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BANK FINANCIAL STABILITY IN SAUDI ARABIA: THE ROLE OF DIGITAL TRANSFORMATION AND PRUDENTIAL FACTORS

Naouel Lachouri
Chadli Bendjedid University–Algeria, Faculty of Economic, Commercial and Management Sciences, Eltarf, Algeria
https://orcid.org/0009-0003-0949-5396

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ABSTRACT

This study aimed to analyze the role of digital transformation and prudential factors in explaining the financial stability of Saudi banks during the period 2017–2024. The study employed dynamic panel data for seven banks listed on the Saudi stock market, using the System Generalized Method of Moments (System GMM) estimator, which accounts for the dynamic nature of financial stability and addresses endogeneity and reverse causality. Financial stability was measured using the Z-score indicator, while the prudential factors included capital adequacy, liquidity, and profitability, in addition to real GDP of non-oil activities and a digital transformation variable. The diagnostic tests confirmed the validity of the model and the appropriateness of the instruments used. The results showed that the lagged dependent variable was the only factor that achieved statistical significance, reflecting a high degree of dynamic persistence in the financial stability of Saudi banks. In contrast, the findings did not provide sufficient statistical evidence of a direct effect of prudential factors or digital transformation during the study period, despite the direction of these variables being consistent with theoretical expectations. The study recommends encouraging Saudi banks to disclose more detailed quantitative indicators to measure the level of digital transformation, thereby enabling the development of more accurate measures and supporting future research on the impact of digitalization on financial stability.

Address of the corresponding author:
Naouel Lachouri
lachouri-nawel@univ-eltarf.dz

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1 INTRODUCTION

The global financial system is witnessing rapid structural transformations driven by the wave of technological innovation and financial digitalization (Fintech), which has reshaped the operational environment of banking institutions. In this context, the concept of financial stability has received increasing attention from academics and policymakers, as it is the fundamental pillar for ensuring the efficiency and soundness of financial intermediation and protecting the macroeconomy from systemic shocks.

Financial stability is no longer limited to traditional prudential indicators such as capital adequacy, liquidity, and profitability; rather, it has become directly affected by the extent to which banks are able to absorb and localize digital transformation tools.

The Kingdom of Saudi Arabia is considered a leading model in this transformation, as the Saudi Central Bank (SAMA) adopts ambitious strategies to develop the financial sector as one of the key objectives of Saudi Vision 2030. These efforts have led to the extensive digitalization of services, instant payments, and open banking. However, this digital acceleration imposes a double-edged dilemma. Although it contributes to reducing operating costs and improving credit management in the long term, it also entails emerging cyber risks and massive capital investment costs in digital infrastructure in the short term, which may put pressure on banks' protective buffers. Accordingly, this study seeks to examine the determinants of financial stability in Saudi banks, allocating an in-depth analytical space to measure the real impact of digital transformation in light of the dynamic behavior of the banking system during the period 2017–2024.

The research problem is centered on the following main research question:

RQ: What is the impact of digital transformation, banking determinants, and macroeconomic determinants in explaining the levels of financial stability of Saudi banks during the period 2017–2024?

The following sub-questions stem from this main question:

RSQ1: What is the impact of the historical and cumulative behavior of financial stability (ZSCORE-1) in shaping current financial soundness?

RSQ2: How do prudential banking determinants and the macroeconomic environment affect the financial stability of Saudi banks?

RSQ3: What is the nature of the impact of digital transformation, as a structural determinant, on the financial stability of Saudi banks?

1.1 Research Hypotheses

To answer the research problem and the sub-questions, the following hypotheses were formulated:

H1. There is a positive, direct, and statistically significant effect of the cumulative historical indicator of financial stability on the levels of financial stability of Saudi banks.

H2. Internal banking determinants and macroeconomic indicators affect the levels of financial stability of Saudi banks.

To facilitate empirical testing, **H2** is decomposed into the following sub-hypotheses:

H2a. Prudential and profitability indicators, represented by capital adequacy and return on assets, have a positive effect on the financial stability of Saudi banks.

H2b. Banking liquidity and the real GDP growth rate of non-oil activities have a negative effect on the financial stability of Saudi banks.

H3. Digital transformation is positively associated with the financial stability of Saudi banks, as it is expected to strengthen banks' protective buffers.

1.2 Study Importance

This study derives its scientific and practical importance from the following points:

- Enriching the Arab and foreign literature with a modern applied framework that integrates the concepts of the digital economy and indicators of banking financial soundness using an advanced econometric technique (System GMM) capable of controlling complex econometric problems.

- The practical importance lies in providing a diagnostic tool and clear quantitative evidence for the Saudi Central Bank (SAMA) and the management of commercial banks, helping them evaluate the efficiency and feasibility of capital investments directed toward digital transformation and guide macroprudential policies to ensure that the cost of technological modernization does not put pressure on banks' protective buffers.

1.3 Study Objectives

This study seeks to achieve the following objectives:

- Measuring the degree of durability and continuity of financial stability (Persistence Effect) within the Saudi banking sector as a cumulative process.
- Decomposing and analyzing the individual impact of both internal determinants, which are bank-specific, and external determinants, which are macroeconomic, in order to determine their relative weight in the dynamic model.

1.4 Study Methodology

This study relied on the descriptive analytical method in the theoretical section to review the literature and establish the concepts, while the empirical econometric method was used in the applied section.

