Does Greater Banking Inclusion Enhance or Undermine Banking Stability in Tunisia? Evidence from a Nonlinear Analysis

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Abstract

This paper employs a panel smooth transition regression approach to investigate the relationship between banking inclusion and banking stability in Tunisia over the period 2006–2022. Considering various dimensions of banking stability, our findings indicate an inverted U-shaped relationship between banking inclusion and stability. This indicates that banking inclusion is pivotal for strengthening banking stability up to a certain threshold. Nonetheless, once this threshold is reached, higher levels of banking inclusion lead to banking instability. This is primarily due to increased exposure to less financially experienced clients. Additionally, rapid credit expansion can strain banks' internal risk management systems, even under strong regulatory oversight in Tunisia. This transition between regimes unfolds gradually. Our research provides essential policy implications and guidance for Tunisian financial regulators in designing strategies to balance banking inclusion and banking stability.

Introduction

In the Tunisian context, significant financial liberalization in the 1990s aimed to deregulate the banking sector and integrate the country into the global economy through numerous agreements with various international partners. These initiatives catalyzed subsequent reforms, leading to the implementation of the 2006 banking law, formally known as "Law n°2006-26 concerning credit institutions and financial organizations". This legislation was introduced to align Tunisia with international standards in financial regulation, facilitating the integration of Tunisian financial institutions into global markets and promoting financial stability by enhancing the transparency of information disclosed by banks.

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Despite these reforms, the banking system has faced ongoing challenges, including financial volatility and regulatory reforms, that reveal weaknesses and vulnerabilities in their implementation. The democratic transition in 2011 and subsequent economic crises have further exacerbated these issues, compelling the banking sector to navigate socio-political changes while ensuring financial stability. The Tunisian revolution of 2011 profoundly impacted the economy and banking sector, triggering political and social unrest that eroded investor confidence and weakened banking asset quality. Many businesses struggled financially, leading to a significant rise in non-performing loans. Consequently, voluntary and involuntary exclusions within the banking sector were observed.

During this period, the Central Bank of Tunisia implemented a series of measures to improve access to banking services and restore trust among Tunisian citizens, with the objective of stabilizing and strengthening the Tunisian banking sector. In 2015, the implementation of Law No. 2015-26 introduced significant regulatory reforms aimed at combating terrorism and money laundering, which were critical post-revolutionary challenges. These reforms sought to enforce stricter standards in risk management, financial transparency, and consumer protection. While the developmental trajectory of the banking system remains crucial for catalyzing industrialization, a major ongoing issue persists with financial inclusion, which has seen renewed interest with the emergence of new information and communication technologies. The Governmental Decree No. 2017-1259 outlines the structure, organizational guidelines, and operational procedures of Tunisia's financial inclusion observatory. It also identifies the institutions and administrative entities engaged in its activities and establishes a legal framework to promote innovation within the banking sector.

Financial inclusion aims to provide universal access to a diverse range of financial services that meet the needs of both individuals and businesses, regardless of socioeconomic status, in a cost- efficient manner (World Bank, 2025). This concept is consistent with financial intermediation theory, which emphasizes that financial institutions act as conduits between those who have excess funds and those who require capital. By directing resources from savers to borrowers, these institutions improve the efficiency of resource allocation and stimulate investment activity. An inclusive financial system further enhances this intermediary function by lowering information gaps and transaction costs, thereby supporting economic stability and promoting sustained growth (levine, 1997; Allen et al., 2016; World Bank, 2025). Nonetheless, persistent barriers, particularly stemming from restricted access to financial resources and compounded by gender inequalities, pose challenges, especially in developing economies such as Tunisia. Although Tunisia has made progress in expanding banking services and introducing innovative financial products, a significant portion of the population, particularly in rural areas, remains excluded from the formal financial system. This financial exclusion is problematic as it limits access to credit and other essential financial services, thereby hindering economic and social development (Demirgüç-Kunt et al., 2015).

Within the broader context of African nations, Tunisia exhibits low levels of financial inclusion due to several factors, including the rigidity of financial institutions, inadequate service quality, lack of accessibility and transparency, and the high cost of financial services. Additionally, bankers face reluctance to operate in an environment characterized by information asymmetry and less effective institutional frameworks (Nkoa and Song, 2020). In 2011, formal financial account ownership among Tunisian adults was reported at 33% (Global Findex Database, 2012). By 2014, this proportion had decreased to 27%, with fewer than 10% utilizing these accounts for savings (Global Findex Database, 2015). The World Bank's 2015 report underscored that 64% of Tunisians aged 15 and above either lacked access to or faced significant barriers in accessing formal financial services. Moreover, the scarcity of financial resources notably affected small and medium-sized enterprises (SMEs); nearly half of these businesses encountered considerable difficulties in obtaining affordable credit during the same period (World Bank, 2015).

According to the Global Findex Database (2021), the proportion of adults with access to formal financial accounts in Tunisia remained stable at 37% from 2017 to 2021. Despite this consistency, significant gender disparities persist in 2021, with female account ownership at 29%, contrasting with 45% for males. Furthermore, only 45% of account holders utilize their accounts for savings, while 51% are involved in borrowing activities. Additionally, 28% of the population engages in digital payments in 2021. By 2023, the availability rate of active ATMs had risen to 87%, as reported by the Tunisian Central Bank (2024). However, Tunisia's progress in financial inclusion continues to fall below World Bank benchmarks, indicating the necessity for further initiatives aimed at enhancing financial

accessibility and participation (World Bank, 2021).

