

Stress Tests, Bank Behaviour and Capital Adequacy: Evidence from Africa

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Abstract: This study investigated banks' behaviour before and after stress tests, in addition to the approaches and methods of testing in nine African countries (Egypt, Ethiopia, Kenya, Namibia, Nigeria, South Africa, Sudan, Tanzania, and Zambia). Statistical tests were done through qualitative analysis between November 2021 and January 2022 for bankers. On the one hand, the survey was limited to bankers from 52 African banks, and on the other, quantitative analysis of annual based data from 2009 to 2020 for African banks according to the Banker Database for 21 banks. According to qualitative analysis, the study found a significant difference in banks' behaviour under stress tests by country. Additionally, a significant difference was found in the weight of stress test approaches by country. Bankers prefer to apply sensitivity tests to assess unsystematic risks over scenario tests to assess systematic risks. There are various obstacles to completing the stress test efficiently and effectively among the African countries. On the other hand, according to quantitative analysis, there is a significant difference in the capital adequacy ratio of African banks under stress scenarios among countries under investigation.

Keywords: Bank behaviour, Stress test, Basel, African banker.

JEL codes: E44, G21, G28, N27.

1. INTRODUCTION

The 2008 global financial crisis exposed several dynamic linkages between economic and financial factors. Several banks defaulted due to excessive levels of financial leverage, incompatible due dates for assets, inadequate liquidity to meet financial obligation responsibilities, asymmetric information, and quick changes in financial position items that make it difficult to properly evaluate banks' financial position (Baba et al., 2009; Fernando et al., 2012; Johnson and Mamun, 2012; Prügl 2012; Dumontaux and Pop, 2013; Gambacorta and Paolo, 2014; Kim and Song, 2017). Stress tests have come to represent a regulatory response to the 2008 financial crisis (Shahhosseini, 2022). But, there has been great interest in the characteristics of banks and their performance in emerging markets like Turkey (Saeed et al., 2021; Çolak and Şenol, 2021), China (Lee et al., 2021; Zhang et al., 2021), Taiwan (Fang et al., 2021), Mexico (Cañón et al., 2022) and BRICS market- BRICS: Brazil,

Russia, India, China and South Africa - (Fernandes et al., 2021), but the study did not find the same amount of interest in the ability of banks in emerging markets to face crises; Except in rare studies such as Isik and Uygur (2021) in Turkey and Su et al. (2021) in China. On other hand, there effect of delays in updating prudential regulation on the likelihood of a country experiencing banking crises, and it disentangles the impact of different aspects of regulation on crisis onset (Garriga, 2017).

The topic of stress tests has gained relevance since the financial crisis of 2008. The growing complexity of the financial system and interrelationships among the various risks experienced necessitates stress test implementation for banks. Much of the previous research on banking regulations lacks theoretical and methodological clarity. While many studies explored Western banks, very few have studied African banks. African banks face several limitations when implementing stress tests. This study contributes to the literature by gauging the attitudes of African bankers regarding stress tests and evaluating banks responses to stress test implementation, in addition to evaluating the results of stress tests across nine African countries based on three scenarios for these tests.

