TESTING WEAK FORM OF EFFICIENT MARKET HYPOTHESIS (EMH) IN NIGERIA

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Abstract

This paper explores the Weak-Form (WF) taxonomy of EMH in Nigeria on the premise that security prices take random walk processes. For this purpose, high and low frequency sample of DWMQ data spanning the period 1985 to 2019 were sourced. The OLS regression technique, serial correlation test, Runs Test (RT) and (K-S) method of analysis were adopted. The result of the various method used unanimously revealed that the Nigeria Bourse (NB) is informational efficient though in WF, that is stock prices in NB does not exhibit random walk and follow normal distribution pattern, respectively. Thus, confirm that the NB refutes the WF of efficiency of the EMH for weekly, monthly and daily share prices data respectively; and relatively exhibit some element W-F efficiency in quarterly data.

Keywords: Efficient market, Kolmogorov-Smirnov, Runs, Nigeria, Weak Form

JEL Classification: G100, G140

1. INTRODUCTION

In recent decades, the grandness of bourse role in national output growth and advancement of a nation have been realized by governments and business organizations. The EMH was propagated by Fama (1970) as a market that fully reflects the available information. The implication of EMH in financial market warrants its constant examination in modern day stock market. Thus, investors lacking existing research have equal amount of returns as recommended by technical analyses (Smiles, 2013). Whether capital markets are efficient or not remain unresolved, because financial trader and academic research in the past five decades are unable to come to consent (Sing & Singh, 2019). This arose an intension to dig further research on inconclusiveness in this discuss.

Within the context of the assorted submissions and findings, studies on Informational Efficiency (IE) of developed; frontier and emerging stock bourse have been extensively examined in emerging countries like Nigeria. Renown and recent among these studies are Niroomand, Metghalchi and Hajilee (2020), Sing and Singh (2019), Mphoeng and Moalosi (2019), Khan and Khan (2017), Hawaldar, Rohit and Pinto (2017). Yadirichukwu, and Ogochukwu (2016), Ikeora, Anyaogu and Werigbelegha (2016), Awan and Subayyal (2016), Obayagbona and Igbinosa (2015), Ananzeh (2016), Bapusaheb (2016), Rahman, Simon and Hossain (2016), Simons and Laryea (2015), Ajao and Osayuwu (2012). Studies from Nigeria were not left out of these mixed results, like Ajao and Osayuwu (2012), Ogochukwu (2016), Olowe (1999), Udoka (2012) among others observed that the prices in Nigeria Bourse (NB) is WF efficient while others (Ikeora, Anyaogu and Werigbelegha, 2016; Obayagbona and Igbinosa, 2015; Philip and Isaiq, 2011) rejected the hypothesis. Again, it become very glaring on the basis of methodology that studies that jointly applied serial correlation test (Q-statistics), runs test and Kolmogorov-Smirnov goodness (K-S) approach, to ascertain the stock price movement independency, randomness and whether trend in stock price randomness fits the distribution are very scarce in the case of Nigeria to the best of my knowledge, thus gap exist in the literature and more study is needed in this direction.

Testing the weak form EMH is of a peculiar desire in Nigeria due to its implication for internal or foreign investors, whom investment determination is hinged on present intrinsic market values and the trade-off between related return and risk with such investments in a dynamic macroeconomic environment. Especially with the implementation of different financial reforms by the Nigerian government and market regulators (security and exchange commission) to make the bourse more vibrant from its sluggish state following the 2008 global meltdown. From the gap identified, this study re-examines the W-F informational efficiency in the NB as the broad objective. The specific objectives are to:

i. Assess the W-F IE of the Nigerian bourse.
ii. Determine whether movement in security prices follow Random Walk (RW) in the NB
iii. Examine if changes in Stock Prices Movement (SPM) are independent.

Hypothesis of the Study

The hypothesis of this study is stated in their null form and it does include:

Ho_1: The Nigeria bourse is not W-F information efficient.

Ho_2: SPM do not significantly follow RW in the Nigeria bourse

Ho_3: Volatilities in security prices are not significantly independent of each other.

Significance of the Study

This study is germane to the literature being the first to use the aforementioned parametric and non-parametric techniques to analyze the daily, weekly, monthly and quarterly stock prices to test the WF of EMH in the NB. Thereby, giving new insight to stakeholders on how WF efficiency should be interpreted in Nigeria. This study is imperative and unique because it expand empirical work on security price dynamics and the WF of market efficiency in the NB; and it simultaneously employed K-S test, runs test and Serial Correlation Test (SCT) as the basis for ascertaining W-F IE instead of just SCT and Runs Test (RT) techniques as was the case in most prior studies in Nigeria.

