Median	0.009724	1.455105	0.013850	0.912780	44.78400
Maximum	0.050185	8.276098	0.230200	1.010581	100.0000
Minimum	-0.102473	-3.731015	-0.018000	0.325938	40.21897
Standard Deviation	0.012260	1.939275	0.022808	0.106079	22.30883
Skewness	-4.716555	0.718760	6.806036	-3.457397	0.955038
Kurtosis	46.43251	3.999506	57.31310	15.39504	1.984886
Jarque_Bera	12675.27	19.67011	20117.54	1292.646	30.02261
Probability	0.000000	0.000054	0.000000	0.000000	0.000000
Sum	1.361908	301.5925	2.596000	135.4171	8792.236
The sum of squared deviations	0.022995	575.4006	0.079593	1.721668	76145.61
N° observations	154	154	154	154	154

Note: ROA: Return on assets, RAROA: Risk-adjusted return on assets, RCRED: Credit risk, FINLEV: Financial leverage, CONC: Concentration. Source: Authors.

Table 2 clearly shows that there is a significant, albeit not very strong, negative relationship between credit risk and measures of banking stability. There is also a negative correlation between FINLEV and banking stability, while CONC is positively correlated with the latter.

Table 2. Correlation matrix.

	ROA	RAROA	RCRED	FINLEV	CONC
ROA	1.000000	0.695322***	-0.392591***	-0.269049***	0.096672
RAROA	0.695322***	1.000000	-0.106574	-0.063968	0.125495
RCRED	-0.392590***	-0.106574	1.000000	-0.088832	-0.122190
FINLEV	-0.269049***	-0.063968	-0.088832	1.000000	0.086322
CONC	0.096672	0.125495	-0.122190	0.086322	1.000000

*Note: ***, **, * statistically significant at 1%, 5% et 10%, resp. Note: ROA: Return on assets, RAROA: Risk-adjusted return on assets, RCRED: Credit risk, FINLEV: Financial leverage, CONC: Concentration. Source: Authors.*

Considering the evolution of risk-adjusted return on assets (RAROA) and return on assets (ROA) over the period 2000-2020 in Figure 1 implies the following observations:

- On average, the eight banks managed to maintain consistent profitability throughout the analyzed period, despite the occurrence of major events such as the global financial crisis, the revolutionary period, and the Covid-19 crisis. The stability of ROA, however, does not necessarily reflect the impact of specific events on individual banks.
- The Euro debt crisis that took place in 2009 has had far-reaching consequences not only in Europe but in the interconnected parts, including Tunisia, through trade, finance, and investment. Therefore, the banks in our sample, have experienced adverse effects (Selvaraj, 2015).

- The subsequent decrease in RAROA suggests that challenges faced the Tunisian banks due to the political and social instability during and post-revolution which disrupted economic activities and the banking sector's performance.
- The peak in RAROA in 2017 indicates that the eight banks, on average, achieved higher profitability due to the pre-crisis recovery leading to increased opportunities of lending for banks.
- The Covid-19 pandemic had a significant adverse effect on the global economy in Tunisia. The lockdowns and increased uncertainties could have further affected the bank profitability in terms of RAROA.

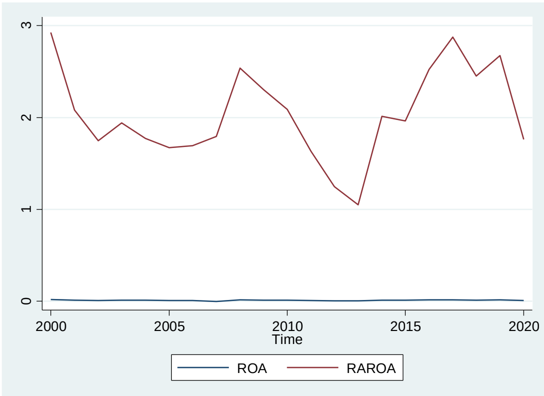

Figure 1. Evolution of bank stability measures (Averaged data over all 8 Banks).

Source: Authors.

Figure 2 traces the progression of the credit risk over the period 2000-2020. W note the following:

- The peak in RCRED in 2010 could be linked to the global financial crisis, the sovereign debt crisis and the spillover effects they had on the eight banks. The crises likely led to a deterioration in borrower's financial health and increased default rates.
- Uncertainty surrounding the political transition in the revolutionary period in 2011 may have led the lenders to tighten credit availability and increasing credit risk between 2012 and 2013. The consequences of the revolution seem to be felt in the subsequent years.
- Shifts in economic conditions such as changes in GDP growth, inflation rate, commodity prices and changes in policies and regulations might have had an impact on the fluctuations of the credit risk in the remaining years.
- A ratio of bad loans is triggered through Covid-19 pandemic which continues to weigh on the banks' asset quality.

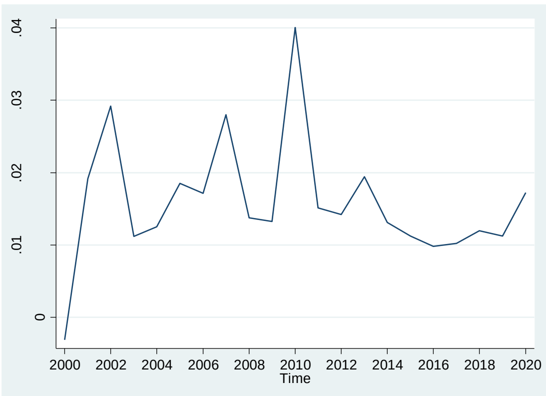

Figure 2. Evolution of credit risk (Averaged data over all 8 Banks).

