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# Are African Stock Markets Inefficient or Adaptive? Empirical Literature

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## Abstract

This chapter reviews empirical studies on weak form of efficiency with the aim of establishing whether the African market is inefficient or adaptive. The reviewed studies are categorised based on their methodological approaches to compare the power of linear and non-linear models in testing for weak-form efficiency. The studies on calendar anomalies, an indication of weak-form inefficiency, are reviewed to assess whether these anomalies are adaptive as portrayed by the relatively recent theory of adaptive market hypothesis (AMH). The scope of reviewed studies is also extended to developed and emerging markets to gain a broad comparison of the findings. This review revealed that non-linear dependence has been revealed in stock returns suggesting that non-linear models are best fit to test for the stock market efficiency. Reviewed studies produced contradictory findings with some supporting and others rejecting weak-form efficiency. Thus, most studies support the AMH, which suggests that market efficiencies and anomalies are time changing. This chapter concludes that most of the existing studies on AMH have been carried out in markets other than Africa, and hence, further empirical studies on the evolving and changing nature of efficiency in African stock markets are recommended.

**Keywords:** African stock markets, AMH, EMH, calendar anomalies, market conditions

## 1. Introduction

From the 1980s, the argument has been whether the behaviour of stock market returns is random or independent and identically distributed and whether there are significant calendar anomalies in stock markets. Three types of efficient market exist, namely the weak-form, semi-strong-form and strong-form. Weak-form hypothesis implies that the price reflects all previous information; the semi-strong hypothesis means that prices incorporate all information available to the public while the strong-form, in addition to public information, also reflects the insiders' information [1]. The most debated of the three forms is the weak-form efficiency [2, 3] note that the violation of this least restricted form of efficient market hypothesis (EMH) is tantamount to the violation of other forms of EMH. Consequently, this study focuses on the examination of weak-form efficiency. The implication of EMH is that no one can earn a return above the market average return in a consistent manner, except if one is lucky [4]. Thus, no amount of security analysis

based on past information could result in consistent higher profit. Several deviations and various types of patterns have been discovered in asset returns, which are at variance with the EMH and, hence, are termed efficient market anomalies [5]. Lo, Blume and Durlauf [6] identified three main categories of anomalies, namely fundamental anomalies, technical anomalies and calendar anomalies. Fundamental anomalies are market anomalies (for example size and value effect), which cause security prices to depart from their intrinsic values [7], while a technical anomaly is one in which the study of past market data results in an estimate of anticipated price trends [6]. Alagidede [8] defines calendar anomalies as the likelihood that returns on financial securities would exhibit systematic patterns during a particular time of the day, week, month or year. The calendar anomalies are reviewed in this chapter because it is an indication of weak-form inefficiency. Vast numbers of empirical investigations have been conducted and they are inconclusive as to whether stock markets are efficient or inefficient. This gave rise to the Adaptive market hypothesis (AMH), which suggests that market efficiencies and anomalies are time changing due to changing market conditions [9].

The first section of this chapter presents a review of existing researches on the weak-form efficiency of financial markets from the absolute point of view. Having identified calendar anomaly as the most popular contradiction to market efficiency, the second section presents the empirical evidence on calendar anomalies, where it is viewed as all or nothing. Moreover, the third section shows the new submissions of the recent researches about efficiency and calendar anomalies from AMH point of view, in other words, taking time-variation and market conditions into consideration. Lastly, this chapter presents gaps in literature and has a summary and the concluding remarks.

## **2. Empirical studies on weak-form EMH**

Large numbers of empirical studies have been carried out in testing the weak form of EMH or random walk in developed and developing stock markets. These studies focus on the relationship between successive price changes to determine whether they are dependent or predictable. Some studies examine linear dependence [1, 10–14] in stock returns, while others focus on non-linear dependence [15, 16]. The types of dependence and the development of the markets examined seem to impart the conclusion from these studies, hence, the empirical review is presented below taking cognisance of the two categories (linear and non-linear) of dependence.

### **2.1 Linear empirical studies from developed and emerging markets**

The linear dependence tests constitute the earliest test of weak form of EMH and they are still in use today. There are four major linear tests employed in testing weak-form efficiency in the literature, namely the autocorrelation/partial autocorrelation tests, VR, run and unit root tests [2]. In most cases, studies of weak-form efficiency have combined various linear estimation tools. Hence, this study presents a general empirical review of linear test-based studies, since having to separate a single study where various linear tests are combined may be cumbersome.

The first set of researchers used the linear serial correlation tests, which test  $RM3^1$  (i.e. the least restrictive hypothesis) to establish non-correlation of returns.

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<sup>1</sup> RWH1 implies independently and identically distributed successive price increments; RWH2 implies independent increments; while RWH3 implies dependent but uncorrelated increments.

The presence of serial correlation in return series implies weak-form inefficiency. Studies such as Working [17]; Kendall [18]; Osborne [19]; Samuelson [10] and Fama [1, 11] and Roberts [12] provide support for the efficiency of the developed stock markets due to insignificant magnitude of autocorrelation. Kendall [20] investigated weekly indices and the idea of serial correlation was debunked in the United State (US). Although serial correlation was found in the United Kingdom (UK), it was considered insignificant. Serial correlation was also found in the US share index by Moore [21] but it was adjudged to be insignificant. In addition, low serial correlation was found by Jennergren and Korsvold [22] whose study was based on the Swedish stock market. Where significant serial correlations were reported earlier, it was dismissed on the ground of spuriousity. Hence, most of the above studies do not really reject weak-form EMH. However, Niederhoffer and Osborne [23] debunk the notion that stock price changes are independent and identically distributed and state that investors are aware of the possibility of price reversal and exploit it for abnormal profits.