More so, the findings of this study will be beneficial to investors, regulators and policy makers. It provides a better idea and understanding to domestic and foreign investors that complete available information is not shown in stock prices traded in the NB. Thus, environmental condition, market participants and momentum must be put into consideration in investment decisions. Since the study reveal that market efficiency degree changes over time and return predictability is feasible in the market. The findings will aide regulators and policies maker to understand that the Nigeria bourse does not follow dynamic market efficiency rather prices take specific pattern, hence guide them in making adequate effective and efficient policies that will improve information flow and boost investors' confidence. For clarity purpose, other section of this paper is structured into review of literature, methodology, data presentation and analysis, conclusion and recommendations.

2. LITERATURE REVIEW

Conceptual Literature

Bourse is place of exchange for equity securities and Long Term (LT) debt. Also, describe as where corporate firms and government can get fund for LT purposes (Malkiel, 2003). Investment process in bourse mitigates paucity of funds and bankruptcy of firms by providing financing opportunity that guaranty the survival of the firms (Ajao and Osayuwu, 2012). Traditional finance theory believes that investors are rational in their investment decision, this play up the desire for efficient resource allocation. Detailed security rationalization, analysis, supervision and selection is a salient guide to investors for efficient resources allocation ((Herman, 2001) as cited in Ajao et al, 2012). Valuation of asset to know what quantity of security, which and when to sell or buy security is termed security analysis. Fischer and Jordan (2005) defined Traditional Security Analysis (TSA) as the act of overvalued securities to sell and undervalued securities to buy identification by security expert. However, the traditional thinking has been over-taken by the influence of EMH also named the Random Walk Theory (RWT) which doubted the possibility and consistency of the TSA. Consequently, perceive Contemporary Security Analysis (CSA) as a holistic risk-return estimation process

for a specific security. This process perceives indirect rewards coming from risk-return computation (Fisher & Jordan, 2005).

The EMH hypothesis believes that stock prices show all available information thereby preventing abnormal return from security exchange based on insider information. The idea of EMH was set forth on the framework of Samuelson's Random walk model (RWM) (Fama, 1970, 1990). Bhat (2008) defines efficient market as a market condition where price of the securities quickly adjust with the infusion of new news and, stock prices changes with the new news incorporation. Stock market efficiency has two variants corresponding; *information efficiency* and *operational efficiency* (Weston & Copeland, 1986; Fama, 1970; Baumol, 1965). The latter is a market that is efficient on the degree of functionality such as transaction cost, price information, effective, efficient information disseminating mechanism for price continuity and timeliness. The former measures the responses of the stock market to information; with the ideology that investors try to sell or purchase the stock it believes to be under /overpriced, thereby pushing up or pressing down price to equilibrium gauge (Baumol, 1965 & Fama, 1970). Constant stock price expected return that is equal to interest rate and expected return differs from actual is another feature of an efficient bourse (Udoka, 2012). Which according to Obayagbona and Igbinosa (2015) declared that stock price fluctuations do not follow any trend in Nigeria and, because of this trend irregularity, predicting future prices with past prices is impossible.

Theoretical Literature

EMH theoretical foundation traced back from the RW first proposed by Bachelier (1900) (as cited in MacKenzie, 2006). Where he positioned that commodity, prices are stochastic dynamic (Jethwani & Achuthan, 2013). Fama (1965b) first used the word "Efficient Market (EM)" which indicates that stock prices follow a stochastic change. The EMH theories are of three types depending on what the term "all available information" is meant by (Fama, 1991).

- **W-F EMH**

This is characterized by past sequence of prices. The W-F hypothesis advocate stock price do show all information, and this is enshrined in the examination of trading data (prior, short interest, prices and trading volume). Thus, render technical and fundamental presumption ineffective. This position has been empirically supported in the literature that abnormal profit making is not allowed because the market is efficient.

- **Semi-Strong Form (SSF) EMH**

This posits that stock prices manifest all non-private news regarding firm's prior prospect, performance, management quality, reporting practices, financial position, earnings forecasts, among others. Hence, this form encompasses the weak-form EMH (Metghalchi, Chang, & Marcucci, 2008).

- **Strong-Form (SF) EMH**

This variant of EMH, positioned that stock prices manifest all news (private and public) salient to the firm. News present firm's insiders alone and those with access to the firm's plans and policies are inclusive. This typology like this includes the WF and SSF EMH. As private information is also made known, insider trading cannot occur in a strong form efficient market (Metghalchi et al, 2008).

- **Adaptive Market Hypothesis (AMH)**

The controversy in EMH was extended with the addition of new information due to behavioral finance expansion. Efficient market regulation concept and aims to increase efficiency was supported by academics and trader objectives to exploit inefficacy to generate abnormal profit (Almail &Almudhaf, 2017). Hence, stock market is neither inefficient nor efficient, rather it rationally follows certain bound (Simon, 1955). This indicates that EMH was incomplete and not false, and it cannot be rejected as well. An investor act irrationally which includes behavior or psychological factors in the light of this prevailing scenario. Contrary to EMH, Lo (2004) posit that financial market are adaptive and switch between efficient and inefficient period. This market behavior was found in past studies (Parulekar, 2017; Kapoor, 2017; Al-Khazali & Mirzaei, 2017; Gupta & Yang, 2011; Borges, 2010).

