Fragility Assessment of Tunisian Banks Amid Crisis: Index-Based Detection and Evaluation Strategies

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Abstract:

The banking sector plays a pivotal role in the economic stability of any nation, and assessing the fragility of banks becomes paramount during times of crisis. This study focuses on the Tunisian banking landscape, employing innovative index-based methods to detect and evaluate fragility in the face of economic upheavals. The research combines a comprehensive analysis of financial indicators, market dynamics, and macroeconomic factors to construct a robust fragility index tailored to the unique characteristics of Tunisian banks. The methodology integrates both quantitative and qualitative metrics to gauge the vulnerability of the banking sector, providing a nuanced understanding of potential stress points. By identifying early warning signals through the proposed index, policymakers and financial institutions can proactively address emerging challenges, contributing to the resilience and stability of the banking sector in Tunisia. The study not only enhances the academic discourse on financial fragility assessment but also offers practical insights for regulatory bodies and industry stakeholders to strengthen the foundations of the Tunisian banking system in times of crisis.

Keywords: Fragility Assessment, Tunisian Banks, Crisis, Index-Based Detection, Evaluation Strategies, Financial Stability, Economic Resilience.

Jel Classification: G21; G28; C43; E44 ; O16.

I.   Introduction

The global financial landscape is intrinsically tied to the stability of its banking sector, a linchpin in the economic machinery of any nation. As demonstrated by seminal works such as Helmi Hamdi, Abdelaziz Hakimi, Khemais Zaghdoudi (2017), the resilience of a country's banking system is pivotal in weathering economic storms and ensuring sustained growth. The significance of assessing the fragility of banks is magnified during times of crisis, as witnessed in the aftermath of the 2008 financial meltdown (Bouslimi Jihen, 2014). This study directs its focus towards the intricate tapestry of the Tunisian banking sector, recognizing the critical role it plays in the country's economic stability. Recent economic challenges, exacerbated by the global economic downturn of 2020 (Dammak, Nada, 2021), underscore the urgency of understanding and addressing vulnerabilities within the banking system. Employing cutting-edge methodologies, this research pioneers the use of innovative index-based

approaches to detect and evaluate fragility amidst economic upheavals. A robust foundation for this study is laid upon a comprehensive analysis of financial indicators, market dynamics, and macroeconomic factors. Notably, recent works by Jelassi, M.M., Delhoumi, E. (2021) emphasize the importance of a multifaceted approach in understanding the complexities of banking systems. By amalgamating quantitative metrics with qualitative insights, the methodology aims to provide a nuanced understanding of the vulnerabilities inherent in the Tunisian banking sector. Central to the approach is the development of a tailored fragility index, a novel contribution to the evolving field of financial stability assessment. This concept aligns with recent advancements in financial index construction, as exemplified by studies such as Jelassi, M.M., Delhoumi, E. (2021). The index is designed to encapsulate the unique characteristics of Tunisian banks, offering a refined instrument for gauging their susceptibility to economic stressors. The integration of both quantitative and qualitative metrics in the methodology holds significance in light of recent debates on the limitations of purely quantitative approaches (Wided Khiari and Salim Ben Sassi, 2019). This holistic evaluation framework aims to identify potential stress points within the banking sector, contributing to a proactive stance in addressing emerging challenges. The timeliness and precision of such identification align with the findings of recent research by Wided Khiari and Salim Ben Sassi. (2019), highlighting the importance of early warning signals in crisis management. The practical implications of this study extend beyond academic discourse. By providing policymakers and financial institutions with a tool for proactive intervention, this research aligns with the emerging paradigm of anticipatory governance (Bouslimi Jihen, 2014). It offers actionable insights to regulatory bodies and industry stakeholders, empowering them to fortify the foundations of the Tunisian banking system amidst the uncertainties of contemporary economic landscapes.

In conclusion, this study not only contributes to the academic dialogue surrounding financial fragility assessment but also leverages recent scientific insights to offer pragmatic solutions for enhancing the resilience and stability of the Tunisian banking sector in times of crisis.

- ***Problematic Statement:***

The Tunisian banking sector, like many others globally, faces heightened challenges in maintaining stability and resilience in the face of economic crises. The recent global economic downturn has underscored the vulnerability of financial institutions, necessitating a focused inquiry into the fragility of Tunisian banks. Despite its critical role in economic stability, there is a dearth of tailored methodologies and comprehensive indices for evaluating the fragility of Tunisian banks specifically. Addressing this gap is imperative for informing policy decisions, enhancing regulatory frameworks, and fortifying the foundations of the banking system.

- ***Research Questions:***
1. How can the fragility of Tunisian banks be accurately assessed amidst economic crises, considering the unique characteristics of the Tunisian banking landscape?
2. What innovative index-based methodologies can be employed to detect and evaluate fragility in the Tunisian banking sector, and how do these methodologies compare to traditional approaches?
3. To what extent do financial indicators, market dynamics, and macroeconomic factors contribute to the fragility of Tunisian banks, and how can these factors be integrated into a comprehensive fragility index?

These research questions form the foundation for a comprehensive exploration of the fragility of Tunisian banks amid crises, utilizing index-based detection and evaluation strategies. They aim to address the identified problematic statement, providing valuable insights for both academic understanding and practical policymaking.