Additionally, some studies have employed runs<sup>2</sup> test as another popular serial correlation test of changes in stock prices with additional benefits of being a non-parametric test. Here, the actual and expected numbers of runs of a series are compared. Using this approach, Fama [1] provided minor support for return dependence in the US while Cooper [13], using different frequencies of stock return series from 36 countries, submitted that the UK and the US are efficient and in conformity with EMH. Apart from the autocorrelation and run test, another linear dependence test is the Variance ratio (VR) test, which has become the commonest test [24, 25] for determining whether price changes are not serially correlated. The test assumes that if changes in asset price are consistent with random walk hypothesis (RWH), the variance of the  $p$ -period change must be  $p$  multiplied by the variance of 1-period change. Applying their own VR test, Lo and MacKinlay [26] found that the RWH does not hold for weekly stock market returns. Also, Smith and Ryoo [27] used the multiple VR test to examine the randomness of European emerging stock markets and found significant violation of the weak form of market efficiency.

The fourth group of linear tests of weak-form efficiency are known as the unit root tests, which are used to examine the stationarity of stock returns, based on the argument that stock returns follow a random walk if they reject stationarity or have a unit root [24]. Unit root test and other linear tests are employed in a study of 16 developed markets, namely Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and the UK and four emerging markets, namely Czech Republic, Hungary, Poland and Russia by Worthington and Higgs [28] in European equity markets using daily returns. Results of the emerging markets showed that only Hungary is characterised by a random walk and, hence, is weak-form efficient, while in the developed markets only Germany, Ireland, Portugal, Sweden and the UK conform to the strictest weak-form efficiency criteria.

In addition, autocorrelation test and the VR test were employed by Lovatt, Boswell and Noor [29] to test firm level and market-wide randomness in the UK from 1992 to 1998. Results from the two tests depict significant dependence of daily stock returns in the UK. On the basis of run test, Borges [14] showed that RWH cannot be rejected in UK (daily and monthly data), Spain, France and Germany (monthly data). Konak and Şeker [30] supported the efficiency of the UK FTSE 100 based on the findings of unit root tests. Drawing from many of the available studies [1, 10–14] in the developed economies, the notion of weak-form efficiency has

<sup>2</sup> A run is 'a succession of identical symbols which are followed or preceded by different symbols' [178].



hardly been rejected [31]. In contrast, findings from the emerging economies are contradictory with some supporting and some rejecting weak-form efficiency. For instance, empirical evidences from Asian, Latin American and European emerging markets and the Middle-East are all contradictory [31]. Kim *et al.* [32] state that there is vast proof of predictable patterns from past price changes, particularly in the emerging financial markets.

## **2.2 Linear empirical studies from African markets**

While the African region studies are not as much as others are, the Johannesburg Stock Exchange (JSE) seems to have received more attention than other African markets in the investigation of market efficiency. The JSE has been identified as the most developed in the league of African stock markets and it has been noted that the market behaves more like those in developed economies. A review of JSE studies by Thomson and Ward [33] indicates conflicting results with some studies supporting JSE efficiency while others do not. However, they submitted that there are more reasons to conclude that JSE is efficient in weak form. According to Vitali and Mollah [31], subsequent investigations on the JSE have maintained this submission [34–37] with the exception of Appiah-Kusi and Menyah [38] and Smith [39]. Conflicting findings, even when similar methodologies are used, may not be unconnected with differences in sample size or data frequencies but one would have expected similar results if markets were to be efficient at all times. Further, while Almudhaf and Alkulaib [40] employed unit root tests and VR and concluded that the JSE is consistent with RWH, Grater and Struweg [41], based on unit root test, discovered that JSE is not consistent with RWH. Sub-period analysis was considered by Fusthane and Kapingura [42] who employed all the popular linear tests except the run test in the pre-, post- and during global financial crisis and showed that the JSE, to a greater extent, is weak-form efficient.

In Nigeria, many investigations have been undertaken to test weak-form efficiency. A review of these studies reveals that the problems of efficiency in Nigerian stock market remain inconclusive. In Nigeria, Gimba [43] applied run, autocorrelation and VR tests; Nwosa and Oseni [44], Nwidobie [45] and Obayagbona and Igbinsosa [46] employed autocorrelation, run test and unit root test. All these studies submitted that stock returns do not comply with weak-form efficiency (implying weak-form inefficiency). On the other hand, Ayadi [47], Olowe [48], Emeh and Obi [49], found that Nigerian stock market is weak-form efficient. The finding is supported by Godwin [50] and Ajao and Osayuwu [51] using autocorrelation test and runs test; Keyur [52] using run test; Arewa and Nwakanma [53] based on portmanteau autocorrelation and LM serial correlation. Apart from the full sample study, certain studies employed sub-sample analyses. For instance, Ezepue and Omar [54] employed daily and monthly indices and sub-sample analyses (2000–2004; 2005–2010) using financial reform as the basis for breaking the sample and found that the market is inefficient, based on run and autocorrelation test results. Similarly, Ikeora, Nneka and Andabai [55] showed that three out of the four sub-periods analyses are characterised with dependence and inefficiency using the runs and unit root test. Violation of EMH is also documented by Ogbulu [56] using the four linear tests and four frequencies of return index from 1999 to 2013.

There are some studies, which combine selected African stock markets. For instance, Magnusson and Wydick [34] studied efficiency in African stock markets from 1989 to 1998 using partial correlation. Botswana, Kenya, Cote d'Ivoire, Mauritius, South Africa and Nigeria markets are found to be weak-form efficient – the exceptions being Ghana and Zimbabwe. Smith *et al.* [35], using multiple VR test and weekly indices from 1990 to 1998, rejected weak-form efficiency of

Egypt, Morocco, Kenya, Zimbabwe, Nigeria, Botswana and Mauritius, with South Africa identified as the only efficient market in the sample. Appiah-Kusi and Menya [38] also employed EGARCH-M to analyse weekly indices and showed that Egypt, Morocco, Kenya, Zimbabwe, Mauritius are efficient while Ghana, Botswana, Ivory Coast, South Africa, Nigeria and Swaziland are not. In Mauritius, Fowdar, Subadar, Lampot, Sannasse and Fawsee [57] used the traditional linear tests except the VR test and found that returns from 1999 to 2004 are autocorrelated. Mlambo and Biekpe [58] analysed daily indices from 1997 to 2002 with the aid of run tests and submitted that stock returns in all African markets other than Namibia exhibit serial correlation and do not conform with RWH. They warned, however, that the rejection of the random walk, based on these tests, does not necessarily imply weak-form inefficiency but a presence of serial correlation.

