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DETERMINANTS OF NON-PERFORMING LOANS AND STRESS TESTING OF ALGERIAN BANKS: A DYNAMIC PANEL APPROACH

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ABSTRACT:
This research examines the causes of non-performing loans (NPLs) and Algerian banks' stress-test resilience. Over the 2016–2021 period, using a Difference GMM model, We evaluate macroeconomic and bank-specific characteristics utilizing panel data from 18 commercial banks, including public, joint-venture, and foreign banks, The findings suggest that credit risk is substantially influenced by lagged NPLs, profitability (ROA), exchange rate, and interest rate, while GDP growth and inflation do not exhibit a significant impact, Secondly, By stressing BNA Bank portfolio, we evaluate the sector's shock resistance. The findings suggest that Algerian banks' solvency ratios continue to surpass the regulatory threshold of 9.5%, despite the fact that loan quality is declining in extreme scenarios. This implies that Algerian institutions are relatively resilient. In the limited literature on developing countries, this research presents empirical data from Algeria and policy ideas for regulators to improve credit risk management and banking stability.

Keywords: Non-performing loans, Stress test, Credit risk, Algerian Banks, Generalized Method of Moments (GMM)

RESUME :
Cette recherche examine les causes des prêts non performants (PNP) et la résilience des banques algériennes aux tests de stress. Au cours de la période 2016–2021, en utilisant un modèle GMM de différence, nous évaluons les caractéristiques macroéconomiques et spécifiques aux banques en utilisant des données de panel provenant de 18 banques commerciales, y compris des banques publiques, des coentreprises et des banques étrangères. Les résultats suggèrent que le risque de crédit est substantiellement influencé par les crédits non performants retardés, la rentabilité (ROA), le taux de change et le taux d'intérêt, tandis que la croissance du PIB et l'inflation n'exhibent pas un impact significatif. Deuxièmement, en stressant le portefeuille de la BNA, nous évaluons la résistance aux chocs du secteur. Les résultats suggèrent que les ratios de solvabilité des banques algériennes continuent de dépasser le seuil réglementaire de 9,5%, malgré le fait que la qualité des prêts diminue

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dans des scénarios extrêmes. Cela implique que les institutions algériennes sont relativement résilientes. Dans la littérature limitée sur les pays en développement, cette recherche présente des données empiriques provenant d'Algérie et des idées de politiques pour les régulateurs afin d'améliorer la gestion des risques de crédit et la stabilité bancaire.

Mots Clés: Prêts non-performants, Test de stress, Risque de crédit, Banques algériennes, La Méthode des Moments Généralisés (GMM)

I. INTRODUCTION

The stability of the banking sector plays a crucial role in fostering financial and economic development, especially in emerging economies where banks serve as the principal source of financing. The banking sector encounters numerous challenges, with credit risk, particularly the buildup of non-performing loans (NPLs), posing a continual risk to both profitability and solvency. The occurrence of financial distress across both developed and developing nations has illustrated that a decline in loan quality poses a significant threat, not only to individual banking institutions but also to the stability of the entire financial system. The situation in Algeria presents a particularly pressing issue, characterized by banks functioning within an environment marked by concentrated lending portfolios, a predominant state-owned sector, and considerable vulnerability to macroeconomic variations.

This paper presents a comprehensive analysis of the determinants of non-performing loans (NPLs), based on extensive empirical research. It highlights the influence of macroeconomic factors such as GDP growth, inflation, interest rates, unemployment, and exchange rates, alongside bank-specific elements including profitability, capital adequacy, size, credit growth, and historical loan performance. Nevertheless, the available evidence presents a complex and contextually variable picture.

Although studies in advanced and emerging markets frequently verify countercyclical patterns, recent discoveries from Algeria indicate that these relationships have diminished or even contradictory, which is indicative of the economy's institutional specificities and structural characteristics. In addition, the majority of the current literature concentrates on determinants in isolation, without connecting them to forward-thinking stress testing frameworks that evaluate how shocks impact banks' resilience over time.

This study explores how macroeconomic and microeconomic variables affect Algerian bank non-performing loans (NPLs) and uses stress-testing scenarios to assess their solvency in adverse conditions. We estimate a dynamic Difference GMM model using panel data from 18 commercial banks from 2016 to 2021 to solve NPL persistence and endogeneity. The econometric findings show that profitability (ROA), lagged NPLs, interest rates, and currency rates affect credit risk. As a case study, we undertake macro and micro stress tests on the solvency ratio of Banque Nationaled'Algérie (BNA) using shocks to profitability, interest rates, and currency rates.

The results show that although significant disruptions impair loan quality and reduce solvency, Algerian banking institutions uphold a capital ratio exceeding the mandated

minimum of 9.5%, thereby exhibiting notable resilience. Nevertheless, limitations to profitability exhibit the most significant negative influence, underscoring the importance of implementing robust risk management and diversification strategies. This research contributes to the limited existing literature on banking risk within North Africa through the integration of econometric modeling and stress testing methodologies. It offers empirical insights into the determinants of non-performing loans (NPLs) in Algeria and delivers practical guidance for regulators, facilitating the institutionalization of stress testing as a supervisory tool to strengthen financial stability.

As a result, this paper aims to highlight these concepts by addressing the following main issue:

"How resilient is the Algerian banking sector under adverse conditions, and what is the impact of macroeconomic and bank-specific stress scenarios on their credit portfolios?"

The objective of this study is to look at the main ideas behind stress tests and credit risk management and go through the different methods and approaches used in stress tests to judge the credit risk of banks. This work will also show how economic stress scenarios affect banks' credit portfolios and their ability to handle losses. The remainder of this work is organized as follows: section two talks about some reviews of literature, section three breaks down our approach and section four presents all obtained results with their interpretation. At the end we make a conclusion

II. LITERATURE REVIEW

This section examines the empirical research conducted by various scholars concerning financial crises, which arise from credit risk that ultimately results in nonperforming loans, as well as macroeconomic, political, and social factors, and the internal manageability of financial institutions.

2.1. The Basel Regulatory Framework and Its Relevance to Algeria:

International banking capital and risk management requirements have improved under the Basel Accords. Credit risk was emphasized by **Basel I (1988)** minimum capital requirements. **Basel II (2004)** included capital adequacy, supervisory review, and market discipline, while **Basel III (2010)** added macroprudential elements such countercyclical buffers and liquidity standards to boost systemic resilience. Increased consensus that sufficient capital and good risk management are crucial for financial stability, especially in crises.

