

Testing Weak Form of Efficiency: Evidence from selected African stock markets

اختبار الكفاءة ذات الصيغة الضعيفة : أدلة من بعض الأسواق المالية الافريقية

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Abstract

This study aims to test a weak-form efficiency of selected financial markets over the period of 2023-2024. Sample study consists of financial market indices for a number of African markets. The African countries concerned in this study are Algeria, Ghana, Morocco, Nigeria, Tunisia and BRVM (a regional market for eight 8 African countries).

Applying variance ratio test, runs test and autocorrelation test to assess whether stock prices follow a random walk, we revealed that only two financial markets, namely, Morocco and BRVM, exhibit a weak-form efficiency. The other markets are inefficient based on the results of three tests. This study is one of the first to include the Algiers Stock Exchange in the sample.

Keywords: Runs test, Autocorrelation tests, Variance ratio test, African stock market, Random walk model.

JEL Classification: G14

ملخص

تهدف هذه الدراسة إلى اختبار الكفاءة الضعيفة لبعض الأسواق المالية المختارة خلال الفترة الممتدة من 2023 الى 2024 وتتكون عينة الدراسة التطبيقية من مؤشرات الأسواق المالية لعدد من الدول الافريقية. هذه الدول المعنية في هذه الدراسة هي الجزائر, غانا , المغرب , نيجيريا , تونس وبورصة BRVM وهي سوق تشمل ثمان بلدان افريقية. وبتطبيق اختبار التباين واختبار التكرارات واختبار الارتباط الذاتي لتقييم ما اذا كانت أسعار الأسهم من خلال المؤشرات تتبع نموذج السير العشوائي كشفنا أن سوقين ماليين فقط (المغرب و BRVM) يظهران كفاءة ضعيفة الشكل أما الأسواق الأخرى فهي غير كفؤة وهذا استنادا الى نتائج الاختبارات الثلاثة المطبقة. وتعد هذه الدراسة من بين أولى الدراسات التي أدرجت بورصة الجزائر ضمن العينة.

الكلمات المفتاحية: اختبار التكرارات، اختبار الارتباط الذاتي، اختبار التباين، الأسواق المالية الإفريقية، نموذج السير العشوائي.

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Introduction

The idea of efficiency of financial markets introduced by Fama (1965, 1970) (Fama, *Efficient Capital Markets: A Review of Theory and Empirical Work*, 1970) is considered a far-off subject of finance linked to the reflection of Abdmoulah (Abdmoulah, 2010) on the distribution of financial flows. Efficient markets are characterized by the impact of information on stock market prices. These are also good estimates of their intrinsic values. The difference between stock prices and intrinsic values is reported as having a random meaning (Fama, *The behavior of stock-market prices*, 1965). (Malkiel, 2003) in this research, have an idea that current prices are variations having a stochastic character by comparison with old prices.

Investors believe that there are situations where stocks are undervalued. Investors who manage to identify and buy undervalued shares can realize large profits by selling those shares at high prices. In the opposite case, we see that there are investors wary of the idea of efficient markets and strategies incurred by active traders. These sceptics argue that if opportunities for excess returns do not exist, there is little incentive to engage in active trading. They also contend that the fees charged by active managers indicate low transaction costs in efficient markets.

Investors, practitioners and academics have very different views on the theory of financial market efficiency, as it is stated in financial theory that there are three forms, namely the strong form, the semi-strong form and the weak form. Those who believe in the strong form of efficiency have reflections similar to that of Fama (1970) (Fama, *Efficient Capital Markets: A Review of Theory and Empirical Work*, 1970), they are passive investors. Supporters of the weak form believe that trading assets can achieve abnormal returns by arbitrage.

Efficiency theory has also been of interest to governments and financial market regulators. An efficient market means that stock prices incorporate available information and reflect core values. A failure of the principle of efficiency can lead to misallocation of funds, which requires action to correct inefficiencies. In the opposite case of the ideal market, free trade systems are expected to allow efficient allocation of resources motivated by rational investor behaviour.

At present, there is no consensus among researchers as to the existence of any form of market efficiency in several financial markets. Researchers generally accept the idea that developed financial markets have a low-meaning efficiency approved (Karemera, Ojah, & Cole, 1999);

(Abdmoulah, 2010). For financial markets in emerging countries, researchers have some vague results (Fuss, 2005); (Nwosu, Orji, & Anagwu, 2013); (Ozkan, 2021). Several factors made a difference in the results of these studies, such as the region, time, sample or methodology used in the research.