The study is based on balanced panel data collected from the annual reports of seven Saudi banks listed on the Saudi financial market (Tadawul) throughout the period from 2017 to 2024. The main econometric tool for estimation is represented by the dynamic panel model using the System Generalized Method of Moments (System GMM), as it is the optimal tool that suits the characteristics of the sample (N > T), provides partial treatment of the problem of endogeneity and autocorrelation, and ensures efficient, consistent, and unbiased estimates.

1.5 Previous Studies

The economic and banking literature on financial stability reflects considerable variation in explaining the determinants of banking stability as measured by the Z-score indicator. Research has ranged from emphasizing internal prudential factors and the effects of efficiency and competitiveness to examining the role of digital transformation and financial technology in strengthening the resilience of the banking sector.

About areas of agreement, empirical studies conducted in both regional and international contexts (Abduallah & Djalila, 2024; Swamy, 2014; Alshubiri, 2016) consistently indicate that asset quality, banking efficiency, and income diversification constitute fundamental pillars that support financial stability and reduce risk. This consensus suggests broad agreement on the importance of structural factors in enhancing bank resilience, although the magnitude of each factor's impact varies across different banking environments.

However, this consensus weakens when examining other prudential determinants, as the literature reveals empirical contradictions regarding the direction and magnitude of the effects of liquidity, capital adequacy, and bank size. While (Swamy, 2014) found a positive interactive relationship between liquidity, capital adequacy, and banking stability, the studies by (Rupeika-Apoga et al., 2020) in Latvia and (Chand et al., 2021) in Fiji reported a significant negative effect of liquidity risk on financial stability. The divergence becomes even more pronounced with respect to bank size and banking concentration. (Chand et al., 2021) and (Alshubiri, 2016) argued that economies of scale and financial concentration may contribute to strengthening banking stability. In contrast, (Rupeika-Apoga et al., 2020) found a negative relationship between bank size and financial stability. Likewise, (Ghassan & Guendouz, 2019) demonstrated that a higher degree of concentration in the Saudi banking sector may weaken financial resilience, although asset diversification partially mitigates this adverse effect. These inconsistencies may be attributed to differences in regulatory and economic environments across countries, as well as variations in the econometric methodologies employed. Many studies have relied on static models such as Ordinary Least Squares (OLS) and Seemingly Unrelated Regression (SUR), whereas others have employed more appropriate dynamic models to address endogeneity and reverse causality.

Regarding technological advancement, recent literature indicates growing interest in

investigating the impact of digital transformation on enhancing financial stability through improvements in operational efficiency and risk management. In this context, the studies by Chen et. al. (2023) and Jia and Liu (2024) concluded that digital transformation reduces banks' risk-taking behavior and lowers credit risk, liquidity risk, and systemic risk by improving operational efficiency and reducing costs. Empirical evidence from emerging and Asian economies (Hu et al., 2025; Uddin & Barai, 2026) also demonstrates a direct positive impact of financial technology and digital transformation on enhancing bank soundness and improving financial stability indicators.

Despite this growing body of research, the findings remain inconclusive regarding the measurement of the impact of digital transformation on financial stability. This inconsistency is partly attributable to differences in the indicators used to measure digital transformation and the econometric methodologies adopted. Consequently, the relationship between digital transformation and financial stability remains an unresolved issue, particularly in emerging economies and banking systems undergoing rapid regulatory reforms.

Based on these considerations, the present study examines the role of prudential factors and digital transformation in explaining the financial stability of Saudi banks during the period 2017–2024. The analysis employs a dynamic panel data model using the System Generalized Method of Moments (System GMM), which captures the dynamic nature of financial stability by incorporating the lagged dependent variable (Z-SCOREit−1) and addresses issues of endogeneity and reverse causality. This approach makes it possible to examine the interaction between prudential factors and digital transformation within the Saudi banking environment while accounting for its regulatory and structural characteristics.

2 THE THEORETICAL ASPECT OF THE STUDY

2.1 A Historical Overview of Financial Stability

According to studies that have addressed financial stability and related issues, interest in questions concerning how to maintain financial stability has become evident, especially in recent decades, attracting the attention of academics and policymakers around the world. The reason for the growing concern about financial stability issues stems from the severe consequences of recent financial crises, including the crisis in East Asia in the late 1990s, the global financial crisis of 2007–2008, and, finally, the financial crisis in the euro area related to sovereign debt (Anatolyevna & Ramilevna, 2013).

Anyone following the global financial crisis of 2007–2008, which severely affected commercial banks in the United States of America, would find that the global financial crisis emerged as a result of what was known as the mortgage crisis. Real estate in the United States represents the largest source of lending and borrowing. The crisis began with subprime mortgages, which had catastrophic repercussions for the global economy in both its real and monetary dimensions, especially for the financial stability of banks. There are four types of banking risks that threaten the financial stability of banks: credit risk, market risk, operational risk, and liquidity risk.

A review of academic history also shows that there are two well-known schools in the financial literature that have addressed the concept of financial stability. Representatives of the first school prefer to discuss the concept of financial instability, whereas representatives of the second school prefer to discuss the concept of financial stability (Odeduntan & Adewale, 2015). The first school argues that financial instability is linked to saving and investment and represents deviations from the saving plan due to inefficiency in the performance of financial management in employing the financial system, or due to the system's instability in facing potential shocks. In contrast, the second school argues that the concept of financial stability refers to the ability of the financial system to achieve stability by avoiding imbalances within the financial system, enabling it to withstand shocks without cumulative effects that would prevent the allocation of savings to investment opportunities and the execution of payment and settlement processes in the economy (Anatolyevna & Ramilevna, 2013).

