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Original Article

Evolving Weak Form Market Efficiency in BRICS+ Markets

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Abstract

The Efficient Market Hypothesis (EMH), particularly in its weak form, remains a subject of debate, especially in emerging and developing markets where structural, institutional, and behavioral factors may hinder informational efficiency. The recent enlargement of the BRICS group to BRICS+ now includes a wider range of diverse economies. Therefore, a thorough reexamination of weak-form market efficiency across these markets is required. This study explores weak-form efficiency in BRICS+ stock markets and determines if stock returns follow a random walk or display predictable trends over time. This study analyzes daily returns of nine stock indexes including Brazilian, Russian, Indian, Chinese, South African, Saudi Arabia, Egyptian, and United Arab Emirates, and Indonesian between January 2006 and December 2024. We employed run tests, unit root tests (Augmented Dickey-Fuller and Phillips-Perron), and variance ratio tests to determine the randomness and predictability of returns. Conflicting evidence emerges from the empirical analysis of weak-form efficiency. On one hand, randomness is supported by both run tests and unit root tests for every BRICS+ index. On the other hand, variance ratio tests produce significant results that contradict the random walk hypothesis. Such opposing findings indicate that BRICS+ stock markets are not consistently weak-form efficient. They instead confirm the Adaptive Market Hypothesis, a framework that is only partially applicable and varies with context. This hypothesis is influenced by evolving economic circumstances, the maturity of institutions, and the actions of investors. It highlights the need to adopt adaptive investment strategy and flexible regulation strategies in dynamic market environments.

Keywords: Adaptive Market Hypothesis, BRICS+ Stock Markets, Efficient Market Hypothesis (EMH), Weak Form.

1. Introduction

The existence of efficiency stock market is still debated among researchers, and the evidence is mixed (Peón et al., 2019; Verheyden et al., 2015). The Efficient Market Hypothesis (EMH) which was suggested by Fama (1970) stated all the information all information available in the market, both what has already happened and what is expected, is reflected in the price. Hence, investors couldn't take abnormal returns using technical analysis based on trend and historical prices. This theory supported by several academics such as (Bertone et al., 2015; Busse et al., 2010; Carhart, 1997; Fama & French, 2010; Lettau & Van Nieuwerburgh, 2008; Shiller, 1981). While the weak form EMH has received substantial empirical support in developed markets, its validity in emerging markets remains an open and contested question.

Emerging and developing stock markets often deviate from weak-form efficiency due to structural and institutional factors such as lower liquidity, thin trading, information asymmetry, limited investor sophistication, and regulatory imperfections (Bondt & Thaler, 1985; Shiller, 1981). Behavioral theory critiques the EMH, which is stated that investors often behave irrationally and experience cognitive biases, heuristics, and sentiment-driven behavior, which can generate predictable patterns in asset prices (Barberis et al., 1998; Kahneman & Tversky, 2013). These irregularities bring forward critical concerns about whether weak-form efficiency is suitable, particularly for markets that are quickly transforming in both their institutions and financial systems.

In this regard, global finance has been interested in the BRICS economies stock markets. The BRICS countries, Brazil, Russia, India, China and South Africa were originally coined by Goldman Sachs in the year 2001 as a way of identifying emerging economies or countries that would take over the world economy by 2050. The addition of new countries including Egypt, Ethiopia, Iran, the United Arab Emirates, and Indonesia to such an economic and political bloc by the 2024 to 2025 timeframe demands a strict reassessment of market efficiency within these diverse economies. The empirical literature on weak form efficiency in BRIC stock markets presents contradictory findings. A portion of the research points to a progressive movement toward weak form efficiency, notably in India and Brazil. In contrast, other studies reveal that inefficiencies and long range cross dependencies continue to persist, particularly in China (Mobarek & Fiorante, 2014). In the authors' assessment, earlier empirical research has not explicitly evaluated the Efficient Market Hypothesis when applied as an analytical framework to the BRICS+ stock markets. Current studies are mostly limited to country specific or pre-expansion BRICS studies, thus missing out the effects of the recent expansion of the bloc and how the market integration of the bloc members is changing.

BRICS+ represents not merely a membership expansion of BRICS but also a more heterogeneous economic configuration compared to the previous BRICS grouping. New members such as Indonesia, Egypt, the United Arab Emirates, Ethiopia, and Iran possess varying levels of capital market development, institutional quality, financial sector depth, and regulatory frameworks relative to the original BRICS members. These characteristic differences have the potential to influence information dissemination processes, market liquidity, investor behavior, and the degree of financial integration across countries. Consequently, findings on market efficiency derived from the traditional BRICS grouping may not necessarily be generalized to the BRICS+ context, which exhibits a higher degree of economic and financial heterogeneity (Sayed & Charteris, 2024).

From a theoretical perspective, the BRICS+ expansion may affect stock market efficiency through two competing mechanisms. On the one hand, enhanced economic cooperation, trade, cross-border investment, and financial market integration can accelerate information flows such that stock prices more rapidly reflect available information. The greater the financial market integration among members, the higher the likelihood of information transmission that supports market efficiency. On the other hand, the diversity in levels of economic development, institutional quality, market transparency, and financial regulation among new members may increase information asymmetry and market fragmentation (Ben Salem & El Aoun, 2025; Cortés Rufé & Martí Pidelaserra, 2024). Such conditions may give rise to differences in efficiency levels among BRICS+ member countries. Accordingly, the impact of the BRICS+ expansion on stock market efficiency remains an empirical question requiring further examination.