Recent research indicates that greater access to financial services brings about positive social and economic outcomes. In particular, increased access to finance: enhances education and income equality (Banerjee et al., 2021; Suhrab et al., 2024), favours economic growth (Siddiki & Bala-Keffi, 2024), reduces economic volatility (Sebai & Talbi., 2024a), stimulates new firm creation (Charfeddine & Zaouali, 2022), facilitates more informed decision-making (Pranajaya et al., 2024), increases employment (Geng & He, 2021; Ren et al., 2023). The expansion of access to banking services has been widely recognized as beneficial across multiple domains. Since 2010, central banks from emerging and advanced economies, in partnership with international organizations such as the IMF, G20, Alliance for Financial Inclusion (AFI), and Consultative Group to Assist the Poor (CGAP), have actively promoted financial inclusion as a practical goal (Ahamed & Mallick, 2019).

The growing attention on financial inclusion has not been matched by an equivalent focus on its implications for banking stability. Partly as a result, banks remain cautious about extending services to marginalized or high-risk populations, influenced by the lasting consequences of the subprime mortgage crisis and the collapse of U.S. investment banks (Demirgüç-Kunt & Huizinga, 2010). The 2008 global financial crisis serves as a stark reminder of the risks associated with extensive lending to borrowers with weak credit profiles (Soederberg, 2013). Yet, technological advances over recent decades have provided financial institutions with the tools to explore and penetrate markets that were previously inaccessible. By combining modern financial technologies with enhanced information and communication systems and leveraging economies of scale, banks are now capable of delivering services to a wider customer base more efficiently, reducing operational costs and risk exposure while relying less on wholesale funding (Ahamed & Mallick, 2019).

The question of whether financial inclusion materially contributes to the stability of banking systems has become increasingly relevant. Scholars offer divergent theoretical explanations regarding this relationship. One perspective asserts that providing broader access to banking services can strengthen institutional durability by expanding both the diversity of clientele and channels of revenue. Such diversification diminishes reliance on volatile deposit flows and promotes the availability of stable long-term financing. This approach encourages lending to small and medium-sized enterprises as well as individuals from a range of socioeconomic groups, reflecting essential banking practices. By adopting these measures, financial institutions can reinforce public confidence and reduce risks associated with excessive concentration (Hannig & Jansen, 2010; Prasad, 2010; Khan, 2011; Cull et al., 2012; Han & Melecky, 2017).

A second theoretical perspective argues that the effects of financial inclusion on banking stability are not inherently advantageous or adverse, as they depend on institutional practices, regulatory frameworks, credit allocation, and the management of information asymmetries (Khan, 2011; Cull et al., 2012; Mehrotra & Yetman, 2015; Allen et al., 2016). Studies highlight that banks holding significant liquidity reserves and occupying dominant market positions may engage in more aggressive lending strategies, which can enhance returns but simultaneously raise the likelihood of default and institutional vulnerability (Khan, 2011; Cihak et al., 2016; Cihak et al., 2021). As financial inclusion expands, credit becomes more accessible, allowing borrowers to take on amounts exceeding immediate financial needs (Demirgüc-Kunt et al., 2008). When multiple lenders offer overlapping loans to the same client, the risk of overextension escalates. While increased access to personal and business credit supports financial participation (Morgan & Pontines, 2014), it can also initiate cycles of unsustainable lending, ultimately jeopardizing the stability of the financial system (José & Garcia, 2016).

Empirical investigations on the relationship between financial inclusion and financial stability illustrate a multifaceted and equivocal landscape. Several studies using the generalized method of moments (GMM), pooled OLS, and fixed or random effects estimations report a positive impact of financial inclusion on financial stability (Banna & Alam, 2021; Wang & Luo, 2022; Nguyen & Du, 2022; Jungo et al., 2022; Song et al., 2024; Srivastava et al., 2025). Using the same empirical approaches, other studies identify a negative relationship (Barik & Pradhan, 2021; Feghali et al., 2021; Foguesatto et al., 2024), attributing this effect to poor risk assessment and the underestimation of default probability when extending credit. In response to these mixed outcomes, some research has shifted toward nonlinear estimation techniques, such as the dynamic panel threshold (DPTR) and panel smooth transition regression (PSTR) models. For instance, Sebai et al. (2024c), Kebede et al. (2024), Sebai et al. (2025), and Talbi & Sebai (2025b) report an inverted U-shaped relationship, suggesting that at low levels of financial inclusion, expanding access to banking services

enhances financial stability by diversifying risk and improving liquidity. However, beyond a certain threshold, excessive credit provision can lead to over-indebtedness, increased default risk, and ultimately a decline in financial stability.