2.2 Definition of Banking Financial Stability

The subject of banking stability has attracted the attention of many researchers since the beginning of the twentieth century, due to the significant importance of the financial sector in the economy. In addition, any deficiency in the functions of the financial system would lead to paralysis in the economy as a whole. Because it is often difficult to establish a precise definition of banking financial stability, it is usually defined on the basis that it is the opposite state of instability. Based on the foregoing, it can be defined as: "the state in which the shocks affecting the banking sector interact with the spread of information that casts doubt on its ability to perform its assigned role, in a way that leads financial and banking institutions to lose their ability to optimally allocate savings to investment activities (Mishkin, 1999)."

It is also defined as: "the absence of pressures that expose the financial sector in general, and the banking sector in particular, to becoming a channel for transmitting negative effects across the economy, whereby confidence in the continued ability of banking institutions to perform their assigned role without government intervention declines, accompanied by substantial and sudden price volatility in financial and banking markets, which may not reflect the reality of economic fundamentals Bin Saha et al. (2014)."

As for the definitions that clarify banking financial stability, some of them can be mentioned by way of example, but not limitation. Banking financial stability is defined as: "the bank's ability to face any disturbances occurring in its external environment. Therefore, it is able to perform the process of intermediation between units with financial deficits and those with financial surpluses, and to distribute risks in a satisfactory manner (Schinasi, 2004)."

It is also defined as: "a system in which most banks are able to meet their obligations and are likely to remain so, through reliance on several aspects such as the bank's ability to generate profits, management efficiency, and banks' capital adequacy. Achieving the principle of banking soundness requires each unit of the banking system to have a sound financial position, in addition to its ability to perform its intermediation role efficiently (Abbasi & Ouladzawi, 2019)."

2.3 The Importance of Banking Financial Stability

The importance of financial stability becomes most evident in cases of financial instability. For example, banks may refuse to finance profitable projects because asset prices deviate excessively from their true value, or payments may not be settled on time. In extreme cases, financial instability may lead to a bank run, thereby causing inflation and then the collapse of the stock market (Wellink, 2002).

The importance of financial stability is reflected in the global effects produced by the financial crisis on the financial sector and the economy as a whole. It has been confirmed that financial instability negatively affects economic growth, which leads to economic contraction and consequently raises unemployment rates. This is what happened in America and Europe in September 2008. This crisis exposed many banks around the world, especially in Asia and Europe, to losses, which led to the spread of fears among banks regarding lending. Credit provision rates declined in many countries around the world, prompting central banks to inject more funds into financial markets in order to reduce the severity of the crisis. This is in addition to many other negative effects caused by the financial instability of banks in the economies of many developed and developing countries, and at all levels, which were clearly observed after the financial crisis. This highlights the importance of banks' financial stability and the effects resulting from its loss (Suleiman et al., 2012).

3 THE APPLIED ASPECT

3.1 Study Population and Sample

The study population consists of all banks listed on the Saudi Stock Exchange (Tadawul) and supervised by the Saudi Central Bank (SAMA) during the period 2017–2024. The study sample comprises seven banks selected based on the availability of complete and consistent annual financial data for all study variables throughout the analysis period, thereby providing a balanced panel data set. Banks that did not meet this criterion were excluded due to incomplete or inconsistent data during the study period. This selection was intended to ensure sample homogeneity and enhance the reliability of the econometric analysis results.

This sample selection is appropriate for the application of the System Generalized Method of Moments (System GMM) estimator, which provides consistent estimates in dynamic panel data models, particularly in the presence of a short time dimension and the potential for endogeneity among the study variables. The following table presents the list of banks included in the study sample.

Table 1. Banks in the Study Sample

No.	Bank
1	Saudi National Bank
2	Alinma Bank
3	Al Rajhi Bank
4	Bank Albilad
5	Saudi Awwal Bank
6	Bank AlJazira
7	Saudi Investment Bank

Source: Prepared by the author

3.2 Temporal and Spatial Boundaries:

The study period was selected from 2017 to 2024, as this period witnessed the launch of several initiatives related to digital transformation within Saudi Vision 2030, alongside regulatory and technological developments that affected the banking sector. This enables us to assess the implications of these transformations for the financial stability of banks.

As for the reason for selecting Saudi banks as the spatial framework of the study, it is due to the remarkable expansion they have witnessed in adopting digital banking services and modern financial technologies, which makes them an appropriate environment for conducting such studies.

3.3 Study Model

To analyze the determinants of financial stability in Saudi banks in light of digital transformation, a dynamic panel model was adopted, given the dynamic nature of the financial stability indicator and the possibility of its being affected by its previous values. The model was also estimated using the Generalized Method of Moments (GMM) methodology, due to its ability to address endogeneity problems and the bias resulting from including the lagged dependent variable among the explanatory variables.