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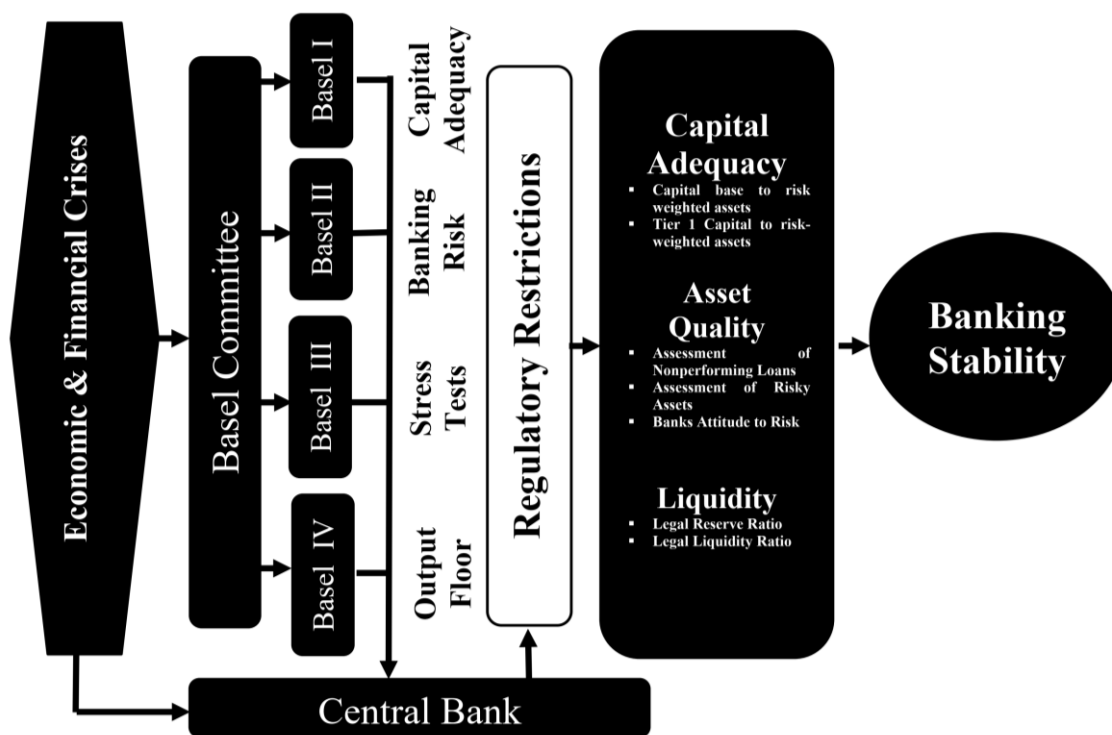


Fig. (1). The Basel Committee on Banking Supervision (BCBS).

2. LITERATURE REVIEW AND THEORETICAL FRAMEWORK

2.1. Basel Committee

The banking environment is relevant to the discussion on banking regulation. Before the 1970s, when banks were functioning in a stable environment and focusing on a restricted range of businesses, the need for managerial control was less of a concern (Billings and Capie, 2004). The business environment has developed since the 1970s, problems of credit risk, guaranteeing depositors’ money appear, leading to greater market risk, and hence, the Basel Committee was established in 1974.

Understanding the dynamics of contagion across financial institutions is the primary goal for regulators and policymakers who want to promote financial stability and avert financial catastrophes (Ballester et al., 2016). In 1988; Basel I mandated that banks must keep at least 8% of their total assets as capital to protect themselves from credit risk; this has raised the relevance of the capital adequacy concept and its evolution in this context. However, Basel I failed to define how much capital banks should have. Subsequently, in 2001, Basel II rules were developed to define the capital adequacy concept, assure the quality of controlling systems, and keep the market discipline in place (Gordy and Howells, 2006). The quality of banking assets has become increasingly important.

Following the 2008 financial crisis, a number of flaws in the Basel II rules and norms surfaced; these included issues associated with high-risk investments, risk management operations, asset assessment, disclosure and transparency, stress

testing and liquidity management, as well as capital adequacy and capital sufficiency. Based on the inadequacies of Basel II, Basel III standards and norms were formulated in 2010.

The Basel IV implementation deadline of 1 January 2023 is quickly approaching. Basel IV introduced new standards for ‘credit risk’, ‘operational risk’, and ‘a credit valuation adjustment’ under part one. Part two comprises the newly introduced concept of ‘output floor’, coupled with revisions to the definition of the leverage ratio and its application to global systemically important banks. A revised market risk framework had already been largely finalised under part two. Presently, the banks have raised concerns regarding the application of the ‘output floor’ at a consolidated and solo level, in addition to the elements of the capital stack to be considered for the output floor.