Algeria's Basel implementation is cautious and selective. Prudential control began with Law 90-10's capital adequacy and liquidity rules, which the Bank of Algeria later enhanced. Basel criteria have been hampered by state-owned banks, concentrated lending to public businesses, and underdeveloped financial markets. Algerian banks operate under capital restrictions defined by government guarantees and sector-specific strategies, unlike industrialized countries.

Despite these limitations, capital adequacy ratios (CARs) are a key resilience metric. Despite these drawbacks, capital adequacy ratios (CARs) measure resilience. Algerian banks frequently report CARs above the Basel III standard due to governmental backing and cautious lending. CAR, a bank-specific factor that influences NPLs, andsolvency ratios evaluate banks' stress-testing readiness in this research. Establishing Algerian banks in Baseldemonstrates their development and institutional shock absorption challenges.

Studies on the factors influencing non-performing loans (NPLs) have shown inconsistent results across several settings. At the macroeconomic level, several studies validate a countercyclical link, indicating that heightened economic activity lowers default risk**(Bonfim, 2009; Klein, 2013). Messai and Jouini (2013**)discovered that increased GDP growth significantly reduces non-performing loans in European and MENA banks. Contrarily**, Gashi et al. (2022)** presented data indicating a positive correlation between GDP and NPLs in Balkan countries, implying that fast credit expansion during periods of boom may subsequently lead to loan degradation. In an identical manner, **Benachour et al. (2025**) examined Algeria and found no significant correlation between GDP and NPLs, highlighting structural characteristics of the Algerian banking sector that may decrease macro-financial transmission.

Inflation and interest rates also produce divergent evidence**. Bhattarai (2018)** determines that inflation's impact is statistically inconsequential, whereas Szarowská (2018) demonstrates that it can either alleviate debt burdens or exacerbate repayment capacity, contingent upon wage rigidities. Anjom and **Karim (2016)** report an insignificant relationship in SAARC countries, despite the fact that interest rates are typically positively associated with defaults **(Messai&Jouini, 2013; Shakeel et al., 2021)**. These variations underscore the context-dependent characteristics of macroeconomic determinants of non-performing loans (NPLs).

Profitability and capitalization received significant attention at the microeconomic level. Numerous research **(Louzis et al., 2012; Messai&Jouini, 2013)** demonstrate that higher ROA correlates with reduced NPLs, indicating enhanced risk management in successful banks. The effect of the capital adequacy ratio (CAR) is inconsistent: some studies indicate that a greater CAR promotes cautious lending and reduces defaults **(Shrieves& Dahl, 1992),** but others contend it fosters risk-taking behavior **(Ghosh, 2017).** This mismatch suggests that the prudential function of capital is significantly contingent upon institutional frameworks and regulatory enforcement.

Beyond determinants, the literature on stress testing emphasizes its value as a complementary risk management tool.Research and recommendations on microfinance in Tunisia **(Ben Youssef, 2018)** and India **(Dua&Kapur, 2018)** indicate that stress situations expose weaknesses overlooked by baseline models. In Algeria, research is limited and disconnected, mostly depending on individual bank case studies **(Tari, 2018; Benachour et al., 2025).**Few integrate economic modeling with stress testing within an overall framework.

In conclusion, whereas global evidence supports both macroeconomic and bank-specific factors influencing NPLs, the results often lack consistency, emphasizing the need

for country-specific study. Furthermore, while stress testing is widely used globally, its utilization in Algeria is still restricted. This research aims to address these deficiencies by using a dynamic panel GMM model on 18 Algerian banks and including stress testing scenarios to assess systemic resilience.

2.2. Long growth and credit expansion:

The literature emphasizes loan growth's impact on credit risk. As banks loosen lending rules to obtain market share, **(Keeton & Morris, 1987)** found that fast credit growth often leads to more defaults. Recent studies show that loan growth increases NPLs in Pakistan and Algeria, where credit portfolios are concentrated in vulnerable sectors like hydrocarbons, construction, and public enterprises. This suggests that industry concentration risk and pro-cyclical lending practices aggravate loan portfolio fragility in emerging economies. Some studies indicate that superior supervision and risk management can attenuate the disruptive impacts of loan growth **(Love &Zicchino, 2006).**

2.3. Exchange rate volatility and external shocks:

The relationship between exchange rate changes and NPLs has been extensively discussed. European studies **(Louzis et al., 2012)** show that currency depreciation lowers asset quality for unhedged foreign currency borrowers. However, Benachour et al. (2025) find a negative link in Algeria, indicating that exchange rate stability boosts macroeconomic confidence and reduces default risk. The disparity across settings shows that currencies, trade openness, and hedging methods shape this link. In closed economies like Algeria, where credit is denominated in local currency, the exchange rate may have less direct influence. However, inflation and import costs may affect it indirectly.

2.4. Unemployment and social vulnerability:

Unemployment is a major contributor to non-performing loans (NPLs), which indicate household repayment capability decline. (**Klein, 2013)** and **(Angela & Irina., 2015)** say rising unemployment predicts European loan defaults. Additionally, (**Melecký et al., 2015)** confirm its significance in Central and Eastern Europe. The effect is less noticeable in certain emerging economies due to informal employment and state-backed credit schemes that safeguard against social risk. Despite minimal empirical data, Algerian labor market dynamics may transmit NPLs more complexly and less than in capitalist economies. Due to the state's important involvement in employment.

2.5. Stress test as a risk management tool:

Regular risk models need stress testing. IMF and Basel Committee stress assessment methods use scenario analysis and sensitivity tests to identify severe but likely shocks **(IMF, 2012)**. **(Ben Youssef, 2018)** indicates that Tunisian banks withstand moderate economic downturns, while risks vary. **(Dua&Kapur., 2018)** say Indian banks implement Basel III requirements but lose capital amid economic and inflationary shocks. **(Tari, 2018)** and

(Mohamed, 2023) stress test Algerian single-bank case studies and discover lower solvency rates but above regulatory criteria. Static assumptions and no system modeling limit these investigations.