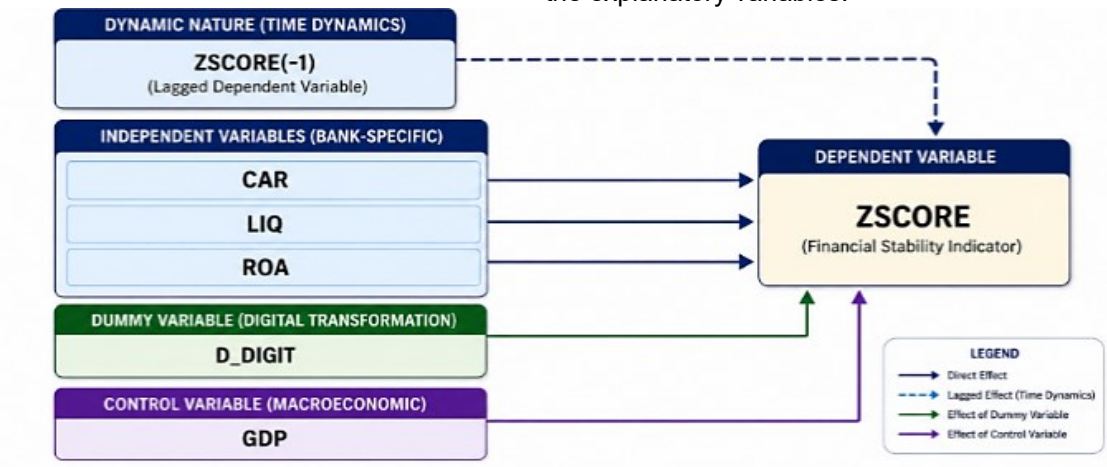

Figure 1. *Study Model*

Source: Prepared by the author

The econometric model can be formulated in the following equation:

$$ZSCOREit = \alpha + \beta1\ ZSCOREit\text{-}1 + \beta2CARit + \beta3LIQit + \beta4ROAit + \beta5GDPit + \beta6D\_DIGITit + \varepsilon it$$

Where:

- **α:** the constant term.
- **ZSCOREit:** the financial stability indicator of bank i during period t.
- **ZSCOREit-1:** the lagged value of the financial stability indicator, included to capture the dynamic effect of financial stability over time.
- **CARit:** the capital adequacy ratio.
- **LIQit:** the liquidity ratio.
- **ROAit:** return on assets.
- **GDPit:** the real GDP growth rate of non-oil activities, as a control macroeconomic variable.
- **D_DIGITit:** a dummy variable expressing the stage of digital transformation in Saudi banks.
- **εit:** the random error term.

Figure 1 illustrates the study model. The study variables, including the independent, dependent, control, and dummy variables, and their methods of measurement can be presented in Table 2.

Table 2. *Study Variables and Their Methods of Measurement*

Type of Variable	Variable	Symbol	Measurement Method
Dependent variable	Financial stability	ZSCORE	(ROA + Equity/Assets) / σ(ROA)
Lagged variable	Lagged financial stability	ZSCOREit-1	The one-period lagged value of the financial stability indicator
Independent variable	Capital adequacy	CAR	(Total regulatory capital / Risk-weighted assets) × 100
Independent variable	Liquidity	LIQ	(Total loans / Total deposits) × 100
Independent variable	Profitability	ROA	(Net profit / Total assets) × 100
Control variable	Real GDP of non-oil activities	GDP	Growth rate of real GDP for non-oil activities
Dummy variable	Digital transformation	D_DIGIT	A binary variable that takes the value (1) for the years 2019–2024, which witnessed the acceleration of digital transformation and the implementation of the Financial Sector Development Program, and the value (0) for the preceding years 2017–2018. This variable captures the shift in the sector's digital policies in the absence of standardized quantitative disclosures by banks regarding their level of digital transformation.

Source: Prepared by the author

3.4 Descriptive Statistics of the Study Variables

The results of the descriptive statistics for the study variables during the period 2017–2024 are presented and analyzed in order to clarify the distributional characteristics and general trends of the financial and banking data. This aims to explore the extent of variation in characteristics among the banks under study and to determine whether the data follow a normal distribution.

Table 3. *Descriptive Statistics of the Study Variables*

Statistic	CAR	D_DIGIT	GDP	LIQ	ROA	ZSCORE
Mean	18.01786	0.600000	2.872000	11.72529	1.726143	74.27229
Median	19.46500	1.000000	3.600000	10.52500	1.815000	69.54000
Maximum	23.30000	1.000000	6.100000	25.35000	2.900000	200.3600
Minimum	4.86000	0.000000	-3.100000	5.210000	-1.510000	16.74000
Std. Dev.	4.66400	0.493435	2.701577	5.205351	0.711987	49.16109
Skewness	-2.09024	-0.408248	-0.884755	1.024220	-1.530674	1.136562
Kurtosis	6.30671	1.166667	2.938344	3.166160	7.808910	3.516970
Jarque-Bera	82.86447	11.74769	9.143647	12.31918	94.78427	15.85019
Probability	0.00000	0.002812	0.010339	0.002113	0.000000	0.000362
Sum	1261.250	42.00000	201.0400	820.7700	120.8300	5199.060
Sum Sq. Dev.	1500.952	16.80000	503.5979	1869.602	34.97786	166760.1
Observations	70	70	70	70	70	70

Source: Prepared by the author based on EViews 10

Through Table 3, the results of the descriptive statistics of the study variables show that there is substantial variation in the financial characteristics among the banks under study, reflecting differences in risk management strategies and operational performance.

Financial Stability Indicator (Z-score): The indicator recorded an average of 74.27, reflecting a good degree of financial stability among Saudi banks on average. However, the high standard deviation of 49.16 indicates a significant variation in the ability of these banks to face risks, with the indicator values ranging between a minimum of 16.74 and a maximum of 200.36, which explains the structural differences in their financial positions.