Our study focuses on some of the African financial markets. Recently, African financial markets have developed rapidly due to their importance in economic growth and financing of investment and infrastructure projects, as well as the financial needs of foreign investors. But with the exception of the financial markets in South Africa, markets in other countries are underdeveloped (Ntim, Opong, Danbolt, & Dewotor, 2011). These markets are characterised by their size being smaller. This mainly concerns their market capitalization, and the number of companies' side. According to Farid (Farid, 2013) the stock market capitalization of these African countries represents less than 20% of the world's capitalization.

The Johannesburg stock exchange, the largest in Africa, has only 350 companies; on the other hand, these African countries suffer from the liquidity problem compared to other financial markets in the world, as it also suffers from the very low number of transactions (Mlambo & Biekpe, 2005). These questions raise the problem of their efficiency.

Since this study, our research aims to contribute to existing literature on the efficiency of financial markets. First, this paper addresses under-explored markets such as Algeria, Ghana, Morocco, Nigeria, Tunisia and the Bourse Régionale des Valeurs Mobilières (BRVM). This one is a stock exchange located in Abidjan, Côte d'Ivoire. Nigeria and Ghana have been relatively well studied on the issue of information efficiency. For Algeria, on the other hand, the question of efficiency has been remarkably under-explored, and our research aims to fill this gap. Secondly, the article focuses on recent developments in order to draw a comparison of the results with other studies on the one hand, and on the other hand, we want to identify emerging trends or contradictions in this historical context.

The remaining sections of this research paper are structured as follows. The second section provides a literature review on the subject. Then the methodology of the study is explained, followed by empirical results. Discussion of the results lead to conclusions that finalize the paper.

1. Literature review

Market efficiency is a metric used to measure how far market prices incorporate information that provides the maximum number of opportunities to purchasers and sellers of securities to effect transactions without increasing transaction costs. This process effects a transaction without necessarily having to increase transaction costs. Basically, the market is assumed to be large and liquid. For this reason, it is essential that investors have access to cost information. This efficiency means that the transaction costs should be low-priced compared to the expected strategy profits from investment. However, it is not possible to continuously do well in the market, especially where the prices of stock in the market are difficult to predict, within a short period of time. Whether or not markets are efficient, or to what degree, has been a heated topic of debate among academics and practitioners in the last 50 years.

(Fama, *Efficient Capital Markets: A Review of Theory and Empirical Work*, 1970) has provided an extensive explanation of his theory of Efficient Market Hypothesis (EMH) and through this explanation has identified three forms of efficiency. The weak form suggests that all past market prices are reflected in current prices. The semi-strong form of EMH extends beyond historical prices and suggests that all publicly available information is instantly priced into the market. This includes financial statements, news releases, economic indicators, and other public disclosures. It is therefore inconceivable and illogical that technical analysis or basic analysis should lead to abnormal returns. Therefore, efficiency in its strong form confirms that all types of information (public and private) are reflected in prices. The conclusion of this analysis is that it is impossible to beat the market and that exceptional and anomalous situations in the market are quickly corrected and incorporated into prices.

Since its inception, the EMH has prompted extensive empirical investigations into market efficiency across various contexts. Most studies have concentrated on the weak form of efficiency, which is considered less restrictive and more likely to be applicable across diverse markets. Nevertheless, tests of the weak form of efficiency allow consideration of the possibility of estimating return-based stock prices in the past, which could be beneficial for investors

As developed countries' financial markets have weak form of efficiency (Karemera, Ojah, & Cole, 1999); (Abdmoulah, 2010), there are mixed results in emerging financial markets. Some

studies confirm that emerging markets have a weak form (Fuss, 2005); (Ntim, Opong, Danbolt, & Dewotor, 2011); (Abdmoulah, 2010). On the contrary, some researchers (Wheeler, B., Kowalski, & Letza, 2002); (Marashdeh & Shrestha, 2008); (Omran & Farrar, 2006) rejected tests for the weak form in emerging markets.