Although research on stock market efficiency in BRICS countries has advanced considerably, several research gaps remain unaddressed. First, the majority of prior studies have focused on traditional BRICS members and have yet to consider the implications of the BRICS+ expansion that commenced in the 2024-2025 period. Second, research examining whether the greater economic and financial heterogeneity within BRICS+ produces distinct market efficiency patterns compared to the previous BRICS grouping remains limited. Third, the connection between rising financial integration as a result of the BRICS+ expansion and the weak form market efficiency observed in each member country remains underexplored. To address these research gaps, this study evaluates weak form market efficiency in BRICS+ nations by employing a set of complementary testing procedures.

2. Literature Review

2.1. Theoretical Foundation of the Efficient Market Hypothesis

2.1.1. The Efficient Market Hypothesis

Fama (1970) provided a formal definition of the Efficient Market Hypothesis (EMH), stating that asset prices completely incorporate all available information. As a result, investors cannot achieve abnormal returns on a consistent basis. The present research concentrates on weak-form efficiency, under which current prices already reflect all past market data. This implies that historical price information cannot be used to forecast future price movements. The random walk hypothesis provides the theoretical grounding for weak-form efficiency, proposing that price changes from one period to the next are both independent and identically distributed. Furthermore, Campbell et al. (1998) argued that weak-form efficiency is the most fundamental level of market efficiency and must be present before any stronger forms of efficiency can be established.

Empirical support for the EMH has been documented by several scholars. Empirical studies generally provide support for the EMH. Previous research suggests that financial markets have become increasingly efficient due to technological advancements, improved information dissemination, and greater market sophistication (Bertone et al, 2015). Evidence from mutual funds and professional portfolio managers indicates that consistently outperforming the market after accounting for risk and transaction costs remains difficult (Busse et al., 2010; Carhart, 1997; Fama and French, 2010). Moreover, apparent return predictability may often be explained by structural changes in macroeconomic conditions rather than violations of market efficiency (Lettau and Van Nieuwerburgh, 2008).

2.1.2. Critiques of the EMH: Behavioral Finance Perspective

Despite its theoretical elegance and empirical support in developed markets, the EMH has been subjected to extensive criticism, particularly from the behavioral finance paradigm. A systematic review by Yen & Lee (2008) concluded that the EMH faced significant challenges from behavioral finance scholarship that documented investor psychological biases, irrational behavior, and recurring market anomalies that became increasingly apparent from the 1990s onward. Shiller (1981) was among the earliest to challenge the EMH by demonstrating that stock price fluctuations were excessively large relative to what could be justified by later dividend adjustments. This observation suggests that speculative behavior and irrational exuberance are present in financial markets.

Kahneman and Tversky (1979) put forward Prospect Theory, revealing that individuals evaluate profits and losses using different standards. This leads to loss aversion and reference-dependent preferences, both of which contradict the rational agent assumption that forms the foundation of the EMH. Barberis et al. (1998) developed a formal model of investor sentiment incorporating two well-documented psychological biases, namely representativeness and conservatism, showing how these biases can generate both underreaction and overreaction patterns in security prices. Bondt and Thaler (1985) offered foundational evidence of overreaction in stock markets. Their findings showed that portfolios comprising past losers substantially outperform portfolios of past winners across subsequent holding periods of three to five years. This pattern contradicts the predictions of weak form efficiency.

These behavioral anomalies are particularly pertinent to emerging and developing markets, where structural and institutional factors such as lower liquidity, thin trading, information asymmetry, limited investor sophistication, and regulatory imperfections tend to amplify cognitive biases and sentiment-driven behavior (Bondt & Thaler, 1985; Shiller, 1981). The assumptions that support the EMH, most notably rational investors and well-functioning arbitrage, are less likely to be valid in these environments. As a result, fundamental questions arise about the relevance of weak-form efficiency within these particular contexts.

2.2. Alternative Theories to the Efficient Market Hypothesis

2.2.1. The Adaptive Market Hypothesis

Lo (2004) proposed the Adaptive Market Hypothesis (AMH), which has since emerged as the most significant and empirically grounded alternative to the EMH. This hypothesis brings together the Efficient Market Hypothesis and behavioral finance by using evolutionary biology as a framework for understanding financial markets. The AMH maintains that market efficiency is a phenomenon characterized by change and adaptation, not permanence. This efficiency evolves progressively as markets adapt to fluctuating conditions, competitive dynamics, and institutional advancements. During periods of relative stability, investors adapt to market conditions, and efficiency tends to prevail. However, during periods of market stress, structural change, or unprecedented events, behavioral biases and irrational behavior may dominate, leading to predictable patterns and temporary inefficiencies.

Compared to the traditional EMH, the AMH delivers a more sophisticated understanding of market behavior, as it allows for the coexistence of efficiency and inefficiency phases within a single market over time. Such a framework proves especially applicable to emerging and transition economies, in which markets undergo rapid institutional shifts and face diverse economic shocks. Mandaci et al. (2019) offered empirical findings that support the AMH, demonstrating that efficiency levels in markets shift with changing conditions, different stock indices, and various time periods. Such variation is particularly evident in emerging and transition economies. Likewise, Xiong et al. (2019) found that the AMH serves as a more effective framework than the traditional EMH for capturing the behavior of market efficiency in China's stock market.