Furthermore, Smith [39] used samples from 2000 to 2006 and various versions of VR tests and found that Egypt, Botswana, Ghana, Kenya, Ivory Coast, Mauritius, Nigeria, Morocco, South Africa, Zimbabwe and Tunisia are not efficient. Also, by employing (G)ARCH effects tests; GARCH family models, BDS tests and bivariate test; Alagidede and Panagiotidis [59] showed that Zimbabwe, South Africa, Morocco, Egypt, Nigeria, Kenya and Tunisia are not efficient but the data are characterised with leverage effect, volatility clustering and leptokurtosis. Nwosu, Orji and Anagwu [60], also using various linear tests, found that the Egypt, Kenya, Nigeria and South African stock markets behave in a manner that is contradictory to weak efficiency while the US S&P500 complies with the notion of efficiency. Similarly, the combination of autocorrelation, run and unit root tests revealed that Kenya stock market is weak-form inefficient [61]. Gyamfi, Kyei and Kyei [62] employed non-linear ADF unit root test and the modified Wald and revealed that unit root is present in Nigeria, Egypt, Mauritius, Kenya, Mauritius, South Africa, Morocco and Tunisia returns except Botswana, hence, non-stationary and weak-form efficient. By and large, findings from stock markets other than developed markets have been mixed with the majority showing that African stock markets are not efficient in weak form.

### **2.3 Non-linear empirical studies from developed and emerging markets**

It is noteworthy that the 'traditional' tests of efficiency, as discussed above, have been said to be of little or no use, in the recent literature. It is because such tools may fail to find evidence of linear structure in the data, but this would not necessarily imply that the same observations are independent of one another [63]. In other words, researchers have observed that markets sometimes exhibit non-linear dependence even when there is no linear dependence [64, 65]. Owing to the presence of non-linear structure in stock returns, which cannot possibly be captured by the study of linear dependence, weak-form efficiency studies have been broadened to cover the examination of non-linear dependence, since the latter portends the possibility of predictability. Thus, where non-linear dependence is observed, absence of linear dependence is not enough to adjudge the market efficient considering the non-normality of return series [64, 66]. This leads to the application of myriads of non-linear test to stock returns in recent times. Non-linear tests include portmanteau tests such as the BDS test [67], the bispectrum test [68], Tsay's test [69], the neural network test [70], the bivariate test [71], Ramsey's RESET test and the specific tests such as SETAR-type non-linearity [69], smooth transition autoregressive [72] and Engle Lagrange multiplier test [73].

The earliest evidence of non-linearity in a stock market was shown by Hinich and Patterson [74] who applied a bispectrum test to daily returns of stocks on the NYSE. In the same vein, De Gooijer [15] further found significant

non-linear dependence in daily returns of 27 stocks and monthly returns of S&P 500 respectively. Similar findings were later documented in the UK market by Abhyankar, Copeland and Wong, [75], Newell, Peat and Stevenson [76] and Opong, Mulholland, Fox and Farahmand, [77]. The results of bispectrum and BDS tests showed that all frequencies of all share indices possess high non-linear dependence that violates RWH. Examination of non-linear dependence is not limited to developed markets alone. Sewell, Stansell, Lee and Pan [78] found support for the presence of non-linear dependence in a sample of emerging markets. Other recognised studies reporting non-linear dependence in stock return include Afonso and Teixeira [79] in Portugal, Dorina and Simina [80] in Turkey, Hungary, Romania, Czech Republic, Slovenia, Poland, Slovakia and Lithuania, among others.

#### **2.4 Non-linear empirical studies from African markets**

The developed markets, especially the US, UK, Japan and Germany, have been highly focused when it comes to the examination of non-linear dependence [16, 67, 75, 81] while non-linear tests on African markets are limited. In African stock markets, Kruger [82] and Kruger, Toerien and MacDonald [83] examined 109 shares from JSE and showed that there is significant nonlinear dependence for all shares. They also explored sub-period analyses and discovered that the nonlinear dependence is episodic in nature. Similarly, Cheteni [84] employed LM test, BDS test and VR test in the investigation of chaotic and non-linear tendencies of all bond indices return in JSE. The presence of non-linear dependence was reported; hence, they concluded that the JSE is highly chaotic. In addition, Sarpong [85] examined chaos on JSE by testing JSE all share index, top 40 and small cap returns with the BDS test. The non-linear model revealed that the three indices negate the notion of RWH with the re-scaled range analysis further showing that JSE small cap index is not as efficient and risky as the rest.

Non-linear tests have also been extended to test the weak-form EMH in other African markets. For instance, the ARCH-LM and McLeod–Li portmanteau tests are combined with linear autocorrelation to investigate efficiency of five indices on the Nigerian stock exchange from 2010 to 2013. The models revealed that all the indices except banking sector are non-linearly dependent and not in support of RWH [86]. In the same vein, Saadi, Gandhi and Dutta [87] examined the efficiency of Tunisian stock market from the non-linear viewpoint using the BDS test. It was shown through the result of the BDS test that non-linear dependence is inherent in the stock return series and that the weak-form efficiency of the market should be rejected. By examining BDS, McLeod-Li, Engle LM tests in Egyptian and Tunisian stock markets, Chkir, Chourou and Saadi [88] found significant non-linear dependence in stock indices return series and advocate for the rejection of RWH in the two African markets. Although this review may not have covered all the available studies, an important observation from the non-linear dependence tests in absolute form is that virtually all the markets (non-African and African) reviewed are culprits of the presence of non-linearity in stock return. While there is limited application of non-linear test in African market studies, JSE seems to have received more attention than others did.