Among the interesting theories regarding the efficiency of financial markets, (Lo, The adaptive markets hypothesis: market efficiency from an evolutionary perspective, 2004) argues that efficiency in fact has a dynamic characteristic and that its components include market conditions, competition, and employability of participants, investors and evolutionary choice. (Lo, The adaptive markets hypothesis: market efficiency from an evolutionary perspective, 2004) noted that with different market conditions over time, market efficiency may arise periodically and in an irregular manner. The reason for periodic efficiency is structural changes and behavioral biases of investors as well as external events. At the conclusion of his research, (Lo, The adaptive markets hypothesis: market efficiency from an evolutionary perspective, 2004) came up with the Adaptive Market Hypothesis (AMH). This new theory of efficiency connects some important elements between them. It links classical financial theory with modern behavioral finance methodology. The latter is to associate behavioral prejudices with the concept of rationality. The Adaptive Market Hypothesis (AMH) states that the degree of market efficiency has to do with environmental factors that characterize the specific market performance.

In instances where the market is considered inefficient by the EMH, as well as in instances where the prices of securities cannot be predicted and follow random walk (weak-form efficiency), the AMH can explain the discrepancy between the assumption of rationality of EMH and behavioral biases. (Soteriou & Svensson, 2017) who had tested the AMH in the context of Sweden, suggest that the AMH is a more complete version of EMH, as it assists in consideration of a periodic market inefficiency. This new framework causes an interesting implication that emerging markets may enhance their efficiency as their underlying environmental conditions improve. This has been evidenced in various studies across emerging economies such as Turkey (Antoniou, Ergul, & Holmes, 1997), Russia (Abrosimova, Dissanaik, & Linowski, 2002), Romania (Harrison & Paton, 2004) and some other countries.

Recent studies focusing on recent anomalies such as the Covid-19 pandemic have validated the theory of AMH. (Ozkan, 2021) discovered deviations from market efficiency at different times during the COVID pandemic 19 and this concerns 6 economies of developed countries. As for emerging markets, (Topcu & Gulal, 2020), shows a negative impact of the COVID-19 pandemic in all regions in terms of weak efficiency. In the same vein, it was revealed that the lowest impact was in Central and Eastern Europe while the largest deviation was from emerging markets in Asia. Thus, the testing of Africa's weak form of efficiency by many academics is of interest to understand whether or not results change by time.

2. Methodology

In order to demonstrate the efficiency of Africa's financial markets referred to above, we must establish the theory of indiscriminate walking by applying some models to a sample of exchange indices for six financial markets, including the Algiers Stock Exchange, which has emerged in recent years.

2.1 The random walk concept

Random walk efficiency market hypothesis (RWEMH) states that changes in stock prices move randomly over time, and future securities' returns contain no information from past securities' returns, beside their mean-variance values (Statman, 2011). Efficient markets are characterized by information on the actual prices of securities (at any time), which are also a good estimate of their intrinsic value. In case the prices deviate from their intrinsic values, prices diverge randomly from intrinsic values (Fama, 1965). According to random walk theory in the finance literature, the current prices are random departures from previous prices (Malkiel, 2003).

There are several mathematical models to examine the efficiency of the financial market in its weak form. Some studies examine the linear dependence in stock returns, using such tests as autocorrelation tests, variance ratio tests, run and unit root tests (Urquhart & Hudson, 2013). Other studies implement different tests to explore non-linear dependencies (Hsieh, 1989; Lee *et al.*, 1993; Kruger *et al.*, 2012)

In our study, we utilize the linear dependence-based approach. The hypothesis of the random walk states that in an efficient market, successive variations of prices follow the random gaussian variable.

A financial asset's price series P_t follow a random walk (Campbell *et al*, 1997) if:

$$P_t = \mu + P_{t-1} + \epsilon_t,$$

$$\epsilon_t \sim \text{IDD}(0, \sigma^2), \quad (1)$$

Where: P_t is the logarithm of the stock market index at time t ; μ is an arbitrary drift parameter;

$\epsilon_t \sim \text{IDD } N(0, \sigma^2)$
: *independently and identically distributed with zero mean and unit variance (σ^2)*

2.2 Data

This article examines the weak form of the efficiency hypothesis of selected African financial markets. Stock market indices of six African financial markets were tested during the period from 1/1/2023 to 31/3/2024. In this study three tests, namely the runs test, the autocorrelation test and the variance ratio test are used to determine whether stock prices follow the random walk or not. These tests are applied for all the stock indices that constitute our study sample. This sample is made up of 6 African financial centers (Algeria, Tunisia, Morocco, Ghana, Nigeria and BRVM), one of which is a Regional Stock Exchange (BRVM: Bourse Régionale des Valeurs Mobilières) for 8 countries in West Africa.