In conclusion, the performance of banks and the stability of the banking industry depends on an interaction between the bank’s characteristics -Such as Bank’s style (Sbeiti and Alqatan, 2021); Bank’s ownership structure (Maswadeh, 2021); bank’s Corporate governance and credit risk (Dibra and Bezo, 2021) addition to “bank’s size”, banks ratios for “deposit”, “loan”, “profitability”, and “leverage”, affect Capital Adequacy adjustment (Dibra and Bezo, 2021)- and economic variables - Such as “regulatory pressure”, “GDP growth rate”, and “banking system restructuring”- (Batten and Vo, 2019; Dibra and Bezo, 2021) as well as the role of the regulatory authorities (Helmy and Wagdi, 2019). Finally; the stability of banks depends on a purposeful balance of market sector interests under elite control and market crises in the banking industry (Yue et al., 2013).

2.2. Stress Tests

Economics-trained lawyers and economists discuss regulation from an optimization perspective. An important managerial literature is based on reliability. The perspectives are not contradictory, but the economist's view occasionally prioritises decisional simplicity and cost reduction over sophisticated judgement and learning (Simon, 2020). The stress tests aimed to determine how well the banking industry could survive the effects of a severe economic and financial crisis. The first annual bank stress tests started in 2009 for the US banking industry with the Supervisory Capital Assessment Program (SCAP) tests followed by the Comprehensive Capital Analysis and Review (CCAR) tests in 2011 (Shahhosseini, 2022).

According to Dibra and Bezo (2021); that Capital Adequacy adjustment is influenced not only by the bank's characteristics such as "loan ratio", "deposit ratio", "profitability", "leverage ratio", and "size", but also by macro variables such as GDP growth rate, regulatory pressure, and banking system reorganisation.

Stress tests involve simulation exercises to determine a bank's or the financial system's resilience to a hypothetical scenario. A quantitative 'what if' exercise is used to determine resilience in the event of specific shocks. There are two types of tests (Baudino et. al., 2018):

- a. system-wide stress tests undertaken by central banks and/or regulatory bodies,
- b. bank-specific stress tests conducted by banks themselves or supervisors.

stress tests give authorities estimates of individual banks' capital deficits, and if the results are made public, they can aid in re-establishing market trust. The distinction between crisis and normal periods in terms of usage has become more pronounced over time (Alfaro and Drehmann, 2009; Hirtle and Lehnert, 2015; Baudino et. al., 2018). The IMF has developed a well-established framework for stress testing, comprising three approaches: 'accounting-based', 'market price-based', and 'macro-financial-based' approaches (Ramall, 2018).

Ballester et al. (2016) developed a framework to differentiate between 'systematic' (related to international issues) and 'idiosyncratic' contagion (related to bank characteristics), revealing that international linkages are key to the transmission of shocks in the banking industry. The impact of international linkages is also supported by Kim et al. (2020), who concluded that bank diversity may enhance bank financial instability or raise the chance of financial market collapse when idiosyncratic events, such as financial crises, occur. This is despite the fact that the majority of regulators worldwide encourage diversification to mitigate bank risk.

According to the IMF, the key barrier to conducting efficient and effective stress tests in African countries is that they are not based on predictions based on large-scale economic indicators. Many African countries lack the data or experience a large lag in data availability on asset values (e.g. comer-

cial/real estate and land), which hinders efficient and effective stress test implementation (Leika et al., 2020).