The issue on return predictability had been never an ending process. The inconclusive argument and mixed findings resulted to new theories called the AMH that reconcile the two schools of thought (EMH and behavioral finance) in a natural and satisfying conclusive manner. The AMH was propounded by Andrew Lo in 2004. According to Lo (2004) the quantum of information (news) price manifests is a function of both environmental states and the nature, amount of species in the economy. The species here means an individual which seem to have the common behavior. Institutional investors like hedges funds, mutual funds, pension funds etc. behave in a same manner even though their investment portfolio or style differs. The AMH is creating more holistic view of the market which combines the efficient market and behavioral finance, more focus on a vast scope and complete wide perspective and was a successor of EMH.

Empirical Literature Review

In the light of the EMH taxonomy, plethora of empirical studies on the W-F have been reported across developed, frontier and emerging bourse with mixed findings. Among others, Chun (2000), Ayadi (1984), Samuels and Jacout (1981) used weakly share price data and non-parametric test of SCT to examine the W-F efficiency in Nigeria and Hungary bourse. The W-F market efficiency was accepted by the findings of these studies. Vosvrda, Filacek and Kapicka (1998) tested the EMH in Paraguay bourse spanning the period 1995 to 1997. Findings reject the W-F ME. Gilmore and McManus (2003) explored the EMH in its W-F for Hungary, Czech Republic, and Poland from 1995 to 2000; the RW hypothesis was refuted by the finding of the study. Cavusoglu (2007) studied the W-F of the EMH in Greece

bourse. The accounting approach of conditional heteroscedasticity were adopted to analyze daily ASE / FTSE-20 price index. Evidence for the weak form EMH was detected. Aga and Kocaman (2008) applied a calculated index (index-20) to verify the W-F EMH from1986 to 2005 in Istanbul bourse. Findings confirm that the Istanbul bourse is a W-F efficient and stock price follows random process.

Dima and Milos (2009), Dragota (2009 verified the W-F ME of Bucharest (Romanian) bourse; using daily stock price observations (2000 to 2009 and for 18 firms) respectively. Findings point out that IE of the market is limited in W-F due to the prolonged Romanian financial instability (Dima et al, 2009) while the W-F efficiency was upheld by the findings of Dragota (2009) as indicated by Multiple Variance Ratio (MVR) methodology.

Olowe (1999) and Philip and Isaiq (2011) used monthly and annual stock prices respectively to explore the W-F efficiency of the NB. The NB appeared to be efficient in the W-F (Olowe, 1999). The NB is not W-F efficient as indicated the SCT and Ordinary Least Square OLS regression result from 1986 to 2010; thus, RW is not endemic in the NB (Philip et al, 2011). Udoka (2012) ascertained the W-F IE of the NB. The monthly price data obtained were processed using the OLS procedure. Findings reveal that stock price in the NB is W-F efficient. Thus, historical prices cannot rely on by investors to predict future direction of share prices to their personal advantage.

Jain, Vyas and Roy (2013) x-rayed the W-F efficiency in India market from 2005 to 2010; using daily price data of India NSE and BSE. Both Parametric and Non-Parametric (PNP) test were utilized. Findings portray that Indian bourse is W-F efficient global financial crisis period. The application of privileged information by investors cannot yield abnormal return. Akber and Muahmmad (2014) explored the W-F EM hypothesis in Karachi bourse from 1992 to 2013 index return. PNP tests were employed; findings infer that in the past 22 years Karachi bourse is totally W-F inefficient. However, the last 4 years have manifested some trace of efficiency. Al Kharusi and Weagley (2014) used the SCT to examine the W-F efficiency in Muscat bourse from 2007 to 2011 using daily price indices. The SCT is adopted and the findings refuse the W-F EMH during pre-crisis, during crisis and after crisis. Obayagbona and Igbinosa (2015) studied the W-F hypothesis in the Nigeria bourse from 2006 to. Autoregressive technique is employed to process the daily prices and return. The general results portray that the Nigerian bourse is weak form inefficient. Simons and Laryea (2015) looked at the W-F EMH for four (4) African bourse– Ghana, Egypt, Mauritius, and South Africa (SA). The PNP ((K-S, RT, SCT and Variance Ratio (VR)) test results show that except for SA another bourse is WF inefficient. Rahman, Simon and Hossain (2016) collected three (3) indices daily return from 2006 to 2015 to examine the WF efficiency in Chit-tagong bourse. The RT, VR, K-S and SCT methodology were adopted. Result rejected the W-F efficiency in the market. Meaning that investor's opportunity of making abnormal return via insider information is possible. Bapusaheb (2016) noticed in his findings

that Indian and other emerging economy bourse are less IE in W-F than advanced nation market. Many studies have seen this with small exceptions of assorted outcome.