Source: Authors.

3.2. Empirical strategy

We proceed to the estimation of a Panel Vector Error Correction Model (PVECM). However, two conditions must be met to apply this method:

- The variables should be integrated of order 1 (I(1)).
- There is a cointegrating relationship between the variables.

We also check for the long run effects of the explanatory variables through Fully Modified Ordinary Least Square (FMOLS) and Dynamic Ordinary Least Square (DOLS) estimation methods. The procedures of the panel unit root and cointegration tests follow.

3.2.1. Panel unit root tests

The literature identifies many panel unit root tests. However, the results of those tests are sometimes mixed.[7] The Stata manual guides the appropriate test based on the sample characteristics. Since N and T are fixed and our panel is unbalanced, we select the IPS unit root test by Im et al. (2003). The autoregressive model is given as follows:

$$\Delta y_{it} = \alpha_i + \beta_i y_{it-1} + \sum_{j=1}^{q_i} \delta_{ij} \Delta y_{it-j} + \varepsilon_{ij}, i = 1,2,\ldots,N \ t = 1,2,\ldots,T \quad (1)$$

Where q_i: number of lags which is selected as the residuals are uncorrelated over time.

β: The autoregressive coefficient.

ε_{ij}: The noise disturbance which is normally distributed with mean 0 and variance σ_i^2.

The test of hypothesis under IPS stems that: $\begin{cases} H_0: \beta_i = 0 \text{ for all } i \\ H_1: \beta_i < 0 \text{ for some } i \end{cases}$

The t-statistic of IPS in Augmented-Dickey-Fuller (ADF) format is given by:

$$\hat{t}_{NT} = \frac{1}{N} \sum_{i=1}^{N} t_{iT}(\delta_i) \quad (2)$$

$t_{iT}(\delta_i)$ in Eq. (2) is the ADF t-statistic for cross-section i based on individual-specific ADF regression.

3.2.2. Cointegration tests and Panel VECM

The cointegration approach allows us to test whether a long run and stable relationship exists between variables. We apply, then, the test of Pedroni (2004) which accommodates heterogeneous individual panels. The cointegration equation in our case is written as follows:

$$BS_{it} = \alpha_i + \delta_t + \beta_1 RCRED_{it} + \beta_2 FINLEV_{it} + \beta_3 CONC_t + \varepsilon_{it} \quad (3)$$

where $i = 1,2,\ldots,N$ stands for banks and $t = 1,2,\ldots,T$ is the temporal dimension (year).

α_i are δ_t the individual and temporal effects, respectively.

BS is the bank stability measure in each model. In Model 1, ROA is the dependent variable, whereas in Model 2, RAROA is the dependent variable.

Pedroni (2004) suggests two cointegration tests for panel data:

[7] Among these tests, we cite LLC by Levin et al. (2002), ADF- Fisher Chi-Square by Maddala and Wu (1999), and PP-Fisher Chi-Square by Choi (2001).

Type 1: Based on Within dimension and includes the following statistics: Panel v-Statistic, Panel rho-statistic, Panel-PP statistic, and Panel ADF-statistic.

Type 2: based on Between dimension or (Group tests) such as Group rho-statistic, Group PP-statistic, and Group ADF statistic.

4. Results and discussion

4.1. Results of panel unit root tests

Results in Table 3 show that our variables are nonstationary in level but are stationary in the first difference. They are integrated of order I(1).

Table 3. Unit root test of IPS.

Variable	IPS		Conclusion
	In level	In first difference	
ROA	-1.329	-2.814***	I(1)
	(0.092)	(0.002)	
RAROA	-1.444	-2.616***	I(1)
	(0.126)	(0.004)	
RCRED	-1.595	-3.196***	I(1)
	(0.055)	(0.001)	
FINLEV	2.632	-2.172***	I(1)
	(0.996)	(0.015)	
CONC	1.947	-2.375***	I(1)
	(0.974)	(0.009)	

*Note: ***, **, * statistically significant at 1%, 5% et 10%, resp. ROA: Return on assets, RAROA: Risk-adjusted return on assets, RCRED: Credit risk, FINLEV: Financial leverage, CONC: Concentration. Source: Authors.*

We conduct a Fisher-type panel unit root test and a panel unit root test with structural breaks as the period encompasses shocks related to the global financial crisis, sovereign debt crisis, the revolutionary period, and the Covid-19 (Chen et al, 2022) for robustness. Results in Table A.1 and Table A.2 in the Appendix support again our conclusions.[8]

4.2. Results of the cointegration tests and PVECM

According to Pedroni (2004), Panel ADF and Group ADF are the most important statistics and we have to rely on these statistics if the results are confusing.

According to Table 4 and Table 5 the results of the Pedroni test reject the null hypothesis of the absence of a cointegrating relationship for our panel in the two models.

In Model 1, the probability of having long-term relationships between credit risk as measured by credit risk (RCRED), return on assets (ROA), financial leverage (FINLEV), and bank concentration (CONC) is justified. In conclusion, the presence of the long-term equilibrium relationship is confirmed. We find the same result if we substitute ROA with RAROA in model 2.