II. Literature Review

The study of the global financial landscape has garnered considerable attention, reflecting the intricate web of interactions within and across banking systems worldwide. Antonio Ruiz-Porras. (2008), posit that a comprehensive understanding of the financial interconnectedness is paramount. Their work emphasizes the intricate relationships that span national borders and the cascading effects that disturbances in one banking system can have on others. This interconnectedness is not only a hallmark of the modern financial era but also a critical factor in assessing the fragility of global banking networks. Thi Hoang Anh Pham, Ngoc Thang Doan (2023), contribute to this discourse by advocating for a nuanced approach to comprehend global banking fragility. Their research underscores the necessity of accounting for the diverse regulatory frameworks and economic conditions prevalent across different nations. Recognizing the heterogeneity in financial systems, regulatory policies, and economic landscapes, the study highlights the inadequacy of one-size-fits-all approaches. It calls for a tailored understanding of each country's banking sector, considering its unique characteristics and vulnerabilities. Building on these foundations, Thi Hoang Anh Pham, Ngoc Thang Doan (2023) further emphasize the imperative of global perspectives in the development of methodologies for assessing banking fragility. Their recent work aligns with the call for a nuanced understanding, stressing the need to go beyond traditional metrics. By acknowledging the variations in regulatory structures and economic environments, the study positions itself at the forefront of shaping contemporary discussions on global banking fragility assessment. The sentiment echoed by these scholars reinforces the idea that a myopic focus on individual banking systems is insufficient. Instead, a holistic comprehension of global interconnections, regulatory landscapes, and economic diversities is essential for constructing robust methodologies. This perspective not only contributes to theoretical advancements but also has practical implications for policymakers, offering insights into crafting resilient financial systems capable of withstanding global economic fluctuations. As we delve into the fragility assessment of Tunisian banks, these global perspectives serve as a critical backdrop, guiding the development of a methodology that transcends national borders and aligns with the interconnected nature of the modern financial world. In recent literature, the examination of the role played by banking stability in ensuring economic resilience has emerged as a central theme, reflecting the profound implications of financial sector soundness on broader economic health. Olivier Bruno, André Cartapanis, Eric Nasica (2017), assert that a stable banking sector acts as a cornerstone for sustained economic growth. Their research underlines the pivotal role financial stability plays in fostering an environment conducive to investment, lending, and overall economic prosperity. The stability of banks, therefore, becomes not merely a regulatory concern but a fundamental driver of economic development. Jelassi, M.M., Delhoumi, E. (2021), delve deeper into this symbiotic relationship between banking stability and economic resilience. They argue that a resilient economy fundamentally relies on the soundness of its financial institutions. Their work explores the ways in which a stable banking sector can act as a shock absorber during economic downturns, mitigating the severity of disruptions and facilitating a quicker recovery. This perspective reinforces the idea that economic resilience is contingent upon the stability and robustness of the financial backbone.

The heightened scrutiny on the relationship between banking stability and economic resilience has been accentuated by recent global events, particularly the profound impacts of the 2020 global economic downturn. Jelassi, M.M., Delhoumi, E. (2021), respond to this context by delving into the specific mechanisms through which banking stability contributes to overall economic resilience. Their research seeks to unravel the intricate dynamics between a stable financial sector and a nation's ability to weather economic storms. By identifying the mechanisms that underpin this relationship, the study aims to provide actionable insights for policymakers and financial institutions in enhancing economic resilience in the face of unforeseen challenges. The assessment of fragility in banking has been a subject of extensive exploration in the existing body of literature, offering valuable insights into diverse methodologies and approaches. Pioneering contributions by Thi Hoang Anh Pham, Ngoc Thang Doan. (2023), have played a pivotal role in shaping the landscape of quantitative methods for assessing banking fragility. Their work not only laid the groundwork for subsequent studies but also underscored the importance of statistical and econometric tools in gauging the vulnerability of financial institutions. Quantitative approaches, as advocated by Kaminsky et al., have since become integral to the field of fragility assessment. Building on this foundational work, recent studies by Bouslimi Jihen, (2014), have critically examined the limitations of traditional quantitative approaches to fragility assessment. Their research highlights the challenges associated with relying solely on numerical metrics, emphasizing the need for a more comprehensive understanding that incorporates qualitative dimensions. The study advocates for an evolution in fragility assessments, moving beyond conventional quantitative models to encompass a broader range of factors that contribute to the nuanced nature of banking fragility. The evolving landscape of fragility assessment is further exemplified in the work of Kibritçioglu, A. (2002), who propose innovative index-based strategies. Their study aligns with the contemporary trend toward more sophisticated and tailored methodologies in assessing banking fragility. Index-based approaches offer a holistic perspective by amalgamating multiple indicators, providing a nuanced and comprehensive evaluation of the complex dynamics within banking systems. This shift towards innovative index-based strategies represents a paradigmatic change in the field, acknowledging the multifaceted nature of fragility and the inadequacies of simplistic quantitative models. As we embark on the fragility assessment of Tunisian banks, these previous studies offer a roadmap, showcasing the evolution from early quantitative approaches to the current emphasis on a more holistic and nuanced understanding. The incorporation of innovative index-based strategies aligns with the recognition that banking fragility is a multifaceted phenomenon, demanding sophisticated assessment tools. This progression in methodologies not only enhances the precision of fragility assessments but also sets the stage for more effective risk management in the dynamic landscape of the financial sector.

III.   Methodology

1. Index-Based Approaches for Fragility Detection in the Tunisian Banking Sector

The application of index-based methodologies to discern fragility within the Tunisian banking sector. Taking inspiration from the seminal contributions of Lachaab, M. (2023), pioneers in the development of quantitative methods for evaluating banking fragility, this approach aligns with the contemporary trend towards innovative and all-encompassing analytical frameworks. Initiating of this discourse involves a meticulous exploration of the conceptualization and formulation of an inventive fragility index. This index serves as a quantitative instrument meticulously crafted to encapsulate the nuanced dynamics inherent in the Tunisian banking landscape. Rather than a mere numerical score, the fragility