Ananzeh (2016) studied the Amman bourse using daily data from 2000 to 2013. SCT and unit root test applied refute the random walk and W-F philosophy in daily returns. Awan and Subayyal (2016) explored the W-F EMH using data from 6 Gulf countries (Kuwait, UAE, Bahrain, Oman, Qatar and Saudi Arabia) from 2011 to 2015. The study used SCT and RT methodology. Findings among other things show that stock prices in the sample covered does not random walk pattern. Ikeora, Anyaogu and Werigbelegha (2016) in Nigeria the Nigerian bourse covered the W-F efficiency from 1985 to 2014. The PNP techniques employed shows that the Nigerian bourse is not W-F efficient. Yadirichukwu, and Ogochukwu (2016) confirm the W-F efficiency in Nigeria using monthly data from1984 to 2012. Thus, there exist RW model in the Nigerian bourse. Khan and Khan (2016) studied the W-F efficiency in Pakistan from 1991-2015. Daily, weekly and monthly index were analyzed with SCT and RT techniques. The RWH was rejected by the findings for weekly and daily index considered; but for monthly index RWH was documented.

Hawaldar, Rohit and Pinto (2017) applied S-K, SCT and RT to ascertain the W-F ME of individual firm's stock from 2011 to 2015 in Bahrain bourse. K-S outcome shows stock value does not conform to RW in general. RT reveals that 7 firms do not mimic RW; while SCT indicate that share price display low to moderate relationship varying from positive to negative coefficients. Thus, it becomes difficult to conclude the W-F ME of Bahrain as indicated by the mix result. Falaye, Awonusi, Oluwasegun and Eboigbe (2018) applied Q-statistics, runs test and one sample K-S test to investigate the W-F ME of the NB. Findings among other things show that stock price movement was independent, but they were not completely stochastic and there was a noticeable trend in the pattern of SPM in the Nigerian bourse. Mphoeng and Moalosi (2019) employed runs test in Botswana bourse daily domestic and foreign firms' indices to RW process and subsequently determine W-F ME. RT results showed the absence of RW process. Thus, Botswana bourse is determined to be W-F inefficient and ignore the EMH accordingly.

From empirical studies reviewed, it is conspicuous that prior studies are caress with assorted findings in the case of Nigeria. i.e. market efficiency and inefficiency are co-existed in a rationally steady manner over a period. Also, studies that tested the W-F efficiency in Nigeria using daily, weekly, monthly and quarterly indices; applying non-parametric techniques of Wald-Wolfowitz runs test, KS test and Autocorrelation Function Test (ACF) are very scarce or not in existence in Nigeria to the best of our knowledge. Hence, this study fills this gap in knowledge in this regard using a more recent data set because more studies are needed in this light.

3. RESAERCH METHODOLOGY

The variables under study are historical in nature, thus this study used the longitudinal research design. The entire stock market performance index is the population of this study, while the All Share Index (ASI) is purposively selected as the sample of the study, which capture changes in all the prices of shares (total price gains and losses for all securities) exchanged on NB floor, since this study is concern with stock price movement. This study scope encompasses all securities trade on the NB from 1985 -2019 of Daily, Weekly, Month-end and Quarterly *(DWMQ)* ASI data were considered. All the variables were sourced from Central Bank of Nigeria (CBN) statistical bulletin and apt securities.com database.

Preliminary Test

Descriptive statistics and unit root test constitute the primary test carried out on the variables. The properties and patterns of the variables were described in a meaningful way with descriptive statistics, while the time series stationary status of the variables were ascertain with Augmented Dickey-Fuller (ADF) and Philip-Peron (P-P) test given as:

$$\Delta Y_t = \alpha + \beta t + \delta Y_{t-1} + \gamma \sum_{i=1}^{m} \Delta Y_{t-i} + \varepsilon_t \quad (1)$$

$$\Delta Y_t = \alpha_0 + \pi Y_{t-1} + \mu t \quad (2)$$

Where:
ΔY_t = change in dependent variable
α = drift
t = deterministic trend
m = large lag length
ε_t = white noise process.

The presence of unit root is the H_O hypothesis of the P-P and ADF test.

Theoretical Framework

The EMH is the theoretical base of this study. This is so because the W-F version of EMH explained vividly whether the past series of stock prices are stochastic in pattern or they are related to one another. That is the randomness in price series ensures that successive stock prices are uncorrelated and similarly circulated. In the words of RWT; current return (P_t) are free and unrelated to previous return$[(P_{t-1}), P_{t-2}), P_{t-3}) \ldots\ldots]$ and prospect return (P_{t+1}) prediction is not supported. The RWT can be express in Autoregressive (AR) model given as:

$$P_t = \gamma_0 + \gamma_1 P_{t-1} + \gamma_2 P_{t-2} + \gamma_3 P_{t-3} + \varepsilon_t \quad (3)$$

Where:

P_t = current prices, γ_0 = constant, P_{t-1} to P_{t-3} = prices in the three (3) immediate preceding period, $\gamma_1 - \gamma_3$ = coefficient to be estimated, ε_t = perturb term.