2.3. Bank Behaviour Under Stress Tests

According to Cornett et al. (2020), banks increase capital ratios at the starting point for annual stress testing significantly more than non-stress test banks. In case a bank fails the stress test, there are many methods through which banks might fulfil greater capital ratio requirements. By issuing stock and repurchasing debt, banks may re-capitalize their balance sheets while leaving their assets intact. There are other ways for banks to extend their assets, such as by issuing additional stock or selling assets to remove their existing debt (Admati et al. 2018), which in turn impacts the structure of the assets, liabilities, and capital of the bank. Lambertini and Mukherjee (2022) found that the credit-pricing rate increases, which is supported by Cortés et al. (2018); meanwhile, Bassett and Berrospide (2018) found that loan growth is lower, which is supported by Bräuning and Fillat (2020).

3. QUALITATIVE ANALYSIS

3.1. Methodology

A questionnaire targeting African bankers was created using Google forms with sponsored ads and administered via social media (Facebook as main platform) to attract the staff in African banks from countries where English is the commonly-used language. The Google form questionnaires were administered between November 2021 and January 2022 to bankers from Egypt, Ethiopia, Kenya, Namibia, Nigeria, South Africa, Sudan, Tanzania, and Zambia. The survey was restricted to bankers from 52 African banks, out of the 763 banks located across the 54 countries in Africa. The low response rate illustrates the difficulty in gaining access to African bankers, which could be due to confidentiality constraints related to sensitive information. For the analysis, 409 African bankers were selected through random sampling.

The questionnaire was divided into four dimensions based on the African banking context (see Appendix A):

D1: Banks' behaviour around stress tests: Banks' behaviour can be classified into two groups: before and after stress testing (Admati et al. 2018, Bassett and Berrospide, 2018; Cortés et al. 2018; Cornett et al., 2020, Lambertini and Mukherjee, 2022; Bräuning and Fillat, 2020).

D2: Approaches to stress testing: The two main methods used for stress testing are sensitivity tests and scenario tests; these may be used alone or together.

D3: Stress testing objectives: The two main methods used for assessing systematic and unsystematic risks

D4: Obstacles to conducting an efficient and effective stress test: This dimension involves an investigation of data unavailability, lag time in disclosing data, lack of data standardization, weak central banks (regulators), weak experience (human capital), weak technology infrastructure, weak laws and regulations, and corruption.

3.2. Results

3.2.1. Examining the Attitudes of African Bankers Towards Bank Behaviour Around Stress Tests

Tables 1 and 2 present the hypothesis testing results for the examination of bank behaviour around stress tests based on the responses of African bankers.

Table 1. Nonparametric Test Results of the First Hypothesis

Independent-Samples Kruskal-Wallis Test Summary	
Total N	408
Test Statistic	406.134 ^a
Degree of Freedom	8
Asymptotic Sig. (2-sided test)	.000

^a The test statistic is adjusted for ties.

Table 2. Parametric Test Results of the First Hypothesis: Analysis of Variance (D1).

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1098.201	8	137.275	60858.665	.000
Within Groups	.900	399	.002		
Total	1099.101	407			

The statistical results (Tables 1 and 2) reveal the differences in banks' behaviour under stress tests (p<0.01).

3.2.2. Examining the Attitudes of African Bankers Towards the Stress Testing Approaches

Tables 3 and 4 present the hypothesis testing results for the examination of the approaches of stress testing based on the opinions of African bankers.

Table 3. Nonparametric Test Results of the Second Hypothesis.

Independent-Samples Kruskal-Wallis Test Summary	
Total N	408
Test Statistic	394.083 ^a
Degree of Freedom	8
Asymptotic Sig. (2-sided test)	.000

^a The test statistic is adjusted for ties.

Source: Statistical Package for the Social Sciences v.28 output

Table 4. Parametric Test Results of The Second Hypothesis: Analysis of Variance (D2).

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	907.896	8	113.487	2005.372	.000

Within Groups	22.580	399	.057		
Total	930.476	407			

The statistical results in Tables 3 and 4 highlight the difference in approaches of stress testing based on a country (p<0.01).