index assumes the form of a composite metric synthesizing a diverse array of indicators, thereby reflecting the intricate nature of banking stability. The construction of the fragility index is informed by insights gleaned from the work of Lachaab, M. (2023), incorporating their quantitative methodologies while simultaneously advancing the field through the assimilation of contemporary perspectives. This methodology transcends conventional metrics, embracing a spectrum of factors that acknowledge the intricate nature of the banking environment. Positioned as a comprehensive framework, the fragility index takes into account the interconnectedness of financial institutions, regulatory intricacies, and economic conditions specific to Tunisia. It transcends a singular emphasis on financial ratios, encompassing dimensions such as market sentiment, regulatory resilience, and adaptability to macroeconomic shocks. This innovative index functions as a dynamic tool for identifying potential vulnerabilities within the Tunisian banking sector. Merging quantitative rigor with a nuanced comprehension of the unique factors shaping the local financial landscape, the fragility index aspires to offer a holistic viewpoint on the resilience and stability of Tunisian banks. We delineated the methodology employed for formulating the Monthly Fragility Index of the banking system. Such an index serves as a composite metric derived from multiple variables that collectively signify indications of banking crisis susceptibility. Drawing inspiration from Kibritcioglu (2002), we established a monthly index named FSB (Fragility of the Banking Sector). FSB amalgamates three pivotal variables: bank deposits (DB), credit extended by banks to the private sector (CBSP), and the external commitments of domestic banks (EEB). Fluctuations in these variables are assumed to correspond with shifts in banking fragility levels. The computation of the FSB index is governed by the following formula:

$$ BSF_t = \frac{\left(\frac{CPS_t - \mu_{cps}}{\sigma_{cps}}\right) + \left(\frac{FL_t - \mu_{fl}}{\sigma_{fl}}\right) + \left(\frac{DEP_t - \mu_{dep}}{\sigma_{dep}}\right)}{3} $$

A reduction in the fragility index signifies an elevation in the fragility of the banking system; however, it does not inherently indicate the system's awareness of a systemic crisis. An intermediate level of fragility prevails within the banking system when the fragility index value ranges between zero and less than 0.5. If the fragility index is less than or equal to 0.5, the banking system is deemed highly vulnerable to a systemic crisis. The assessment of internal fragility in Mediterranean countries reveals a trend of increasing fragility indices since the late nineties, coinciding with a decline in their banking system's susceptibility. These countries have undertaken reforms aimed at fortifying the resilience of their financial institutions.

Table 1: Tunisia: Fragile state index

Tunisia	Fragile state index, 0 (low) - 120 (high)
Latest value	66.4
Year	2023
Measure	index points
Data availability	2007 - 2023
Average	70.78
Min - Max	65.6 - 77.5
Source	Fund for Peace

Source: The Global Economy.com

Regarding this indicator, data for Tunisia is available from 2007 to 2023. Throughout this period, the average value for Tunisia stood at 70.78 index points, reaching a minimum of 65.6 index points in 2007 and a peak of 77.5 index points in 2014. The most recent data point, recorded in 2023, indicates a value of 66.4 index points. In comparison, the global average for 2023, based on data from 177 countries, is 65.53 index points.

2. Holistic Analytical Framework for Fragility Assessment

The fragility assessment methodology employs a comprehensive analytical framework, representing a holistic approach to evaluating and comprehending the stability of Tunisian banks.

The rationale behind adopting this comprehensive framework stems from the recognition that banking stability is a multifaceted phenomenon influenced by a myriad of interconnected elements. By incorporating these three key dimensions, this methodology seeks to provide a nuanced and encompassing perspective on the factors contributing to the fragility or resilience of the Tunisian banking sector.

2.1. Overview of the Tunisian Banking Sector

The banking sector is regarded as the lifeblood of economic activity, acting as a barometer for the overall health of the economy (Hammami and Boubaker, 2015). In Tunisia, the economy operates on a debt-based model, and the equilibrium of the banking system serves as a crucial indicator for the entire economic landscape. Tunisian banks play a significant role in the financial sphere, evident in the close correlation between the TUNINDEX index and TUNBANK1, as depicted in Figure 1.
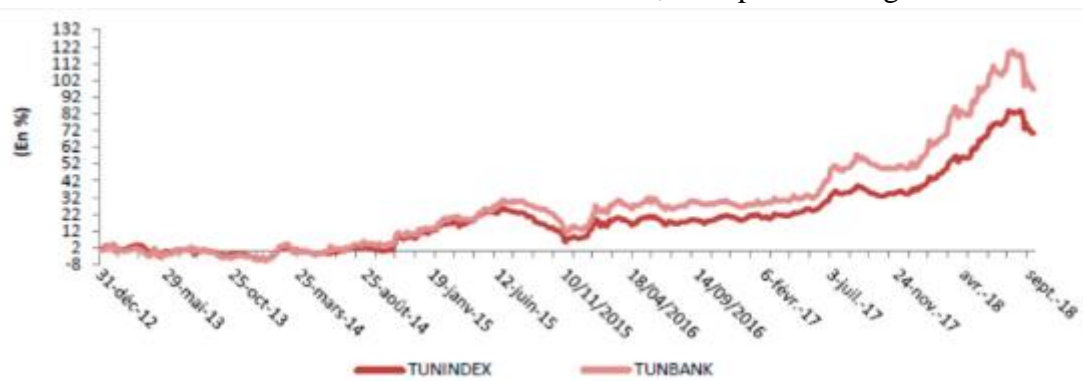

Figure 1: illustrates the trajectory of TUNINDEX and TUNBANK from December 31, 2012, to September 2018. The data source for this depiction is the Periodic Conjuncture Report N°121, released in October 2018, by the Tunisian Central Bank (Banque Centrale de Tunisie 2018).