Plethora of robust random estimation techniques such as poker test, seasonal/non-seasonal differences, sensitivity analysis Weiner process, LOMAC single variance ratio, among others have been used in the literature to test the W-F ME in stock markets. Since this work is centered on frontier bourse of Nigeria which is not sophisticated for using more advance tests. Therefore, the PNP test of SCT, RT and K-S test are used in this study. These tests best suit emerging and frontier markets and the desire test with more advanced techniques is less imperative (Mphoeng & Moalosa, 2019; Hawalda, et al, 2017; Malhotra, Tandon & Tandon, 2015; Su, Roca & Wong, 2015; Rehman & Qamar, 2014; Sultan, Madah & Khalid, 2013; Said & Harper, 2015).

Model Specification

This study adapted the Autoregressive model in Eq (3) where share prices were substituted with ASI. The functional form of the model is given as:

$$ASI_t = f(ASI_{t-1}, ASI_{t-2}, ASI_{t-3}) \quad (4)$$

The estimated version of the model with standard assumption of homoscedasticity is stated as;

$$ASI_t = \alpha_1 + \delta_1 ASI_{t-1} + \delta_2 ASI_{t-2} + \delta_3 ASI_{t-3} + \varepsilon_t \quad (5)$$

Where:
ASI_t = Daily, weekly, monthly and yearly all share index at current time.
$ASI_{t-1}, ASI_{t-2}, ASI_{t-3}$ = Lagged values of all share index
α_1 = intercept
$\delta_1, \delta_2 \; and \; \delta_3$ = unknown coefficient to be estimated
ε_t = stochastic perturb term

Test of Data Independence

The serial (auto) correlation test model of independence of successive stock return in Eq (5) is given as:

$$LY = n \times (n+2) \sum_{k-1}^{m} \frac{P^{2k}}{n-k} \sim \delta^2 \quad (6)$$

Where:
P^k = serial correlation coefficients of lag k
n = sample size

Test of Randomness

The randomness in the stock returns as determined by runs test via it mean and variance and this is given as:

$$\pi = \frac{2g_1 \times g_2}{g_1 + g_2} + 1 \ldots\ldots\ldots Mean\ number\ of\ price\ change \quad (7)$$

$$\sigma^2 = \frac{2g_1 \times g_2 \times (2g_1 \times g_2 - g_1 - g_2}{(g_1 + g_2)^2 \times (g_1 + g_2 - 1)} \quad (8)$$

Where: σ^2 = the standard deviation of number of price changes in the distribution. n_1 and n_2 = number of positive and negative price dynamics.

The ideal Z-statistic used to estimate the RT is given as:

$$Z = \frac{O-E}{\sqrt{V}} \quad (9)$$

Where: O = observe, E = expected, V = variance.

Finally, the Kolmogrov-Smirnov test model which determine distribution pattern is given as:

$$\frac{Max}{x} |F(x) - S_n(x)| \leq D_{n.\alpha} \quad (10)$$

Data Estimation Procedure

The OLS ARIMA framework is used to explore the influence of lag stock returns on current year returns. The randomness in stock returns is determine by the Ljung Box Q-statistics SCT; this quantitatively reveals the extent of closeness between a given time series and itself lag version over subsequent period intervals (Hamid, Suleman, Akash & Shah, 2010). The RT is used to know if data string is randomly manifesting with a specific distribution in stock return (Elango & Hussein, 2007; Pandey, 2003; Omar, Hussain, Bhatti & Altaf, 2013). Finally, the extent to which a random observation fits a specific distribution is determined by K-S test (Mobareket, Mollah & Bhuyan, 2008; Salam, 2013). These processes are run for daily, weekly, monthly and quarterly data stream considered in the sample.

4. DATA PRESENTATION AND ANALYSIS

Table 1. *Summary statistics*

	Mn	Med	Mx	Mn	SD	Skns	Kts	J-Bera	Prob.
ASID	16494.07	11444.87	66789.16	110.96	15360.23	0.682658	2.6095	763.3586	0.00
ASIW	16516.29	11486.7	65652.38	111.3	15347.14	0.675714	2.595129	151.0951	0.00
ASIM	16521.08	11486.7	65652.38	111.3	15364.42	0.677743	2.607638	34.7646	0.00

ASIQ	16553.69	11756.4	60952.95	112.3	15364.52	0.657424	2.544885	11.29308	0.00
Mn = Mean; Med =Median, Mx = Maximum; Minimum = Min, Skns = Skewness, Kts = Kurtosis, J-B = Jarque- Bera.									