Capital Adequacy (CAR): The average value of this indicator reached 18.01, indicating the strength of banks' capital base and their compliance with prudential standards. Meanwhile, the standard deviation of 4.66 indicates a moderate variation in capital adequacy levels among the banks included in the study sample.

Liquidity (LIQ): Its average reached 11.72, reflecting an appropriate ability to meet short-term obligations, with a relative dispersion of 5.20, which reflects differences in liquidity management policies among Saudi banks.

Profitability (ROA): The banks recorded an average profitability level of 1.72, reflecting stable operational efficiency, while the standard deviation of 0.71 indicates a slight variation in financial performance levels.

Economic Environment and Digital Transformation: The average economic growth rate (GDP) reached approximately 2.87, with a standard deviation of 2.70, reflecting the banks' exposure to fluctuations in the economic environment. As for the digital transformation variable (D_DIGIT), its average reached 0.60, embodying the growing trend toward adopting digital technologies during the study years.

Normal Distribution Test: Based on the Jarque-Bera test, the results show that the probability values reached 0.0000 for all variables, which means that the hypothesis of normal distribution is rejected. This is common in financial data and does not affect the estimates of GMM models, which do not require the variables to follow a normal distribution.

3.5 Linear Correlation among the Explanatory Variables

The examination of the correlation matrix among the explanatory variables allows for identifying possible correlation pairs among these variables, and thus ensuring that the model is free from the main problems that may occur when estimating a dynamic panel model.

Table 4. *Linear Correlation among the Explanatory Variables*

	CAR	D_DIGIT	GDP	LIQ	ROA
CAR	1.000000	0.057558	0.032389	0.236440	0.322566
D_DIGIT	0.057558	1.000000	0.349160	-0.596817	-0.121199
GDP	0.032389	0.349160	1.000000	-0.335125	0.254713
LIQ	0.236440	-0.596817	-0.335125	1.000000	0.137575
ROA	0.322566	-0.121199	0.254713	0.137575	1.000000

Source: Prepared by the author based on EViews 10

The results of the table above show that all correlation coefficients were below the critical threshold of 0.80, with the highest correlation among the variables reaching -0.59 between the digital transformation variable and liquidity. This result confirms the independence of the explanatory variables (CAR, D_DIGIT, GDP, LIQ, ROA) and the absence of multicollinearity problems in the model, which enhances the efficiency and reliability of the statistical estimates in the GMM model adopted in this study.

3.6 Econometric Study

3.6.1 Unit Root Test

The unit root test is an important methodological step for verifying the stationarity properties of the time series of the variables under study. In this context, there are several tests for detecting unit roots in panel data. However, the LLC test proposed by Levin et al. (2002), the IPS test by Im et al. (2003), in addition to the ADF-Fisher test, are considered among the most important tests for detecting the stationarity of time series (Hurlin &

Mignon, 2005). These tests aim to avoid problems of spurious regression, thereby providing a sound statistical basis for using the variables in their levels or first differences, especially in dynamic panel models. This is done to ensure the validity and reliability of the estimated model. Table 5 illustrates this.

Table 5. *Stationarity Tests for the Study Variables*

Variables	Test Type	LLC Test	IPS Test	ADF Test	PP Test
Z-score	Level	-5.73975 (0.0000)***	-2.85540 (0.0021)***	35.3741 (0.0013)***	50.3057 (0.0000)***
ROA	Level	-0.54916 (0.2914)	0.33724 (0.6320)	10.9067 (0.6934)	10.9306 (0.6915)
ROA	1st Difference	-3.51247 (0.0002)***	0.68184 (0.2477)	16.5842 (0.2790)	42.9278 (0.0001)***
LIQ	Level	-9.35556 (0.0000)***	-1.07494 (0.1412)	22.6885 (0.0655)	22.6885 (0.0481)**
LIQ	1st Difference	-1.86161 (0.0313)**	-1.54732 (0.0609)	25.0461 (0.0341)**	62.5024 (0.0000)***
CAR	Level	-5.29677 (0.0000)***	-2.44131 (0.0073)***	34.1102 (0.0020)***	58.4676 (0.0000)***
GDP	Level	-1.48473 (0.0688)	0.27106 (0.6068)	8.67807 (0.8511)	32.9343 (0.0029)***
GDP	1st Difference	-6.96643 (0.0000)***	-2.89475 (0.0019)***	36.9516 (0.0008)***	145.635 (0.0000)***

Note: The values in the table represent the t-statistic. (1%)*** and (5%)** indicate statistical significance at the 1% and 5% significance levels, respectively.

Source: Prepared by the author based on EViews 10

From the table above, we note that the variables Z-score, CAR, and LIQ are stationary at level according to most tests, namely LLC, IPS, ADF, and PP, at the 1% and 5% significance levels. The stationarity of these variables at level means that they are integrated of order zero, I(0), which allows their actual values to be used in the model without concern about spurious regression.

The variables ROA and GDP were found to be non-stationary at levels but became stationary after first differencing, indicating that they are integrated of order one, I(1).

Based on the previous results, it is clear that there is a mixture of variables, some of which are stationary at level and others at first difference, I(1), which supports the use of a dynamic panel model.