Conversely, Sebai & Talbi (2024b), Anton & Nucu (2024), and Talbi & Sebai (2025a) observe a U-shaped relationship. This pattern indicates that limited financial inclusion may initially destabilize the banking system due to the costs associated with initial expansion and the efforts required to strengthen risk management. Nonetheless, as financial inclusion expands further, it tends to enhance financial stability by promoting formal savings, improving risk-sharing, and reinforcing capital buffers. Other investigations argue that the heterogeneity of these findings is influenced by differences in banking structure (Antwi et al., 2024; Obiedallah & Abdelaziz, 2024), as well as by diverse economic (Frączek, 2019; Oanh et al., 2023), institutional (Ha & Nguyen, 2023; Ofoeda et al., 2024; Setianto et al., 2025), and regional contexts (Chen et al., 2018). The observed effects are also shaped by the nature of the financial inclusion measures employed. For instance, Pham & Doan (2020) report that formal account ownership and savings positively affect banking stability, whereas credit provision and electronic payment usage exhibit nonlinear effects. Similarly, Kumar et al. (2021) find that financial inclusion enhances bank profitability, with branch density exerting a significant influence, while the number of loan accounts and ATMs does not show a statistically significant effect. Correspondingly, Khatib et al. (2022) observe that the expansion of ATMs and branch networks contributes positively to bank profitability, whereas other indicators (such as point-of-sale terminals, total account numbers, and SME lending) do not demonstrate a measurable impact.

In light of the discussion above, the influence of banking inclusion on the stability of the banking system remains uncertain and debated. While increasing access to financial services can strengthen resource allocation, secure sustainable funding, and improve mechanisms for sharing risk, uncontrolled or excessive expansion may lead to inefficient lending practices that threaten system stability. This pattern points to the existence of a pivotal threshold in financial inclusion, after which further growth could undermine the resilience of banks (Khan, 2011; José & Garcia, 2016). Against this backdrop, the present research examines how banking inclusion interacts with bank stability in Tunisia, aiming to provide three distinct contributions to the scholarly discourse. Accordingly, this paper makes three significant contributions to the existing literature.

First, to the best of our knowledge, existing studies have predominantly examined diverse samples of countries and regions, encompassing both developed and developing economies. However, such cross-country analyses often face a major limitation: the heterogeneity of economic structures, regulatory frameworks, financial development strategies, and institutional contexts across nations may bias the estimated threshold levels of financial inclusion. Since these countries operate under distinct macroeconomic environments and financial regulations, the resulting thresholds may not accurately capture the dynamics specific to any one economy. For this reason, assessing threshold effects within a single-country framework provides a more coherent and meaningful estimation. Focusing on one country allows for the analysis of banks operating under the same monetary authority, regulatory environment, and institutional conditions. This ensures that the identified threshold reflects a consistent financial and economic reality shared across domestic banks. In the case of Tunisia, this approach is particularly relevant. The Tunisian banking sector faces several structural challenges, including persistent nonperforming loans, a high concentration of public banks, evolving regulatory reforms, and the need to enhance risk management practices. Moreover, the sector operates in a context marked by economic volatility, fiscal constraints, and socio-political transitions that affect banking performance and financial stability. Investigating the impact of banking inclusion in Tunisia is therefore crucial, as it provides context-specific insights that can guide financial regulators and policymakers in formulating effective strategies to promote a more resilient and inclusive banking system.

Second, this study focuses on the Tunisian financial sector over the period 2006–2022, a timeframe characterized by profound structural and institutional transformations. This period captures several major events that have significantly shaped the banking landscape, including the democratic transition in 2011, the implementation of the 2015 banking law, and the economic disruptions caused by the COVID-19 pandemic. It also coincides with a series of monetary and financial reforms led by the Central Bank of Tunisia, particularly through adjustments in the policy rate aimed at stabilizing liquidity conditions, containing inflationary pressures, and safeguarding banking soundness. Moreover, these years witnessed the gradual expansion

of banking services, the introduction of innovative financial products, and strengthened efforts to promote financial inclusion as a pillar of economic resilience. Examining this specific period therefore provides an appropriate framework to assess how changes in financial inclusion interact with monetary policy dynamics and the evolving regulatory and economic environment in Tunisia.

Third, to overcome multicollinearity, which often arises in empirical studies using polynomial terms to examine nonlinear effects, this study employs the panel smooth transition regression (PSTR) approach. Unlike other threshold-based methods, PSTR does not require the number of regimes or the threshold to be predetermined. These parameters are instead identified through formal statistical tests. The model estimates threshold values and determines whether transitions between regimes occur gradually or abruptly. This feature allows the method to capture smooth adjustments between regimes, rather than imposing sudden shifts as observed in conventional threshold models. This approach facilitates an in-depth assessment of the dynamic interactions inherent in the relationship under investigation.

The structure of this paper is as follows. The second section presents a detailed description of the variables and their data sources. The third section explains the panel smooth transition regression methodology. The fourth section discusses the main empirical findings. The fifth section concludes the study and provides policy recommendations based on the results.

Data Set and Variables Measurements

Data

Focusing on a sample of nine commercial banks over the period 2006–2022, this study utilizes a dataset integrating both financial and macroeconomic information from authoritative sources, including the World Development Indicators (WDI), the International Monetary Fund (IMF), and Datastream. The dataset enables a comprehensive analysis of the relationship between banking inclusion and banking stability in Tunisia, capturing both bank-level performance and broader trends in financial inclusion throughout the study period. The banks included in the sample represent the institutions most actively involved in promoting banking inclusion in Tunisia. They serve a large and diversified customer base and play a central role in expanding access to banking services. Institutions with limited involvement in financial inclusion initiatives were excluded, as their contribution to broadening banking access remains marginal. The selection of banks is detailed in Table 1.