Table 6 gives a supplementary rejection of the null hypothesis of no cointegration through the Kao test of residuals. Kao’s (1999) test in Table 6 shows that the probability of both models is less than 5%, so the two models are co-integrated in the long run.

[8] We did not conduct the Levin-Lin-Chu (LLC) panel unit root test because it is suitable for balanced data. For details see: https://www.stata.com/manuals/xtxtunitroot.pdf

Table 4. Cointegration test of Pedroni (2004) for Model 1 (Dep var: ROA).

	Tests	With constant		With constant and trend		Without constant and trend	
		Statistic	Probability	Statistic	Probability	Statistic	Probability
Type 1	Panel v-Statistic	0.7953	0.2132	-0.8560	0.8040	-0.5810	0.7194
	Panel rho-Statistic	-2.8806***	0.0020	-1.8389**	0.0330	-1.1254	0.1302
	Panel-PP Statistic	-8.2548***	0.0000	-9.4957***	0.0000	-3.7611***	0.0001
	Panel ADF-Statistic	-3.3825***	0.0004	-10.484***	0.0000	-0.5457	0.2926
Type 2	Group rho-Statistic	-0.1494	0.4406	0.9733	0.8348	0.1244	0.5495
	Group PP-Statistic	-4.6078***	0.0000	-4.2006***	0.0000	-3.2524***	0.0006
	Group ADF Statistic	-3.2132***	0.0007	-6.1456***	0.0000	-4.3641***	0.0000

*Note: ***, **, * statistically significant at 1%, 5% et 10%, resp. Source: Authors.*

Table 5. Cointegration test of Pedroni (2004) for Model 2 (Dep. Var: RAROA).

	Tests	With constant		With constant and trend		Without constant and trend	
		Statistic	Probability	Statistic	Statistic	Probability	Statistic
Type 1	Panel v-Statistic	2.0440**	0.0205	0.9057	0.1825	1.0524	0.1463
	Panel rho-Statistic	-0.8677	0.1928	0.1442	0.5574	-1.0704	0.1422
	Panel-PP Statistic	-2.7281***	0.0032	-2.4986***	0.0062	-2.8705***	0.0020
	Panel ADF-Statistic	-1.5718	0.0580	-3.5874***	0.0002	-3.3199***	0.0005
Type 2	Group rho-Statistic	-0.0329	0.4869	1.0879	0.8617	0.2521	0.5995
	Group PP-Statistic	-4.5506***	0.0000	-4.0046***	0.0000	-3.0966***	0.0010
	Group ADF Statistic	-3.1124***	0.0009	-5.9515***	0.0000	-4.2054***	0.0000

*Note: ***, **, * statistically significant at 1%, 5% et 10%, resp. Source: Authors.*

Table 6. Kao (1999) test of residuals (H0: No cointegration).

ADF		Statistic t	Probability
	Model 1	-10.84669***	0.0000
	Model 2	-4.714566***	0.0000

*Note: ***, **, * statistically significant at 1%, 5% et 10%, resp. Source: Authors.*

Table 7 shows that the adjustment coefficient (cointeq(-1)) is negative, ranging from -1 to 0, and significant at 1% in both models. The PVECM model is validated. This means that it is possible to adjust 13.5% of the imbalance between the desired and actual level of bank stability in Tunisia if ROA is used as the dependent variable, and 2.87% if RAROA is used as the dependent variable.

Table 7. Results of PVECM.

Variables	$DROA_{it}$		$DRAROA_{it}$	
	Coefficient	Prob.	Coefficient	Prob.
Cointeq (-1)	-0.135691	0.0000***	-0.028667	0.0086***
D(ROA(-1))	-0.451135	0.0000***		
D(RAROA(-1))			-0.235157	0.0123*
D(RCRED(-1))	-0.135479	0.0036***	-5.784328	0.1042
D(FINLEV(-1))	0.019393	0.7557	5.613339	0.2214
D(CONC(-1)	6.72E-05	0.4181	0.011116	0.0913*

*Note: ***, **, * statistically significant at 1%, 5% et 10%, resp. Source: Authors.*

4.3. Results of the long run estimations

In this study, we employed a three-step approach to analyze the impact of various factors on the outcome variable. Initially, we run the model using Eq. (3) to assess the main effects of the independent variables on the outcome. Subsequently, we incorporate a Covid-19 dummy variable to account for the influence of the pandemic on the dependent variable, enhancing the model's explanatory power, and seeking whether it alters the effect of other variables. Finally, we introduce an interaction variable, enabling us to examine the combined effects of the credit risk and the Covid-19 variable on the outcome. This sequential approach allows us to progressively refine our understanding of the relationship between the variables under investigation.

4.3.1. Without accounting for Covid-19

To track the behavior of cointegrating variables in panel data, we need to apply efficient estimation methods. For instance, we distinguish two main estimators: FMOLS developed by Pedroni (2000) and Phillips and Moon (1999), and DOLS by Kao and Chiang (2000). The first panel of Table 8 shows the FMOLS results of the two models (a model with ROA, and a model with RAROA). The long-term coefficients of RCRED and FINLEV are significant at 1%, but CONC has no impact on bank stability in the first model (see specification (1)). Using risk-adjusted return on assets (RAROA) instead of ROA in the second model displays significant long run coefficients of RCRED, FINLEV, and CONC at 1% (see specification (3)). We can conclude that when credit risk decreases, the financial stability of the Tunisian banks improves. We, therefore, support hypothesis H1.