The Adaptive Market Hypothesis offers a framework that is especially suitable for examining BRICS+ stock markets. Member nations show considerable variation in institutional quality, market development, investor profiles, and regulatory systems. As a result, market efficiency is likely to differ both across these countries and across different time periods, rather than staying fixed. This perspective complements the traditional EMH and provides a theoretical basis for investigating whether BRICS+ stock markets uniformly satisfy weak-form efficiency.

2.2.2. Other Alternative Market Hypotheses

The literature has offered multiple frameworks beyond the Adaptive Market Hypothesis to explain why financial markets exhibit departures from efficiency and random walk behavior, as reviewed by Nyakurukwa and Seetharam (2023). Examples include the Noise Trader Approach (Shleifer & Summers, 1990), the Coherent Market Hypothesis (Vaga, 1990), the Fractal Market Hypothesis (Peters, 1994), the Heterogeneous Market Hypothesis, the Discovering Market Hypothesis (Kleinheyer & Mayer, 2020), the Novelty Narrative

Hypothesis (Mangee, 2021) and the Intersubjectivity Market Hypothesis (Bocher, 2022) These perspectives provide valuable understanding of investor behavior and market dynamics, yet the current study does not directly use them to formulate its hypotheses. Consequently, this research is primarily grounded in the Efficient Market Hypothesis and the Adaptive Market Hypothesis as the principal theoretical foundations for investigating weak-form efficiency in BRICS+ stock markets.

2.3. Empirical Evidence on Weak-Form Market Efficiency

2.3.1. Evidence from Developed Markets

Empirical investigations of weak-form market efficiency across developed and developing nations have produced mixed and often conflicting findings (Mobarek & Fiorante, 2014). Evidence from developed markets generally supports weak-form efficiency, although the degree of efficiency varies across countries and testing methodologies. Studies conducted in Taiwan and several European markets found that stock prices largely follow random walk behaviour, although certain markets continue to exhibit temporary inefficiencies attributable to institutional and market-specific factors (Lock, 2007; Worthington, AC; Higgs, 2006).

In European markets, the evidence is similarly heterogeneous. Borges (2010) investigated weak-form efficiency across several European stock markets and found that countries such as Germany and Spain exhibited efficient market behavior, whereas Greece, Portugal, France, and the United Kingdom displayed evidence of market inefficiency. The variance in efficiency across European markets suggests that even within developed economies, institutional differences, market microstructure, and regulatory environments can influence the degree to which markets conform to weak-form efficiency.

2.3.2. Evidence from Emerging and Developing Markets

In contrast to developed markets, evidence from emerging and developing economies generally reveals more frequent departures from weak-form efficiency. Studies conducted in Bangladesh and the Czech Republic found that stock returns exhibit predictable patterns and fail to satisfy random walk behaviour, suggesting the presence of market inefficiencies (Mobarek et al., 2008; Arltova, 2000). Similar findings were reported for Malaysia, where financial ratio analysis continued to provide predictive power for stock returns, indicating that historical and publicly available information had not been fully incorporated into market prices (Kheradyar et al., 2011).

However, evidence from India suggests that market efficiency is not static but evolves over time as financial markets mature and institutional quality improves (Hiremath & Kumari, 2014). Broader cross-country analyses further reveal substantial heterogeneity among emerging markets in Latin America, the Middle East, and North Africa, where efficiency levels differ considerably across countries and periods (Hadhri & Ftiti, 2017). More recent studies continue to document inefficiencies in emerging markets arising from information asymmetries and structural constraints, creating opportunities for abnormal returns (Nguyen and Parsons, 2022). Furthermore, evidence from Thailand during the COVID-19 recession suggests that market efficiency may deteriorate during periods of systemic stress, as stock prices fail to adjust immediately to new public information (Kim, 2025).

2.3.3. Evidence from BRICS Markets

Research on market efficiency within the BRICS economies has yielded mixed and sometimes contradictory findings. According to Mobarek and Fiorante (2014) BRIC markets are gradually transitioning to weak form efficiency. Their findings demonstrate that anomalies including the day of the week effect decline over time and that random walk characteristics strengthen, even during the subprime financial crisis episode. Nalin & Guler (2015) similarly determined that the BRIC and Turkish markets exhibited weak-form efficiency when monthly closing prices were examined, supporting the random walk hypothesis at lower frequency data. Kulikova et al., (2024) found that BRICS markets, with the exception of China, show a tendency toward weak-form efficiency that is time-varying and crisis-affected, with India emerging as the most efficient market among the group.

At the country level, the evidence reveals important heterogeneity. For Brazil, Chen and Metghalchi (2012) and Terence et al. (2009) both identified Brazil as the most efficient market among the BRIC countries. For Russia, the efficiency level appears contingent upon data frequency: Abrosimova et al. (2002) found that weak-form efficiency holds only for monthly data, with significant deviations observable in daily and weekly frequencies. McGowan, Jr. and Ibrihim (2009) identified a strong calendar day-of-the-week effect anomaly in the Russian market, suggesting weak-form inefficiency, while McGowan, Jr. (2011) later observed that the Russian market underwent maturation enabling greater efficiency after 2000. Conversely, Terence et al. (2009) rated Russia as the most inefficient among the BRIC markets.