3.2.3. Examining the attitudes of African bankers towards stress testing objectives

Tables 5 and 6 present the hypothesis testing results for the examination of the Stress testing objectives based on the opinions of African bankers.

Table 5. Nonparametric Test Results of the Third Hypothesis.

Independent-Samples Kruskal-Wallis Test Summary	
Total N	408
Test Statistic	374.287 ^a
Degree of Freedom	8
Asymptotic Sig. (2-sided test)	.000

^a The test statistic is adjusted for ties.

Table 6. Parametric Test Results of the Third Hypothesis: Analysis of Variance (D3).

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	540.348	8	67.544	530.110	<.001
Within Groups	50.838	399	.127		
Total	591.187	407			

The statistical results (Tables 5 and 6) show the difference in stress testing objectives based on a country (p<0.01).

3.2.4. Examining the Attitudes of African Bankers Towards Obstacles to Conducting an Efficient and Effective Stress Test

Tables 7 and 8 present the hypothesis testing results for the examination of the obstacles of the stress test based on the opinions of African bankers.

Table 7. Nonparametric Test Results of the Fourth Hypothesis.

Independent-Samples Kruskal-Wallis Test Summary	
Total N	408
Test Statistic	363.490 ^a
Degree of Freedom	8
Asymptotic Sig. (2-sided test)	.000

^a The test statistic is adjusted for ties.

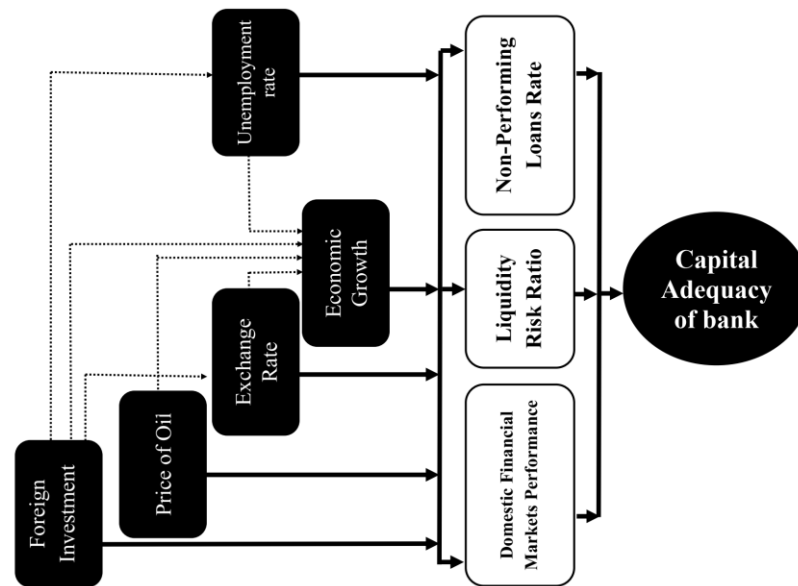


Fig. (2). The quantitative analysis layout.

Table 8. Parametric Test Results of the Third Hypothesis: Analysis of Variance.

D4					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1147.056	8	143.382	298.900	<.001
Within Groups	191.400	399	.480		
Total	1338.456	407			

The statistical results (Tables 7 and 8) reveal the difference in obstacles of the stress test ($p < 0.01$).

3.3. Discussion

This study found a significant difference in banks' behaviour under stress tests by country. Furthermore, a significant difference was found in the weight of the most likely approach between accounting-based, market price-based and macro-financial-based approaches based on a country when applying stress tests addition to sensitivity tests.

This study interprets African bankers attitude according to the differences' (1) the efficiency and effectiveness of financial and economic information systems, whether governmental or non-governmental, (2) the level of independence of the central bank, (3) economic flexibility, (4) pattern of the interest rate structure, (5) human experiences (representing human capital), (6) the structure of the financial system, and finally (7) the nature of markets and financial institutions in each African country.