Table 1
List of banks in Tunisia

Tunisian banks	International bank, Amen Bank, Attijari Bank, BH Bank, Arab Tunisian bank, Tunisian Bank, National Agricultural Bank, Banking Union, International Union Bank.

Source: Authors' compilation from the Datastream source.

Variable Measurements

Independent Variable: Banking inclusion

Banking inclusion is assessed through multiple facets, typically categorized into banking access and banking utilization (Amidžić et al., 2014). Constructing a single, comprehensive index is challenging due to strong interconnections between these facets and the absence of a standardized measurement. In this study, a composite index is generated by applying principal component analysis (PCA), following the approach developed by Talbi & Sebai (2025b). The index integrates six sub-components, each representing distinct dimensions of banking inclusion. Measures of accessibility include both spatial and population-based indicators: the number of commercial bank branches and ATMs per 1,000 km² (BB_Km², ATM_Km²) and per 100,000 adult residents (BB_POP, ATM_POP). The extent of banking usage is captured using the share of outstanding loans (OLC) and deposits (ODC) relative to GDP. To allow comparability, the index is normalized between 0 and 1, where 0 corresponds to minimal inclusion and 1 to maximal inclusion. The outcomes of the PCA are summarized in Table 2.

Table 2.
Principal Component Analysis of Banking Inclusion Index in Tunisia (Bank_Inclusion)

	PC_1	PC_2	PC_3	PC_4	PC_5	PC_6
Eigen values	5.8250	0.1106	0.0604	0.0031	0.0009	0.0000
Percentage of variance	0.9708	0.0184	0.0101	0.0005	0.0002	0.0000
Cumulative percentage	0.9708	0.9893	0.9993	0.9998	1.0000	1.0000
Variables	**Comp_1**	**Comp_2**	**Comp_3**	**Comp_4**	**Comp_5**	**Comp_6**
OLC	0.4040	0.0195	0.9008	-0.0993	-0.1226	-0.0011
ODC	0.3962	0.8714	-0.1552	0.1963	0.1449	0.0090
BB_Km²	0.4120	-0.2831	0.5532	-0.3102	-0.3102	-0.5675
BB_POP	0.4110	-0.3732	0.3097	0.6099	0.6099	0.4696
ATM_Km²	0.4130	-0.0838	-0.2547	-0.6304	-0.6304	0.5217
ATM_POP	0.4131	-0.1174	-0.2173	-0.6962	0.3138	-0.4303

Source: Authors

Dependent Variables, Control Variables, and Descriptive Statistics

In assessing banking stability, this paper draws on various measures from the studies of Adusei (2015), Kumar (2016), and Sang (2021). These measures include the Z-score calculated for Return on Equity (ROE) using both total assets and total liabilities, the liquidity ratio (Liquidity_ratio), and the Risk-adjusted Return on Equity (RAROE). Additionally, a set of control variables is integrated, including the Return-on-Assets ratio (ROA) (Feghali et al., 2021), Loan-to-Deposit ratio (LDR) (Bod'a & Zimkovà, 2021), Deposits-to-Assets ratio (DEPOSIT) (Mwangi et al., 2015), and the real exchange rate (REER) (Afshan et al., 2024). Table 3 presents the definitions and data sources for the variables of interest.

Table 3
Definitions and sources of variables

Variables	Definition	Sources
Z_score_1	The Z-score index within the banking system functions as an inverse indicator of a bank's failure probability, where a higher value suggests a lower likelihood of insolvency. $$Z\_score(1)_{it} = \frac{ROE_{it} + CAR_{it}}{\sigma(ROE)_{it}}$$ Where ROE_{it} : represents the return on equities, CAR_{it}: signifies the equity-to-assets ratio, $\sigma(ROE)_{it}$: denotes the standard deviation of the return-on-equities over a span of three successive years.	Authors' calculation, Datastream
Z_score_2	$$Z\_score(2)_{it} = \frac{ROE_{it} + LEV_{it}}{\sigma(ROE)_{it}}$$ Where ROE_{it} : represents the return on equities, LEV_{it}: measured as the equity-to-total liabilities ratio, $\sigma(ROE)_{it}$: denotes the standard deviation of the return-on-equities over a span of three successive years.	Authors' calculation, Datastream
RAROE	Risk-adjusted Return on Equity (RAROE) is defined as the ratio of Return on Equity (ROE) to its standard deviation, calculated over a consecutive three-year period.	Authors' calculation, Datastream
Liquidity_ratio	The ratio of total loans to total assets.	Datastream
BB_Km²	Number of commercial bank branches per 1000 Km².	IMF
BB_POP	Number of commercial bank branches per 100.000 adults.	IMF
ATM_Km²	Number of ATMs per 1000 Km².	IMF
ATM_POP	Number of ATMs per 100.000 adults.	IMF
OLC	Outstanding Credits to private sector as a % of GDP.	IMF