The study utilized data from the “Il Boursa” database, a Tunisian financial website specializing in stock exchange information. While the platform primarily focuses on Maghreb countries—Algeria, Tunisia, and Morocco—it also includes financial and economic data from other African markets, enabling the construction of a comprehensive sample for our study.

The database provides stock prices and market indices for selected markets in three-month intervals. To compile data for an extended period, manual renewal of data requests was required for every three months.

The daily closing market indices extracted from the “Il Boursa” database, were used to test the weak-form efficiency. Table 1 presents the preliminary statistics about the sample study, namely

the name of each stock market index, the period of time series, and the number of observations per financial market.

Table1. Preliminary statistics about the sample.

	ALGERIA	BRVM	GHANA	MOROCCO	NIGERIA	TUNISIA
Name of the stock index	DZIDX	BRVM - 30	GSEC	MASI	NGSE	TUNINDEX
Series data period	01/01/2023 to 31/03/2024	01/01/2023 to 31/03/2024	01/01/2023 to 31/03/2024	01/01/2023 to 31/03/2024	01/01/2023 to 31/03/2024	01/01/2023 to 31/03/2024
Number of observations	174	325	276	323	74	314

Source: Omar BOUFAMA, Elena ROGOVA, 2025.

The collected data was processed for further analysis. No missing values were present in the sample. Daily stock market prices were obtained for all stock exchanges in the selected countries, except for the Algiers Stock Exchange and the BRVM, where market indices are quoted only three days per week. To maintain consistency, the most recent available quotation was carried forward for the intervening days, aligning with the exchange's three-day trading schedule. While the thin trading activity on these markets raises potential concerns - as quoted prices may not fully reflect true market values on non-trading days - previous research (Khadri, 2023) notes that the market remains relatively illiquid with limited intra-week volatility. Given these conditions, the assumption of price stability between trading days does not materially compromise the robustness of our sample or findings.

2.3 Methods of study

To test the time series of stock market indices for the African financial markets included in the sample, we need to perform several statistical tests to confirm the random walk of returns on stock market indices. We initially run the variance ratio test for (Lo & MacKinlay, Stock Market Prices Do Not Follow Random Walks: Evidence from a Simple Specification Test, 1988) but if the random walk hypothesis of the time series is rejected, additional tests are required, the most important being the runs test and autocorrelation test.

2.3.1 Variance Ratio test

(Lo & MacKinlay, Stock Market Prices Do Not Follow Random Walks: Evidence from a Simple Specification Test, 1988) discovered that when k random variables are independent and equally distributed, the variance of their sum is equal to k times the variance of one of these variables. Assuming that future equity returns are not influenced by past or current equity returns, the variance of returns over several k -day intervals should be equal the daily variance of returns multiplied by k where k is the number of these selected intervals.

Under the assumption of market efficiency or random walk this variance ratio statistic follows a normal distribution. With a mean of 0, we expect that on average, k -days variance should equal k time's daily variance. This would mean that this on average equals to 0 and has variance σ^2 , and this variance parameter can be estimated from the number of observations that we have and the length of the interval that we use. In summary, the variance ratio (VR) test proposed by (Lo & MacKinlay, Stock Market Prices Do Not Follow Random Walks: Evidence from a Simple Specification Test, 1988) is conducted through several steps outlined below:

Step 1: To determine the variance of returns, we first calculate the respective returns over the selected intervals and then compute the variance for this series of returns.

Step 2: To calculate the variance ratios, we use the k -day variance as the numerator and multiply the number of days in the interval (k) by the 1-day variance for the denominator. We then normalize it to an expected value of 0 by subtracting 1:

$$\text{Variance ratio} = \frac{k\text{-day variance}}{k \times \text{daily variance}} - 1. \quad (2)$$

Next, we calculate the variance of variance ratio:

$$\sigma^2 = \frac{2(k-1)(2k-1)}{3kn}. \quad (3)$$

Step 3: We then compute the standard deviation of the VR and derive the corresponding z -statistics to perform a z -test for calculating p -values and testing the null hypothesis. Since our expected value of VR is 0, we divide the observed VR by its standard deviation to obtain our z -statistic.