### **3. Empirical studies on calendar anomaly**

Although, the reviewed linear and non-linear tests provide some insight into testing for EMH, it has been observed that test of independence of stock returns is incomplete without testing for the presence of anomalies. One of the anomalies that



is relevant to the test of weak-form EMH is the calendar anomaly. Much attention has been paid to the examination of calendar anomalies in the literature, making it the most observed or studied of all the types of stock market anomalies. In line with the previous section on the review of empirical studies relating to EMH, empirical review on calendar anomalies is also presented in this section and attention is paid to the markets where the studies are carried out.

### **3.1 Calendar anomaly from developed and emerging markets**

It is not surprising that the earliest empirical studies of calendar anomalies were carried out in developed countries since the theories also emanated from developed economies. In the New York Stock Exchange (NYSE), Rozeff and Kinney [89] studied the January effect from 1904 to 1974 and found that the January average return is significantly higher than other months. Keim [90], using the same set between 1963 and 1979, established that just about 50 percent of the average magnitude of risk-adjusted premium of small firms relative to large firms was caused by the January abnormal returns. Over 50 percent of the January excess return was traceable to the first week of January. Likewise, Gultekin and Gultekin [91] provide international evidence in 17 countries from a 1959 to 1970 sample. January and April effects are identified in all the countries including the UK. Further, Choudhry [92] evaluated month-of-the-year (MOY) anomalies in three developed countries between 1870 and 1913 using the GARCH [1, 1] model. It was concluded that MOY and January effects are found in the US and UK only and not in Germany. GARCH [1, 1] was also adopted by Wing-Keung, Aman and Nee-Tat [93] in the investigation of calendar anomalies in Singapore using a full period over 1993–2005 and sub-periods 1993–1997 and 1998–2005. Results showed that there is the January effect in the post-crisis period, weekend and holiday effects disappear in the post crisis, while turn of the month effect is present in both periods.

Apart from the MOY effects, day-of-the-week (DOW) effect is another prominent calendar anomaly. The earliest academic report on DOW effect was traceable to Cross [94] who found that Friday return is significantly higher than Monday return based on observation of the US stock market index returns over 1953 to 1970. In addition, Lakonishok and Smidt [95] investigated the presence of DOW calendar effect in the US from 1897 to 1986 and found high presence of a negative Monday return in the market. Hakan and Halil [96] also examined the DOW effect on stock market volatility by using the S&P 500 market index during the period of January 1973 and October 1997. The findings showed that the DOW effect is present in both volatility and return equations. While the highest and lowest returns are observed on Wednesday and Monday, the highest and the lowest volatility are observed on Friday and Wednesday, respectively. Further investigation of sub-periods reinforces the findings that the volatility pattern across the days of the week is statistically different. In addition, Shiok, Chong and Brian [97] used non-parametric test to study stock market calendar anomalies in Malaysia. This study was able to give clear view that Mondays are the only days with negative returns and represent the lowest stock return in a week and there was positive effect in Friday but not as high as the returns on Wednesday. Conversely, some international studies [98–102] have equally argued that both DOW and MOY have grown weaker.

Furthermore, both the MOW and DOW effects are combined in some studies. For instance, Lei and Gerhard [103] investigated calendar effects in the Chinese stock market, especially monthly and daily effects. Returns of the market index in Shanghai and Shenzhen stock exchanges were used to analyse the monthly and daily effects in stock returns. Results revealed that the highest returns could be achieved after the Chinese year-end in February while Mondays are seen to be



weak and Fridays showed significant positive average returns. Yet the daily effect has a minor magnitude and relevance for determining average returns compared to monthly effects. Similarly, Rossi [104] examined the calendar anomalies in stock returns in South America from 1997 to 2006, focusing on the existence of DOW effects and the monthly patterns in Argentina, Brazil, Chile and Mexico. In full period, it was concluded that there existed the traditional positive Friday effect in Brazil and in Chile; the returns had been lowest on Mondays. In addition, the study documented positive returns on Wednesdays and Fridays. In Mexico highest returns appeared on Wednesdays. For Argentina, there was no record of DOW anomaly. These results change when examined over two sub-periods. Overall, there is absence of monthly anomalies in full period and first sub-period, but January effect is found in Argentina in second sub-period. Additionally, Lukas [105] studied stock market seasonality with focus on DOW effect and January effect by analysing 30 stocks traded on the German Stock Exchange from 1995 to 2009. By adopting a dummy variable approach to investigate Monday effect and the September effect, it was confirmed that the DOW effect started disappearing in the second half of 1990s. Moreover, Martin [106] carried out a comprehensive review of the literature on calendar anomalies from 1915 to 2009. It was found that intraday, holiday and intra month effects still exist, the weekend effect seems to have disappeared and the January effect has halved.

With reference to part of the month anomalies, Ariel [107] discovered that average return in the first half of the month is significantly higher than the remaining half of the month. This finding is supported by Jaffe and Westerfield [108] in Australia, Arsad and Coutts [109] in the UK and Bildik, [110] in Istanbul. Similarly, Kohli and Kohers [111] found that first week in the month possesses average returns that are higher than other weeks using daily returns of the US composite index from 1962 to 1990. In addition, Lukas [112] investigated seasonality in the US stock exchange across six [6] major industrial sectors using descriptive statistics, GARCH(1,1) model and Wald-chi squared test. The study rejected the DOW and January effects in the US stock market but cannot reject the presence of the part of the month anomaly. In addition, Dragan, Martin and Igor [113] examined the DOW effect of stock returns in south eastern Europe, namely Bosnia and Herzegovina, Bulgaria, Croatia, Macedonia and Serbia between 2006 and 2011. Results of dummy regression, analysis of variance and Wald test revealed that the mean daily return of all stock indices is negative on Monday in all markets; lesser and significant on Monday than the other days of the week in Croatia and Bulgaria but insignificant in Macedonia. Likewise, Guglielmo, Luis, Alex and Inna [114] investigated weekend anomalies in the US and Russian stock markets, FOREX market and gold market using the trading-boot approach and fractional integration technique. The study revealed that there is evidence of weekend effect characterised by lowest Monday returns. The evidence is weak in other markets but strong in foreign exchange market as the exploitable profit opportunities based on the weekend anomalies are significant in the FOREX market. Oprea and Țilică [115] also examined the DOW anomaly in 18 post-communist East European stock markets, namely Bosnia, Bulgaria, Croatia, Czech Republic, Estonia, former Yugoslav Republic of Macedonia, Hungary, Kazakhstan, Latvia, Lithuania, Montenegro, Poland, Romania, Russia, Serbia, Slovakia, Slovenia and Ukraine from January 2005 to March 2014. The results showed that there is presence of DOW effect in Bosnia, Bulgaria, Croatia, Latvia, Serbia and Slovenia while DOW effect is absent in other markets. More recently, Rossi and Gunardi, [116] studied monthly effect in Spain, France, Italy and Germany from 2001 to 2010. They reported a significant presence of positive April effect in Italy, January effect in Spain and a negative September effect in Germany. In addition, Aziz and Ansari [177] report the presence of the