2.6. Research gaps:

The literature shows three major gaps. Despite equal credit risk, Algeria and North Africa have less data than Europe and Asia. Second, most research focuses on NPL drivers or stress testing, but not frequently both. Third, Algerian research uses descriptive or OLS models, ignoring NPLs and endogeneity. This study employs a dynamic Difference GMM model to identify Algerian banks' NPL causes and then conducts macro- and micro-stress tests to determine resilience

III. RESEARCH METHODOLOGY

We investigated 18 Algerian banks based on data availability. Our five-year study used 108 yearly evaluations from 2016 to 2021 to evaluate the model. Balance Sheets, Income Statements, Annual Reports, and World Bank indicators were used. Two methods were used in the investigation. Firstly, Ordinary LeastSquares (OLS), a linear econometric model, is used to identify credit risk (NPL) components and explanatory factors but fails to account forthe panel structure of the data,which can lead to biased estimates. In order to remove endogeneity concerns by incorporating lagged values of regressors, while also accounting for heteroscedasticity, we secondly apply the **(GMM) method** which is advantageous as it mitigates the effects of high persistence of the independent variables. The second step is applying scenarios to variables and analyzing banks' shock resistance. we apply shocks of three and six times the standard deviation to the chosen variables for the second phase of stress testing, We next calculate the post-test value of each variable, and predict NPLs. After setting the post-test non-performing loan level, we calculate the solvency ratio. Assuming regulatory capital stays intact, only risk-weighted assets will be amended.

3.1. Hypothesis development:

1-1- Bank specific factors:

- **BANK SIZE:**

(Ahmed, 2021) states that larger banks manage better, handle economic crises better, and earn more. This significantly lowers Pakistan's NPL ratio. According to **Swamy (2012),** large banks may have better risk management practices and technology, allowing them to lower NPAs.Studies on the “too big to fail” concept suggest that larger banks view themselves as vital and engage in riskier lending. These banks frequently assume government bailouts in case of financial failures. **Louzis et al. (2012)**

H01: There is a negative and significant impact of Bank size on NPLs

- **ROA:**

Return on Assets (ROA) measures the profit generated by a bank relative to its total assets.Non-performing loans decrease due to bank profitability. Banks that make money lend prudently, ensuring financial stability, Profit-maximizing commercial banks avoid high-risk businesses, reducing NPLs. **(Shakeel, et al., 2021)**

(Messai&Jouini, 2013) found a strong negative correlation between ROA and NPLs at 5%. ROA may hurt non-performing loans since prosperous banks are less motivated to make profits and less inclined to make high-risk loans **(Bhattarai, 2018).**

According to **(Louzis et al., 2012),** Poor management and inefficient lending cause low-profit banks to lose more loans, according to **Mendoza and Rivera (2017),** Credit risk significantly reduces rural Philippine bank profitability,

A 1984–2013 study of 50 US banks supported the prior findings and revealed successfulinstitutions take less risks, enhancing loan quality.

Spanish banks observed a significant correlation between delayed profitability and NPLs in 1993–2000. Badly performing banks use cautious lending practices and lend carefully to avoid additional losses. (García Marco & Fernández, 2008).

H02: There is a negative impact between ROA and NPL

- **CAPITAL ADEQUACY RATIO:**

The capital adequacy ratio assesses banks' solvency and risk tolerance. It protects depositors and improves financial stability and efficiency **(Bhattarai, 2018).** CAR may affect non-performing loans uncertainly. Banks with high CAR may chase opportunities more aggressively, which increases risk and credit portfolio risk **(Demirguc-Kunt and Huizinga, 1999).**

(Ghosh,2017) found that loan losses are associated with high capital adequacy in uscommercial banks from 1992 to 2016,this causes banks to lend riskier with inadequate risk evaluations.

(Naceur&Kandil., 2014) conducted an analysis of the Basel Accord and the MENA. The study found that loan growth increased substantially after capital restrictions were implemented. Despite a higher capital adequacy ratio, banks increased lending and asset growth. This negative correlation is attributable to the fact that banks with substantial capital adequacy are more inclined to engage in prudent lending in order to preserve their capital reserves **(Shrieves& Dahl., 1992).**

HO3: There is a positive relationship between CAR and NPLs

- **LOAN GROWTH:**

According to one of the earliest studies on credit expansion and nonperforming loans (NPLs), loan losses are exacerbated by rapid loan growth **(Keeton andMorris,1987).** Algerian bank loans are concentrated in hydrocarbons, construction, and state enterprises, which is why **Benachour, Abdlemalek, &Tarhlissia (2025)** discovered a positive association between loans and NPLs in their study. These enterprises are exceedingly

susceptible to fluctuations in energy prices and global financial crises. Enterprises and households that depend on these industries experience difficulty repaying their loans when they are disrupted,resulting in an increase in nonperforming loans (NPLs).

HO4: There is a positive impact between loans growth and NPL

1-1- Macroeconomic factors:

- **GDP GROWTH:**

Research shows that non-performing loans are anti-cyclical. Higher real GDP growth boosts income and borrower debt payment capability **(Klein, 2013).**

GDP growth rate is a key macroeconomic determinant of NPLs. According to **(Gashi et al., 2022),** their panel regression analysis found a positive relationship between GDP annual sales and non-performing loans. However, (**Messai&Jouini, 2013)** found an inverse relationship, believing that higher economic growth will lower NPL ratios.

In the Italian instance, the Autoregressive Distributed Lag (ARDL) cointegration model was used with quarterly data from 2008Q3–2020Q4 **(FOGLIA, 2022).**He studied macroeconomic factors' short- and long-term implications on NPLs. Both periods showed a negative correlation between GDP and NPLs.

GDP growth is strongly correlated with NPLs, highlighting its countercyclical nature. Reduce non-performing loans via increasing GDP. (**Shakeel et al., 2021)**.

Non-performing loans are negatively impacted by yearly real GDP growth. When economic activity drops, borrowers' wages and collateral value decrease, which may raise the non-performing loans rate. (**Angela & Irina, 2015)**

H05: There is a negative impact between GDP and NPL

- **EXCHANGE RATE:**

An increasing nominal effective exchange rate (NEER) may lower foreign currency loans, which may hurt NPLs. **(Szarowska, 2018)**

(Louzis et al., 2012) emphasize macroeconomic factors in banking non-performing loans. In nations with considerable foreign currency loans to unhedged borrowers, exchange rate depreciation may deteriorate asset quality.

(Melecký et al., 2015) examine how macroeconomic variables affect NPLs in the Czech Republic. Bayesian instrumental variable estimates are utilized for 1993–2014 data. Borrowers benefit from economic growth and exchange rate income.

NPL factors were analyzed utilizing the Banque Extérieured'Algérie (BEA) from 2010-2022 by (**Benachour et al., 2025).** The OLS method revealed currency rates harm NPLs. They claim a steady currency rate boosts macroeconomic stability, foreign investment, and growth. This reduces default risk by improving firm and individual finances. Falling currencies cause inflation, increased import costs, and debt repayment issues, which increase non-performing loans.(**Shakeel et al., 2021)** observed higher exchange rates increase NPLs

H06: There is a positive impact between the exchange rate and NPL.