Kao and Chiang (2000) show the superiority of the DOLS method over the FMOLS method and that it is considered to be the most efficient technique for the estimation of cointegration relationships on panel data and it addresses serial correlation and the endogeneity bias.[9] The two long-term models of bank stability variables by DOLS are available in the second panel of Table 8. The long run coefficients (RCRED, FINLEV) are negative and significant at 10%, while bank concentration is positive, but statistically 5% (see specification (5)). If we substitute ROA with RAROA, we still find that the same set of variables with plausible signs helps explain bank stability (see specification (8)).

The detrimental effect of increased credit risk is consistent with previous papers such as Ben Khedhiri and Ben Khedhiri (2011), Hamid et al. (2017), Zaghdoudi (2019), and Bekri et al. (2020). A negative impact of a sharp rise in credit risk means that the more customers fail to meet their payment obligations, the more the stability of the bank is affected.

Financial leverage exerts a negative effect on bank stability. This result refutes the Agent Cost Theory, according to which a positive impact is expected and FINLEV acts as a disciplinary tool for management (Ilyukhin, 2015). For highly indebted banks, financial constraints harm bank performance. The negative sign is due to high-interest rates and ineffective corporate governance in the Tunisian banking sector. This result contradicts the advances of Vintila and Duce (2012), Abdul and Adelabu (2015), Menacer et al. (2020), and Ahmed et al. (2022) for conventional banks of the Middle East and Africa (MEA) region.

Bank concentration seems to enhance the stability of the Tunisian banks. The positive effect of bank concentration on stability promotes the ability of banks to diversify their activities and may make it easier for banks to invest in portfolios and sectors that are more attractive to customers. The result confirms the one by Boyd et al. (2005), Hakimi and Zaghdoudi (2017), and Hamdi et al. (2017), but contradicts the views of Ameur and Mhiri (2013) and Jaouad and Lahsen (2018).

[9] The DOLS method has also limitations including sensitivity to lag selection, limited short-run dynamics, and assumptions of stable coefficients. The Generalized Method of Moments (GMM) also addresses the endogeneity bias but is not specifically tailored for long-run relationships and cannot be performed in our case due to the limited number of cross-sections (banks) because it always results in a large number of instruments (Roodman, 2009).

Table 8. Long run results.

Method of estimation	FMOLS				DOLS					
	Model 1: ROA_{it}		Model 2: $RAROA_{it}$		Model 1: ROA_{it}			Model 2: $RAROA_{it}$		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Dep. Variable	Coefficient (Prob.)	Coefficient (Prob.)	Coefficient (Prob.)	Coefficient (Prob.)	Coefficient (Prob.)	Coefficient (Prob.)	Coefficient (Prob.)	Coefficient (Prob.)	Coefficient (Prob.)	Coefficient (Prob.)
RCRED	-0.2755*** (0.0000)	-0.2715*** (0.0000)	-15.583*** (0.0000)	-12.862** (0.0128)	-0.0678* (0.0528)	-0.2434*** (0.0000)	0.0296*** (0.0000)	-18.5458*** (0.0000)	-15.9860** (0.0128)	-16.7866*** (0.0000)
FINLEV	-0.0639*** (0.0000)	-0.0795*** (0.0083)	-15.275*** (0.0046)	-4.7369*** (0.0050)	-0.0323* (0.0867)	-0.1398*** (0.0000)	0.0406*** (0.0000)	-6.7022* (0.0514)	-10.1479*** (0.0029)	-14.8262*** (0.0001)
CONC	3.53E-05 (0.2900)	1.55E-05 (0.7492)	0.0167*** (0.0078)	0.0111** (0.0385)	6.72E-05** (0.0267)	5.01E-06 (0.9161)	4.49E-05 (0.2194)	0.0108** (0.0439)	0.0080 (0.1476)	0.0103** (0.0404)
COVD19		-0.0054* (0.0922)		-0.9186* (0.0877)		-0.0069** (0.0341)	0.1143 (0.2114)		-0.9628** (0.0175)	0.6921 (0.4907)
*RECRED*COVID-19*							-1.3728** (0.0381)			-90.0343* (0.0939)
R^2	0.4472	0.5434	0.8837	0.7743	0.9248	0.576187	0.6266	0.9322	0.8596	0.8919
Adjusted R^2	0.4071	0.4761	0.8581	0.7532	0.8451	0.517836	0.5721	0.8897	0.8397	0.8677
S.E. of the regression	0.0092	0.0086	0.7268	0.9361	0.0048	0.008443	0.0079	0.6456	0.7762	0.7051
Long run variance	7.85E-05	5.21E-0.5	0.4713	1.3923	1.13E-05	5.44E-05	5.53E-05	0.2570	0.7195	0.4051

*Note: ***, **, * statistically significant at 1%, 5% et 10%, resp. ROA: Return on assets, RAROA: Risk-adjusted return on assets, RCRED: Credit risk, FINLEV: Financial leverage, CONC: Concentration, COVID-19: Covid-19 crisis, RCREDCOVID=RCRED*COVID-19. Source: Authors.*

4.3.2. The impact of Covid-19

As mentioned earlier, we are interested in quantifying the effect of Covid-19 on Tunisian bank stability. With annual data, this is possible by inserting a dummy variable that states the occurrence of a sanitary crisis in 2020 (=1) and 0 otherwise. Eq. (3) is extended so that it has the following expression:

$$BS_{it} = \alpha_i + \delta_t + \beta_1 RCRED_{it} + \beta_2 FINLEV_{it} + \beta_3 CONC_t + \beta_4 COVID19_t + \varepsilon_{it} \quad (4)$$

We go, then, onto the estimation of FMOLS and DOLS with panel data again. As expected, the crisis has not only affected human health but also the health of the banking system, proliferating its vulnerability. This effect is portrayed by the negative sign on the dummy coefficient in Table 8 in both models (see specifications (2), (4), (6), and (9)). The coefficient is statistically significant at 5%. We could not reject H2. Furthermore, we note that the results on the other variables RCRED, FINLEV, and CONC duplicate the previous findings. The contribution of these variables is not sensitive to the inclusion of the Covid-19 dummy.