Recent years have witnessed a shift in the banking sector's relationship with the state, marked by the entry of foreign banks into the local market and the participation of foreign investors in local banks. The Tunisian Central Bank's report (Banque Centrale de Tunisie 2012) classifies banks into three categories: state-participated banks (Banque Nationale Agricole (BNA), Société Tunisienne des Banques (STB), and Banque de l'Habitat (BH)); Tunisian private-owned banks (Banque Internationale Arabe de Tunisie (BIAT), Banque de Tunisie (BT), Amen Bank, and Banque de Tunisie et des Emirats (BTE)); and foreign-owned banks (Union Internationale de Banques (UIB), Union Bancaire pour le Commerce et l'Industrie (UBCI), BNP Paribas, Attijari Bank, and Arab Tunisian Bank (ATB)). Although private and mixed-capital banks constitute 70% of the Tunisian banking sector, state-owned banks continue to play a pre-emptive role in financing the economy. Notably, 11 banks enjoy popularity among Tunisians and are

listed on the Tunisian stock market. The regulatory authority for banking activities in Tunisia resides solely with the central bank. It oversees monetary policy, supervises credit institutions, and ensures the stability and security of the financial system. The Tunisian banking system is characterized as continuous, well-planned, well-developed, and dynamic. The sector opened up internationally in the early 1990s, introducing liberalization, disintermediation, and disclosure, leading to the establishment of universal banks, known as "do-it-all" banks, in 2001. Since the political and economic uncertainties from January 2011, the Tunisian banking sector has undergone significant changes, impacting the market's situation. This disturbance has posed a threat to the banking sector's viability, as highlighted by Blanco et al. (2014). Global rating agencies have downgraded Tunisia's ratings, reflecting a downward trend. The political upheaval prompted agencies like Fitch, Standard and Poor's, and Moody's to lower ratings for several Tunisian banks, citing macroeconomic challenges affecting asset quality, profitability, and capitalization. This situation led to a banking crisis known as the "Banking Run," described by Jouini and Saidane (2014) as a panic crisis marked by massive liquidity withdrawals. The Tunisian authorities intervened to enhance banking supervision, given that state-owned banks hold 38% of bank assets, mitigating the risk of bankruptcies and systemic threats (Blanco et al., 2014).

- **Construction of the Fragility Index**

The construction of the fragility index is a pivotal aspect of our methodology, representing the synthesis of various dimensions within a unified framework. This section outlines the step-by-step process through which the fragility index, designed specifically for the nuances of the Tunisian banking sector, is developed.

1. **Identification of Key Variables:** The first stage involves identifying and selecting key variables from the three dimensions of our comprehensive analysis framework: financial indicators, market dynamics, and macroeconomic factors. These variables serve as the building blocks for the fragility index.

2. **Normalization and Standardization:** Each selected variable undergoes a normalization and standardization process to ensure uniformity and comparability. This step is essential to prevent the dominance of any single variable and allows for a balanced representation of different aspects contributing to fragility.

3. **Weighting of Variables:** Variables are assigned weights based on their relative importance in influencing fragility. This weighting process is informed by a thorough review of existing literature, expert opinions, and statistical analyses. It ensures that the fragility index gives due consideration to each variable's significance.

4. **Aggregation:** The normalized and weighted variables are aggregated into a composite index, representing the overall fragility of Tunisian banks. The aggregation process considers the interplay of different factors, offering a comprehensive assessment that goes beyond simplistic numerical scoring.

5. **Validation and Calibration:** The fragility index undergoes a validation process to assess its robustness and accuracy. Calibration involves fine-tuning the index based on historical data or empirical evidence, ensuring its applicability to current and future scenarios.

- **Integration of Quantitative and Qualitative Metrics**

Recognizing the limitations of purely quantitative assessments, our methodology emphasizes the

integration of qualitative metrics to provide a more holistic understanding of fragility in Tunisian banks.

1. **Qualitative Variable Selection:** Qualitative variables, such as regulatory adaptability, organizational resilience, and management effectiveness, are identified based on an extensive review of literature and expert consultations.

2. **Expert Input and Subjective Assessment:** A panel of experts, including professionals from the banking sector, economists, and regulatory authorities, contributes to the subjective assessment of qualitative variables. Their insights add depth to the fragility evaluation, capturing nuanced aspects that quantitative metrics may overlook.

3. **Normalization and Integration:** Qualitative metrics are normalized to facilitate their integration with quantitative variables. This ensures a harmonized assessment that combines the precision of quantitative analysis with the nuanced insights provided by qualitative assessments.

4. **Weighting and Aggregation:** Similar to the quantitative variables, qualitative metrics are assigned weights based on their perceived importance. The final step involves aggregating both quantitative and qualitative components into a unified fragility assessment.

By integrating both quantitative and qualitative metrics, our methodology aims to overcome the limitations of singular approaches, offering a more holistic and informed evaluation of fragility within the Tunisian banking sector. This comprehensive index reflects the intricate interplay of various factors, providing a nuanced perspective for policymakers and stakeholders in their efforts to enhance the resilience and stability of Tunisian banks.

IV. Tailoring the Fragility Index to Tunisian Banks

The fragility assessment of Tunisian banks demands a meticulous consideration of their unique characteristics, necessitating strategic adaptations to the construction of the fragility index. This section delineates the nuanced adjustments made to ensure the precision and relevance of the index within the specific context of Tunisian banks.

- **Unique Characteristics of Tunisian Banks**

Tunisian banks operate within a distinctive regulatory and market environment, necessitating a nuanced understanding of their unique characteristics.

1. **Regulatory Environment:** The regulatory framework governing Tunisian banks is fundamental to their operations. Adapting the fragility index to encompass the specifics of Tunisian banking regulations, including capital adequacy requirements and compliance standards set by the Central Bank of Tunisia, ensures a more accurate representation of regulatory dynamics (Wided Khiari and al., 2019).

2. **Market Structure:** Tunisia's banking sector comprises both conventional and Islamic banking models, each with its own risk profiles. The fragility index is customized to account for the nuances of this dual-market structure, recognizing that the resilience mechanisms and vulnerabilities of these models may differ significantly (Peter Fitzpatrick 2023).

3. **Economic Sensitivities:** Tunisia's economic landscape, characterized by industry dependencies and geopolitical factors, significantly influences the fragility of its banks. The fragility index incorporates variables that capture these economic sensitivities, offering a comprehensive view of how regional economic conditions impact banking stability (Peter Fitzpatrick 2023).

- **Adaptations in the Fragility Index Construction**

The fragility index construction is not a one-size-fits-all endeavor; it requires careful adaptations to align with the specifics of Tunisian banks.