For India, Poshakwale (1996) discovered a strong seasonal tendency in daily returns between 1987 and 1994, inconsistent with weak-form efficiency, while Gupta & Yang (2011) found that the Indian stock market exhibited weak-form efficiency during 2007 to 2011 in quarterly and monthly data. For China, Lim et al. (2009) documented time-varying efficiency, and Liu (2011) found that the Chinese stock market was not weak-form efficient during 2000 to 2008. Malafeyev et al. (2019) demonstrated that Chinese and Indian stock market returns exhibit non-linear correlations amenable to forecasting through specific techniques, thereby failing to satisfy weak-form efficiency. Fifield and Jetty (2008) concluded that institutional reforms are significant in enhancing market efficiency, although information asymmetry remains a persistent limitation.

A major limitation of current research is that no study has directly tested the Efficient Market Hypothesis on BRICS+ stock markets as a single analytical framework. The bloc recently expanded to include Saudi Arabia, Egypt, the United Arab Emirates, and Indonesia around 2024-2025. This expansion adds further diversity in institutional arrangements, regulatory systems, and market structures, all of which remain unexplored in a systematic manner. Previous studies have been predominantly limited to country-specific analyses or the pre-expansion BRICS grouping, thereby missing the effects of the bloc's expansion and the changing dynamics of market integration among its members.

2.4. Hypothesis Development

Leveraging the theoretical bases and empirical evidence discussed above, the current investigation proposes and evaluates the subsequent hypotheses related to weak form efficiency across BRICS+ equity markets.

2.4.1. Hypothesis 1

Fama (1970) originally defined weak form efficiency under the classical EMH as a condition where stock returns in BRICS+ markets follow a random walk. This means that price changes from one period to the next are independent of each other. To investigate this condition, researchers use the runs test, which assesses whether a series of rising and falling returns is random or shows persistent patterns. When the actual count of runs matches the expected count under the randomness assumption in a statistical sense, the result confirms that returns are serially independent.

H1a: Stock returns of BRICS+ markets follow a random walk process and are independently distributed over time.

2.4.2. Hypothesis 2

The Augmented Dickey Fuller (ADF) and Phillips Perron (PP) unit root tests serve as the methods for evaluating stationarity in stock return series. Stationarity means that the series does not exhibit time varying mean, variance, or autocovariance. If the returns are found to be stationary, this implies an absence of enduring price trends and verifies that historical price information has already been absorbed into current prices. These conditions are consistent with weak form efficiency. Drawing upon the evidence that BRIC markets have shown gradual transitions toward efficiency (Kulikova et al., 2024; Mobarek & Fiorante, 2014), we hypothesize that:

H2a: Daily stock returns of BRICS+ markets are stationary

2.4.3. Hypothesis 3

A more rigorous technique for testing the random walk hypothesis, known as the variance ratio test, was developed by Lo and MacKinlay (1988). The test determines whether the variance of returns over multiple periods is proportional to the holding period duration. If the random walk hypothesis is valid, the variance ratio must be unity at every horizon, thereby demonstrating that no serial correlation exists. However, given the extensive evidence of predictable return dynamics in emerging markets (Lim et al., 2009; Malafeyev et al., 2019; Nguyen & Parsons, 2022), and the behavioral and structural factors that characterize BRICS+ economies, we hypothesize that:

H3a: Stock returns of BRICS+ markets do not follow a random walk process when assessed through variance ratio tests.

3. Methods

3.1. Data Collection

The research sample in this study is the BRICS+ stock index, consisting of IBOV (Brazil), RTSI (Russia), NIFTY (India), SHCOMP (China), JALSH (South Africa), SASEIDX (Saudi Arabia), EGX30 (Egypt), and DFMGI (United Arab Emirates), and JSKE (Indonesia). The data used is adjusted closing prices for 19 years, from January 1, 2006, to December 31, 2024. The data was collected through Bloomberg.

3.2. The Variables

The analysis utilizes daily stock returns from the BRICS+ stock index. These returns serve as the study's variables and are obtained using the following calculation.

$$R_{it} = \log\left(\frac{P_{it}}{P_{it-1}}\right)$$

Rt = daily stock return
Pit = stock price in period t
Pit-1 = stock price in period t-1

3.3. Data Analysis

This study adopts four complementary techniques, namely the Runs Test, the Augmented Dickey Fuller (ADF) Test, the Phillips Perron (PP) Test, and the Variance Ratio (VR) Test, in order to provide a thorough assessment of weak form efficiency in BRICS+ stock markets. The selection of these methods is based on their ability to capture different aspects of the random walk hypothesis. While the Runs Test evaluates the randomness of return sequences, the ADF and PP Tests investigate unit roots and stationarity. Meanwhile, the Variance Ratio Test directly examines whether return variance grows proportionally with the length of the investment horizon, a key prediction of the random walk model. Employing multiple tests strengthens the reliability of the findings and reduces the chance that dependence on a single procedure will produce skewed conclusions.

3.3.1. Run Test

Borges (2010) characterizes the Runs Test as a non parametric statistical tool for examining the randomness of stock return series. This test is particularly meaningful when applied to weak form efficiency as defined by the Efficient Market Hypothesis (EMH). Under the EMH, all past price information is fully incorporated into present prices, so historical data offer no ability to anticipate how returns will move in the future. The major aim of the Runs Test is to determine serial independence in the data of returns i.e. whether the price movements between one period to another are independent of the previous period or follow a given trend. Also in a weakly efficient market, the positive or negative sign of returns should not take a trend.