3.6.2 Model Estimation

In this study, dynamic cross-sectional time-series data analysis methods, namely Dynamic Panel Data Models, were used through the Generalized Method of Moments (GMM) technique in order to measure the quantitative effect of the independent variables and digital transformation on the financial stability of Saudi banks. The model was estimated, and its validity was examined as follows:

Table 6. *Estimation Results*

Dependent Variable:	ZSCORE
Method:	Panel Generalized Method of Moments
Date:	03/31/26 Time: 18:08
Sample (adjusted):	2017 2024
Periods included:	8
Cross-sections included:	7
Total panel (balanced) observations:	56

2SLS instrument weighting matrix				
Instrument specification:	C ZSCORE (-2) CAR LIQ ROA GDP D_DIGIT			
Constant added to instrument list				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
ZSCORE(-1)	0.994578	0.017999	55.25722	0.0000
CAR	0.165383	0.181383	0.911791	0.3663
LIQ	-0.316555	0.222551	-1.422393	0.1611
ROA	0.446514	1.209343	0.369221	0.7135
GDP	-0.160547	0.322347	-0.498057	0.6206
D_DIGIT	0.052798	1.970217	0.026798	0.9787
R-squared	0.986497	Mean dependent var	74.53768	
Adjusted R-squared	0.985147	S.D. dependent var	48.85006	
S.E. of regression	5.953467	Sum squared resid	1772.189	
Durbin-Watson stat	2.424222	J-statistic	1.066628	
Instrument rank	7	Prob(J-statistic)	0.301708	

Source: Prepared by the author based on EViews 10

Table 7. *Arellano-Bond Test (AR2)*

Arellano-Bond Serial Correlation Test				
Equation:	Untitled			
Date:	03/31/26 Time: 18:20			
Sample:	2015 2024			
Included observations:	49			
Test order	m-Statistic	rho	SE(rho)	Prob.
AR(1)	-1.674600	-1727.44...	1031.555...	0.0940
AR(2)	-0.998012	-691.089...	692.465812	0.3183

Source: Prepared by the author based on EViews 10

A. Validity Test of the Estimated Dynamic Model

Before interpreting the estimation results using Panel GMM models, it was necessary to subject the model to a set of diagnostic tests to verify its econometric soundness and the validity of the instruments used. The Arellano-Bond test (AR2) was conducted to detect second-order autocorrelation, while the Hansen/Sargan test was used to verify the validity of the instruments and the absence of over-identifying restrictions.

- *Arellano-Bond Test (AR2):* From Table 7, we note that the probability value reached 0.3183, which is greater than the adopted significance level of 5%. This confirms the absence of second-order autocorrelation in the residuals. Accordingly, one of the basic conditions for the validity of GMM estimates is fulfilled, which supports the reliability of the results derived from the model.
- *Hansen/Sargan Test:* The estimation results shown in Table 6 indicate that the J-statistic value reached 1.066, with a J-statistic probability value of 0.3017. Since this value exceeds the 5% significance level, this means accepting the null hypothesis H0, which states that the instruments used are valid and are not correlated with the error term. Therefore, the estimation instruments adopted in the GMM model can be considered valid and satisfy the condition of over-identification restrictions.

Based on the results of the two previous tests, it became clear that the estimated Panel GMM model meets the basic conditions required for estimating such models, both in terms of the absence of second-order autocorrelation in the residuals and the validity of the instruments used. Therefore, the estimated results enjoy an acceptable degree of statistical reliability, which allows moving on to examine the quality of the

model, interpret the estimated parameters, and discuss their economic significance.

B. Dynamic Model Quality Tests

Explanatory Power of the Panel Model: The adjusted coefficient of determination (Adjusted R^2) reached approximately 0.9851, which means that the independent variables have an explanatory power of about 98.51% of the variations in the financial stability indicator (ZSCORE). However, this value should be interpreted with caution in dynamic models, due to the inclusion of the lagged dependent variable among the explanatory variables.

It is clear from the Durbin-Watson statistic, estimated at 2.42 and close to the value of two, that there is no autocorrelation problem in the model residuals.

C. Economic and Econometric Interpretation of the Estimated Parameters

The econometric estimation using the System Generalized Method of Moments (System GMM) showed that the lagged dependent variable, ZSCOREt−1, had a positive coefficient of 0.9946 and was the only variable that achieved statistical significance at the 1% significance level (p = 0.0000). From an econometric perspective, this result indicates a high degree of dynamic persistence in the financial stability of Saudi banks, implying that the current level of financial stability is strongly influenced by its level in the previous period. From an economic perspective, this suggests that banks with high levels of financial stability tend to maintain that stability over time, which may be attributed to the continuity of prudential policies and the accumulation of institutional experience in risk management.

In contrast, none of the other independent or control variables achieved statistical significance at the conventional significance levels (p > 0.10). Therefore, it is important to distinguish clearly between the direction indicated by the estimated coefficients and the conclusions supported by statistical evidence. Accordingly, the signs of the estimated coefficients may be considered either consistent or inconsistent with theoretical expectations; however, they do not constitute sufficient empirical evidence of the direct effect of these variables on financial stability during the study period.

Capital Adequacy (CAR): The variable recorded a positive coefficient of 0.1654, but it was not statistically significant (p = 0.3663). The positive sign is consistent with the banking literature, which suggests that higher levels of capital adequacy enhance banks' ability to absorb risks and support financial stability, in line with the Basel Accords and the supervisory regulations of the Saudi Central Bank (SAMA). However, the study's findings do not provide sufficient statistical evidence to confirm a direct effect of capital adequacy on financial stability during the study period. One possible explanation for this result is the relatively limited variation in capital adequacy ratios across the sampled banks, which may have reduced the variability required to detect a statistically significant effect.