The long run panel cointegration framework endows us with more insights. Experiencing this crisis should not be viewed as a pure threat, but as a challenge, as policymakers and supervisors of the Central Bank of Tunisia should grapple with defining proper measures and developing strategies to hold back the situation at hand. This is possible by laying the foundations of the macroprudential framework. This framework includes measures to mitigate vulnerability affecting the banking sector and to strengthen the resilience of the sector. In particular, macroprudential instruments slow, if not prevent the accumulation of vulnerabilities. Crucially, macroprudential instruments help to increase the capitalization of the banking sector, thereby strengthening the resilience of institutions.

When we talk about macroprudential policy, we associate not only instruments but also transparency in the policy process. Macroprudential transparency is an essential target and much effort needs to be made to improve it since all emerging countries still show moderate levels. For instance, its positive effect seems to be timely and effective in curbing inflation in these countries (Trabelsi, 2022).

4.3.3. The moderating role of Covid-19

Once we evidenced the respective effects of the credit risk and the epidemic on Tunisian bank stability, we need to explore how the occurrence of the sanitary crisis shapes the credit risk-bank stability relationship. We apply, thus, a moderation analysis. A moderator was defined by Hayes (2017, p. 9), "X's effect on Y is said to be moderated by W if the size or sign of X's effect on Y varies with W [..]Moderation is also known as interaction".

We augment Eq. (3) as follows:

$$BS_{it} = \alpha_i + \delta_t + \beta_1 RCRED_{it} + \beta_2 FINLEV_{it} + \beta_3 CONC_t + \beta_4 COVID19_t + \beta_5 RCRED_{it} * COVID19_t + \varepsilon_{it} \quad (5)$$

where Covid-19 dummy plays the role of a moderator in Eq. (5). The first derivative relating to credit risk is given by:

$$\frac{\partial BS_{it}}{\partial RCRED_{it}} = \beta_1 + \beta_5 * COVID19_t$$

In the absence of a crisis, the effect of the credit risk pertains to the one found after estimating Eq. (3). In the presence of the crisis, the effect of the credit risk on bank stability becomes $(\beta_1 + \beta_5)$. We report the associated results in the specifications (7) and (10) of Table 8 for the respective measures of bank stability (ROA and RAROA).[10] Not only does the credit risk have a direct negative effect on bank stability, but this effect is exacerbated during the pandemic crisis. Both coefficients $\hat{\beta}_1$ and $\hat{\beta}_5$ show up with a negative sign and are statistically significant. We have enough evidence to validate hypothesis H3. The result sounds logical, especially if we relate it to real facts based on a figure's lecture. Indeed, Covid-19 is leading to higher credit risk costs for banks. Prudential regulation is again appealing for possible recovery. Our finding is noteworthy because it enriches the literature on the relationship between credit risk and bank performance in Tunisia. We see added value when we also compare our study to others conducted in other countries or regions.

4.3. Robustness check

To ensure the robustness of our findings, we conducted additional tests to account for potential confounding factors and to validate the consistency of our results. First, we performed a robustness check by accounting for other crisis events (such as the Global financial crisis, the sovereign European debt crisis, and the Tunisian revolution in 2011) that might have influenced our analysis. By including these events as control variables in our model, we aimed to isolate the specific impact of the variables of interest and confirm the stability of our findings. Results are available in Table A.1 in Appendix. The inclusion of other crisis events dummies does not change our previous conclusions. Further, only the European debt crisis seems to have a fairly significant effect on bank stability, but the sign is positive. This indicates that Tunisian banks have only limited exposure to sovereign debt.

Second, to further strengthen the reliability of our results, we replicated the analysis using another database. Balanced yearly data on 21 banks are manually collected from the Tunisian Professional Association of Banks and Financial Institutions (https://www.apbt.org.tn/) for the period 2011-2020. Our study utilized panel unit root tests, specifically the LLC of Levin et al. (2002) test and PVECM, to validate the model. The model included the dependent variable, Return on Assets (ROA), and explanatory variables such as ROA as the dependent variable, credit risk

[10] The outcome from DOLS is shown only, as the FMOLS is not feasible with insufficient observations/cross-sections after including the interaction term.

(RCRED), Overhead (defined as the ratio of operating expenses to total revenues), and CONC.[11] Table A.3 and Table A.4 present the results of our analysis using DOLS and accounting for the interaction between credit risk and the Covid-19 pandemic. The negative and statistically significant marginal effect ($\hat{\beta}_1$ + $\hat{\beta}_5$) suggests that the impact of credit risk is amplified during the sanitary crisis.