turn-of-the-month (TOM) effect in 11 out of the 12 markets examined in Asia from 2000 to 2015. It can be seen that many studies confirmed significant presence of calendar anomalies in developed and emerging markets. On the other hand, some sub-period studies revealed different behaviour in different sub-periods, while others observed weakening and disappearing of calendar anomalies in some quarters. Overall, the evidence is mixed.

### **3.2 Calendar anomaly from African markets**

The hype of calendar anomaly would mean that other emerging markets and developing African stock markets are not overlooked in the investigation of calendar effects. In the JSE, a negative Monday effect was documented by Bhana [117] who studied two market-wide JSE indices and Treasury bills from 1978 to 1983, using descriptive statistics and OLS regression. Other days were positive with Wednesday having the highest returns. Similarly, Alagidede and Panagiotidis [118] analysed the calendar effect of Ghana Stock Exchange using daily closing prices of all equities, dummy regression and asymmetric GARCH models. The study found the presence of April effect as opposed to the usual January effect and the weekend effects with lower Monday and higher Friday returns. On the other hand, Chukwuogor [119] in another study using Kruskal Wallis and descriptive statistic tests concluded that DOW effect is absent in African countries. The findings could be questioned based on the tests used. Further, Brishan [120] examined calendar anomalies in nine sectors of the Johannesburg stock market using descriptive statistics, OLS regression and two-sample Kolmogorov–Smirnov test. The study concluded that anomalies are a worldwide phenomenon present in developed and emerging markets; there is presence of daily and monthly effects, reducing pre-holiday effects and absence of weekend or January anomalies. In addition, Umar [121] used EGARCH model to estimate the DOW anomaly in mean and variance equations for Nigerian and South African equity markets over pre-liberalisation and post-liberalisation periods. After liberalisation, Nigerian stock market exhibits DOW effect on Fridays and Tuesdays/Thursdays in the mean and variance equation respectively. South African market exhibits significant DOW effect on Mondays and Fridays in the pre-liberalisation and Thursdays and Fridays respectively in mean and variance equation in the post-liberalisation era.

In addition, Julio and Beatriz [122] evaluated six emerging markets (Colombia, Indonesia, Vietmen, Egypt, Turkey and South Africa (CIVETS)) stock indices return from inception to 2012 using GARCH and IGARCH models. There is DOW effect in CIVETS; there is evidence of lags in the effect. Bundoo [123], in Mauritius, examined stock indices of 10 companies from 2004 to 2006. Dummy regression results found negative Tuesday returns but positive returns for other days of the week especially significant Friday and September effects. Similarly, dummy variables regression and GARCH models were also adopted by Alagidede [8] in an examination of calendar effect in African countries stock markets using data from inception of the markets to 2006. Holiday effect is reported in South Africa, February effect for Morocco, Kenya, Nigeria and South Africa and January effect in Egypt and Zimbabwe. However, skewness and kurtosis of daily index from 2004 to 2008 were estimated by Shakeel, Douglas and Chimwemwe [124] and it was submitted that Zambia, Botswana, Nigeria and Morocco displayed significantly different DOW effects in the pre and post financial crisis while South Africa did not exhibit such. Furthermore, Derbali and Hallara [125] showed through GARCH [1, 1] and asymmetry GARCH models that positive Thursdays effect is found in Tunisian market stock returns while negative Tuesday effects is present in both return and volatility. More recently, Du Toit, Hall and Pradhan [126] studied eight

sectors of JSE for DOW effect from 1995 to 2016 using GARCH model. The study found a significant positive Monday/Tuesday and negative Friday effect respectively and argued that the DOW effect is significantly influenced by the estimation techniques.

The review of empirical studies so far revealed that calendar anomalies have been documented in the literature. Although, some studies have observed that weekend/DOW and January/monthly effects are disappearing in recent times [106], especially from developed markets and little has been said regarding this in the emerging African markets. The question is whether these anomalies are disappearing from emerging markets too. It can also be observed from a few sub-periods (pre/post crisis for instance) studies that some calendar anomalies appear in one period (say pre crisis) and disappear in the other period (say post) and vice versa. Could calendar anomalies be disappearing and reappearing? It can also be observed that conflicts at times appear in the findings of different studies; for instance, Chukwuogor [119] rejected presence of calendar anomalies in African markets while others accepted it.

#### **4. Empirical studies on AMH**

The majority of the weak-form EMH and calendar anomaly literature largely applies tests and models on the full sample period, assuming that market efficiency is a fixed feature that remains the same, irrespective of stages of market development, or happenings in the market ecology. By so doing, they ended up addressing the issue of market efficiency and anomalies in absolute form and producing conflicting findings. Considering the inconclusiveness of the absolute efficiency tests, Campbell et al. [127] suggest the notion of relative efficiency, a new methodology that permits the level of market efficiency to be tested over time. This is akin to Lo's [128] argument in AMH, that market efficiency should be treated as a feature that changes over time and that is relative to market environment conditions. Available studies on the AMH, which considered alternative approaches to fixed state models; that is the possibility of time-varying efficiency/anomaly and market condition are presented in this section. Unlike the previous sections (2 and 3), where presentation takes market setting into consideration, this section presents a general review because African market studies on this topic seem to be limited.