Step 4: To obtain p-value, we need to subtract from 1 the value of the normal standard distribution of absolute value of z-stat and cumulate.

In conclusion, if p-values are less than $\alpha=0.05$, it means that the null hypothesis is rejected at 5% level of significance, and the stock returns do not follow the random walk and that there is a significant deviation of the variance ratio from 0.

2.3.2 Runs Test

The runs test aims to test the randomness of the returns' series. A run is defined as a sequence of successive returns of the same sign. Thus, a positive run of length (i) consists of successive positive returns preceded and followed by a negative or zero return. A negative run is defined in the same way, that is, it consists of negative returns preceded and followed by a positive or zero return.

Given a series of price changes, each price change is determined by sign (+) if the price change is in excess or a sign (-) if the price change is in decrease. The result is a series of positive and negative signals as: ++ + - ++ - ++ + + + and calculates the number of times the price changes differently such as a negative price change followed by a positive change. To test independency, the number of price changes is compared to the table of expected values for the number of changes that must occur in a random series. The financial market is considered efficient when the number of positive runs and the number of negative runs should be close. The runs test is widely used to verify dependency in time series that the series correlation test was unable to detect.

The runs test is applied following steps to tell at the end if the data series prove the low form of efficiency. First, we will have to attribute a positive or negative sign to each observation that is part of the stock index series for all stock markets in the sample.

Then we will have to calculate for the whole series, the number of positive signs n_1 the number of negative signs n_2 and the total number of signs of price changes (r). The average number of runs μ_r is calculated according to the following formula:

$$\mu_r = \frac{2 n_1 n_2}{n_1 + n_2} + 1 \quad (4)$$

Where, n_1 and n_2 indicates respectively the number of positive and negative signs. The standard deviation $\hat{\sigma}_r$ of the number of runs is calculated as follows:

$$\hat{\sigma}_r = \sqrt{\frac{2 n_1 n_2 (2 n_1 n_2 - n_1 - n_2)}{(n_1 + n_2)^2 (n_1 + n_2 - 1)}} \quad (5)$$

This formula can also be calculated as follows based on the average of the runs (μ_r):

$$\hat{\sigma}_r = \sqrt{\frac{(\mu_r - 1)(\mu_r - 2)}{n_1 + n_2 - 1}}. \quad (6)$$

Since too few runs in the case would indicate that the movement of prices is not random. We employ a two-tailed test the randomness of prices. Test at 5% level of significance at $(n_1 + n_2 - 1)$ degrees of freedom using t-table:

$$\text{The lower limit : } \mu_r - t * \sigma_r$$

$$\text{The upper limit : } \mu_r + t * \sigma_r$$

The value of (t) at a specific level of significance and a specific degree of freedom is to be found. For a sample of size (n), the t-distribution will have (n-1) degrees of freedom, where $(n = n_1 + n_2)$.

It is therefore necessary to determine whether the value of (r) lies between these limits, hence the market exhibits a weak form of efficiency.

2.3.3 Autocorrelation Test

The autocorrelation test is considered a reliable approach to detect random stock price movements. This is valid for stock prices, or stock exchange prices. The correlation coefficient is intended to measure the relationship between the return of stocks or stock index in the current period and its value in an earlier period. It is used to determine the relationship between stock or stock market index returns in current and past periods. It aims to determine the autonomy of equity returns compared to others by testing the correlation coefficients of equity returns or stock market index, in the current period with values from their previous periods.

To begin with, it is necessary to split data series into 2 equal parts, for example if data for 20 days is given then first 10 days is termed as series one and last 10 days data is termed as series 2. Then we calculate the changes in share prices or stock market prices as a percentage of value. To

calculate the correlation coefficient (r) we will first need to calculate the standard deviations of both variables (x) and (y) and the covariance of x and y , as follows:

$$\sigma_x = \sqrt{\frac{\sum (x - \bar{x})^2}{N}}$$

$$\sigma_y = \sqrt{\frac{\sum (y - \bar{y})^2}{N}}$$

$$Cov_{x,y} = \frac{\sum (x - \bar{x})(y - \bar{y})}{N} \quad (7)$$

The correlation coefficient ($r_{x,y}$) is calculated as follows:

$$r_{x,y} = \frac{Cov_{x,y}}{\sigma_x \times \sigma_y}. \quad (8)$$

If weak positive or negative correlation is found then the market exhibits weak form of efficiency, more precisely, the correlation coefficient must be confined between -0.25 and +0.25. Otherwise, if the correlation is not between -0.25 and +0.25 hence the market is not weak-form efficient.