4.4. Results of the short run dynamics

According to Figure 3, we find that at the 5% threshold exists there is a one-way causality between credit risk (RCRED) and return on assets (ROA). Credit risk, in Granger's sense, causes the return on assets, and not the other way around. Thus, we share the same view as Almekhlafi et al. (2016) for commercial banks in Yemen, but our result is inconsistent with Ozili's (2019) observations for the case of Nigeria, that a short-term relationship between credit risk measured by non-performing loans and ROA is rejected.

Between bank concentration (CONC) and credit risk (RCRED), there is a unidirectional causality at the 5% threshold, that is to say, credit risk causes concentration. At the 5% threshold, there is a short-term bidirectional relationship between CONC and ROA and FINLEV and ROA. Gavurova et al. (2017) also find an effect of ROA on bank concentration in the European Union in the short run, but they do not confirm it for bank concentration on ROA. The bidirectional causality between financial leverage and ROA corroborates the result of Dalci (2018) for Chinese manufacturing firms.

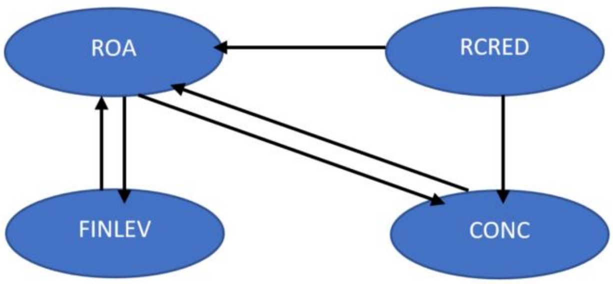

Figure 3. Granger causality: Test by Dumitrescu and Hurlin (2012) for model 1.

Note: The bold arrow means a significant relationship at 5%. ROA: Return on assets, RCRED: Credit risk, FINLEV: Financial leverage, CONC: Concentration. Source: Authors.

Switching to Figure 4 reveals a one-way causality at the 1% threshold between credit risk (RCRED) and the return on assets adjusted for risk (RAROA). There is a mutual relationship between financial leverage (FINLEV) and risk-adjusted return on assets (RAROA) at the 5% threshold, i.e., financial leverage causes risk-adjusted return on assets and vice versa. We observe the same causality direction behavior between CONC and RAROA. Finally, we depict a unidirectional causality at the 5% threshold between RCRED and CONC with causality going from credit risk to concentration.

5. Conclusion

We have studied the impact of credit risk on the financial stability of banks, taking the case of Tunisia. We use two measures of bank stability related to bank profitability represented by the return on assets (ROA) and risk-

[11] We recall that a PVECM is estimated based on two conditions: All variables should be integrated of order 1 (I(1)) and Pedroni's (2004) and Kao's (1990) tests show the existence of a cointegrating relationship between variables. Finally, a model is selected if the adjustment coefficient (cointeq(-1)) is negative and statistically significant in the PVECM because we essentially seek to show a cointegrating relationship that goes from the credit risk to bank stability. All these results are available upon request from the author.

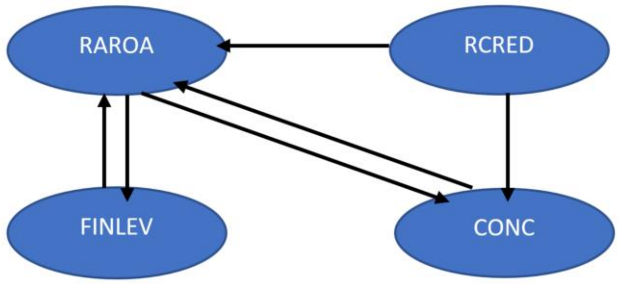

Figure 4. Granger causality: Test by Dumitrescu and Hurlin (2012) for model 2.

Note: The bold arrow means a significant relationship at 5%. RAROA: Risk-adjusted return on assets, RCRED: Credit risk, FINLEV: Financial leverage, CONC: Concentration. Source: Authors.

adjusted bank performance, namely the return on risk-adjusted assets (RAROA). Two models include credit risk (RCRED) as the variable of interest, augmented by financial leverage (FINLEV) and bank concentration (CONC). The econometric model known as Panel VECM allows for specifying long-term stable relationships and at the same time analyzing the short-term dynamics of the considered variables. We adopted the FMOLS and DOLS estimation methods to determine the impact of credit risk on the stability of banks in Tunisia. From the empirical work done, we can say that the stability and performance of Tunisian banks thrive when credit risk is adjusted to low levels. The stability of banks is also sensitive to external shocks and the occurrence of crises leads to bank failures. Particular vigilance is required regarding the adverse effects of crises that could undermine the soundness and health of the banking system. We provide evidence that the Covid-19 pandemic has a substantial negative effect on the stability of Tunisian banks and makes bank systems more vulnerable. Accounting for the sanitary crisis doesn't affect the statistical and economic contribution of the other variables, mainly an upswing in credit risk decreases ROA and RAROA. This effect amplifies during the epidemic after controlling for the interaction term between credit risk and the Covid-19 dummy. Our results imply several policy recommendations:

- To reduce credit risk and achieve maximum financial stability, banks must allocate more funds to managing default rates and reducing bad debt costs.
- Each bank should establish, document, and maintain sound policies, procedures, and controls that address the assessment and calculation of credit risk for all of its lending exposures. The determination of allowances should be based on these sound methods and allow for appropriate and timely recognition of expected credit losses.
- A bank's financial reporting should promote transparency and comparability by providing timely, relevant, and decision-useful information (Comité du Bâle sur le Contrôle Interne, 2015). Risk disclosure requirements should be further explained.
- Reduce moral hazard risk and ensure the adoption of good credit risk management practices, while promoting the best possible allocation of new credit.
- Migration towards IFRS9 (a new approach to the classification and measurements of financial assets) allows for establishing "good governance, competitive equity and transparency in the regulation of the banking market" according to CBT's press release.[12]

Despite the detrimental economic consequences, the Covid-19 crisis could be a real catalyst for the further digitalization of financial services. Upcoming research could address the role of digital financial inclusion in maintaining the stability of Tunisian banks.