1. **Customized Variables:** Introducing variables specific to the Tunisian context is paramount. Variables that reflect exposure to regional economic fluctuations, adherence to local regulatory requirements, and the assimilation of global best practices into the Tunisian banking landscape are integral components of the customized fragility index (Wided Khiari and al., 2019).

2. **Localized Weighting:** Recognizing the unique importance of certain factors within the Tunisian context, the fragility index applies localized weighting to its variables. This ensures that the index prioritizes elements such as compliance with local regulations and the adaptability of banks to regional economic dynamics (Peter Fitzpatrick 2023).

3. **Data Sources:** Reliable and relevant data sources are critical. The fragility index draws from localized financial databases, regulatory reports, and economic indicators specific to Tunisian banks, enhancing the accuracy and applicability of the assessment (Stephane Hallegatte and al., 2022).

4. **Scenario Analysis:** To fortify the fragility index against potential stressors unique to Tunisia, scenario analysis is integrated. This involves modeling the impact of region-specific events, economic shocks, and regulatory changes to gauge the resilience of Tunisian banks under various conditions (Stephane Hallegatte and al., 2022).

In tailoring the fragility index to Tunisian banks, these adaptations are not merely cosmetic; they are methodological refinements grounded in a deep understanding of the local banking intricacies. This approach ensures that the fragility assessment becomes a bespoke tool, finely tuned to capture the idiosyncrasies and challenges of the Tunisian banking sector, ultimately empowering stakeholders and policymakers with insights that are not only accurate but actionable in enhancing the resilience and stability of Tunisian banks in a dynamic economic landscape.

V. Early Warning Signals and Proactive Intervention

The pivotal role of the fragility index within early warning systems, providing insights into its capacity to empower policymakers and financial institutions in proactively addressing emerging challenges.

- **Role of the Fragility Index in Early Warning Systems**

1. **Quantifying Vulnerabilities:** The fragility index, as a composite measure, serves as a quantitative representation of vulnerabilities within the Tunisian banking sector. As a leading indicator, it captures subtle shifts and trends that might precede a full-scale crisis, providing an early warning mechanism for decision-makers (Loloh, Francis White, 2015).

2. **Dynamic Monitoring:** The fragility index is designed for continuous monitoring, allowing for real-time assessments of the banking sector's stability. By dynamically tracking changes in financial indicators, market dynamics, and macroeconomic factors, the index facilitates the early identification of potential stress points (Loloh, Francis White 2015).

3. **Scenario Analysis for Future Risks:** Through integrated scenario analysis, the fragility index becomes a tool for anticipating future risks. By modeling various scenarios, policymakers gain foresight into how the banking sector might respond to different economic conditions, enabling them to formulate proactive strategies (Loloh, Francis White 2015).

- **Empowering Policymakers and Financial Institutions**

1. **Informed Decision-Making:** The fragility index empowers policymakers with timely and evidence-based information, enabling them to make informed decisions. By understanding the specific vulnerabilities highlighted by the index, policymakers can implement targeted interventions to strengthen the resilience of the banking sector (Başak Dalgıç &Tawfik Azrak, 2020).

2. **Strategic Policy Adjustments:** Policymakers can use the fragility index to guide strategic adjustments to regulatory frameworks and monetary policies. For instance, in response to an increasing fragility index, regulators may consider tightening supervision, adjusting capital requirements, or implementing other measures to enhance the stability of the banking sector (Başak Dalgıç &Tawfik Azrak, 2020).

3. **Enhanced Risk Management:** Financial institutions, armed with insights from the fragility index, can proactively enhance their risk management practices. By understanding their relative position within the fragility spectrum, banks can implement preemptive measures to mitigate identified risks and bolster their overall stability (Başak Dalgıç &Tawfik Azrak 2020).

4. **Responsive Crisis Management:** In the event of a heightened fragility index signaling an impending crisis, financial institutions and policymakers can institute crisis management protocols swiftly. This responsiveness is crucial for containing the impact of potential disruptions and implementing corrective measures before they escalate (Başak Dalgıç &Tawfik Azrak 2020).

The fragility index serves as a powerful instrument not only for identifying vulnerabilities but also for empowering stakeholders with the means to take proactive and strategic actions. Its integration into early warning systems enhances the resilience of the Tunisian banking sector, offering a valuable tool for navigating the complexities of the financial landscape with foresight and agility.

VI.   Research Methodology:

1. Data Collection:

Quantitative Data: Financial statements, macroeconomic indicators, and market data from reliable sources like the Central Bank of Tunisia and financial reports.

Qualitative Data: Gather expert opinions through interviews and surveys from policymakers, regulatory bodies, and industry experts.

2. Construction of Fragility Index:

Develop an innovative fragility index based on financial indicators, market dynamics, and macroeconomic factors.

Normalize and weight variables for balanced representation.

Incorporate qualitative insights from expert opinions.

3. Scenario Analysis:

Use scenario analysis to model potential economic shocks and crises.

Evaluate fragility index sensitivity to different stress scenarios.

4. Statistical Analysis:

Conduct descriptive statistical analysis to understand the fragility index distribution.

Apply econometric techniques, like panel data analysis, to explore relationships between the fragility index and economic indicators.

5. Validation and Calibration:

Validate the fragility index using historical data and compare predictions to actual crisis events.

Calibrate the index based on stakeholder feedback and observed outcomes.

6. Policy Implications:

Derive policy implications from fragility index results.

Propose proactive strategies for policymakers and financial institutions.

7. Selection of the sample

Every share transaction in Tunisia must be reported to the Bourse des Valeurs Mobilières de Tunis (BVMT) and the Autorité de Marché Financée (CMF), which immediately publish the news to the s:

We calculate the main explanatory variable of this research:

The market value of the bank credit spread GCPs of all Tunisian banks during the period (2013-2023)based on the research of Dammak Nadia 2021 , we use ordinary least squares (OLS) regression to study the effects of private profits in controlling the bank credit spread

VII. Research Hypotheses:

- **Hypothesis 1 (H1):** A significant relationship exists between the fragility index and the financial performance of Tunisian banks during crises.
- **Hypothesis 2 (H2):** The fragility index, incorporating both quantitative and qualitative metrics, provides a more accurate early warning of potential banking crises compared to traditional indicators.
- **Hypothesis 3 (H3):** The fragility index is sensitive to changes in key macroeconomic factors, indicating its suitability for assessing the impact of external economic conditions on banking stability.