- **INFLATION:**

The value of a currency diminishes as inflation increases the prices of goods and services within an economy. Inflation may be unclear. Elevated inflation may facilitate debt

repayment by diminishing their value; nevertheless, it might concurrently reduce borrowers' real income if wages remain static.

The reduced inflation rate is expected to decrease lending rates, enabling banks to anticipate a deterioration in credit quality, Inflation may reduce debt repayment, although it may simultaneously elevate interest rates and adversely affect borrowers' income. Economic development is contingent upon price stability, but non-performing loans (NPLs) and inflation can have either beneficial or adverse effects. **(Szarowska, 2018)**

(Melecký et al., 2015) identified a substantial negative correlation between inflation and non-performing loans (NPLs), corroborating the findings of **(Angela & Irina., 2015)** that elevated inflation rates might diminish the actual value of outstanding loans, hence facilitating debt servicing. Nevertheless, elevated inflation may exacerbate debtors' actual income, rendering the impact of inflationuncertain, **Bhattarai (2018)** believe that Marginal inflation positively influences non-performing loans (NPLs).

H07: There is a positive impact between the inflation rate and NPL.

- **INTEREST RATE:**

In their examination of SAARC nations, (**Anjom&Mahbub Karim., 2016)** identified a negligible yet positive correlation between interest rates andnon-performing loans (NPLs). (**Szarowska, 2018),** in her analysis of Central and Eastern European nations employing Granger causality approach and panel regression, identified a positive correlation between lending interest rates and non-performing loans (NPLs).

H08: There is a positive impact between interest rate and NPL.

- **UNEMPLOYMENTRATE:**

Due to rising unemployment and borrower repayment difficulties, NPLs are likely to grow. (**Klein, 2013), (Melecký et al., 2015)** claim that unemployment significantly affects NPLs. They observed that loan rates hurt borrowers' finances.

High unemployment increases nonperforming loans owing to revenue gaps and borrowers' inability to repay. **Angela & Irina. (2015)**

H09: There is a positive impact between unemployment rate and NPL.

3.2. Determinants of credit risk:

Through this section, we have identified the most significant determinants of credit risk using GMM modelling, that will be employed in forthcoming stress tests. Prior to assessing the relationship between the variables, it is essential to conduct preliminary tests that align with the assumptions of regression analysis.

- ***Descriptive statistics of the sample***:

Before estimating our econometric model, it is crucial to examine certain fundamental aspects of the data, as indicated by the descriptive analysis. The summary of the descriptive analysis for all variables is presented in the tables below:

Table 01:Descriptive statistics of the bank specific factors and the dependent variable

Test	Obs	Log_NP	Log_Bank	ROA	CAR	Log_total_Cre	Log_NPL
minimu	108	0.1371	3.620	0.002000	0.103700	1.129	-1.9177
maximu	108	6.1974	8.302	0.067800	0.584700	7.947	6.0965
Mean	108	2.7963	5.545	0.026395	0.216113	5.165	2.4524
Median	108	2.4169	5.274	0.026400	0.177400	4.820	2.2718
Std.dev	108	1.82603	1.30676	0.014241	0.092454	1.442039	2.149265
Skewne	108	0.38715	0.5693887	0.428815	1.139977	0.3899468	0.0080656
Kurtosi	108	-	-1.027296	0.037449	1.248647	-0.7405722	2.033549

3.3. Econometric Tests on Residuals :

- ***Normality tests of the errors:***

Table 02: Descriptive statistics of the macroeconomic factors

Test	Obs	Log_GDP	Exchange rate	Interest rate	Inflation
minimum	108	9.725	109.00	0.055000	0.020000
maximum	108	10.002	135.00	0.065000	0.072000
Mean	108	9.816	119.56	0.060000	0.046500
Mediane	108	9.795	118.29	0.060000	0.049500
Std.dev	108	0.0899588	9.193652	0.003432	0.019531
Skewness	108	1.243699	0.424075	0.000000	-0.162081
Kurtosis	108	0.2786977	-1.124309	-1.300486	-1.540290

This test checks whether the errors follow a normal distribution and it is based on the following hypotheses:
H0: The errors follow a normal distribution.

H1: The errors do not follow a normal distribution.

The results of the test are presented below:

Jarque-Bera Test

data: residuals(model)

X-squared = 3.1029, df = 2, p-value = 0.2119

Source: R 4.4.3 Version

Based on the results in the table above, the residuals are indeed distributed as a normal distribution. The Jarque-Bera test accepts the null hypothesis of normality (the p-value of the test = 0.2119 is well above the 5% threshold)

- ***Heteroscedasticity Test:***

This test allows us to check for heteroscedasticity in the residuals and is based on the following hypothesis:

H0: Homoscedasticity of the model's residuals.

H1: Heteroscedasticity of the model's residuals.

The results of the test are presented below:

studentized Breusch-Pagan test

Data: model

BP = 6.6252, df = 8, p-value = 0.5776

Based on the results in the table above, the Breusch-Pagan-Godfrey test accepts the null hypothesis of homoscedasticity and rejects the alternative hypothesis of heteroscedasticity (the p-value of the test = 0.5776 is well above the 5% threshold).

- ***Correlation Test of the residuals:***

Durbin-watson test: This test allows us to check for correlation in the residuals and it is based on the following hypotheses:
H0: No correlation of the model's residuals.
H1: Correlation of the model's residuals.
The results of the test are presented below:
Durbin-Watson test
data: model
DW = 0.67176, p-value = 0.000..P-value < 5% which means we reject the null hypothesis, The DW test reveals that the residuals are correlated,

3.4. Estimation of the GMM Model Relationship:

In order to delete the autocorrelation problem of the residuals we run a dynamic panel regression Difference GMM model of the form:

$$Log_NPL = \beta\ log_NPL_{t-1} + \alpha_0\ ROA + \alpha_1\ CAR + \alpha_2 log_BANK_SIZE + \alpha_3 log_TOTCRDT + \alpha_4 log_GDP + \alpha_5\ TXCHANGE + \alpha_6\ INTRATE + \alpha_7\ INFL + \varepsilon t$$

Where:

Lag (log_NPL , 1) : Lagged dependent variable

ROA : Return on Assets

CAR: Capital Adequacy Ration
Size: BANK SIZE measured by Total Assets
TOTCRDT: TOTAL CREDITS
GDP: Gross Domestic Product
TXCHANGE: Exchange rate
INTRATE: INTEREST RATE
INFL: Inflation

Table 03: Estimated coefficients using Difference GMM method

Test	p-value	Std.	Estimate
Log_NPL_{t-1}	0.563	0.223	0.011 sig
Log_bank_size	-0.073	0.170	0.666
ROA	-5.119	0.893	<0.001 sig
CAR	0.179	0.218	0.411
Log_total_credits	0.133	0.123	0.280
Log_GDP	-0.024	0.781	0.976
Exchange_rate	-0.046	0.026	0.081 sig
Interest_rate	-163.613	99.157	0.099 sig
inflation	1.400	2.831	0.621

3.5. Stress test:

- ***AlgerianBanks' situation before the shocks:***

Before talking about the shocks that will be used and the variables that go with them, it is important to define Algerian Banks' starting point, which is necessary for the next analysis. The tables below displays the diverse statistics.