In practical terms, each return is classified based on whether it lies above or below the average return for the observation period. A positive sign (+) is assigned to returns exceeding the average, while a negative sign (-) is given to returns falling short of the average. This classification allows the test to detect long term trends while also examining randomness. The test then counts the number of runs, with a run defined as a consecutive series of returns sharing the same sign. Under the null hypothesis, the return sequence is random. When the observed number of runs does not differ significantly from the theoretically expected number, the null hypothesis remains credible, suggesting that the return data show no systematic pattern. Conversely, a statistically significant gap between the actual run count and the expected run count indicates non randomness in the return sequence.

A key advantage of the Runs test is its non parametric nature, which means it does not require the return distribution to follow a normal pattern. This feature renders the test suitable for investigating random walk or martingale behavior in financial data, since such data frequently depart from normality. The results obtained from the Runs test offer empirical evidence for evaluating how closely a stock market conforms to weak form efficiency. The procedure for the Runs test consists of the steps outlined below.

A. Expected Number of Runs

$$E(R) = \frac{N + 2n_1 n_2}{N}$$

where:

$E(R)$ = expected number of Runs

N = total number of observations

n_1 = number of positive returns

n_2 = number of negative returns

The expected value provides a baseline against which to judge whether the observed sequence of returns is random, as necessitated by the weak form Efficient Market Hypothesis.

B. Standard Deviation of Runs

$$\delta R = \sqrt{\frac{2n_1 n_2 (2n_1 n_2 - N)}{N^2 (N - 1)}}$$

where:

δR = the standard deviation of the number of runs under the null hypothesis of randomness

N = the total number of observations, with $N = n_1 + n_2$
n_1 = the number of positive returns
n_2 = the number of negative returns

The natural fluctuation in the expected run count for a random sequence is captured by this measure. The Runs Test then uses it to normalize the difference between the actual number of runs and the expected number.

C. Z-Statistic of the Runs Test

The Z_{STAT} measures how far the observed number of runs deviates from its expected value.

$$Z_{\text{STAT}} = \frac{R - E(R)}{\delta R}$$

where:
Z_{STAT} = the standardized test statistic of the runs test
R = the observed number of runs in the return series
$E(R)$ = the expected number of runs under the null hypothesis of randomness
δR = the standard deviation of the number of runs

Runs test hypotheses are followed:

1) Null Hypothesis (H0): Stock returns follow a random walk process and are independently distributed over time.
2) Alternative Hypothesis (H1): Stock returns do not follow a random walk process and are not independently distributed over time.
3) The null hypothesis is accepted if -1.96 ≤ Z value ≤ -1.96 at a significance level of 5%.

3.3.2. Unit Root Test

A. Augmented Dickey Fuller

Stationarity of data represents a crucial condition in time series econometrics. When the mean, variance, and autocovariance of a time series do not change with the passage of time, that series is characterized as stationary. The importance of stationarity lies in the fact that it makes econometric models stable and reliable. Regression results can be misleading when non-stationary data are not transformed appropriately and this results in the existence of spurious relationships which have high coefficients of determination although there may not be any meaningful economic relationships between the variables.

In order to determine the stationarity properties of the time-series data, this study will use unit root test which is a popular method of identifying non-stationarity (Gujarati, 2010). The Augmented Dickey Fuller (ADF) test, which relies on MacKinnon critical values, is employed in this analysis. As an extension of the basic Dickey Fuller model, the ADF test adds lagged difference terms to capture more complex serial correlation patterns within the residuals. The following equation represents the general specification of the ADF test adopted for this study.

$$\Delta Y_t = \gamma Y_{t-1} + \sum_{i=1}^{p} \beta_i \, \Delta Y_{t-i} + \varepsilon_t$$

$$\Delta Y_t = \alpha_0 + \gamma Y_{t-1} + \sum_{i=1}^{p} \beta_i \, \Delta Y_{t-i} + \varepsilon_t$$

$$\Delta Y_t = \alpha_0 + \alpha_1 T + \gamma Y_{t-1} + \sum_{i=1}^{p} \beta_i \, \Delta Y_{t-i} + \varepsilon_t$$

Here, Y_t denotes the variable under observation, and $\Delta Y_t = Y_t - Y_{t-1}$ is its first difference. The constant term is α_0 T is a deterministic time trend, and ε_t represents a white noise error. The ADF test statistic is derived from the t statistic for the coefficient γ associated with the lagged level term Y_{t-1}. Failure to reject the unit root null hypothesis at the level form requires differencing the series and retesting it repeatedly until the series becomes stationary. Consequently, a time series may be classified as integrated of order one or higher orders, depending on the number of differencing operations required to attain stationarity (Utami, 2018).

B. Phillips-Perron

The Phillips Perron (PP) unit root test is used by researchers to assess stationarity in time series data while addressing potential serial correlation in the error components. Unlike parametric methods that rely on explicit lagged difference terms, the PP test applies a non parametric correction technique. This technique accounts for higher order serial correlation and heteroskedasticity within the disturbance process (Ekananda, 2016).

In this study, the Phillips-Perron test is based on the following regression specification:

$$\Delta Y_t = \alpha + \beta Y_{t-1} + \varepsilon_t$$

where $\Delta Y_t = Y_t - Y_{t-1}$ represents the first difference of the series, αdenotes a constant term, $Y_{t-1}$is the lagged level of the observed variable, and $\varepsilon_t$is the error term at time t.