3 Empirical results

The African financial markets sample is tested with the variance-ratio test, which is based on random-walk theory. This test was applied to the intervals $k = 2, 4, 8, 16$ days of the available data for each African market. The duration of time series for each African market is the same, from 1/1/2023 to 31/3/2024, but the number of observations varies from one market to another due to several factors, particularly the regulatory provisions for each market as indicated above. Table 1 summarizes the results of (Lo & MacKinlay, Stock Market Prices Do Not Follow Random Walks: Evidence from a Simple Specification Test, 1988) non-parametric variance ratio tests. As we see that for daily returns, the hypothesis of random walk at a significance level of 5% was accepted for the Algerian financial market, the regional financial market (BRVM) and the Moroccan financial market while this hypothesis was rejected for other markets, especially for Nigeria and Tunisia.

Table 1. Results of Variance ratio test.

ALGERIA					
n= 173					
K	1	2	4	8	16
Variance	0.0001	0.0001	0.0003	0.0005	0.0009
VR		-0.1279	-0.1935	-0.2558	-0.3432
Variance of VR		0.0058	0.0202	0.0506	0.1120
Std		0.0760	0.1422	0.2249	0.3347
Z-stat		-1.6822	-1.3603	-1.1375	-1.0256
P-value		4.63%	8.69%	12.77%	15.25%
BRVM					
n= 324					
K	1	2	4	8	16
Variance	0.0000	0.0000	0.0001	0.0002	0.0003
VR		-0.0986	-0.1034	-0.0760	-0.0352
Variance of VR		0.0031	0.0108	0.0270	0.0598
Std		0.0556	0.1039	0.1643	0.2445
Z-stat		-1.7752	-0.9949	-0.4627	-0.1438
P-value		3.79%	15.99%	32.18%	44.28%
GHANA					
n= 275					
K	1	2	4	8	16
Variance	0.001	0.0002	0.0005	0.0011	0.0025
VR		0.1022	0.1959	0.3181	0.4566
Variance of VR		0.0036	0.0127	0.0318	0.0705
Std		0.0603	0.1128	0.1784	0.2654
Z-stat		1.6942	1.7367	1.7831	1.7202
P-value		4.51%	4.12%	3.73%	4.27%
MOROCCO					
n= 322					
K	1	2	4	8	16
Variance	0.0000	0.0001	0.0002	0.0004	0.0006
VR		0.1554	0.2103	-0.0975	-0.2304
Variance of VR		0.0031	0.0109	0.0272	0.0602
Std		0.0557	0.1043	0.1648	0.2453
Z-stat		2.7888	2.0176	-0.5912	-0.9393
P-value		0.26%	2.18%	27.72%	17.38%
NIGERIA					
n= 273					
K	1	2	4	8	16
Variance	0.0001	0.0003	0.0007	0.0019	0.0061
VR		0.2026	0.4948	1.1591	2.4461

Variance of VR		0.0037	0.0128	0.0321	0.0710
Std		0.0605	0.1132	0.1790	0.2664
Z-stat		3.3482	4.3700	6.4743	9.1819
P-value		0.04%	0.00%	0.00%	0.00%
TUNISIA n= 313					
K	1	2	4	8	16
Variance	0.0000	0.0000	0.0001	0.0002	0.0005
VR		0.2237	0.5383	0.9214	1.2900
Variance of VR		0.0032	0.0112	0.0280	0.0619
Std		0.0565	0.1057	0.1672	0.2488
Z-stat		3.9569	5.0902	5.5110	5.1849
P-value		0.00%	0.00%	0.00%	0.00%

Source: Omar BOUFAMA, Elena ROGOVA.