- ***Choices of variables to stress:***

The stress tests were conducted in accordance with the GMM model results, which identified ROA, latent NPLs, interest rate, and exchange rate as significant determinants of credit risk in Algeria. For each variable, two shocks were implemented, equivalent to three times (3σ) and six times (6σ) their historical standard deviation. This approach is consistent with international practice **(IMF, 2012),**considering both moderate and severe shocks.

IV. RESULTS AND DISCUSSIONS

All research variables' lowest and maximum values vary as shown in the tables above. LGDP, LBank size, LNPL, and LTotal Credits show the greatest variations. Additionally, these four variables' mean and median values are similar in magnitude. In addition, the variables show periodic fluctuations. Exchange rate has the largest standard deviation, Tables

show that Skewness and Kurtosis statistics range from 0 and 3, respectively, suggesting a lack of regularity and a volatile series.

1- Interpretation of the results:

log_NPL$_{t-1}$: p-value = 0.011 => Positive and Statistically significant at the 1% level

NPLs from the previous year considerably impact those of the current year, causing credit risk inertia. This shows that non-performing loans have a steady impact year after year, as in banking models. Our estimates show that the coefficient of lagged NPLs is relatively high (0.56), implying that a shock to NPLs will have a long-term effect on the financial sector.

log_BANK_SIZE: p-value = 0.666 ⇒ Not significant.

The relationship between bank size and NPLs is multifaceted and impacted by risk management, law, and the economy. Many studies, like **Klein (2013)** and **Louzis, Vouldis& Metaxas (2012),** have mixed results. We found no correlation between the two variables, contradicting the economic fact that larger public banks have fewer non-performing loans (NPLs) than smaller private banks due to their state backing, prudent credit issuance methods, enhanced risk diversification, superior risk management, and more conservative lending regulations.

ROA (Return on Assets): p-value < 0.001 Highly significant at 1%.

ROA is a crucial metric of bank profitability, measures profit per unit of assets and is negatively correlated with NPLs. NPLs suggest that more of the bank's loans aren't producing revenue owing to borrowers' inability to repay. Thus, the bank's interest revenue falls, lowering profitability and ROA. Due to rising non-performing loans, banks must make reserves for losses. These provisions reduce the bank's net profits by deducting earnings. Increased non-performing loans require larger provisions, lowering revenues and return on assets. Algeria's economic instability, especially regarding hydrocarbons, makes businesses and individuals vulnerable, forcing banks to make large provisions and hurting profits.This consistent with the results of **(Anjom & Mahbub Karim, 2016)**, **(Shakeel , M.Ejaz, & Eleftherios Thalassinos, 2021)**, but contrary to some studies such as **(Fajar & Umanto, 2017)** and **(Swamy, 2012)** who found a positive relationship between the two variables

Log_total_credits: p-value = 0.280 ⇒ Not significant.

The total quantity of loans issued is not statistically significant for non-performing loans (NPLs), however it is positive. Additional specific attributes, such as loan quality or credit type, may be more relevant in elucidating the NPLs. This is uncommon since several studies such as **(Benachour & et al., 2025)**have shown a substantial correlation between the two variables, concluding that increasing loan issuance results in a greater risk of default.

Log_GDP: p-value = 0.976 Insignificant

In our model, GDP has a negative but no effect on non-performing loans (NPLs), suggesting that bank-specific factors like credit risk management may be more important than general economic conditions. This conclusion agrees with **(Benachour, Abdlemalek,**

&Tarhlissia, 2025), who found no association between GDP and NPLs, but contradicts several studies like **(Klein, 2013)**. A boost in GDP typically increases employment and real income, which improves borrowers' financial situation and ability to repay loans, decreasing non-performing loans.

Exchange rate: p-value = 0.081 => Marginally significant (at 10%)

Non-performing loans are negatively impacted by the currency rate. This matches**(Benachour, Abdlemalek, &Tarhlissia, 2025)** and **(Szarowska, 2018).** The **Klein (2013)** study disagrees. A currency depreciation may increase risks for banks with foreign currency loans or import/export businesses. In Algeria, the exchange rate and non-performing loans (NPLs) are inversely correlated because currency appreciation (or a stable exchange rate) reduces import costs, which benefits businesses that rely on imported goods and services. As these expenditures decrease, companies' margins improve, enhancing their debt service capabilities. Non-performing loans fall. A strong exchange rate promotes macroeconomic stability, foreign investment, and economic growth. This improves businesses' and individuals' finances, lowering default risk.

Interest rate: p-value = 0.099 → Marginally significant (at 10%).

The interest rate adversely impacts non-performing loans (NPLs), indicating that elevated interest rates may result in more stringent loan selection or enhanced credit risk management practices. This result is not consistent with so many studies who found a positive relationship between the two variables such as **(Messai & Jouini , 2013)**, **(Shakeel , M.Ejaz, & Eleftherios Thalassinos, 2021)**, **(Gashi, Tafi, & Bajrami, 2022)** and This can be explained by the decrease in the ability of borrowers to meet their obligations which would certainly lead to a higher NPLs.

Inflation: p-value = 0.621 Insignificant.

Our model shows that inflation boosts non-performing loans but not significantly. This agrees with **(Klein, 2013)** and contradicts several research like **(Gashi, Tafi, &Bajrami, 2022),(Szarowska, 2018), (Fajar&Umanto, 2017), (Anjom& Mahbub Karim, 2016),** and **(Angela & Irina, 2015)** that NPL may be positively or negatively affected. Positively, higher inflation rates may make borrowers' payment ability simpler since money's value drops or higher inflation connects to decreased unemployment. Since real income is adjusted to inflation, inflation may make it difficult for borrowers to pay their loans when their income declines despite being constant. Inflation and NPL have two-sided effects.

The results of Table 3. indicate that:

Sargan Instrument test: p-value = 0.754 => Instruments are valid (no issues with over-identification).