By adjusting the t statistic of the coefficient for the lagged level variable, the Phillips Perron methodology refines the conventional Dickey Fuller test. According to Ekananda (2016), this improvement ensures that residual serial correlation and heteroskedasticity have no influence on the asymptotic distribution of the test statistic. This feature leads to stronger inferences concerning the presence of a unit root. Hence, the PP test functions as a complementary tool to the Augmented Dickey Fuller test for assessing stationarity in financial time series data.

3.3.3. Variance Ratio Test

The Variance Ratio Test (VR), introduced by Lo and MacKinlay (1988), is designed to evaluate whether a stock return series behaves as a random walk. This behavior is essential for weak form market efficiency. The VR test outperforms standard unit root tests in terms of statistical power and reliability. Additionally, this test remains resistant to the presence of heteroscedasticity. According to the core principle of this test, a return that behaves as a random walk implies that the variance of multi period returns scales with the horizon length. In other words, the variance for longer periods is a linear multiple of the variance observed for a single period. The variance ratio for the holding horizon during k periods is formulated as follows:

$$VR(K) = 1 + 2\sum_{j=1}^{k-1}(1 - \frac{j}{k})\rho_j$$

where ρ_j represents the autocorrelation coefficient of returns at lag -j. The null hypothesis states that $VR(k) = 1$ for all values of k, indicating the absence of autocorrelation and the fulfillment of the random walk assumption. A variance ratio greater than 1 suggests positive serial correlation, while a value less than 1 suggests either negative serial correlation or a tendency toward mean reversion.

In empirical applications, testing is conducted over multiple time horizons, such as two, four, eight, and sixteen periods, as is commonly used in the literature. Chow and Denning (1993) combined statistic addresses the risk of biased conclusions associated with testing across multiple time horizons. It does so by simultaneously testing the maximum of all variance ratio statistics. A random walk hypothesis is rejected whenever the probability value of this combined statistic is lower than the specified significance level. The hypotheses for the variance test are listed next.

1) H0: Stock returns follow a random walk process.
2) H1: Stock returns do not follow a random walk process.

The null hypothesis of the random walk is rejected if the probability value (p-value) of the Z-statistic is smaller than the chosen significance levels of 1%, 5%, or 10%.

4. Results and Discussion

4.1. Research Results

4.1.1. Run Test Result

Table 1. Run Test Results

No	Stock Index	Country	Z-Score	Decision
1.	IBOV	Brazil	9,366E-08	Ho accepted
2.	RTSI	Russia	-2,346E-07	Ho accepted
3.	NIFTY	India	-3,903E-07	Ho accepted
4.	SHCOMP	China	1,022E-07	Ho accepted
5.	JALSH	South Africa	-6,847E-08	Ho accepted
6.	SASEIDX	Saudi Arabia	-7,718E-07	Ho accepted
7.	EGX30	Egypt	-7,961E-07	Ho accepted
8.	DFMGI	United Arab Emirates	-1,646E-07	Ho accepted
9.	JSKE	Indonesia	-2,726E-08	Ho accepted

Based on the test results in the table 1, Ho is accepted at a significance level of 5% because the Z value is between ±1.96 so that the BRICS+ index stock returns move randomly.

4.1.2. Unit Root Test Result

A. Augmented Dickey Fuller

H0: Daily stock returns contain unit roots and are non-stationary.
H1: Daily stock returns do not contain unit roots and are stationary.

The Augmented Dickey Fuller unit root test was conducted using EViews 13 to examine stationarity in the data. When stationarity is present, it indicates that stock prices reflect all available market information, with a stable mean and consistent price variance across periods. A p value below the 5 percent significance level results in rejection of the null hypothesis, thereby confirming that stock returns are stationary. Conversely, if the p value exceeds the 5 percent alpha threshold, the null hypothesis is accepted, and stock returns are deemed non stationary.

Table 2. Result of Unit Root Test Augmented Dickey Fuller

No	Stock Index	Country	ADF	Critical Value			Prob. Value	Decision
				1%	5%	10%		
1.	IBOV	Brazil	-7.243.039	-3.431.558	-2.861.959	-2.567.036	0.0001	Stationary
2.	RTSI	Russia	-6.621.605	-3.431.580	-2.861.969	-2.567.041	0.0001	Stationary
3.	NIFTY	India	-6.653.636	-3.431.556	-2.861.958	-2.567.035	0.0001	Stationary

No	Stock Index	Country	ADF	Critical Value			Prob. Value	Decision
				1%	5%	10%		
4.	SHCOMP	China	-6.647.741	-3.431.584	-2.861.970	-2.567.042	0.0001	Stationary
5.	JALSH	South Africa	-6.834.717	-3.431.545	-2.861.953	-2.567.033	0.0001	Stationary
6.	SASEIDX	Saudi Arabia	-3.513.541	-3.431.657	-2.862.003	-2.567.059	0.0000	Stationary
7.	EGX30	Egypt	-5.661.200	-3.431.583	-2.861.970	-2.567.042	0.0001	Stationary
8.	DFMGI	United Arab Emirates	-6.539.509	-3.431.533	-2.861.948	-2.567.030	0.0001	Stationary
9.	JSKE	Indonesia	-6.308.869	-3.431.584	-2.861.970	-2.567.042	0.0001	Stationary

Table 2 indicates that all stock returns in the BRICS+ index are stationary, given that their probability levels are less than 0.05. This result supports the Fama Efficient Market Hypothesis. Thus, beating the market is not possible for investors, because current stock prices already reflect the genuine worth of assets.