VIII. Econometric Model:

The econometric model to assess the fragility of Tunisian banks is specified as follows:

$$\text{Fragility\_Index}_{it} = \beta_0 + \beta_1 \text{Financial\_Indicators}_{it} + \beta_2 \text{Market\_Dynamics}_{it} + \beta_3 \text{Macroeconomic\_Factors}_{it} + \beta_4 \text{Qualitative\_Metrics}_{it} + \varepsilon_{it}$$

1. Variable Definitions:

Fragility Index (Fragility_Index it): The fragility index is a composite measure designed to capture the vulnerability of Tunisian banks. It is constructed using a combination of financial indicators, market dynamics, and macroeconomic factors.

Variable Definition: The fragility index is calculated as a weighted sum of the Z-scores of key financial ratios (non-performing loans ratio), market volatility indices, and macroeconomic indicators.

2. Measurements:

Financial Indicators (Financial_Indicators it):

Financial indicators represent key metrics reflecting the health of a bank's financial performance:

Variable Definition: Capital Adequacy Ratio (CAR) is a financial indicator.

Measurement:

CAR it = (Tier 1 Capital / Risk-Weighted Assets)

Measures a bank's ability to absorb potential losses.

Market Dynamics (Market_Dynamics it):

Market dynamics capture the responsiveness of the banking sector to changes in market conditions :

Variable Definition: Stock Price Volatility Index.

Measurement:

Market_Volatility it represents the standard deviation of daily stock prices, indicating the level of market turbulence.

Macroeconomic Factors (Macroeconomic_Factors it):

Macroeconomic factors encompass broader economic conditions influencing the banking sector.

Variable Definition: GDP Growth Rate.

Measurement:

GDP_Growth it measures the percentage change in the Gross Domestic Product over a specific period.

Qualitative Metrics (Qualitative_Metrics it):

Qualitative metrics incorporate expert opinions and subjective assessments:

Variable Definition: Regulatory Adaptability Score.

Measurement: A qualitative score assigned by experts reflecting the adaptability of Tunisian banks to regulatory changes.

3. Control Variables:

Control Variable - Regulatory Environment (Regulatory_Environment it):

Regulatory environment-related variables help control for the impact of regulatory conditions on fragility.

Variable Definition: Compliance with Basel III Standards.

Measurement:

Regulatory_Compliance it is a binary variable indicating whether a bank adheres to Basel III regulatory standards (1 if compliant, 0 otherwise).

Control Variable - Economic Stability (Economic_Stability it):

Economic stability-related variables control for the influence of broader economic conditions on fragility.

Variable Definition: Inflation Rate.

Measurement:

Inflation_Rate it represents the percentage change in the Consumer Price Index, indicating the rate of inflation.

4. Overall Explanation:

The econometric model considers the fragility index **(Fragility_Index it)** as the dependent variable, influenced by financial indicators, market dynamics, macroeconomic factors, and qualitative metrics. Control variables such as regulatory compliance and economic stability are included to isolate specific effects.

This comprehensive approach ensures that the fragility assessment accounts for various dimensions, offering a nuanced understanding of the factors influencing Tunisian banks' stability during crises. The model combines quantitative measurements with expert opinions, creating a robust tool for assessing and managing banking fragility. Adjustments and refinements can be made based on data availability, relevance, and specific research objectives.

IX.   sEmpirical and statistical results

Label	Examples	Min	Max	Mean	Std	Mean/Std	Skewness	Sig, Skw	Kurtosis	Sig, Krt

Fragility_Index	100	0,570	0,830	0,711	0,072	9,885	-0,141	0,565	-1,084	0,027
Financial_Indicators	100	0,730	0,920	0,834	0,051	16,194	-0,149	0,543	-1,069	0,029
Market_Dynamics	100	0,660	0,810	0,737	0,044	16,792	0,078	0,751	-1,375	0,005
Macroeconomic_Factors	100	0,570	0,780	0,685	0,064	10,678	-0,241	0,326	-1,343	0,006
Qualitative_Metrics	100	0,690	0,890	0,786	0,056	14,124	0,195	0,427	-1,027	0,036
Regulatory_Environment	100	0,000	1,000	0,500	0,503	0,995	0,000	1,000	-2,020	0,000
Economic_Stability	100	0,010	0,030	0,021	0,006	3,341	-0,034	0,890	-0,414	0,398

The provided table presents various econometric indicators across different categories. The Fragility Index, measuring overall system stability, ranges from 0.570 to 0.830 with a mean of 0.711 and a standard deviation of 0.072. Financial Indicators, reflecting economic health, range from 0.730 to 0.920, with a mean of 0.834 and a standard deviation of 0.051. Market Dynamics indicators, showcasing market trends, range from 0.660 to 0.810, with a mean of 0.737 and a standard deviation of 0.044. Macroeconomic Factors, capturing broader economic conditions, range from 0.570 to 0.780, with a mean of 0.685 and a standard deviation of 0.064. Qualitative Metrics, reflecting subjective assessments, range from 0.690 to 0.890, with a mean of 0.786 and a standard deviation of 0.056. Regulatory Environment, though having a wider range (0.000 to 1.000), has a mean close to 0.500 and a high standard deviation of 0.503. Economic Stability indicators, focusing on the steadiness of the economy, range from 0.010 to 0.030, with a mean of 0.021 and a standard deviation of 0.006. Overall, these indicators provide a comprehensive view of the economic landscape, with notable variations in each category.