The AR(1) autocorrelation test yielded a p-value of 0.152, indicating the expectation of first-order-autocorrelation.

AR(2) autocorrelation test: p-value = 0.842 => Absence of second-order autocorrelation (condition-satisfactory).

The Wald Test indicates global significance with a p-value less than 2.2e-16, confirming the model's overall significance.

Thus, the model relationship takes the following form:

$$Log_NPL = 0.563\ log_NPL_{t-1} - 0.073\ log_BANK_SIZE - 5.119\ ROA + 0.179\ CAR + 0.133\ log_TOTCRDT - 0.024\ log_GDP - 0.046\ EXCHANGE_RATE - 163.613\ INTRATE + 1.400\ INFL + \varepsilon t \ldots\ldots\ldots (1)$$

Table 04: Public Banks' Situation in 2021

Indicator	In thousands of DZD
Regulatory capital	1 187 487 374
Total loans	7 989 911 911
Total classified loans	1 671 872 351
Risk weighted assets	5 674 283 855
Solvency ratio	20,93%

Table 05: Private Banks' Situation in 2021

Indicator	In thousands of DZD
Regulatory capital	354 563 844
Total loans	1 427 703 989
Total classified loans	136 895 479
Risk weighted assets	1 768 586 913
Solvency ratio	20,05%

Table 06: Algeria's macroeconomic factors in 2021

Indicator	Amounts in thousands of DZD
Real GDP Growth	3,8 %
GDP	24 691 322 028
Official Exchange rate per US $	135,06
Interest rate	8%
Inflation	7,2 %

In light of the tables.4 and 5, we observe that Algerian public and private banks have a solvency ratio of20,93% ; 20,05% respectively, which is above the regulatory threshold required by the Algerian central bank of 9.5%.

The model (1) demonstrates a negative correlation between non-performing loans (NPLs) and the exchange rate, as previously noted. Consequently, the applied shocks will result in a reduction in the exchange rate. We will subtract six times and three times the standard deviation from the 2021 exchange rate value to get the adjusted numbers for that year. The following table delineates the essential components for implementing the shocks to the exchange reserves:

4.1. Stress test application:

- ***Shock on exchange rate :***

The shocks used are inspired by the study of (Benachour, Abdlemalek, & Tarhlissia, CREDIT RISK MANAGEMENT THROUGH STRESS TESTING DURING THE COVID-19 CRISIS: CASE OF BANQUE EXTERIEURE D'ALGERIE, 2025) we have chosen to apply two shocks to each variable. These shocks will be six times and three times the standard deviation of the variable in issue. A shock encompassing a six-standard-deviation fluctuation is considered a substantial shock, given that the typical variation around the mean in a normal distribution is around one standard deviation.

The model demonstrates a negative correlation between non-performing loans (NPLs) and the exchange rate, as previously noted. Consequently, the applied shocks will result in a reduction in the exchange rate. We will subtract six times and three times the standard deviation from the 2021 exchange rate value to get the adjusted numbers for that year. The following table delineates the essential components for implementing the shocks to the exchange reserves:

Table 07 : Shocks on exchange rate

Indicator	Amounts in
Standard Deviation (σ)	9.193652
Scenario 1: decrease by an amount of 3*σ	27.580956
Scenario 2: decrease by an amount of 6*σ	55.161912

Table 08 :Values of exchange rate after shocks in both scenarios

Value in 2021	135.00
Scenario 1: value in 2022 after shock	107.41
Scenario 2: value in 2022 after shock	79.83

Table 09: Additional risk after the exchange rate shocks 2022

	Baseline scenario	Scenario 1	Scenario 2
NPL	490,47	217,37	-62,35
Additional risk		-273,09	-552.82

Table 10: The solvency ratio after the exchange rate shocks 2022

	Baseline scenario	Scenario 1	Scenario 2
Regulatory capital	605	605	605
RWA	1789,94	1516,85	1237,12
Solvency ratio	33,80 %	39,88 %	48,90%

We notice that the post-test exchange rate for the year 2021 is positive in both situations.

Consequently, we will advance with both scenarios. Subsequently, we will project the NPL values for the remaining duration using the forecast function in Excel, with the resultant forecasts shown in the following graph:

Figure 01: Prediction of NPL through a choc on exchange rate

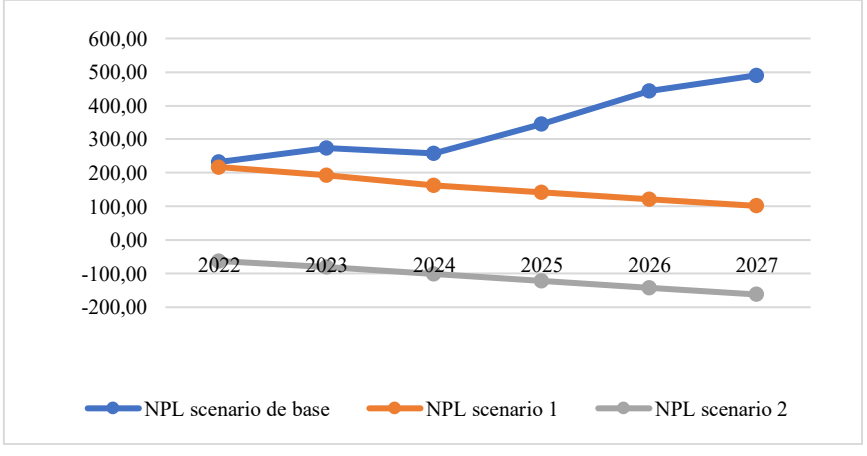


Table 11: The Solvency Ratio After Exchange Rate Shocks (2023-2027)

	2023	2024	2025	2026	2027
Scenario 1	40,55%	41,39%	41,98%	42,56%	43,19%
Scenario 2	49,67%	50,49%	51,39%	52,26%	53,20%

According to the test results, we note that the quality of the bank's credit portfolio is improving. The analysis indicates that the level of non-performing loans declines in both scenarios during the period from 2023 to 2027, ultimately reaching approximately 100 billion DA and -150 billion DA by 2027, respectively. This can be understood through the idea that when currency appreciates (or maintains a stable exchange rate), it positively impacts the economic environment by lowering import costs, which in turn decreases expenses for businesses reliant on imported goods and services. As these expenses decrease, companies experience improved margins, thereby enhancing their ability to manage their debts. This leads to a reduction in non-performing loans (NPLs). And this result not consistent with the study of (Benachour & al, 2025)

- ***Effect on solvency ratio:***

The solvency ratio serves as a crucial metric, enabling banks to evaluate their financial robustness, or in other terms, their capacity to endure potential risks. It is important to note that the solvency ratio is determined by the relationship between regulatory capital and risk-weighted assets (RWA).