##### **4.1 Time varying efficiency studies**

The formulation of AMH has ignited the reinvestigation of market efficiency in recent times. The most popular implication of the AMH is that market evolves over time in cyclical version. To examine this assumption, Anatolyev and Gerko [129] investigated AMH in the US stock market and documented that inefficiencies do alternate efficiencies. Similarly, Todea, Ulici and Silaghi [130], using daily indices and portmanteau and bi-correlation tests, revealed that there are sub-periods of non-linear and linear dependency in Australia, Hong Kong, Singapore, Japan, India and Malaysia with changes in degrees of dependencies over time. In another study, Ito, Noda and Wada [131] employed time-varying auto-regressive and moving average models as the estimation tools and concluded that stock market evolves through time and that there are cyclical movements in market efficiency in the US. In Austria and 12 other emerging markets, results of rolling window automatic, wild-bootstrap and joint-sign VR tests showed that developed markets are less predictable compared to less developed markets [132]. Likewise, Urquhart and Hudson [2] employed sub-sample methods to examine the evolution of linear and non-linear dependence



in the long run US, UK and Japanese stock markets data. The findings from the linear runs, autocorrelation and VR tests showed that all the markets undergo eras of dependence and independence, while findings from the non-linear tests revealed high dependence in all windows. In addition, Mobarek and Fiorante [133] tested the same hypothesis in the BRIC, Japan, UK, and US using autocorrelation, run and VR tests in five-year fixed length moving windows. It was submitted that the markets are trending towards higher levels of efficiency. In the same period, Dourad and Tabak [134] examined daily stock index return in Brazil over the 1991 to 2012 period using rolling wild bootstrap VR statistic and generalised spectral to test linear and non-linear dependencies respectively. It was found that RWH is present but varies in line with the AMH. Further, rolling automatic VR and generalised spectra tests are adopted by Shi, Jiang and Zhou [135] in China using daily and weekly data from 1990 to 2015. They found that the return predictability changes through time and high predictability were discovered around 2007 financial crisis.

It is noteworthy that the study of AMH has been introduced to markets other than stock markets. For instance, Charfeddine, et al. [136] employed state-space GARCH-M model, which revealed time-varying efficiency in the developed US and UK and emerging South Africa and India bond markets with the US market being the most efficient. Similarly, Kumar [137] validated the AMH in the Indian FOREX market using data from 1999 to 2017. Based on the application of non-overlapping sub-period and rolling automatic VR and Belaire-Franch and Contreras [138] rank-based tests, they found that though the market is not efficient in full sample, it varies in the level of efficiency over time depending on occasion of fundamental macroeconomic events. In addition, Urquhart [139] later studied the time-varying behaviour of precious metal returns via the application of rolling window Hurst exponent, VR and BDS tests and showed that the market is not static but time-varying, with the silver market being less predictable and platinum being most predictable. Shahid et al. [140] indicated that Bitcoin market is inefficient, rather than adaptive using a series of linear and nonlinear tests. Shahid et al. [140] confirms the applicability of AMH in the commodity markets while anomalies and efficiency are said to interchange on UK stock market according to Rosini and Shenai [141]. Almudhaf, Aroul and Hansz, [142] suggest that technical trading moving average are capable of exploiting changing predictability in the FTSE real estate markets.

In the case of emerging markets, Ahmad, Shahid, Ateeq, Zubair and Nazir [143] focus on Asia and used four popular linear tests and sub-period approaches. They established that the Indian and Pakistan stock markets are adaptive, fluctuating between inefficiency and efficiency. Kayani, Ayub, and Jadoon [144] also documented a repetitive pattern of efficiency and inefficiency in Pakistan stock exchange using a rolling nonlinear autoregressive neural network. Applying varying Hurst exponents in the Indian market, Patil and Rastogi [145] assert that arbitrage chances emerge from time to time in line with the AMH and a nonlinear cross-correlation exists in the price and volume series. In a sample of 384, Indian investors, Mushinada [146] provides a proof of existence of investors rationality and biases in an adaptive manner. Comparing developed and emerging markets, Jiang and Li [147] indicated that the Japanese and US stock exchanges are efficient in the normal market condition, while Chinese market was found to be generally inefficient. Conversely, Yang et al. [148] suggest that US and Chinese stock markets are adaptive.

It can be seen that most of the above studies concentrate on the developed markets while there are limited empirical studies on time-varying efficiency in emerging and African markets. One the first studies in the African stock market was carried out by Jefferis and Smith [36] who examined evolving efficiency and used daily indices from 1990 to 2001 and GARCH with time-varying factor. They submitted that South Africa is efficient right through the period; Egypt, Morocco and Nigeria



are moving towards efficiency while Zimbabwe, Mauritius and Kenya are inefficient all through. Likewise, Smith and Dyakova [149] applied linear VR tests to daily index between 1998 and 2011. Fixed-length rolling sub-period window analyses disclosed successive periods of inefficiency and efficiency with Egypt, South Africa and Tunisia found to be less predictable while Kenya, Zambia and Nigeria are the most predictable. Seetharam (1509) examined daily, weekly and monthly indices of 44 shares and six local indices of JSE from 1997 to 2014 using traditional linear tests, Hurst exponent, non-linear BDS and artificial neural network and sub-sample analysis. The outcome described the JSE as a market with changing levels of efficiency through time. In Egypt, Botswana, Morocco, Kenya, Nigeria, Mauritius, South Africa, Tunisia; Gyamfi, Kyei, Gill [62] provide support for AMH as markets, which were found to be inefficient in absolute forms revealed periods of unpredictability in rolling window generalised spectra test results. The same finding was reported in a separate study of Ghana stock market using rolling window VR and generalised spectra tests and index return data from 2011 to 2015 [151]. In addition, Heymans and Santana [152] used rolling window of the three versions of VR test to examine AMH in JSE ALSI and other smaller and sectoral indices. They found that the broad market index is ranked more efficient than the others, while the smaller and younger indices from communication, small cap, media and automobiles and parts are found to be most inefficient. However, all the indices exhibit cyclicity in the level of efficiency over time. It can be observed that most of the existing studies on AMH were carried out in markets other than Africa, although there are few studies covering African markets. In this context, Obalade and Muzindutsi [153] asserted that three African stock markets are adaptive from linear and nonlinear point of view. At this stage, an investigation of an evolving and changing nature of efficiency in African stock markets has not received adequate attention within the framework of AMH. In addition, there is need to compare and exploit linear and non-linear tests because Lim and Hooy [154], among others, affirmed that non-linear dependence has been revealed in stock returns where linear tests showed absence of dependence. In the presence of non-linear dependence, markets cannot be said to be efficient.