Bankers prefer to apply sensitivity test to assess unsystematic risks over scenario tests to assess systematic risks. Applying a scenario test is the most likely approach when assessing the risk of an exchange rate, a securities bubble; On

the other hand, there was a lack of preference for applying a scenario test as the most likely approach when assessing a real estate bubble risk. The study can explain this according to the weakness of the African mortgage market. For a sensitivity test, it is the most likely approach when assessing a bank's liquidity risk and credit risk. On the other hand, there was a lack of preference for cyberattacks risk; The study can explain this according to the poor of technological banking services in the African banking industry.

There are various obstacles to completing the stress test efficiently and effectively among the African countries under investigation. According to the descriptive analysis, the lowest level of obstacles to achieving effective and efficient stress tests were seen in Egypt, Nigeria, and South Africa.

4. QUANTITATIVE ANALYSIS

4.1. Methodology

Using the Capital Adequacy Ratio (CAR), the study seeks to measure the bank's available capital, in order to determine and face risks in African banks approved by the Committee, under normal conditions, and measure the capital adequacy ratio required under three scenarios of "Stress Testing" for normal and abnormal conditions is embodied.

$$\text{Capital Adequacy Ratio} = \int \text{Non-performing loans rate} + \text{Domestic financial markets performance} + \text{Liquidity risk ratio} + \text{Macroeconomic Variables Function No.1}$$

The first function explains the proposed framework for determinants of the bank's capital adequacy ratio through the dynamic groups. It includes the rate of Non-Performing Loans (NPL), the Performance of Domestic Financial Markets (PDFM), Liquidity Risk Ratio, and macroeconomic variables. Both of them are intermediate variables, transferring changes in the business environment resulting from changes in the macro economy to the bank. The macroeconomic variables are based on the flow of direct and indirect foreign investment affects the economy as a whole.

4.2. Quantitative Analysis Variables

Fig. (2) shows that the bank has many dynamic relationships with domestic and international economic variables. The variables of quantitative analysis as follows:

Table 9. Quantitative Analysis Variables.

Variables	Symbol	Measurement
Independent Variables	GGDP	Economic growth according to growth of gross domestic production
	UNEMP	Unemployment rate
	FX	The natural logarithm of exchange rate of the national currency against the US Dollar
	OPI	The log of Price of a Barrel of Oil based USD
	FDI	The natural logarithm of net foreign Direct Investment based USD
	FPI	The natural logarithm of net foreign indirect Investment (Securities portfolio) based USD
Intermediate Variable	NPL	Ratio of Non-performing loans to total loans
	LRR	Liquidity risk ratio
	MCE	The natural logarithm of market capitalization of domestic exchange
Dependent Variable	CAR	Capital Adequacy Ratio

4.3. Data Collection

The study used an annual based data from 2009 to 2020 for African banks according to the Banker Database for 21 banks from nine African countries. In addition to macroeconomic variables according to the World Bank database for

Table 10. Test Method According to ARDL.

First Stage	Second Stage	Third Stage	Fourth Stage	Fifth Stage	Sixth Stage
an augmented Dickey–Fuller test (ADF) tests	Pounds Test	ARDL ERROR (Correction Regression)	Conditional Error (Correction Regression)	Estimating the relationship in the long term	Growth Quality Test The CUSUM-of-squares test Jarque–Bera test

Table 11. Scenarios of Stress Tests.

Drop of Foreign Indirect Investment (Securities portfolio)	Drop of Foreign Direct Investment	Oil Prices Increase	Currency Depreciation	Unemployment Rates Increase	Drop of Economic Growth	
FPI	FDI	OPI	FX	UNEP	GGDP	The main scenario
0%*	0%*	0%*	0%*	0%*	0%*	The black case scenario
- 20%	- 20%	+20%	- 20%	+20%	- 50%	
- 50%	- 50%	+50%	- 50%	+50%	- 150%	The worst-case scenario

* Stable based on three-year average for each country.