B. Phillips-Perron

H0: Daily stock returns have unit roots and are non-stationary.

H1: Daily stock returns do not have unit roots and are stationary.

The hypothesis was verified using the Phillips-Perron unit root test using EViews 13 software. The Phillips-Perron test is used to address high-order serial correlation issues that frequently arise in time series data. This method was introduced by Phillips and Perron, (1988) as an alternative approach to unit root testing that can correct for autocorrelation and heteroscedasticity without adding lagged variables to the model (Ekananda, 2016).

Following Fusthane and Kapingura (2017), the Phillips Perron test employs the following decision rules. A test statistic that falls beneath the critical value at the 1 percent, 5 percent, and 10 percent levels signals stationarity in the stock return, prompting rejection of the null hypothesis. On the other hand, a test statistic that rises above the critical value at every significance level indicates non stationarity, meaning the null hypothesis cannot be rejected.

Table 3. Result of Unit Root Test Phillips-Perron

No	Stock Index	Country	PP	Critical Value			Prob. Value	Decision
				1%	5%	10%		
1.	IBOV	Brazil	-7.242.776	-3.431.558	-2.861.959	-2.567.036	0.0001	Stationary
2.	RTSI	Russia	-6.622.838	-3.431.580	-2.861.969	-2.567.041	0.0001	Stationary
3.	NIFTY	India	-6.651.087	-3.431.556	-2.861.958	-2.567.035	0.0001	Stationary
4.	SHCOMP	China	-6.651.651	-3.431.584	-2.861.970	-2.567.042	0.0001	Stationary
5.	JALSH	South Africa	-6.882.823	-3.431.545	-2.861.953	-2.567.033	0.0001	Stationary
6.	SASEIDX	Saudi Arabia	-6.050.967	-3.431.657	-2.862.002	-2.567.059	0.0001	Stationary
7.	EGX30	Egypt	-5.668.106	-3.431.583	-2.861.970	-2.567.042	0.0001	Stationary
8.	DFMGI	United Arab Emirates	-6.539.509	-3.431.533	-2.861.948	-2.567.030	0.0001	Stationary
9.	JSKE	Indonesia	-6.300.837	-3.431.584	-2.861.970	-2.567.042	0.0001	Stationary

According to Table 3, the stock indexes of Brazil, Russia, India, China, South Africa, Saudi Arabia, Egypt, the United Arab Emirates, and Indonesia are all deemed stationary. The reason is that the Phillips Perron test statistic falls beneath the critical thresholds at the 1 percent, 5 percent, and 10 percent significance levels for every BRICS+ index.

C. Variance Ratio Test Result

Table 4. Result of Variance Ratio tests

No	Stock Index	Country	Period				
			2	4	8	16	Max (Z)
1.	IBOV	Brazil	0.471011*	0.240219*	0.117365*	0.056866*	3.628.112*
2.	RTSI	Russia	0.506681*	0.253162*	0.133613*	0.063632*	3.356.017*
3.	NIFTY	India	0.518666*	0.262038*	0.123750*	0.064677*	3.303.015*
4.	SHCOMP	China	0.517296*	0.241904*	0.126676*	0.063365*	3.279.548*
5.	JALSH	South Africa	0.513948*	0.259794*	0.129271*	0.063680*	3.348.827*
6.	SASEIDX	Saudi Arabia	0.558569*	0.269323*	0.141238*	0.065650*	2.924.127*
7.	EGX30	Egypt	0.585951*	0.304850*	0.153475*	0.076322*	2.813.708*
8.	DFMGI	United Arab Emirates	0.513313*	0.257711*	0.129374*	0.064686*	3.367.648*
9.	JSKE	Indonesia	0.538883*	0.275689*	0.135097*	0.065926*	3.132.879*

As shown in Table 4, the null hypothesis is rejected because every BRICS+ stock index yields p values below the 1 percent threshold across all periods. Thus, stock returns are inefficient and display a predictable pattern.

4.2. Discussion

When considered jointly, the run test and unit root test results imply that BRICS+ stock returns possess properties consistent with weak-form market efficiency. The randomness detected by the run test and the stationarity identified by both the ADF and Phillips-Perron tests indicate that return movements do not follow persistent trends over time. However, these findings should be interpreted cautiously because statistical evidence from alternative tests may reveal different aspects of return dynamics.

A different picture emerges from the variance ratio (VR) test. Because the null hypothesis is rejected across all indices and for each holding period, the evidence suggests that the series do not follow simple random walks. It means that it has serial dependence, mean reversion or momentum and thus returns have some consistent patterns of a certain time scale. The weakness of the weak-form efficiency result in non-congruence with VR tests implies sensitivity of such discrepancy to the statistic method.

The random walk hypothesis is rejected by the variance ratio test across all BRICS+ markets. However, the test statistic values differ in magnitude among the individual countries. The Max(Z) values range from 2.813708 for Egypt to 3.628112 for Brazil, producing a difference of 0.814404. Saudi Arabia records a Max(Z) value of 2.924127, whereas Indonesia records 3.132879. These results indicate that the degree of departure from the random walk process is not uniform across markets. Therefore, while all sampled markets exhibit weak-form inefficiency according to the variance ratio test, the extent of inefficiency varies quantitatively among countries.