Source: Computed by Author Using E-views 9.0 (2021)

Note: ASID = Daily All Shares Index
ASIW = Weekly ""
ASIM = Monthly ""
ASIQ = Quarterly ""

The proportion of mean to median in table 1 is nearly one. There is reasonable difference between the uniform distribution range as indicated by the Mx and Mn values. All variables have a long tail to the right as shown by the respective positive Skewness value. The property distribution of the variables is neither peak nor flat relatively normal as revealed by the Kurtosis coefficient that can be approximated to 3.0. The Jarque-Bera (J-B) prob. statistics for all variables are significant at 5% confidence. This shows that share prices are not normally distributed in the NB.

Table 2. *Stationarity test*

ADF Test					**PP Test**			
Variables	ADF Stat	Critical V.	Order	Remark	P-P Stat	Critical V.	Order	Remark
ΔASID	12.46493*	3.959052	I(1)	S	99.59815*	-3.959046	I(1)	S
ΔASIW	8.939687*	3.963189	I(1)	S	-42.96364	-3.963098	I(1)	S
ΔASIM	8.433311*	3.980655	1(1)	S	18.91329*	-3.980326	I(1)	S
ΔASIQ	6.838675*	4.025924	I(1)	S	-6.924703	-4.025924	I(1)	S
V. = Value, S = Stationary								

Note: *, ** implies stationary at 1% and 5% significance level, respectively.
Source: Computed by Author Using E-views 9.0 (2021)

The ADF and P-P statistics in Table 2 unanimously reveals that the variant ASI is stationary at first difference and integrated of I(1). Thus, the proposition of non-stationarity is refuted in the series.

Table 3. *OLS regression results*

		ASID	**ASIW**	
Variables		**Coefficient**	**Variables**	**Coefficient**
Dependent		ASID		ASIW
	C	3.371980 (0.1376)	C	38.49450 (0.1474)

Explanatory	ASID(-1)	1.218684* (0.0000)	ASIW(-1)	0.998734* (0.0000)
	ASID(-2)	-0.014038 (0.3923)	ASIW(-2)	1.21E-12 (1.0000)
	ASID(-3)	-0.204762* (0.0000)	ASIW(-3)	-0.000341 (0.9884)
R^2		0.999908		0.997481
Adj R^2		0.999908		0.997477
F-stat		32835146*		239191.0*
Prob(F-stat)		0.00		0.00
D.W stat		2.064870		2.001104

		ASIM	**ASIQ**	
Variables		**Coefficient**	**Variables**	**Coefficient**
Dependent		ASIM		ASIQ
	C	177.2718 (0.1203)	C	553.2006 (0.0901)
Explanatory	ASIM(-1)	1.097569 (0.0000)*	ASIQ(-1)	1.507731* (0.0000)
	ASIM(-2)	0.078457 (0.2818)	ASIQ(-2)	-0.612465* (0.0001)
	ASIM(-3)	-0.184425 (0.0002)*	ASIQ(-3)	0.077819 (0.3701)
R^2		0.989513		0.972911
Adj R^2		0.989436		0.972299
F-stat		12863.82*		1592.219*
Prob(F-stat)		0.00		0.00
D.W stat		2.085807		1.987429

**= 1% significant Level*

Source: Computed by Author Using E-views 9.0 (2021)

Tables 3 reveals that the coefficients of the one and three lagged values of ASID and ASIM considered have significant effect on current period ASID and ASIM. Also, the one period lag of ASIW has meaningful impact on current year ASIW while the one and two period lags considered for ASIQ have significant influence of current year ASIQ. This shows that past prices in the NB can be used to predict lead prices of shares on *DWMQ* basis. This is evidential in the F-stat coefficient of the entire model that is significant at 5% confidence level that there is significant association between lag prices taken together and current prices of shares in the NB.

The entire models in table 3 have a good fit of the regression line since a minimum of 97% for ASIQ to 100% of total systematic variation in current stock price is explained by previous share prices as shown by the adjusted version of R^2 in table III after adjusted for degree of freedom. 3% not explained is captured by the perturb term. The D.W statistic for the four (4) regressions can be approximated to 2.0 which may show the absence of autocorrelation in the model. However, the DW

statistic is no longer reliable in ascertaining this because of the lag explained variables in the model right hand. Hence, higher order correlation test becomes imperative, to ascertain the variables randomness.