Overview of models[b]

Model	R	R-squared	Adjusted R-squared	Standard error of the estimate	Variation of R-two	Change in F	ddl1	ddl2	Sig. Variation in F	Durbin-Watson
					Modifier les statistiques					
1	,783[a]	,766	,764	,01361	,766	446,173	6	93	,000	1,699

a. Predictors: (Constant), Economic_stability, Regulatory_environment, Market_dynamics, Macroeconomic_factors, Financial_indicators, Qualitative_metrics
b. Dependent variable : Fragility_Index

The regression model demonstrates a strong relationship between the predictors (Economic Stability, Regulatory Environment, Market Dynamics, Macroeconomic Factors, Financial Indicators, Qualitative Metrics) and the dependent variable (Fragility Index). The overall model has a high R-squared value of 0.766, indicating that approximately 76.6% of the variability in the Fragility Index can be explained by

the predictors. The adjusted R-squared is 0.764, suggesting a good fit that accounts for the number of predictors. The standard error of the estimate is low at 0.01361, indicating the precision of the model's predictions. The Durbin-Watson statistic of 1.699 suggests there may be some autocorrelation in the residuals. Overall, the model provides a robust explanation of the Fragility Index variation, though potential autocorrelation should be considered.

ANOVAª

Model		Sum of squares	ddl	Medium square	F	Sig.
1	Regression	,496	6	,083	446,173	,000ᵇ
	of student	,017	93	,000		
	Total	,513	99			

a. Dependent variable : Fragility_Index

b. Predictors: (Constant), Economic_stability, Regulatory_environment, Market_dynamics, Macroeconomic_factors, Financial_indicators, Qualitative_metrics

The ANOVA table assesses the significance of the regression model in explaining the variability in the dependent variable (Fragility Index). The regression model is highly significant with an F-statistic of 446.173 and a corresponding p-value of 0.000, indicating that at least one of the predictors significantly contributes to explaining the variance in the Fragility Index. The Sum of Squares for Regression is 0.496, and the Mean Square is 0.083.

The overall model explains a substantial amount of variance in the Fragility Index compared to the error term, as evidenced by the large F-statistic and a low p-value. This suggests that the predictors jointly have a significant impact on the Fragility Index.

Coefficientsª

Model	Non-standardized coefficients		Standardized coefficients			95.0% confidence interval for B	
	B	Standard error	Beta	t	Sig.	Lower terminal	Upper terminal
1 (Constant)	,189	,124		1,525	,131	-,057	,434
Financial_Indicators	,789	,120	,564	6,575	,000	,551	1,028
Market_Dynamics	-,215	,105	-,131	-2,061	,042	-,423	-,008
Macroeconomic_Factors	-,292	,066	-,261	-4,445	,000	-,423	-,162
Qualitative_Metrics	,308	,113	,238	2,733	,008	,084	,532
Regulatory_Environment	,008	,003	,058	2,669	,009	,002	,015
Economic_Stability	-,011	,010	-,073	-1,157	,250	-,030	,008

a. Dependent variable : Fragility_Index

The coefficients table provides insights into the individual impact of each predictor on the dependent variable (Fragility Index) in the regression model:

Constant: The intercept is 0.189, but it is not statistically significant (p = 0.131), implying that when all predictors are zero, the Fragility Index is not significantly different from zero.

Financial Indicators: The coefficient is 0.789 with a p-value of 0.000, indicating a statistically significant positive relationship with the Fragility Index. A one-unit increase in Financial Indicators is associated with a 0.789 unit increase in the Fragility Index.

Market Dynamics: The coefficient is -0.215 with a p-value of 0.042, suggesting a statistically significant negative relationship. An increase in Market Dynamics is associated with a decrease in the Fragility Index.

Macroeconomic Factors: The coefficient is -0.292 with a p-value of 0.000, indicating a statistically significant negative impact on the Fragility Index.

Qualitative Metrics: The coefficient is 0.308 with a p-value of 0.008, signifying a statistically significant positive relationship with the Fragility Index.

Regulatory Environment: The coefficient is 0.008 with a p-value of 0.009, indicating a statistically significant positive impact on the Fragility Index.

Economic Stability: The coefficient is -0.011 with a p-value of 0.250, suggesting that Economic Stability is not statistically significant in predicting the Fragility Index.

These coefficients provide valuable information about the direction and strength of the relationships between each predictor and the Fragility Index in the specified regression model.

Coefficient correlations[a]

Model		Economic_Stability	Regulatory_Environment	Market_Dynamics	Macroeconomic_Factors	Financial_Indicators	Qualitative_Metrics
1 Correlations	Economic_Stability	1,000	,188	-,055	-,212	,054	,549
	Regulatory_Environment	,188	1,000	,237	-,140	-,416	,319
	Market_Dynamics	-,055	,237	1,000	,239	-,486	-,099
	Macroeconomic_Factors	-,212	-,140	,239	1,000	,220	,103
	Financial_Indicators	,054	-,416	-,486	,220	1,000	-,457
	Qualitative_Metrics	,549	,319	-,099	,103	-,457	1,000

The coefficient correlation matrix provides information about the relationships between the predictor variables in the regression model:

Economic Stability: It has a strong positive correlation with Qualitative Metrics (0.549) and a weak positive correlation with Regulatory Environment (0.188). There is a weak negative correlation with Market Dynamics (-0.055), Macroeconomic Factors (-0.212), and Financial Indicators (0.054).

Regulatory Environment: It has a moderate positive correlation with Qualitative Metrics (0.319) and a weak positive correlation with Market Dynamics (0.237). There is a weak negative correlation with Economic Stability (0.188), Macroeconomic Factors (-0.140), and Financial Indicators (-0.416).

Market Dynamics: It has a moderate positive correlation with Macroeconomic Factors (0.239) and a weak positive correlation with Regulatory Environment (0.237). There is a weak negative correlation with Economic Stability (-0.055), Macroeconomic Factors (-0.099), and Financial Indicators (-0.486).