Egypt, Ethiopia, Kenya, Namibia, Nigeria, South Africa, Sudan, Tanzania, and Zambia. Such data was tested according to ARDL in table (10); while Table (11) presents three scenarios of stress tests that were investigated for African banks.

The test is carried out in two stages: the first seeks to estimate the intermediate variables, and the second stage seeks to estimate the dependent variable (Capital Adequacy) under three scenarios of stress tests.

The study exams stationary of data to make sure that the mean and variance were at a significance level of less than 0.05. on other hand. The study removed the outliers using winsorization at 1% for the continuous variables before examining the capital adequacy within ARDL.

4.4. Examining the Capital Adequacy Based on African countries

Tables 12 presents the hypothesis testing results for the examination of the capital adequacy based on African countries under three scenarios of stress tests.

Table 12. Nonparametric Test Results of the Fifth Hypothesis.

Independent-Samples Kruskal-Wallis Test Summary	
Total N	63
Test Statistic	16.156 ^a
Degree of Freedom	8
Asymptotic Sig. (2-sided test)	.04
^a The test statistic is adjusted for ties.	

The statistical results (Tables 12) reveal the difference in the average Capital Adequacy Ratio according to the three scenarios of stress tests (p<0.05). Fig. (3) shows the range of change at the country level

According to Fig. (3), Egypt, Nigeria, and South Africa have the strongest banks under the economic shocks, while the rest of the countries under investigation, banks that suffer from clear weaknesses in facing these shocks.

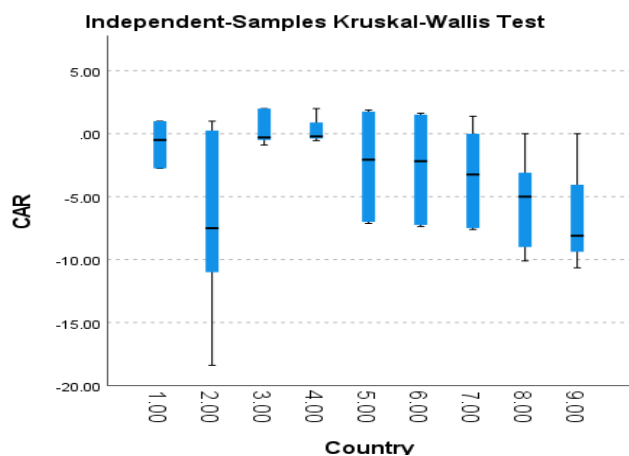


Fig. (3). Change of capital adequacy at the country level.

4.5. Discussion

The independent variables in the short term does not have an effect on the capital adequacy rate in the current period, except the economic growth, as it is affected by the first nullification periods for the rest of the variables, In contrast to the inverse relationship with for each of unemployment rate and the oil price, all of the significant indices at a confidence interval (5%), that is due to the impact of macroeconomic variables which come late on both the rate of non-performing loans, the performance of domestic financial markets, and Liquidity risk ratio.

The study, also, found a positive long-term equilibrium relationship between the capital adequacy ratio with economic growth, FPI, and FDI at (5%) as expected, since the rise of GDP contributes to the financial stability of African countries in a way that enhances confidence and reduces the risks of investment and employment. This has an impact on capital adequacy ratio.

The increase in the value of FPI and FDI is an indication of investors' assessment of risks and the financial environment, where the performance of banks is affected accordingly. It is also noted that the sensitivity of the capital adequacy ratio to the exchange rate. However, the African economies is open, the high exchange rate of its national currency makes, it more competitive at the international level. This boosts its exports of goods and services and boosts tourism, FPI and FDI.