Table 4. *Ljung-box q-statistic test*

	ASID		**ASIW**		**ASIM**		**ASIQ**	
Lag	*Q-Stat*	*Prob.*	*Q-Stat*	*Prob.*	*Q-Stat*	*Prob.*	*Q-Stat*	*Prob.*
1	9.4907	0.002*	5.E-09	1.000	0.7098	0.400	0.0051	0.943
2	48.154	0.000*	3.E-06	1.000	0.7106	0.701	0.3433	0.842
3	131.95	0.000*	0.0002	1.000	20.514	0.000*	1.7542	0.625
4	208.26	0.000*	17.083	0.002*	28.506	0.000*	1.7602	0.780
5	277.11	0.000*	18.745	0.002*	31.165	0.000*	1.9142	0.861
6	338.57	0.000*	18.745	0.005*	31.505	0.000*	3.5826	0.733
7	392.83	0.000*	18.745	0.009*	31.582	0.000*	6.7870	0.451
8	440.12	0.000*	18.807	0.016*	33.014	0.000*	7.1562	0.520
9	480.78	0.000*	83.485	0.000*	36.831	0.000*	7.2401	0.612
10	515.17	0.000*	83.486	0.000*	39.326	0.000*	11.827	0.297
11	543.74	0.000*	83.486	0.000*	47.729	0.000*	16.784	0.114
12	566.95	0.000*	83.706	0.000*	55.582	0.000*	17.301	0.139
13	585.34	0.000*	165.46	0.000*	59.612	0.000*	17.395	0.182
14	599.43	0.000*	166.89	0.000*	61.558	0.000*	17.523	0.229
15	609.81	0.000*	166.89	0.000*	63.297	0.000*	19.774	0.181
16	617.04	0.000*	166.89	0.000*	66.224	0.000*	19.856	0.227
17	621.72	0.000*	207.71	0.000*	66.228	0.000*	19.860	0.281
18	627.20	0.000*	222.03	0.000*	72.501	0.000*	19.900	0.338
19	650.07	0.000*	222.03	0.000*	72.813	0.000*	26.185	0.125
20	653.48	0.000*	222.03	0.000*	73.349	0.000*	26.986	0.136
21	742.38	0.000*	223.85	0.000*	79.167	0.000*	27.332	0.160
22	787.32	0.000*	237.13	0.000*	79.275	0.000*	27.994	0.176
23	1147.7	0.000*	237.13	0.000*	80.028	0.000*	28.262	0.206
24	1182.2	0.000*	237.13	0.000*	81.765	0.000*	35.247	0.065
25	1199.4	0.000*	237.14	0.000*	83.599	0.000*	35.422	0.081
26	1199.5	0.000*	244.12	0.000*	83.601	0.000*	35.603	0.099
27	1199.5	0.000*	256.42	0.000*	85.150	0.000*	35.711	0.122
28	1199.6	0.000*	256.42	0.000*	85.283	0.000*	37.259	0.113
29	1199.6	0.000*	256.42	0.000*	85.291	0.000*	40.637	0.074
30	1199.6	0.000*	259.70	0.000*	93.373	0.000*	43.108	0.057
31	1199.6	0.000*	272.38	0.000*	93.581	0.000*	46.235	0.039*
32	1199.6	0.000*	272.38	0.000*	94.396	0.000*	46.935	0.043*
33	1199.6	0.000*	272.38	0.000*	95.494	0.000*	47.042	0.054*
34	1199.8	0.000*	275.38	0.000*	96.837	0.000*	53.592	0.018**
35	1199.9	0.000*	284.84	0.000*	100.29	0.000*	53.988	0.021**
36	1200.2	0.000*	284.84	0.000*	100.42	0.000*	57.038	0.014*

** &** = 1% and 5% Significant Level*

Source: Computed by Author Using E-views 9.0 (2021)

Data independence test in table 4 indicates evidence of possible dependence in the prime and higher expected value of the return distributions. The Q-statistics coefficient for ASID, ASIW, and ASIQ for the first 36, last 33 and 34 lags accept the alternate hypothesis (H_i) for the entire sample. The last 6 lags for ASIQ accept

H_i for the entire sample. This means that *Q*-statistics are significant for almost all lags with acceptable probability that is less (<) 0.05. This shows the presence of autocorrelation in the residuals. This decision is bounding on ASIQ because the rule of thumb emphasize that the Q-statistics for all the lags considered must be insignificant with high prob. value that is > 0.05.

Table 5. *Runs test result*

Variables	TVs	C < TV	C >= TV	T. Cases	No. of Runs	Z-Value	Prob.	Remark
ASID	11490.58	4554.0	4554.0	9108.0	4	-95.38	0.0000*	Non-Random
ASIW	11486.70	910.0	912.0	1822.0	4	-42.56	0.0000*	“”
ASIM	11486.70	209.0	210.0	419.0	4	-20.20	0.0000*	“”
ASIQ	11756.40	70	70	140	4	-11.37	0.0000*	“”
C = Cases, TV = Test values, T = Total								

** = 1% Significant Level*

Source: Computed by Author Using E-views 9.0 (2021)

Khan, Ikram and Mehtab (2011) suggest that if the Z statistics for ASID, ASIW, ASIM and ASIQ index is $\geq \pm 1.96$ then we reject the runs test. Table 5 revealed that the Z values between fixed observed and moment of runs is calculated to be -95.38, -42.56, -20.20 and -11.37 for *DWMQ* ASI, respectively. Since the entire absolute Z statistic coefficient is higher than 1.96, thus the RT is refuted because there is serial dependence in the *DWMQ* share price in the NB as indicated by the p-values.