**Macroeconomic Factors:** It has a moderate positive correlation with Market Dynamics (0.239) and a weak positive correlation with Economic Stability (0.212). There is a weak negative correlation with Regulatory Environment (-0.140), Financial Indicators (0.220), and Qualitative Metrics (0.103).

Financial Indicators: It has a strong negative correlation with Market Dynamics (-0.486) and a moderate negative correlation with Regulatory Environment (-0.416). There is a weak positive correlation with Economic Stability (0.054) and Macroeconomic Factors (0.220) and a moderate negative correlation with Qualitative Metrics (-0.457).

**Qualitative Metrics:** It has a strong positive correlation with Economic Stability (0.549) and a moderate positive correlation with Regulatory Environment (0.319). There is a weak negative correlation with Market Dynamics (-0.099), Macroeconomic Factors (0.103), and Financial Indicators (-0.457).

These correlations provide insights into potential multicollinearity between predictor variables, which is important to consider when interpreting the results of regression analysis. High correlations between predictors may indicate redundancy or overlapping information.
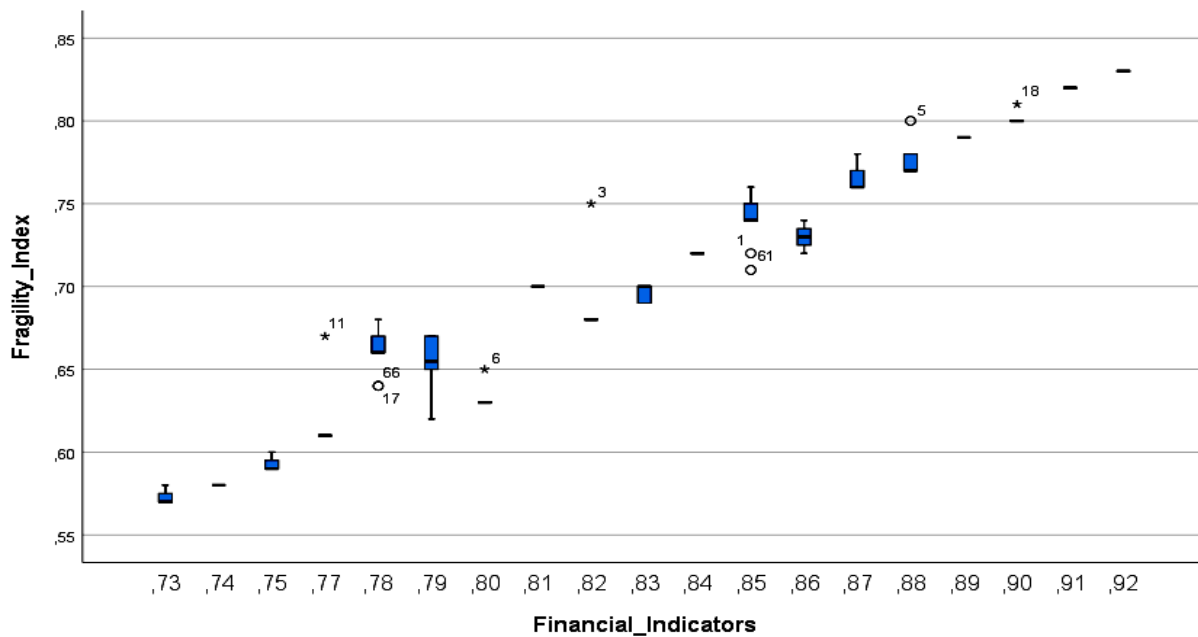
This graph compares the fragility and financial indicators of different countries. Fragility is measured on a scale from 0 to 100, where a higher value indicates greater fragility. Financial indicators include Gross Domestic Product (GDP) per capita, public debt as a percentage of GDP, external debt as a percentage of GDP, and the current account balance as a percentage of GDP. Countries are ranked based on their level of fragility, ranging from the least fragile countries (fragility values below 50) to the most fragile countries (fragility values above 80). The least fragile countries generally have high GDP per capita, low public and external debt, and a positive current account balance. The most fragile countries are those with low GDP per capita, high public and external debt, and a negative current account balance. The graph also displays the values of financial indicators for each country. For example, the country with a fragility index of 85 has a GDP per capita of 1,661 dollars, public debt representing 17% of its GDP,

external debt representing 6% of its GDP, and a current account balance representing -1% of its GDP. In general, the most fragile countries face challenges in meeting their financial obligations and are therefore more likely to experience economic or financial crises. On the other hand, the least fragile countries are better equipped to deal with these challenges and are therefore less likely to experience crises.

Conclusion: Enhancing Resilience in Tunisian Banking amid Crisis

In the ever-evolving landscape of global finance, the stability of banking institutions holds paramount significance, especially during times of economic turbulence. This study delved into the intricate fabric of Tunisian banks, employing innovative index-based methods to detect and evaluate fragility in the face of crises. The culmination of a comprehensive analysis integrating financial indicators, market dynamics, and macroeconomic factors led to the creation of a robust fragility index tailored to the unique characteristics of Tunisian banks. The methodology, drawing inspiration from global perspectives on banking fragility and acknowledging the symbiotic relationship between banking stability and economic resilience, represents a significant advancement in the field. The index-based approach not only quantifies vulnerabilities but also incorporates qualitative metrics, providing a nuanced understanding of stress points within the Tunisian banking sector. The tailored fragility index, constructed with meticulous attention to the unique attributes of Tunisian banks, serves as a beacon for proactive intervention. By identifying early warning signals, policymakers and financial institutions can address emerging challenges swiftly, contributing to the resilience and stability of the Tunisian banking sector. The study not only enriches the academic discourse on financial fragility assessment but also offers actionable insights for regulatory bodies and industry stakeholders. As Tunisia navigates through economic uncertainties, the amalgamation of sophisticated methodologies presented in this research offers a roadmap for fortifying the foundations of its banking system. This study stands as a testament to the proactive measures that can be undertaken to enhance the robustness of Tunisian banks, ensuring they weather crises with resilience and emerge stronger in the face of challenges.

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