Continuation of Table 3
Definitions and sources of variables

Variables	Definition	Sources
ODC	Outstanding Deposit in private sector as a % of GDP.	IMF
ROA	A measure of banking performance, calculated as Return on assets ratio.	Datastream
LDR	The ratio of total loans to total deposits.	Datastream
DEPOSIT	The ratio of total deposits to total assets.	Datastream
REER	Real effective exchange rate index.	WDI

Note: WDI refers to the World Bank's World Development Indicators database (World Bank, 2024). IMF denotes the International Monetary Fund (IMF, 2024). Datastream refers to Datastream-Financial Data (Reditiv, 2024).
Source: Authors' compilation

The descriptive statistics are presented in Table 4 and provide important insights into the Tunisian banking sector over the period under study. The four indicators of banking stability (Z_score_1, Z_score_2, liquidity ratio, and RAROE) display considerable variability, reflecting the heterogeneous risk profiles and financial health of banks in the sample. For instance, the Z-scores, which measure banks' buffer against insolvency, range widely from slightly negative to 346.525, suggesting that while some banks operate with strong stability, others are closer to potential distress. The liquidity ratio averages 0.807, indicating that, on average, banks maintain a relatively healthy proportion of liquid assets to meet short-term obligations, although variation across banks points to differing liquidity management practices.

The banking inclusion index, constructed using principal component analysis (PCA) and normalized between 0 and 1, has a mean value of 0.578. This suggests a moderate level of inclusion relative to the maximum potential captured by the index, indicating that access to banking services has improved but still offers substantial potential for further expansion to enhance financial intermediation. Among the control variables, Return on Assets (ROA) averages 1.290, indicating generally positive profitability across banks, while the Loan-to-Deposit ratio (1.172) implies that banks extend slightly more loans than deposits collected, signaling moderate credit expansion. The Deposit-to-Asset ratio (0.706) and real effective exchange rate (0.935) reflect a stable asset structure and relatively stable currency conditions during the period.

Table 4
Descriptive statistics

Variables	Obs	Mean	St. dev.	Min	Max	Q1	Q3
Z_score_1	143	16.109	32.834	-1.406	341.293	5.051	15.148
Z_score_2	143	17.198	34.223	-1.399	346.525	5.306	16.112
Liquidity_ratio	143	0.807	0.132	0.086	1.113	0.729	0.892
RAROE	142	9.619	23.996	-1.530	270.998	2.791	9.873
Bank_Inclusion	153	0.578	0.312	0	1	0.366	0.845
ROA	113	1.290	0.991	-5.23	3.08	0.98	1.78
LDR	143	1.172	0.223	0.119	1.635	1.046	1.328
DEPOSIT	153	0.706	0.098	0.465	0.955	0.626	0.778
REER	153	0.935	0.088	0.784	1.083	0.858	1

Source: Authors

Methodology: Panel Smooth Transition Regression

This research utilizes the panel smooth transition regression (PSTR) approach, following González et al. (2005), to explore the nonlinear influence of banking inclusion on banking stability in Tunisia. Standard linear models that overlook nonlinear patterns may yield underestimated effects. Introducing quadratic terms can also generate multicollinearity, potentially biasing the results (Sebai & Talbi, 2024c). Other approaches that account for nonlinearity, such as semiparametric panel techniques, can identify nonlinear structures while avoiding multicollinearity problems. However, these methods do not determine the precise threshold levels at which structural changes occur. The panel threshold regression (PTR) method also detects nonlinearities but assumes that regime shifts occur abruptly. This assumption may not hold in situations involving banking instability or potential bank failures. In contrast, the PSTR

framework captures complex nonlinear interactions and identifies the threshold points where the influence of banking inclusion on stability changes direction. It also models the transition between regimes as a smooth and gradual process, providing a deeper understanding of the dynamic adjustments within the banking system. Furthermore, the PSTR specification is flexible and can be extended to capture more than two regimes, thereby allowing for richer regime dynamics. The formal specification of the PSTR model is presented below:

$$Y_{it} = \omega_i + \alpha_0' X_{it} + \alpha_1' X_{it} g(q_{it}; \gamma, c) + \varepsilon_{it} \quad (1)$$

Where Y_{it} denotes banking stability for bank i at time t, measured by four indicators: Z-score_1, Z-score_2, RAROE, and Liquidity_ratio. X_{it} represents the explanatory variables, including the main variable of banking inclusion and several control variables. All variables are reported in Table 3.

The function $g(q_{it}; \gamma, c)$ governs the transition between regimes and is constrained to take values within the range of 0 to 1. The threshold variable q_{it} corresponds to the level of banking inclusion that triggers changes in the relationship. The parameter γ determines the speed at which the transition occurs, while c identifies the threshold point itself. Unobserved heterogeneity across banks is captured by ω_i ; ε_{it} represents the model's stochastic error term. For a detailed explanation of the model structure, see González et al. (2005).

Empirical Results

Panel Unit Root Test Results

A critical step in obtaining robust estimations is to verify that the variables under study exhibit stationarity. Establishing stationarity is important because it ensures that any detected relationships among the variables correspond to authentic economic patterns rather than being driven by random noise, thereby supporting the validity and consistency of results in panel econometric models. In line with this, the results presented in Table 5 confirm that all variables included in the analysis are stationary, rendering the dataset suitable for model estimation. Specifically, for variables that are non-stationary at levels, the tests indicate that they achieve stationarity after first-differencing. To this end, three panel unit root tests were applied, namely the Augmented Dickey-Fuller (ADF) test, the Phillips-Perron (PP) test, and the Im, Pesaran, and Shin (IPS) test (2003).