[12] HYPERLINK "https://www.bct.gov.tn/bct/siteprod/actualites.jsp?id=587&la=AN".

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Conflict of interest

All the authors claim that the manuscript is completely original. The authors also declare no conflict of interest.

Author contributions

Conceptualization: Emna Trabelsi, Malek Ben Mansour; Investigation: Emna Trabelsi, Malek Ben Mansour; Methodology: Emna Trabelsi, Malek Ben Mansour; Formal analysis: Emna Trabelsi; Writing – original draft: Emna Trabelsi, Malek Ben Mansour; Writing – review & editing: Emna Trabelsi.

Appendix

Table A1. Panel unit root test (Fisher type).

Variables	ADF-Fisher	Level	First difference	Conclusion
ROA	Inverse chi-squared P	23.0071 (0.1135)	219.2610*** (0.0000)	I(1)
	Inverse normal Z	-1.2272 (0.1099)	-12.8669*** (0.0000)	I(1)
	Inverse logit L*	-1.2001 (0.1183)	-21.6220*** (0.0000)	I(1)
	Modified inv. chi-squared Pm	1.2387 (0.1077)	35.9318*** (0.0000)	I(1)
RAROA	Inverse chi-squared P	22.7147 (0.1216)	207.6504*** (0.0000)	I(1)
	Inverse normal Z	-1.1974 (0.1156)	-12.5622*** (0.0000)	I(1)
	Inverse logit L*	-1.1679 (0.1246)	-20.4770*** (0.0000)	I(1)
	Modified inv. chi-squared Pm	1.1870 (0.1176)	33.8793*** (0.0000)	I(1)
RCRED	Inverse chi-squared P	15.1275 (0.5153)	263.7716*** (0.0000)	I(1)
	Inverse normal Z	-0.3868 (0.3494)	-14.7034*** (0.0000)	I(1)
	Inverse logit L*	-0.4111 (0.3415)	-26.0120*** (0.0000)	I(1)
	Modified inv. chi-squared Pm	-0.1542 (0.5613)	43.8002*** (0.0000)	I(1)
FINLEV	Inverse chi-squared P	16.0643 (0.4485)	125.6546*** (0.0000)	I(1)
	Inverse normal Z	-0.4896 (0.3122)	-8.9780*** (0.0000)	I(1)
	Inverse logit L*	-0.4513 (0.3270)	-12.3734*** (0.0000)	I(1)
	Modified inv. chi-squared Pm	0.0114 (0.4955)	19.3844*** (0.0000)	I(1)
CONC	Inverse chi-squared P	1.4224 (1.0000)	131.5985*** (0.0000)	I(1)
	Inverse normal Z	3.8800 (0.9999)	-9.7926*** (0.0000)	I(1)
	Inverse logit L*	3.7481 (0.9997)	-12.9772*** (0.0000)	I(1)
	Modified inv. chi-squared Pm	-2.5770 (0.9950)	20.4351*** (0.0000)	I(1)
Variables	PP-Fisher	Level	First difference	Conclusion
ROA	Inverse chi-squared P	60.6897*** (0.0000)	219.2610*** (0.0000)	I(0) & I(1)
	Inverse normal Z	-4.1294*** (0.0000)	-12.8669*** (0.0000)	I(0) & I(1)
	Inverse logit L*	-5.2344*** (0.0000)	-21.6220*** (0.0000)	I(0) & I(1)
	Modified inv. chi-squared Pm	7.9001*** (0.0000)	35.9318*** (0.0000)	I(0) & I(1)
RAROA	Inverse chi-squared P	58.8017*** (0.0000)	207.6504*** (0.0000)	I(0) & I(1)
	Inverse normal Z	-4.0391*** (0.0000)	-12.5622*** (0.0000)	I(0) & I(1)
	Inverse logit L*	-5.0482*** (0.0000)	-20.4770*** (0.0000)	I(0) & I(1)
	Modified inv. chi-squared Pm	7.5663*** (0.0000)	33.8793*** (0.0000)	I(0) & I(1)
RCRED	Inverse chi-squared P	76.9602*** (0.0000)	263.7716*** (0.0000)	I(0) & I(1)
	Inverse normal Z	-6.5301*** (0.0000)	-14.7034*** (0.0000)	I(0) & I(1)