#### **4.2 Return predictability and market condition studies**

Another inference of the new AMH is that the fluctuation in efficiency arises from changes in market conditions, although the hypothesis did not itemise the exact makeup of market conditions or its expected relation with return predictability. Researchers, however, have relied on the literature in determining what constitutes market conditions. For instance, where the stock market price or return behaviour or trend is considered, the market conditions may be defined as up or down or bull, bear and normal [155, 156]. Lo [157] also mentioned external environments such as political, economic, financial, cultural environments and so on. One of the foremost attempts in the direction of changing efficiency cum market condition is the study by Kim et al. [32], which applied automatic VR and portmanteau tests to generate predictability and OLS regression to examine the effect of market conditions. In consonance with the AMH, they concluded that predictability varies over time and that market conditions such as bubbles, normal, political and economic crises influence return predictability in the US stock market using index return from 1900 to 2009.

In addition, the application of VR and portmanteau test by Zhou and Lee [158] revealed declining predictability over time. The dummy OLS regression further showed that the US real estate market efficiency is influenced by market development, inflation, volatility and regulatory changes from 1980 to 2009. In a similar study, Urquhart and McGroarty [159] used the VR and BDS tests, in 2-year fixed length moving window and dummy regression to analyse daily indices in the US,

UK, Japan, and Europe. Changing return predictability is reported in different markets overtime; a behaviour, which can be explained by up, down, bull, bear, normal and volatile conditions. These findings are supported by Soteriou and Svensson [160] in the Swedish market using joint rank and sign tests, dummy regression, BDS test, autoregressive-generalised autoregressive conditional heteroscedasticity (AR-GARCH) filter and OLS. It can be seen from the review in this section that studies on the effect of market conditions on market efficiency have largely been a developed market affair. Thus, there is a need for further study on other emerging markets such as the African stock markets. In this context, Obalade and Muzindutsi [161, 162] found that certain market conditions are responsible for changing efficiency of selected African markets.

### **4.3 Time-varying calendar anomalies studies**

Owing to its dominance in the determination of weak-form inefficiency, calendar anomalies are now also being evaluated within the time-varying approach of AMH. Although some of the studies [59, 163] have applied the rolling window approach out of curiosity to question the persistence of the calendar anomalies without mentioning of the AMH. Coincidentally, their approach is in line with the AMH. Alagidede and Panagiotidis [59] seem to be the earliest recognised African stock market calendar anomaly study where a rolling window analysis was mentioned to examine the persistence of DOW effect in Ghana. The study employed OLS, GARCH, EGARCH and TGARCH and submitted that there is significant Friday effect in the Ghana stock exchange in absolute form, however, they concluded that April and DOW effect evaporates with rolling window estimation. Additionally, Borges [163] employed GARCH [1, 1] to investigate 17 European stock market indices and documented evidence of cross-country rather than across-the-board calendar anomalies, especially in August and September. He submitted that the identified anomalies vary with time and could be more as a result of data mining due to high instability in the behaviours of the anomalies over time. Based on Borges' finding, Ching [164] states, "the calendar effects may only be a 'chimera' delivered by intensive data mining as they are country-specific results and may not be stable over time" (p. 1). Similarly, Urquhart [165] employed sub-period analyses to evaluate calendar anomalies within the AMH framework and found that January and Monday effects all change over time while TOM effect remains at all times. Further, Urquhart and McGroarty [166] also showed in the US that the behaviour of the Monday, January, Halloween and the TOM calendar anomalies change over time using rolling window estimation for the S&P 500 index. This study confirmed that AMH provides better descriptions of the behaviour of the studied calendar anomalies.

Additionally, Bampinas, Fountas and Panagiotidis [167] used daily data and GARCH [1, 1], TGARCH and EGARCH to check the DOW effect in global, European and country-specific real estate indices from 1990 to 2010. The full sample analysis indicates the presence of the effect while about 75 percent of the rolling windows reject the presence of the anomaly. Hence, they submit that the effect could be due to data mining and sample selection bias criticism. This conclusion supported Borges' [163] study in European markets. Similarly, various GARCH family models are analysed in rolling windows by Bampinas, Fountas and Panagiotidis [167] to establish that the DOW effect, found in two regional and six national indices and Monday effect found in three national indices, all experienced significant reduction in power when rolling window analyses were carried out. Also, eight Dow Jones Islamic indices were studied by Osamah and Ali [168] using sub-period mean-variance and stochastic dominance analyses and the findings supported varying behaviour of calendar effects in line with the AMH. In addition,

Zhang, Yongzen and Jianghong [169], via the application of GARCH model, established the presence of DOW effect in 25 countries (made up of 13 developed and 15 developing markets), the anomalies, which disappear with rolling windows in all except six countries. Moreover, Evanthia [170] showed that DOW is present in all the sectors and the general S&P500 indices using non-linear models (EGARCH and TGARCH) in full sample but only one-fifth of the total number of regressions/windows are associated with the anomaly. Hence, the study concluded that the anomalies are weak and time-variant as opposed to being persistent. Similarly, Obalade and Muzindutsi [171] provided supports for time-varying calendar anomalies in African stock markets by applying GARCH family models. Overall, the studies of time-varying AMH are not only few, but many of them (apart from [165, 166, 168, 170, 171] who supported AMH), have not supported the presence of calendar anomaly because only a small proportion of the estimated windows or sub-periods confirms the identified anomaly.