Table 5
Unit root tests

	Level			First difference		
	ADF	**PP**	**IPS**	**ADF**	**PP**	**IPS**
Z_score_1	-1.672**	-2.851***	-1.458			-4.332***
Z_score_2	-1.710**	-2.868***	-1.490			-4.322***
RAROE	-1.460	-2.984***	-1.296	-5.544***		-4.728***
Liquidity_ratio	-1.123	-2.238**	-1.042	-5.312***		-4.419***
Bank_Inclusion	-1.848**	-3.427***	-1.621			-4.450***
ROA	-3.348***	-3.842***	-2.701***			
LDR	-0.642	-1.040	-0.631	-5.751***	-9.110***	-4.747***
DEPOSIT	-0.963	0.502	-0.836	-3.850***	-8.573***	-3.226***
REER	0.608	0.123	0.317	-5.598***	-4.273***	-4.633***

Note: This table displays the results of panel unit root tests conducted on all variables from 2006 to 2022 in Tunisia, using a maximum lag of one. Significance levels are denoted by (***) for 1% and (**) for 5%.
Source: Authors

Panel Smooth Transition Results

To model gradual rather than abrupt shifts between regimes, this study adopts the panel smooth transition regression (PSTR) framework. The PSTR model differs from the panel transition regression (PTR) of Hansen (1999), which assumes sudden regime changes. In contrast, the PSTR approach allows transitions to evolve smoothly. This feature makes it suitable for examining nonlinear patterns and identifying threshold effects.

The model considers a continuum of intermediate regimes bounded by two extreme states. It employs two transition functions: the logistic function (m = 1), which captures a smooth transition, and the exponential function (m = 2), which represents two distinct transitions. These functions provide insights into how the system adjusts gradually or abruptly between regimes.

The estimation process follows three sequential stages: model specification, parameter estimation, and model

evaluation (Talbi & Sebai, 2025b). Estimating threshold parameters helps assess how banking stability responds to variations in banking inclusion. Further methodological details can be found in González et al. (2005).

Evaluation of Linearity and Regime Assumptions

The estimation of the PSTR model begins with verifying whether the relationship between banking inclusion and banking stability exhibits nonlinear characteristics. This assessment is conducted through linearity tests, which identify whether regime-switching effects are statistically significant. When linearity is rejected, it signals the presence of nonlinear dynamics and the need to determine the number of regime transitions to include in the model. Following the recommendations of Talbi & Sebai (2025b), two types of transition functions are evaluated, logistic (m = 1) and exponential (m = 2), to select the most appropriate specification. The first criterion is the p-value obtained from linearity tests, with lower values indicating stronger evidence of a particular function. The second criterion relies on information-theoretic measures, specifically the Akaike Information Criterion (AIC) and Bayesian Information Criterion (BIC), to identify the model that best fits the data.

The results summarized in Table 6 indicate that nonlinearity is statistically validated with m = 1, as the p-values of all linearity tests fall below the 5% significance threshold. This provides robust evidence supporting the existence of a nonlinear relationship between banking inclusion and banking stability.

Table 6

Comparison of Linearity and Non-Linearity Tests

		LMW	LMF
	Z_score_1		
$\mathbf{H_0}$ **compared to** $\mathbf{H_1}$	m=1	14.140** (0.015)	2.832** (0.020)
$\mathbf{H_0}$ **compared to** $\mathbf{H_1}$	m=2	21.453** (0.018)	2.208** (0.025)
	Z_score_2		
$\mathbf{H_0}$ **compared to** $\mathbf{H_1}$	m=1	12.945** (0.024)	2.559** (0.033)
$\mathbf{H_0}$ **compared to** $\mathbf{H_1}$	m=2	20.502** (0.025)	2.087** (0.034)
	RAROE		
$\mathbf{H_0}$ **compared to** $\mathbf{H_1}$	m=1	16.567*** (0.005)	3.409*** (0.007)
$\mathbf{H_0}$ **compared to** $\mathbf{H_1}$	m=2	21.053** (0.021)	2.157** (0.028)
	Liquidity_ratio		
$\mathbf{H_0}$ **compared to** $\mathbf{H_1}$	m=1	28.530*** (0.000)	6.688*** (0.000)
$\mathbf{H_0}$ **compared to** $\mathbf{H_1}$	m=2	32.278*** (0.000)	3.759*** (0.000)

Note: The analysis is based on the LMW (Wald) and LMF (Fisher) statistical tests. The logistic transition function is represented by m = 1, while m = 2 corresponds to the exponential transition function. The hypotheses are formulated as follows: the null hypothesis ($\mathbf{H_0}$) assumes a linear relationship, whereas the alternative hypothesis ($\mathbf{H_1}$) specifies a PSTR model with at least one threshold variable.