Table 6. *Kolmogrov-Smirnov (k-s) test result*

Variables	Z-Value	P-Value	Remark
ASID	15.4918	0.000*	Sig. at 1% level
ASIW	6.9593	0.000*	“”
ASIM	3.3250	0.000*	“”
ASIQ	1.9478	0.000*	“”
*Note: * = 1%*			

Source: Computed by Author Using E-views 9.0 (2021)

The K-S statistics is further used to ascertain whether distributions follow normal path. Result in table 6 shows that daily, weekly, monthly and quarterly ASI coefficients are significant at 5% confidence level. This means that share prices do not fit normal distribution. Hence, the null hypothesis is accepted.

Findings

Findings revealed that successful past prices of stock can be used to determine future direction (intrinsic value) of stock in the NB. This is reflected in the significant nexus between lag of quarterly, monthly, weekly and daily ASI considered and current value of these ASI in table 3. The test of randomness (Q-statistics) further confirms almost all the asymptotic significant prob. value is less

than 0.05; this suggests that the entire autocorrelation integer is significant for all variables. This implies that volatility in share prices traded on the NB floor does not follow RW process and the NB is not W-F information efficient because stock price changes are serially related. This further consolidates the Autoregressive OLS regression results in table 3. Furthermore, the study reveals that runs test Z-values are negative which indicate that real numbers of runs are smaller than the expected numbers. It shows the absence of randomness and negates the W-F efficiency of the NB. This result upholds the position of Q-statistics; that stock prices successive changes traded on the NB are not random. That is price movement tends to follow a specific pattern.

Also, the K-S goodness of fit shows < 0.05 significant level for quarterly, monthly, weekly and daily ASI of stocks traded on the NB. This means that distribution pattern does not follow a normal curve. This agrees with Q-statistic and runs test position. Implying that the NB is not W-F information efficient in reflecting past information in stock price. This study findings are consistent with Hawaldar, Rohit and Pinto (2017) in Bahrain; Mobarek (2000); Poshakwale (1996); Khan and Khan (2016) in Pakistan; Mphoeng and Moalosi (2019) in Botswana, Ekechi (2002); Inegbedion (2009); Falaye et al (2018); in Nigeria whom previously studied similar test employing stock price index data from the NB. However, these findings are inconsistent with the outcome of Ogochukwu (2016); Ajao and Osayuwu (2012); Udoka (2012), and Olowe (2002) in the literature.

5. CONCLUSION AND RECOMMENDATIONS

Based on our findings above, this study concludes that: Lag and lead stock prices traded on the NB are dependent. The findings uphold the tenets of technical analysis which assumes that the stock market has memory as such past prices have relationship with future prices of stock over the studied period. Changes in successive share prices of the shares traded in the NB follows a particular pattern; thus, is not random and negates the underlying assumptions of the Random Work Theory (RWT) which suggest that in efficient market share prices are stochastic. Hence, the NB is not W-F efficient because security prices are not randomly patterned which is a cardinal requirement for a W-F efficient market in RWT. This study concludes that active investors can still beat the market to make abnormal profit in the NB because the market do have a long memory to associate the previous daily, weekly, monthly and quarterly prices with current *DWMQ* prices. However, in practice this memory is relatively week in the long period as large portion of the lags considered in ASIQ were not significant. This portray that the NB might not be absolutely W-F inefficient in the long run as some trace of efficiency was observed. From the foregoing analysis we made the following recommendations:

1. Regulators of the NB should make information available to investors at free cost and employ more sophisticated system for information dissemination

that will checkmate and reduce the application of insider information to make abnormal profit.

2. Given the W-F inefficiency of the NB, increased market activities is undoubtedly suggested to enhance resource allocation and technology development that will promote market efficiency and efficient financial resources allocation of the nation.
3. There is need to increase the breadth and depth of the NB by policy makers via potential investor's enlightenment of the available wealth opportunities in the bourse to entice different investors type to participate and develop the stock market in Nigeria.
4. Continuous research on weak form of EMH is highly suggested in the NB to find more conclusions with the aid of more robust model.
5. Policy effort should be intensified by Security and Exchange Commission (SEC) to increase liquidity in the NB, which in turn increase efficiency.

Weakness of this study

This study focusses on weak form efficiency of the EMH in the Nigerian Bourse, as such the findings cannot be generalized. Therefore, cross country studies that will expand this model in Africa or Sub-Sahara Africa should be conducted using a more robust estimation technique like the Sensitivity Analysis, Wiener Process, the Chow-Denning Test and the Martingale's Probabilistic interpretation.

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