In the subsequent analysis, we are going to calculate the solvency ratio for each scenario across the entire period from 2022 to 2027. In this analysis, we will proceed under the assumption that the regulatory capital remains constant, with only the risk-weighted assets (RWA) subject to variation.

The model equation was employed to compute the NPLs for each scenario. The table below presents the quantity of non-performing loans across various scenarios, accompanied by the associated risk factors.

- ***Shock on ROA:***

Table 12: Application of shocks on ROA

	ROA
Standard Deviation (σ)	0.014241
Scenario 1: decrease by an amount of 3*σ	0.042723
Scenario 2: decrease by an amount of 6*σ	0.085446

Table 13:Values of ROA rate after shocks in both scenarios

Value in 2021	0.067800
Scenario 1: value in 2022 after shock	0.025077
Scenario 2: value in 2022 after shock	Negative

- ***Effect on solvency ratio :***

Table 14: Additional risk after the ROA shocks 2022

		Baseline scenario	Scenario 1
NPL	232,32	266,8049856	
Additional risk		34,4849856	

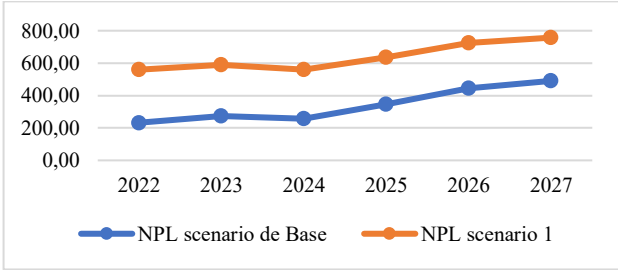
Table 15: The solvency ratio after the ROA shocks 2022

	Baseline scenario	Scenario 1
Regulatory capital	605	605
RWA	1788,28	1940,76
Solvency ratio	33,8 %	31,14 %

Table 16: The solvency ratio after ROA shocks (2023-2027)

	2023	2024	2025	2026	2027
Scenario 1	20,19%	22,9%	24,6%	27,32%	29,4%

Figure 02: Prediction of NPL through a choc on ROA



The test findings indicate a decline in the quality of the bank's credit portfolio. The number of non-performing loans (NPLs) rises after the test throughout the period from 2023 to 2027. Reaching around 790Billion DA in 2027, The current level of non-performing loans raises significant concerns, as they deplete capital while simultaneously undermining management capacity.

- ***Shock on interest rate:***

Table 17 : Shocks on interest rate

	Interest rate
Standard Deviation (σ)	0.003432
Scenario 1: decrease by an amount of 3*σ	0.010296
Scenario 2: decrease by an amount of 6*σ	0.020592

Table 18: Values of interest rate after shocks in both scenarios

Value in 2021	6.0965
Scenario 1: value in 2022 after shock	12.544
Scenario 2: value in 2022 after shock	18.992

- ***Effect on Solvency ratio:***

Table 19: Additional risk after the interest rate shocks 2022

	Baseline scenario	Scenario 1	Scenario 2
NPL	490,47	715,37	993,54
Additional risk		224,90	503,07

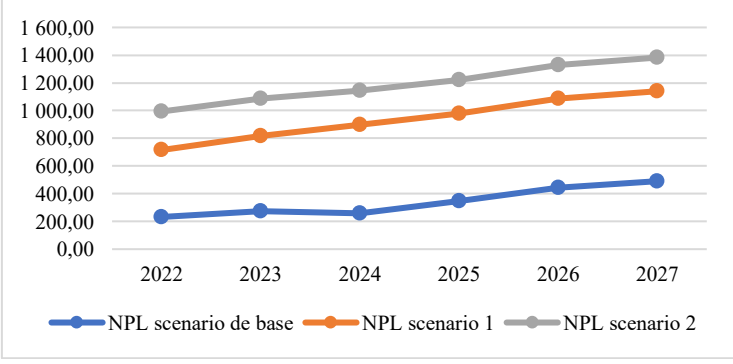
Table 20: The solvency ratio after the interest rate shocks 2022

	Baseline scenario	Scenario 1	Scenario 2
Regulatory capital	605	605	605
RWA	1789,94	2014,84	2293,01
Solvency ratio	33,80 %	30%	26,38%

Table 21: The solvency ratio after interest rate shocks (2023-2027)

	2023	2024	2025	2026	2027
Scenario 1	28,61%	27,55%	26,57%	25,37%	24,80%
Scenario 2	25,37%	24,78%	24,01%	23,02%	22,56%

Figure 03: Prediction of NPL through a choc on interest rate



The test findings indicate a decline in the quality of the bank's credit portfolio. The number of non-performing loans (NPLs) rises after the test throughout the period from 2023 to 2027. Reaching around 1193,64 Billion DA and 1382,80 Billion DA in scenario 1 and 2 respectively in 2027.

- ***shocks on early NPL :***

Table 22: Application of shocks on early NPL

	Log_NPL_{t-1}
Standard Deviation (σ)	2.149265
Scenario 1: decrease by an amount of 3*σ	6.447795
Scenario 2: decrease by an amount of 6*σ	12.89559

Table 23: Values of early NPL after shocks in both scenarios

Value in 2021	0.065000
Scenario 1: value in 2022 after shock	0.054704
Scenario 2: value in 2022 after shock	0.044408

- ***Effect on solvency ratio:***

Table 24: Additional risk after the early NPL shocks 2022

	Baseline	Scenario 1	Scenario
NPL	490,47	533,93	561,64
Additional risk		43,46	71,17

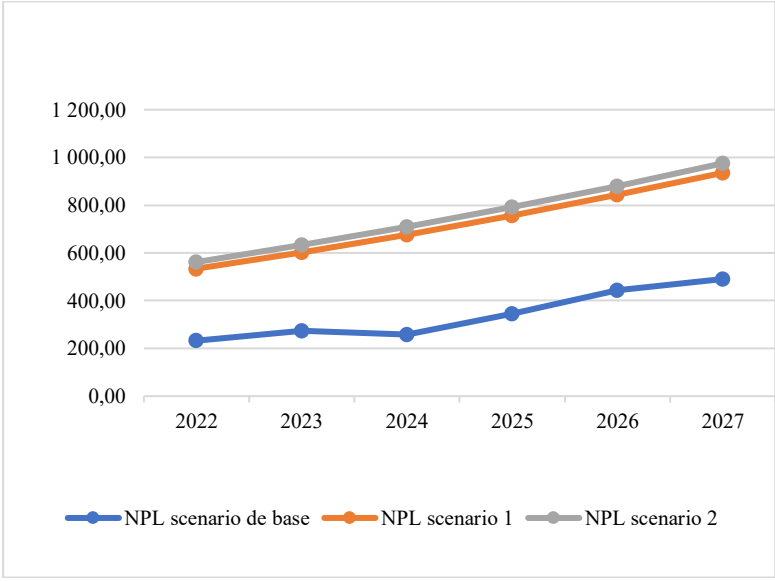
Table 25: The solvency ratio after the early NPL shocks 2022