Source: Authors

Next, Table 7 presents the detailed estimation results, showing that both the Akaike Information Criterion (AIC) and the Bayesian Information Criterion (BIC) select the logistic function as the most appropriate specification, as their values are lowest when m = 1. The results thus indicate that regime transitions occur gradually, with changes in banking inclusion producing smooth adjustments in banking stability and reflecting the adaptive behavior of the banking system.

Table 7
Model Comparison (m=1 and m=2) with BIC, AIC, and RSS

RSS	AIC	BIC	RSS	AIC	BIC
Z_score_1 (m=1)			Z_score_1 (m=2)		
18328.762	5.031	5.269	25434.311	5.379	5.637
Z_score_2 (m=1)			Z_score_2 (m=2)		
22579.199	5.240	5.478	31371.659	5.589	5.847
RAROE (m=1)			RAROE (m=2)		
5181.992	3.768	4.006	6486.401	4.013	4.270
Liquidity_ratio (m=1)			Liquidity_ratio (m=2)		
0.010	-9.368	-9.130	0.011	-9.310	-9.052

Source: Authors

The analysis in Table 8 examines whether the relationship between banking inclusion and banking stability exhibits multiple regimes. Specifically, the PSTR model is tested under the assumption of a single threshold (null hypothesis) against the possibility of two or more thresholds (alternative hypothesis). The test results, with p-values exceeding 5%, do not provide sufficient evidence to support multiple thresholds. This outcome implies that the nonlinear effects of banking inclusion on all indicators of banking stability can be effectively captured using only one threshold.

Table 8
Tests for the Number of Regimes

	Wald Test	Fisher Test
	Z_score_1 (m=1, r=1)	
Statistics	2.880	0.457
p-value	0.718	0.807
	Z_score_2 (m=1, r=1)	
Statistics	2.448	0.387
p-value	0.784	0.857
	RAROE (m=1, r=1)	
Statistics	4.491	0.724
p-value	0.481	0.607
	Liquidity_ratio (m=1, r=1)	
Statistics	2.042	0.328
p-value	0.843	0.895

Note: H_0 assumes a single-threshold specification in the PSTR model (r = 1), whereas H_1 allows for multiple thresholds (r ⩾ 2).
Source: Authors

Findings on Banking Inclusion and Stability: Evidence from the PSTR Model

Drawing on the results of the preceding tests, Table 9 presents the main estimation, indicating a nonlinear relationship between banking inclusion and banking stability. Specifically, banking inclusion contributes to greater banking stability up to a certain point. Beyond which banking inclusion leads to banking instability. These findings remain robust across various indicators of banking stability, including Z_score_1, Z_score_2, RAROE, and Liquidity_ratio, with identified threshold points of 0.947, 0.944, 0.958, and 0.538, respectively. Notably, the transition between regimes occurs gradually. The results support an inverted U-shaped relationship between banking sector inclusion and banking stability (Antwi et al., 2024; Sebai and Talbi, 2024c; Sebai et al., 2024b).

Our empirical findings indicate that, at moderate levels, expanded access to banking services enhances financial stability, as reflected in higher Z-scores, by broadening the depositor base, improving risk diversification, and promoting more formalized lending practices. Banking inclusion also supports higher risk-adjusted returns (RAROE) by creating broader investment opportunities and initially increasing liquidity through higher deposits and lending activity. However, beyond a critical threshold, further growth appears to destabilize the banking system. This outcome can be attributed to the rapid extension of credit to low- and middle-income

households, as well as the provision of formal loans to workers in the informal sector, whose irregular income and limited repayment capacity elevate default risk. The concentrated nature of the Tunisian banking sector exacerbates these vulnerabilities, as substantial exposures in a few institutions can propagate systemic shocks. Regional disparities further influence these dynamics: in rural and underserved areas, moderate inclusion continues to support stability, whereas in urban and well-banked regions, excessive credit growth increases instability. Moreover, high loan demand associated with extensive inclusion may reduce liquidity relative to total assets, thereby constraining banks' capacity to absorb potential shocks.

Overall, these results indicate that the economic impact of banking inclusion in Tunisia is highly context-dependent. While moderate levels of inclusion strengthen stability, profitability, and liquidity, over-expansion generates rising credit risk, potential defaults, and systemic fragility, reflecting the complex interplay between borrower income levels, informality, bank concentration, and regional characteristics.

Table 9

Effects of banking inclusion (Bank_Inclusion) on banking stability: A panel smooth transition regression analysis

	Z_score_1 (m=1, r=1)		Z_score_2 (m=1, r=1)		RAROE (m=1, r=1)		Liquidity ratio (m=1, r=1)	
Variables	**Regime (1)**	**Regime (2)**	**Regime (1)**	**Regime (2)**	**Regime (1)**	**Regime (2)**	**Regime (1)**	**Regime (2)**
Bank_Inclusion	0.041*** (3.442)	-2.208*** (2.501)	0.042*** (3.255)	-2.296** (2.427)	0.027*** (4.025)	-1.203*** (2.600)	0.064*** (3.836)	-0.092*** (5.781)
ROA	0.002* (1.924)	0.058*** (2.719)	0.002* (1.862)	0.062*** (2.708)	0.002*** (2.585)	0.027** (2.340)	0.002** (2.110)	0.007** (2.189)
LDR	0.024*** (2.755)	-0.013 (0.237)	0.023*** (2.561)	-0.009 (0.159)	0.013*** (2.951)	-0.026 (0.778)	0.658*** (31.40)	0.058*** (2.793)
DEPOSIT	0.054 (1.450)	-0.137 (1.256)	0.051 (1.246)	-0.134 (1.174)	0.029 (1.472)	-0.094* (1.503)	1.341*** (37.560)	0.087** (2.281)
REER	0.160*** (3.685)	2.633*** (2.772)	0.162*** (3.560)	2.722*** (2.682)	0.110*** (4.281)	1.483*** (2.923)	0.077 (1.470)	-0.100** (2.359)
Location parameter	0.947		0.944		0.958		0.538	
Slope parameter	29.053		31.295		23.293		226.569	