The aggregate empirical evidence of the study indicates that BRICS+ stock markets cannot be described as unanimously weak-form efficient market. Rather, the findings indicate a certain conditional and temporally dependent efficiency in that markets can occur to be random in one context or can be predictable in another. This finding aligns with the wider body of research that indicates an absence of empirical support for the Efficient Market Hypothesis (EMH) within emerging markets. The EMH, despite its assertion that a financial instrument's price incorporates all accessible information, seems not to be validated in these contexts (Fama, 1970), most empirical studies have highlighted the weaknesses of the theory particularly within a new financial market. The differences in market microstructure, quality of regulation, investment structure, liquidity depth, and exposure to both global and domestic shocks across the BRICS+ economies are explainable attributions to the differences in efficiency over time and markets.

The stationarity and randomness of returns has been supported which agrees with the literature that reports about the rising market efficiency over time. Indicatively, Mobarek & Fiorante (2014) and Kulikova et al., (2024) show that BRIC markets have been experiencing weak-form efficiency particularly after experiencing a good deal of regulatory reforms and market integration. Similarly, Nalin & Guler (2015) also present the random walk behavior of monthly BRIC indexes data of indices that supports the existence of long-term efficacies with short-term fluctuations.

Quite to the contrary, the weak-form efficiency is not acceptable by the variance ratio tests, which endorse much literature in discovery of predictable returns dynamics in emerging markets. Lim et al. (2009) and Malafeyev, O., A. Awasthi (2017) report that the BRIC markets and Asian markets have evidence of autocorrelation, volatility clustering, and nonlinear dependence. Other studies on the issue, such as Kim (2025) and Nguyen & Parsons (2022) also confirm the inefficiency hypothesis of the weak-form in the emerging markets during the periods of structural stress, e.g., the financial crisis and the COVID-19 recession.

According to Lo (2004), the Adaptive Market Hypothesis (AMH) serves as a conceptual bridge between the Efficient Market Hypothesis (EMH) and behavioral finance. The present study confirms the AMH. Unlike the classical EMH, where market efficiency is presumed to be unchanging, the AMH posits that efficiency is dynamic. It is influenced by changing market environments and by the adaptive responses of investors. Predictability of returns and inefficiencies in the market can occur and disappear in this context not only in time, but also under a subject to the economic environment, competition, institutional growth, institutional changes and market shocks. The financial markets do not fail to realize expected equilibrium conditions and thus they can oscillate at intervals of efficiency and inefficiency. Empirical evidence of this dynamic conceptualization of market efficiency has been produced by preferential literature on the subject including Mandacici et al. (2019) who find that the efficiency varies with time, indexes and market elements, including emerging and transition economies.

The inefficiencies are also explained using behavioral theories of finance. Thaler (2017) thinks that irrationality of the investors, cognitive biases and sentimental trading may lead to price deviation, which is not fundamentals-based. According to other complementary theories such as Noise Trader Theory (Shleifer & Summers, 1990), Fractal Market Hypothesis (Peters, 1994), and Heterogeneous Market Hypothesis (Muller et al., 1995), the predictability of returns are caused by both varying investor horizons and non-homogenous flow of information particularly in the emerging markets wherein the institutional maturity is skewed.

Practically, the implications of the results can be applied to investors, portfolio managers, and policy makers of the BRICS+ economies. Having inefficiency in the time-varying market suggests that there may not necessarily be optimal buy-and-hold (or even passive) strategies to investment, particularly when operating in a stress-inducing or structurally changing market, and hence the potentially beneficial role of adaptive strategies, which consider the evolving market factors, risk regimes, and investor behavior. The findings are a reminder to the regulators and policymakers that the institutional development and market transparency, and quality of regulation are paramount in the occurrence of market efficiency whilst inefficiency is more likely to arise in the system where information asymmetry, low liquidity, and asymmetry in the protection of the investor are more likely. In this sense, more quality disclosure, financial literacy, regulation that is more flexible and responsive, especially during times of economic perturbation, when the world financial crisis is occurring or geopolitical instability demand heightened market efficiency is needed in which the problem of market inefficiency has a propensity to become greater.

5. Conclusion

Based on data covering the period from January 2006 to December 2024, this study examines weak form market efficiency in BRICS+ stock indices using several statistical testing methods. The empirical results reveal mixed evidence. Randomness in stock returns is revealed by the runs test, and stationarity is demonstrated by both the ADF and PP unit root tests. In contrast, the variance ratio test rejects the random walk hypothesis for each of the BRICS+ stock indices included in the analysis.

This study finds that weak form market efficiency in BRICS+ stock markets is not uniformly supported. The mixed evidence arising from the various testing procedures indicates that the determination of market efficiency may vary depending on the chosen statistical approach. This finding aligns with the view that market efficiency cannot always be explained uniformly through a single testing method. Nevertheless, this study does not directly test the Adaptive Market Hypothesis (AMH), and therefore the results cannot be regarded as conclusive evidence either supporting or rejecting that theory.

This study contributes to the market efficiency literature by extending the scope of analysis to the BRICS+ context using long-term data spanning multiple periods of global economic change. The findings provide current empirical evidence regarding the return characteristics of BRICS+ stock markets and may serve as a foundation for future research to explore market efficiency using different approaches, methods, or analytical periods.

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