	Inverse logit L*	-7.5280*** (0.0000)	-26.0120*** (0.0000)	I(0) & I(1)
	Modified inv. chi-squared Pm	10.7763*** (0.0000)	43.8002*** (0.0000)	I(0) & I(1)
FINLEV	Inverse chi-squared P	28.2231** (0.0297)	125.6546*** (0.0000)	I(0) & I(1)
	Inverse normal Z	-1.8289** (0.0337)	-8.9780*** (0.0000)	I(0) & I(1)
	Inverse logit L*	-1.8248** (0.0374)	-12.3734*** (0.0000)	I(0) & I(1)
	Modified inv. chi-squared Pm	2.1608** (0.0154)	19.3844*** (0.0000)	I(0) & I(1)
CONC	Inverse chi-squared P	1.4224 (1.0000)	131.5985*** (0.0000)	I(1)
	Inverse normal Z	3.8800 (0.9999)	-9.7926*** (0.0000)	I(1)
	Inverse logit L*	3.7481 (0.9997)	-12.9772*** (0.0000)	I(1)
	Modified inv. chi-squared Pm	-2.5770 (0.9950)	20.4351*** (0.0000)	I(1)

*Note: ***, **, * statistically significant at 1%, 5% et 10%, resp. P-values are between parentheses. Source: Authors.*

Table A2. Panel unit root test with structural breaks.

Variables	Level	First difference	Conclusion
ROA	-0.0006 (0.6000)	-13.6377*** (0.0000)	I(1)
RAROA	-7.2720*** (0.0000)	-18.2515*** (0.0000)	I(0) & I(1)
RCRED	-0.0014 (0.8200)	-0.0695** (0.0200)	I(1)
FINLEV	0.0002 (0.9800)	-0.0145*** (0.0000)	I(1)
CONC	-15.4998 (1.0000)	-14.6102*** (0.0000)	I(1)

*Note: ***, **, * statistically significant at 1%, 5% et 10%, resp. P-values are between parentheses. Source: Authors.*

Table A3. Effect of credit risk on bank stability in the long run while accounting for other crisis events (8 banks for 2000-2020).

Method:	FMOLS	FMOLS	DOLS	DOLS	DOLS	DOLS
Dep. Var:	ROA	RAROA	ROA	ROA	RAROA	RAROA
	(1)	(2)	(3)	(4)	(5)	(6)
RCRED	-0.286166*** (0.0000)	-16.673157*** (0.0006)	-0.255745*** (0.0000)	-0.252532*** (0.0000)	-16.398252*** (0.0001)	-15.602535*** (0.0000)
FINLEV	-0.084510*** (0.0034)	-6.721871*** (0.0000)	-0.138489*** (0.0000)	-0.160660*** (0.0000)	-5.195530*** (0.0002)	-16.693977*** (0.0002)
CONC	0.000044 (0.4146)	0.017161*** (0.0033)	0.000029 (0.5724)	0.000020 (0.6980)	0.015246*** (0.0049)	0.003906 (0.4845)
COVID-19	-0.006536** (0.0381)	-0.984417** (0.0420)	-0.007417** (0.0209)	0.012506 (0.2563)	-0.920931** (0.0499)	-0.249904 (0.8241)
RCRED*COVID-19				-1.183751* (0.0599)		-64.981409 (0.2821)
GFC	-0.002527 (0.2494)	0.546013* (0.0852)	-0.001755 (0.4297)	-0.001389 (0.5350)	0.348961 (0.2101)	0.513411** (0.0127)
EDC	0.005256* (0.0647)	0.620417* (0.0832)	0.005704** (0.0450)	0.005848** (0.0408)	0.524498 (0.1008)	0.504556** (0.0409)
REVOL	-0.003482 (0.3929)	-0.008979 (0.9753)	-0.002008 (0.6121)	-0.001582 (0.6910)	-0.122786 (0.6243)	-0.172252 (0.6315)
Observations:	149	130	158	158	154	154
R-squared:	0.5732	0.7972	0.5990	0.6076	0.8259	0.9079

*Note: ***, **, * statistically significant at 1%, 5% et 10%, resp. Probabilities are between parentheses. ROA: Return on assets, RAROA: Risk-adjusted return on assets, RCRED: Credit risk, FINLEV: Financial leverage, CONC: Concentration, COVID-19: Covid-19 crisis, RECREDCOVID: RCRED*COVID-19, GFC: Global Financial crisis, EDC: European Debt crisis, REVOL: Revolution. Source: Authors.*

Table A4. Effect of credit risk on bank stability in the long run (21 banks for 2011-2020).

Method:	FMOLS	FMOLS	DOLS	DOLS	DOLS
Dep. Var:	ROA	ROA	ROA	ROA	ROA
	(1)	(2)	(3)	(4)	(5)
RCRED	-0.042582	-0.020253**	-0.024040	-0.013425	-0.009493

	(0.0497)	(0.0424)	(0.2185)	(0.5007)	(0.6316)
OVERHEAD	-1.628849 (0.0000)	-1.626161*** (0.0000)	-1.564176*** (0.0000)	-1.581850*** (0.0000)	-1.563566*** (0.0000)
CONC	-0.000112 (0.0519)	-0.000202*** (0.0000)	-0.000123** (0.0259)	-0.000164*** (0.0042)	-0.000164*** (0.0038)
COVID-19		-0.013363*** (0.0000)		-0.010606*** (0.0002)	0.033541 (0.1416)
RCRED*COVID-19					-0.056339* (0.0503)
Observations:	189	189	210	210	210
R-squared:	0.9892	0.9906	0.9875	0.9884	0.9886

*Note: ***, **, * statistically significant at 1%, 5% et 10%, resp. Probabilities are between parentheses. ROA: Return on assets, RCRED: Credit risk, OVERHEAD: Overhead, CONC: Concentration, COVID-19: Covid-19 crisis, RECREDCOVID: RCRED*COVID-19. Source: Authors.*

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