Note. Significance levels are indicated by ***, **, and * to denote statistical significance at the 1%, 5%, and 10% levels, respectively. t-statistics are reported in parentheses.

Source: Authors

Conclusions

Using a sample of nine banks in Tunisia, this paper investigates the relationship between banking inclusion and banking stability from 2006 to 2022. To this end, it employs the empirical methodology of panel smooth transition regression (PSTR). This approach discerns potential nonlinearities and threshold effects inherent in the data, thereby enabling the determination of the speed of transition between regimes. Our empirical findings suggest an inverted U-shaped relationship between banking inclusion and banking stability. This indicates that banking inclusion enhances financial stability up to a certain point. Beyond this point, increased banking inclusion may lead to financial instability. This adverse effect can be attributed to risky financial practices and the negative externalities associated with excessive credit, which may trigger a vicious cycle of continuous decline, ultimately resulting in financial system instability.

Limitations and Future Research

Although this study offers valuable insights into the literature, it also has certain limitations. First, the analysis focuses exclusively on the Tunisian banking system. This focus allows for a precise identification of the threshold level of banking inclusion within a specific institutional and financial environment. However, by restricting the study to a single country, the sample size is relatively small, limiting the number of observations available for empirical analysis. This limited sample may affect the precision of the PSTR estimates, and the threshold values obtained should therefore be interpreted with caution. It is therefore important for future research to extend this analysis to other countries

that share similar regulatory and economic characteristics, in order to assess whether the observed effects hold in comparable institutional contexts.

In addition to sample size limitations, the study faces constraints related to data availability. While banking inclusion is emphasized, data disclosure and accessibility from Tunisian banks remain limited. In particular, detailed information on credit allocation across income segments is largely unavailable, restricting the ability to identify which borrower brackets contribute most to financial instability. Improved access to such data would enable policymakers and researchers to conduct more precise analyses, tailor regulatory interventions, and implement evidence-based measures to mitigate systemic risk. Beyond conventional banking, the postal system plays a critical role in promoting financial inclusion by providing essential services to marginalized populations in areas with limited banking access. Therefore, future research should incorporate both disaggregated banking data and postal inclusion to better understand how different income segments influence overall financial stability in Tunisia.

Another limitation concerns the potential bidirectional relationship between banking inclusion and stability. This study focuses exclusively on the threshold effect of banking inclusion and does not consider the reverse influence, where stable and well-functioning banking systems may facilitate the expansion of inclusion. Future studies could explore this potential simultaneity by employing alternative econometric approaches, which may provide additional insights into the dynamic interaction between financial inclusion and banking stability.

Finally, the findings are specific to Tunisia and cannot be directly generalized to other African or developing countries, which differ in institutional, regulatory, and economic contexts. Observed effects may vary in other settings, highlighting the need for further research on additional samples to validate and extend these results. Taken together, these limitations suggest that the conclusions should be interpreted cautiously, while providing a foundation for future studies to explore similar questions in broader and more diverse contexts.

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Ali večja vključenost v bančni sistem krepi ali ogroža stabilnost bančnega sistema v Tuniziji? Ugotovitve nelinearne analize

Izvleček

V tem članku uporabljamo panelni regresijski pristop z gladkim prehodom za preučitev razmerja med vključenostjo v bančni sistem in stabilnostjo bančnega sistema v Tuniziji v obdobju 2006–2022. Ob upoštevanju različnih razsežnosti stabilnosti bančnega sistema naši izsledki kažejo na razmerje v obliki obrnjene črke U med vključenostjo v bančni sistem in stabilnostjo. To kaže, da je vključenost v bančni sistem ključna za krepitev stabilnosti bančnega sistema do določene meje. Vendar pa višja raven vključenosti v bančni sistem po doseganju te meje vodi k nestabilnosti bančnega sistema. To je v prvi vrsti posledica večje izpostavljenosti finančno manj izkušenim strankam. Poleg tega lahko hitra kreditna ekspanzija obremeni notranje sisteme za obvladovanje tveganj v bankah, celo ob močnem regulativnem nadzoru v Tuniziji. Ta prehod med režimi poteka postopoma. Naša raziskava ponuja bistvene smernice za tunizijske finančne regulatorje pri oblikovanju strategij za uravnoteženje bančne vključenosti in bančne stabilnosti.

Ključne besede: Bančna vključenost, bančna stabilnost, razmerje v obliki obrnjene črke U, Tunizija, panelna regresija z gladkim prehodom