Results obtained through the Variance ratio test using actual daily returns show that the random walk hypothesis has been accepted for some time series only at the significance level of 5%. Markets whose null hypothesis has been accepted are imposed by markets with high market capitalization and the number of companies registered with it considered. But this is not applicable to the Algerian financial market, where the index is composed only by four listed companies,

So, the null hypothesis has been rejected in favor of the alternative hypothesis for Ghana, Nigeria and Tunisia for all intervals $k = 2, 4, 8, 16$ days, this means that the mentioned market index series does not follow the random walk, resulting in investors taking advantage of the opportunity to make abnormal returns. The second statistical test to demonstrate the random walk comportment of financial markets index series is the runs test; the results are presented in Table 2.

Table 2. Basic run analysis statistics.

	ALGERIA	BRVM	GHANA	MOROCCO	NIGERIA	TUNISIA
Series Data Period	01/01/2023 to 31/03/2024	01/01/2023 to 31/03/2024	01/01/2023 to 31/03/2024	01/01/2023 to 31/03/2024	01/01/2023 to 31/03/2024	01/01/2023 to 31/03/2024
Number of observations (n)	174	325	276	323	274	314
Number of runs (r)	44	159	103	148	106	142
Number of positive signs	33	162	112	168	149	171
Number of negative signs	18	144	88	140	97	142
Average of runs (μ_r)	24.29	153.47	99.56	153.73	118.50	156.16
Standard deviation of runs (σ_r)	3.22	8.70	6.95	8.69	7.48	8.76
Lower Limit at 5%	17.98	136.42	85.94	136.70	103.85	139.0
Upper Limit at 5%	30.61	179.53	113.18	170.76	133.16	173.32

Source: Omar BOUFAMA, Elena ROGOVA.

The number of runs must be within the limits specified by the lower and upper limits of the statistics. For example, in the case of the Algerian financial market, the number of runs is high but not within the lower and upper statistical levels. This indicates that the Algerian financial market is inefficient in its weak form. On the contrary, the null hypothesis was accepted for the rest of the financial markets included in the sample at a significance level of 5%, indicating that the time series of index returns of these markets follow the random walk, this leads us to say that these markets are efficient in their weak form as shown in Table 4.

Table 3. Summary of results for the runs test.

	<i>t-statistic at 5%</i>	<i>t-statistic at 1%</i>	<i>t-statistic at 10%</i>
ALGERIA	(r) lies outside the range	(r) lies outside the range	(r) lies outside the range
BRVM	136.42<159<170.53	Weak-Form Efficiency	Weak-Form Efficiency
GHANA	85.94<103<113.18	Weak-Form Efficiency	Weak-Form Efficiency
MOROCCO	136.70<148<170.76	Weak-Form Efficiency	Weak-Form Efficiency
NIGERIA	103.85<106<133.16	Weak-Form Efficiency	No Efficiency
TUNISIA	139.0<142<173.32	Weak-Form Efficiency	Weak-Form Efficiency

Source: Omar BOUFAMA, Elena ROGOVA.

The third test we have conducted to test the random walk approach of time series that represent the returns of the stock exchange indexes of some African financial markets is Autocorrelation. The results of this test are summarized in Table 4.

As previously mentioned, this test is performed after the time series of the index's return has been distributed into two equal groups and the Autocorrelation coefficient has been normally calculated according to the formulated equation. The serial correlation coefficient must be confined between -0.25 and + 0.25 to accept the null hypothesis i.e., the index's return follows the random walk which means that the financial market is efficient in its weak form.

Table 4. Results of Autocorrelation test.

	Name of market index	Number of observations	Autocorrelation coefficient
Algeria	DZIDX	86	0.0293
BRVM	BRVM - 30	161	-0.0037
Ghana	GSEC	137	0.0336
Morocco	MASI	160	0.0428
Nigeria	NGSE	136	0.1277
Tunisia	TUNINDEX	156	-0.0066

Source: Omar BOUFAMA, Elena ROGOVA.

All the correlation coefficients shown in the table are close to zero, including two negative coefficients, but all six coefficients have values limited between -0.25 and + 0.25. Therefore, all African financial markets belonging to the sample study accept the null hypothesis that the stock exchange indexes return follow in their distribution the random walk and therefore have a weak form of efficiency.

4 Discussion

The results obtained in this study, which includes 6 varying African financial markets, are mixed. According to three different tests conducted, only two markets—the Moroccan Stock Exchange and the BRVM Regional Stock Exchange—exhibit weak-form efficiency, as detailed in Table 6. The results for the remaining four markets indicate a lack of weak-form efficiency. Specifically, the Variance Ratio test revealed inefficiency in the financial markets of Tunisia, Nigeria, and Ghana, while Algeria's market was assessed using the runs test, showing that the number of runs fell outside the acceptable limits.