Liquidity (LIQ): The variable recorded a negative coefficient of −0.3166, although this effect was not statistically significant (p = 0.1611). Accordingly, the study does not provide statistical evidence of a direct effect of liquidity on financial stability during the study period. Nevertheless, the negative coefficient is consistent with certain theoretical arguments suggesting that excessive liquidity holdings may reduce the efficiency of financial resource allocation and limit profitability. However, this relationship remains theoretical and cannot be confirmed based on the current findings.

Return on Assets (ROA): The variable had a positive coefficient of 0.4465, but it did not reach statistical significance (p = 0.7135). Therefore, the study does not provide sufficient statistical evidence of a direct effect of profitability on financial stability during the study period. Although the positive coefficient is consistent with the economic rationale that higher profitability enhances banks' ability to build reserves and strengthen their capital base, this effect was not statistically supported by the results. One possible explanation is that the lagged dependent variable absorbed a substantial portion of the model's explanatory power, while the effect of profitability may be cumulative in nature and therefore may not be directly observable in the short run.

Real GDP of Non-Oil Activities (GDP): The variable recorded a negative coefficient of −0.1605, but it was not statistically significant (p = 0.6206). Consequently, the study does not

provide statistical evidence of a direct effect of real GDP of non-oil activities on the financial stability of Saudi banks during the study period. From a theoretical perspective, the negative sign suggests the possibility of an inverse relationship; however, the absence of statistical significance does not allow this effect to be confirmed. One possible explanation is that the financial stability of Saudi banks is more closely associated with internal factors and prudential policies than with short-term economic fluctuations. Nevertheless, this interpretation remains speculative and requires further investigation in future research.

Digital Transformation (D_DIGIT): The variable exhibited a positive coefficient of 0.0528, but it was not statistically significant (p = 0.9787). Accordingly, the study does not provide sufficient statistical evidence of a direct effect of digital transformation on the financial stability of Saudi banks during the study period. However, positive coefficient is consistent with theoretical expectations that digital transformation improves operational efficiency and strengthens the resilience of the banking sector over the long term. One possible explanation for this finding is the existence of a time lag between the initial investments in digital infrastructure and cybersecurity and their eventual impact on financial stability indicators. Nevertheless, this explanation remains a hypothesis that should be examined in future studies employing more detailed quantitative measures of the intensity of digital transformation.

4 CONCLUSION

In light of the rapid transformations taking place in the Saudi banking sector within the framework of digital transformation, this study aimed to analyze the role of digital transformation and prudential factors in explaining the financial stability of Saudi banks during the period 2017–2024. This objective was addressed by examining the research problem and questions through the application of a dynamic panel data model using the System Generalized Method of Moments (System GMM) estimator, which accounts for the dynamic nature of financial stability while mitigating endogeneity among the study variables. The diagnostic tests confirmed the validity of the econometric model and the reliability of its estimates, thereby providing a sound basis for testing the proposed hypotheses and drawing conclusions within the limits supported by the statistical evidence derived from the data.

4.1 Study Results

The diagnostic tests confirmed the validity of the adopted model. The results of the Arellano–Bond (AR2) test and the Hansen/Sargan test indicated the absence of second-order serial correlation and verified the validity of the instruments used, thereby enhancing confidence in the estimates obtained from the System GMM model.

The findings supported the hypothesis concerning the persistence of financial stability. The lagged dependent variable (ZSCOREt−1) exhibited a positive and statistically significant effect at the 1% significance level and was the only variable that achieved statistical significance. This result confirms that current levels of financial stability are strongly influenced by their values in the previous period, reflecting the dynamic persistence and cumulative nature of financial resilience in the Saudi banking sector.

The results did not provide sufficient statistical evidence to support the hypothesis regarding the effects of prudential factors and real GDP of non-oil activities during the study period. Specifically, the banking determinants represented by capital adequacy (CAR), profitability (ROA), and liquidity (LIQ), together with real GDP of non-oil activities (GDP), did not exhibit statistically significant direct effects, despite the estimated coefficient signs being consistent with theoretical expectations and the banking literature. Statistically, this finding may be attributed to the high degree of homogeneity among Saudi banks, as well as their strong capital buffers and relative resilience to cyclical economic fluctuations.

The findings also failed to provide sufficient statistical evidence to support the hypothesis that digital transformation (D_DIGIT) has a direct effect on financial stability during the study period, although the estimated coefficient was positive and consistent with theoretical expectations. One possible explanation is the existence of a time lag between foundational digital investments and the emergence of their tangible effects on financial stability. Another possible explanation is the limitation of measuring digital transformation using a dummy variable.

Overall, the study indicates that the statistical evidence primarily supports the dynamic and cumulative nature of financial stability in Saudi banks, whereas the hypotheses concerning prudential factors and digital transformation remain grounded in theoretical expectations and the characteristics of the available data, without empirical evidence of a direct effect during the study period.

4.2 Study Recommendations

Continue supporting digital transformation programs in the Saudi banking sector while adopting a long-term perspective when evaluating their effects on financial stability, given that the current findings do not provide statistical evidence of a direct impact during the study period.

Strengthen the integration between digital transformation initiatives and risk management, particularly cybersecurity risk management, in order to maximize the expected benefits of digitalization while preserving the resilience of the banking sector.

Maintain the high levels of capitalization and liquidity that characterize the Saudi banking sector while improving the efficiency of deploying these resources to enhance banking performance and support long-term financial stability.