#### **4.4 Calendar anomalies and market condition studies**

By inference, AMH also portends that variation in calendar anomaly would emanate from changing market conditions. In line with the reasoning, Agnani and Aray [172] applied two state Markov-switching models (MSMs) and documented time-changing January effect in the US. The effect is found to be pronounced during the period of high volatility. Similarly, Urquhart and McGroarty [166] investigated time-varying calendar anomaly in the US market using daily and monthly index from 1900 to 2013. Results of GARCH (1,1) and Kruskal–Wallis test in 19-years equal length sub-samples and 5-year fixed length rolling window disclosed that calendar anomalies vary over time. When market conditions were taken into consideration, the study further showed that calendar anomalies are influenced by conditions such as the up, down bull, bear, normal, expansionary and contractionary, republican and democrat's dispensation. These findings were supported by Shahid and Sattar [173] in Pakistan who documented that the behaviour of calendar anomalies (Monday, January, TOM, Holiday and Ramadan) change through time and under different market conditions, using similar methodology. Evanthia [170] further examined the presence of DOW effect in relation to recession, uncertainty, liquidity and bearish sentiment. The study submitted that both the positive and negative DOW effect are more likely in the boom than in recession, Monday effect is highly correlated with the uncertainty index, weak relationships exist between DOW effect and liquidity/trading volume and negative DOW effect is associated with an increase in bearish investors. Recently, Rich [174] in JSE applied MSMs and showed that there is no clear evidence of DOW effect under any market condition, but found a negative January effect in bull, negative July effect in bear and positive August effect in bull regimes. It must be noted that studies reviewed in this subsection are not linked with AMH except the Urquhart and McGroarty [166] and Shahid and Sattar [173]. In support of responsiveness of calendar anomalies to changing regimes of AMH, Obalade and Muzindutsi [175, 176] applied Markov-Switching Models in selected African markets. In essence, there is a dearth of study of calendar anomalies cum market condition and only a few studies seem to support AMH.

#### **4.5 Gap in AMH empirical studies**

The gaps in the subject under review are depicted by the fact that while the empirical investigations of market efficiency and calendar anomalies under AMH are limited, African market studies are rare, the contributions in the last two years, notwithstanding. It can also be seen that recognised studies on the effect of market



conditions on market efficiency or return predictability in other markets, other than US, UK, Japan and Germany and Sweden, are needed, thereby creating a need for further studies in emerging and African markets. Further, the review shows that the consideration of time-changing calendar anomaly is new and the investigation is limited to a few markets. Just as the EMH, which has taken many years of investigation, there are still a lot of markets to cover in the examination of calendar anomalies within the AMH framework. Lastly, calendar anomalies could also be investigated vis-à-vis market conditions. Obviously, there is a dearth of empirical study on the explanatory power of market conditions on the behaviour of calendar anomalies globally, especially in the small and so-called inefficient markets like African stock markets. The identified gaps suggest that further investigation of AMH in smaller markets can shed more light on the topic. At this stage, an investigation of changing nature of efficiency and anomalies in response to market conditions in African stock markets has not received adequate attention under AMH. An attempt in this direction will make meaningful contribution to the existing body of knowledge on AMH and bridge the empirical literature gaps between developed markets and African Markets.

## **5. Summary and concluding remarks**

This chapter presents the review of empirical studies on weak-form EMH and calendar anomalies, both in absolute form and under AMH. It can be seen from the review that evaluation of market efficiency is a controversial subject in the literature. While there is preponderance of linear dependency tests in the early periods (believed to be unable to capture non-linear dependency), there has also been an upsurge in the adoption of non-linear testing tools later. In the same manner, investigation of calendar anomalies has evolved from the linear OLS test to the non-linear types of GARCH family models. The rationale for the influx of non-linear tests and models is due to the realisation of the fact that many aspects of economic behaviour may not be linear. Since the existence of non-linearity also disagrees with the EMH and gives market participants an occasion to earn surplus profits, reliance on linear testing tools alone, to determine predictability, may lead to wrong inferences. Thus, reviewed studies revealed that (i) combining both the linear and non-linear testing tools or one that is able to pick both non-linear and linear dependence will ensure the avoidance of possible wrong inferences. Generally, the linear tests of EMH have produced conflicting findings, although developed markets have been found to be more efficient than other markets. On the other hand, non-linear tests, in most cases found non-linear dependence, whether the market is developed or developing. Hence, (ii) the issue of weak-form efficiency has remained inconclusive and its problem has been traced to the approach of evaluating EMH and calendar anomalies in absolute form. Thus, a market when investigated for dependency and predictability can be found to be either efficient or inefficient. This assumption can be described as viewing efficiency as absolute or all-or-nothing. In other words, the EMH can be described as a fixed or final state model [150].

Due to the defect of the absolute efficiency and calendar anomaly studies, Campbell et al. [127] and Lo [9] have advocated evolving efficiency and time-varying efficiency respectively as the alternatives to the traditional EMH methods. Consequently, there are a gradually increasing number of investigations of time-varying efficiency and calendar anomaly in recent times. Some efficiencies/anomalies found in one sub-period sometimes change/disappear in another sub-period; seasonal effects such as weekend/DOW and January/monthly effects are said to be disappearing or weaker in some markets. This observation suggests that AMH approach could



be more appropriate but this will require investigation of several sub-samples. Rolling analyses has so far been pointed out as the best-developed class of alternative tests to the absolute approach, while researchers are still facing the task of identifying models best suited to capture cycles or dynamics inherent in the AMH. While the investigation started from developed markets like the US, other emerging markets are now receiving a fair share of interest from researchers. Obviously, there is now a shift from absolute framework to time-varying frameworks. Recent empirical evidences are suggesting that AMH could be a more appropriate approach to describe the stock returns patterns. Consequently, stock market efficiencies and anomalies are now being linked to market conditions. However, very few studies have tested this in the developing markets. Thus, there is a need for further studies from African stock markets that are often considered to be illiquid and inefficient.

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