Table 5. The results of three tests.

	Variance ratio test	Runs test	Autocorrelation test
Algeria	efficiency	inefficiency	efficiency
BRVM	efficiency	efficiency	efficiency
Ghana	Inefficiency	efficiency	efficiency
Morocco	efficiency	efficiency	efficiency
Nigeria	Inefficiency	efficiency	efficiency
Tunisia	Inefficiency	efficiency	efficiency

Source: Omar BOUFAMA, Elena ROGOVA.

This study’s results—evaluated through three models testing the weak-form efficiency hypothesis under random walk theory—align with prior empirical work, particularly (Ntim, Opong, Danbolt, & Dewotor, 2011). With the exception of Morocco, other national indicators are weakly qualified in at least one of the three tests applied in this study. This divergence may reflect Morocco’s more developed regulatory framework, higher liquidity, or integration with global markets compared to its regional peers. The Casablanca Stock Exchange (CSE), representing Morocco’s financial market, is the second-largest in our sample (after Nigeria) and has undergone significant reforms to position itself as a leading financial hub in the MENA region. In 2021, the CSE replaced its legacy index, MADEX (phased out in 2022), with the MSCI20 - a benchmark aligned with global standards and better suited to international investors' needs. Since 2018, new bylaws have been implemented to increase transparency and reduce equity concentration among institutional majority holders, promoting broader market participation. These reforms underscore Morocco’s commitment to financial modernization, likely contributing to its relative weak-form efficiency compared to other African markets in our study. Conversely, a study of (Benthabet & Benthabet, 2023) shows that the Moroccan market enjoyed weak efficiency during the period 2010-2019.

Similar to previous studies by (Nwidobie, 2014), (Obayagbona & Igbinosa, 2015), and (Viktor, 2012), we reject the notion of weak-form efficiency for Nigeria, suggesting persistent market anomalies (e.g., autocorrelation, seasonal effects). Additionally, (Mlambo & Biekpe, 2005) did not find evidence supporting weak-form efficiency in other tested countries.

A notable finding pertains to Algeria, where the stock market demonstrated weak-form efficiency according to variance ratio tests. Algeria has been overlooked in prior research due to

its relatively small market size. Despite the Algiers Stock Exchange being operational since 1999, it remains small and lacks significant internationalization or growth incentives. The exchange is not affiliated with any regional or continental associations, which suggests that these results should be interpreted cautiously and require further investigation. The BRVM index also adheres to the random walk model, indicating weak-form inefficiency, a conclusion consistent with the broader literature on African markets (the broader indices demonstrate better efficiency than the stock prices in separate markets).

Conclusion

This study investigated the efficiency of African financial markets through the lens of three widely recognized tests, revealing that the majority do not conform to the conditions of weak-form efficiency. The primary objective was to underscore the challenges faced by these markets in their quest for development and competitiveness on a global scale, with the ultimate goal of attracting investors and enhancing the financial capabilities of local companies. The findings indicate a significant misalignment between the current state of financial markets and the demands of emerging economies, highlighting an urgent need for regulators to adopt a proactive policy in addressing these issues. Inefficient markets may benefit from reforms enhancing transparency, liquidity, and investor protection. Policymakers should focus on improving market infrastructure, enhancing transparency, and fostering a more conducive environment for financial market development to promote efficiency and attract investment.

However, this research is not without its limitations. A notable constraint is the exclusive reliance on linear testing methods, which may overlook certain market anomalies or non-linear relationships that could influence our findings. While existing literature suggests that non-linear tests do not substantially differ from their linear counterparts, expanding the range of analytical methods employed would be beneficial. Additionally, given the unique characteristics of African financial markets, it would be prudent to explore the Adaptive Market Hypothesis through time-varying efficiency studies.

Further limitations pertain to our sample selection and the period of our analysis. Although we focused on recent data, extending the timeframe could yield valuable insights, particularly in light of ongoing economic fluctuations. Future research should consider these factors to provide a more

comprehensive understanding of the dynamics at play within African financial markets. In addition, Algeria's outlier status highlights the need for granular studies on small, illiquid markets.

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