Encourage Saudi banks and regulatory authorities, particularly the Saudi Central Bank (SAMA), to expand their disclosure of quantitative indicators reflecting the level of digital transformation, such as the volume of digital banking transactions, the number of users of electronic banking channels, investments in digital infrastructure, and cybersecurity expenditures. Such disclosures would enable researchers to develop more accurate quantitative measures of digital transformation and better assess its role in promoting financial stability.

Expand the scope of future research to include longer time periods, larger samples, and comparative analyses between Saudi banks and their counterparts in the Gulf Cooperation Council (GCC) countries. Future studies should also incorporate additional institutional variables, such as corporate governance quality, risk management, and asset quality, in order to develop a more comprehensive model for explaining financial stability.

BIBLIOGRAPHY

Abbasi, T., & Ouladzawi, A. (2019, 12 30). The reality of the resilience and soundness of the Algerian banking system under the Basel III agreement. *Journal of Financial, Accounting and Administrative Studies*, pp. 462-483. https://asjp.cerist.dz/en/article/110395

Abduallah, A., & Djalila, S. (2024, January 22). Determinants of commercial banks' financial stability: Evidence from MENA countries. *Journal of Business and Finance Economy*, pp. 1111-1124. Retrieved from https://asjp.cerist.dz/en/article/239480

Alshubiri, F. N. (2016, 12 31). Determinants of financial banking stability: An empirical study of commercial banks listed in Muscat Security Market. *Journal of Development and Foresight for Research and Studies*, pp. 1-11. Retrieved from https://asjp.cerist.dz/en/article/71726

Anatolyevna, M. I., & Ramilevna, S. L. (2013). Financial stability concept: main characteristics and tools. *World Applied Sciences Journal, 22*(6), pp. 856-858. https://doi.org/10.5829/idosi.wasj.2013.22.06.609

Bin Saha, A., Bin Bouziane, M., & Moustapha, A. (2014). Analysis of the relationship between banking stability and bank competitiveness - a case study of banking institutions. *Journal of Financial and Accounting Studies*, pp. 115-140. Retrieved from https://asjp.cerist.dz/en/article/38459

Chand, S. A., Kumar, R. R., & Stauvermann, P. J. (2021, February 8). Determinants of bank stability in a small island economy: a study of Fiji. *Accounting Research Journal*, pp. 22-42. https://doi.org/10.1108/ARJ-06-2020-0140

Chen, Z., Li, H., Wang, T., & Wu, J. (2023, December 2023). How digital transformation affects bank risk: Evidence from listed Chinese banks. *Finance Research Letters*. https://doi.org/10.1016/j.frl.2023.104319

Ghassan, H. B., & Guendouz, A. A. (2019, August 21). Panel modeling of z-score: evidence from Islamic and conventional Saudi banks. *International Journal of Islamic and Middle Eastern Finance and Management*, pp. 448-468. https://doi.org/10.1108/IMEFM-04-2018-0122

Hu, H., Wei, T., & Wang, A. (2025). Does digital transformation enhance bank soundness? Evidence from Chinese commercial banks. *Journal of Financial Stability*. https://doi.org/10.1016/j.jfs.2025.101374

Hurlin, C., & Mignon, V. (2005). *Une synthèse des tests de racine unitaire sur données de panel.* Université d'Orléans. https://doi.org/10.3917/ecop.169.0253

Jia, K., & Liu, X. (2024). Bank digital transformation, bank competitiveness and systemic risk. *Frontiers in Physics*. https://doi.org/10.3389/fphy.2023.1297912

Mishkin, F. S. (1999). Global financial instability: Framework, events, issues. *Journal of Economic Perspectives, 14*(4), pp. 3-20. https://doi.org/10.1257/jep.13.4.3

Odeduntan, A. K., & Adewale, A. A. (2015). Financial stability of Islamic banks: A Review of the literature. *European Journal of Islamic Finance, 2*. https://doi.org/10.13135/2421-2172/848

Rupeika-Apoga, R., Romānova, N., & Grima, S. (2020). The Determinants of Bank's Stability: Evidence from Latvia, a Small Post-Transition Economy. *Contemporary Issues in Business Economics and Finance: Emerald Publishing Limited*, pp. 235-253. https://doi.org/10.1108/S1569-375920200000104016

Schinasi, G. J. (2004, October). Defining financial stability. *IMF Working Paper, International Capital Markets Department*. Retrieved from https://www.imf.org/external/pubs/ft/wp/2004/wp04187.pdf

Suleiman, Y. F., Ahmed, S. A., & Al-Sabawi, M. M. (2012). Financial stability under the Islamic financial and banking system: An analytical study of a sample of Islamic banks in light of global indicators of the financial crisis. *Kirkuk University Journal of Administrative and Economic Sciences, 2*(2), pp. 65-90. Retrieved from https://ukjaes.uokirkuk.edu.iq/article_64647.html

Swamy, V. (2014, April 1). Testing the interrelatedness of banking stability measures. *Journal of Financial Economic Policy*, pp. 25-45. https://doi.org/10.1108/JFEP-01-2013-0002

Uddin, H., & Barai, M. K. (2026). Fintech Adoption and Bank Risk, Efficiency and Stability: Evidence from Panel Data of Selected Asian Economies. *FinTech*. https://doi.org/10.3390/fintech5010014

Wellink, N. (2002, 11 14). Central banks as guardians of financial stability. *Oranjestad: Central Bank of Aruba*. Retrieved from https://www.bis.org/review/r021120a.pdf