	Baseline	Scenario	Scenario 2
Regulatory capital	605	605	605
RWA	1789,94	1833,40	1861,11
Solvency ratio	33,80 %	33%	32,50%

Table 26: The solvency ratio after the early NPL shocks (2023-2027)

	2023	2024	2025	2026	2027
Scenario 1	31,81%	30,61%	29,43%	28,24%	27,07%
Scenario 2	31,31%	30,12%	28,94%	27,76%	26,60%

Figure 04: Prediction of NPL through a choc on early NPL



- ***Shocks on Exchange Rate and interest rate Simultaneously:***

We will simultaneously apply the previously used scenarios for each variable (three times the standard deviation and six times the standard deviation) to assess their influence on the bank's credit portfolio. The applied shocks will indicate a reduction in both the interest rate and the exchange rate. Subsequently, we will anticipate the values of NPLs for the remaining time, with the results shown in the below graph (the same calculation methodology is used throughout the duration of the work):

Figure 05: prediction of NPL after the simultaneous shock on the exchange rate and interest rate

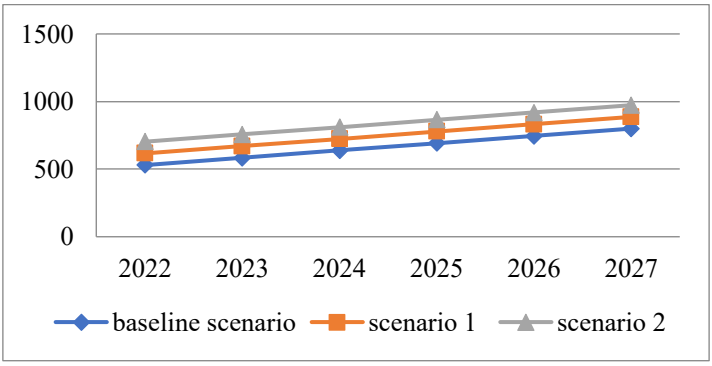


Table 27:additional risk after simultaneous shock on interest rate and exchange rate 2022

	Baseline scenario	SC1 (IR + FX)	SC2 (IR + FX)
NPL	490,47	442,28	440,72
Additional risk		−48,19	−49,75

Table 28: The solvency ratio after simultaneous shock on interest rate and exchange rate in 2022

	Baseline	Scenario 1	Scenario 2
Regulatory capital	605	605	605
RWA	1789,94	1741,75	1740,19
Solvency ratio	33,80 %	34,72%	34,75%

Table 29: The Solvency Ratio After interest rate and exchange rate Shocks (2023-2027)

	2023	2024	2025	2026	2027
Scenario 1	31,94%	29,55%	27,50%	25,72%	24,15%
Scenario 2	32,28%	30,13%	28,25%	26,59%	25,11%

Tables 11, 16, 21, 26, and 29 demonstrate that the post-shock solvency percentage consistently exceeds the Bank of Algeria's 9.5% threshold. This stress test evaluates BNA-Bank's solvency and resilience to provision shocks. These shocks indicate that the bank is well funded and does not require more equity. Consequently, BNA-Bank can endure individual shocks of varying intensity; nevertheless, a macroeconomic shock above our forecasts might jeopardize its stability.

V. POLICY IMPLICATIONS

The results have a multitude of implications for bank managers and regulators:

Improve the resilience of profits: Because ROA shocks have the worst effects, banks should focus on being more efficient, finding new sources of revenue, and improving their provisioning policies.

Stabilize the currency rate: Given Algeria's reliance on imports, policymakers should acknowledge the beneficial contribution a stable dinar makes to the stability of the financial system.

Enhance credit recovery procedures: The ongoing increase in non-performing loan shocks reveals deficiencies in legal enforcement and collection systems, necessitating institutional improvements.

Institutionalize stress testing: Systematic and comprehensive stress testing must be integrated into supervisory practices, overcoming static assessments of individual banks.

Sectoral risk surveillance: Particular emphasis must be placed on concentrated sectors (hydrocarbons, construction, state businesses), since disturbances in these areas might increase systemic risk.

VI. CONCLUSION

This research conducts a comprehensive analysis of the factors influencing non-performing loans (NPLs) in Algerian banks and using stress-testing methodologies to assess the effects of variations in critical macroeconomic variables, including the currency rate, inflation, interest rates, and historical NPL levels. This research employs a dynamic analytical framework, as opposed to the static methodologies used in previous studies, so providing a more thorough comprehension of the impact of significant economic shocks on the stability of the Algerian banking system.

Concentrating only on Algeria addresses a major gap in the literature, considering the nation’s distinctive financial framework and risk landscape. The findings not only corroborate existing correlations between macroeconomic circumstances and credit risk but also offer significant insights for enhancing risk-management strategies. These insights can assist policymakers, regulators, and banking executives in enhancing the resilience of the financial system.

The results of the stress tests, especially concerning BNA-Bank, underscore many strategic concerns. The bank must integrate crisis-specific simulations into its standard risk-management framework, ensuring that capital planning accounts for weaknesses discovered in stress scenarios. Secondly, using an internal credit-rating system would provide a more

precise evaluation of borrowers' financial robustness and anticipated losses in both normal and adverse situations. Third, establishing a comprehensive, routinely updated stress-testing program—created cooperatively among internal departments—would improve the bank's ability to foresee and endure various economic shocks.

The institution must formulate explicit and functional contingency plans, as demonstrated by the interruptions experienced during the COVID-19 crisis. These strategies must delineate reaction methods and ascertain safe cash sources amid financial distress. Ultimately, vigilant oversight of high-risk industries, especially real estate, is vital. Enhancing loan assessment frameworks and refining recovery protocols in these industries would aid in alleviating possible losses during economic downturns.

This research highlights the structural weaknesses in Algeria's banking system and recommends specific risk-management techniques to enhance its stability against future economic challenges.

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