Many factors contributed to the variation in the results of stress tests in the African countries under investigation. Banks in different countries have different structures for their assets and liabilities. In addition to differences in the regulatory rules, the structure of the economy and the flow of foreign investment among African countries

5. CONCLUSIONS

The purpose of stress testing is to clarify the dynamics between the strength of the bank's financial position and major macroeconomic variables. Diverse macro prudential regula-

tions were implemented following the financial crisis of 2008 (at the level of G7 as well as emerging markets), which contributed to the emergence of Basel III. However, there is evidence of rate manipulation using a difference-in-differences approach to compare changes to mislead the results of stress tests (Clark, 2022). Therefore, the authors recommend that central banks need a variety of stress testing tools and methodologies to reduce the impact of this unethical practice. Basel IV norms are intended to supplement Basel III changes and contains many significant revisions to core Basel III provisions, such as 'large exposures', 'leverage ratio', 'liquidity', 'counterparty credit risk', and 'market risk', in addition to developing control and supervision systems to ensure financial stability (Feridun and Özün, 2020).

According to qualitative analysis, African bankers refer to data characteristics (unavailability, lag time, and standardized), weak independence of the central bank, Corruption and weak technology infrastructure are obstacles to conducting an efficient and effective stress test, most countries have not begun implementing changes of Basel IV, effective application of stress tests on banks requires the availability of appropriate information, which may not be available in many African countries due to the small size of the economy, poor coverage from major financial institutions (such as Fitch, Moody's, and Standard & Poor's) for many African countries, addition to unethical practices. But these restrictions are minimal for Egypt, Nigeria, and South Africa.

On the other hand, the study found a significant difference in the average capital adequacy ratio according to the three scenarios of stress tests based on economic shocks, including "Drop of economic growth", "unemployment rates increase", "Currency Depreciation", "Oil Price Increase", "Drop of Foreign Direct Investment," and "Drop of Foreign Indirect Investment". These shocks are transmitted to the bank's financial position through three mediating variables: "The Rate of Non-Performing Loans", "The Performance of Domestic Financial Markets", and "Liquidity Risk Ratio".

According to quantitative analysis, Egypt, Nigeria, and South Africa have the strongest banks under the economic shocks, while the rest of the countries under investigation, have banks that suffer from clear weaknesses in facing these shocks. Many factors contributed to the variation in the results of stress tests in the countries under investigation. African banks in different countries have different structures for their assets and liabilities - this agrees with Büyüksalvarcı and Abdioğlu, 2011; El-Ansary & Hafez, 2015; Wagdi et al., 2019-. In addition to differences in the regulatory rules -this indirectly agrees with Cecchetti and Li, 2008 but directly agree with Helmy and Wagdi, 2019-, the structure of the economy - this indirectly agrees with both "Aktas et al., 2015" and "Batten and Vo, 2019"- and the flow of foreign investment among African countries

Finally; Stress Tests are considered a complementary tool, and not a substitute for the rest of the risk management tools. Such risks are different in nature in African banks than in Western banks, even if they are similar to the methods and tools on which the measurement is based.

The study recommends developing Basel IV norms to keep pace with unethical practices in some banks, who may justify

these practices to maintain profitability levels; however, these unethical practices hamper financial stability. Basel IV should be more effective in reducing these practices through the integration of modern management accounting tools and big data analysis under the umbrella of RegTech.

The study recommends that African central banks should issue a report similar to the quarterly 'FR Y-9C' data, as it helps increase transparency in the banking industry, which would translate to the stability of this industry in African countries. Moreover, banks should adopt the Africa Initiative to support the dissemination of financial and economic data through cooperation with major financial institutions by obtaining support from Financial Stability Board.

The study agrees with Diaz Diaz et al., 2017, governments should continue their efforts to regulate governance in order to boost consumer trust in the banks. When doing so, they should take into account size as an important component. Benvenuto et al. (2021) also referred to this indirectly

Last recommendation, theoretical and applied frameworks for stress tests in banks, should be developed and improved to keep pace with the rapid changes in the business environment, to develop the design of hypothetical scenarios through simulation using artificial intelligence with Big Data analysis.

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