Characterization of Volatilities in the Nigerian Stock Exchange: Prospects for Options Trading

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Abstract
This paper examined the characteristics of volatilities in the Nigerian stock exchange (NSE) and their prospects for option trading. Also, the paper tested the information efficiency of the historical volatilities of the NSE All Share Index (ASI) and NSE30 Index equities using Variance Ratio Wild Bootstrap Joint Tests. The study found that one equity has a long left tail distribution, while others were positively skewed. Three equities have kurtosis and Jarque Bera probability statistics that approximate that of a normal distribution. All other stocks including the NSE ASI are leptokurtic and have Jarque Bera statistics that indicate strong conditional heteroscedasticity. The standard deviation statistics show that the degree of volatility vary among the NSE30 index equities. The Variance Ratio Wild Bootstrap Joint Tests based on the Chow-Denning maximum |z| statistic show that for the monthly volatilities, eight equities and the NSE ASI generally reject the null hypothesis that they are martingales. The three month moving volatilities, shows that three stocks strongly reject the null of a martingale while the NSE ASI and the rest of the NSE30 Index equities failed to reject the null hypothesis. Given the standard deviation of the NSE30 Index equities monthly and three month moving volatilities, option traders may be better off writing/buying options on these equities than the NSE ASI which is comparably the least volatile. As for whether investors can rely on past volatility information on the NSE ASI and NSE30 Index equities, the results are mixed and therefore depends on the particular asset of interest.
Keywords: Nigerian Stock Exchange, Characterization of Volatility, Options, Variance Ratio Test, Wild Bootstrap, Martingale

1.0 Introduction

Among the factors that affect options pricing – stock price volatility, time to expiration, exercise price, current stock price, dividend rates and interest rate – stock price volatility is the most important. Black & Scholes (1973) emphasis this in their model and show that investors needed to estimate only one parameter, the volatility, and input it into a relative simple formula to find the price of an option. True, the importance of stock price volatility is not lacking in support. Sharpe (1985) had written that the risk of the underlying stock greatly influences the value of an option and therefore it is important to give it due consideration. For Brigham (1989), an option on an extremely volatile stock will be worth more than one on a very stable stock. Furthermore, Van Horne (1998) had stated that the most important factor in the valuation of options is the price volatility of the associated security. This he says is because if two stocks had the same volatility and option futures but one had greater expected returns, the option values for the two stocks are the same. Thus, understanding volatility is crucial for informed investment decisions so notes Fama and French (2012) in their work: "Volatility and Premiums in the US Equity Returns". Bates (2002) also stated that derivatives are products with payoffs and prices dependent upon the stochastic evolution of associated underlying financial variables. Specifically, he writes that option payoffs depend upon the evolution of the asset price upon which the options are written. This assertion is corroborated by Nasdaq.com on its investment/options-guide/pricing-options page where it notes that the value of equity options is derived from the value of their underlying securities and the market price of options will rise or decline based on the related securities performance. Similarly, according to the Options Industry Council (OIC) the effect of volatility is the most subjective and perhaps the most difficult factor to quantify, but it can have a significant impact on the time value portion of an option's premium.

The importance attached to stock market and equity price volatility is due to its value for investors. Investors are constantly searching for information that will aid them predict the market in such a way as to outperform the market and reap excess returns from their investments. To the extent that Volatility is now a traded instrument in many advanced stock exchanges. Terms like Volatility Skew, Volatility Smile, and Volatility Trading all contribute to the ever growing status of volatility in option pricing. Thus, the quest to outperform the market has resulted to highly sophisticated economic and financial data modeling. In this regard, several Studies that model stock exchange/equity price volatility abound. These will include most studies on option pricing models with different variants of how volatility can be estimated, and most tests of efficient market hypothesis, the random walk model as well as the martingale model. The family of ARCH/GARCH specifications also accomplishes the same purpose of predicting the future path of investment returns. Abken and Nandi (1996) provide an overview

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of different specifications of asset price volatility that are widely used in option pricing models. These studies seek one thing in common: to establish whether financial markets are "informationally efficient" to the extent that investors may or may not consistently achieve returns in excess of average market returns on a risk-adjusted basis given the information available at the time the investment was made. In Engle (2001) words, "the goal of such models is to provide a volatility measure—like a standard deviation—that can be used in financial decisions concerning risk analysis, portfolio selection and derivative pricing".

In 2011, the management of the Nigerian Stock Exchange (NSE) headed by Oscar N. Onyema announced its plans to introduce option trading at the flour of the Nigerian stock exchange as a measure to deepen the market (Nwanma, 2011). While they are at it, it is important for investors to begin to appreciate the nature and characteristics of both the NSE Index and equity price volatilities as well as the intricate nature of options trading and the issues that make it exciting and risky. Thus, we examine the time series properties of equity and stock market volatilities in the Nigerian stock exchange. Of interest also is whether the historical volatilities of stocks quoted at the NSE and the NSE index are martingale difference. Following the above introduction, the paper is organized as follows. Section two deals with review of related literature. Section 3 explores our methodology while section four deals with data analysis and results. Finally, the conclusion is presented in section 5.

2.0 Literature Review

2.1 Volatility

Volatility is simply a measure of risk (uncertainty) or variability of price of a financial instrument over time. The term "volatility" may refer to historical volatility (how much the company stock actually fluctuated in the past) or implied volatility (how much the market expects the stock will fluctuate in the future). Historical volatility is defined as: the annualized standard deviation of past stock price movements. While Implied is what the marketplace is implying the volatility of the stock will be in the future, based on price changes in an option. Like historical volatility, this figure is expressed on an annualized basis. However implied volatility is typically of more interest to option traders than historical volatility because it is forward-looking and has implications for options pricing. Importantly, it helps predict the magnitude but not the direction of future price movement and higher volatility estimates reflect greater expected fluctuations (in either direction) in underlying price levels. This expectation generally results in higher option premiums.

2.2 Options

Options are generally defined as contracts that give the holder the right, but not the obligation to buy or sell a specific financial product officially known as the option's underlying instrument or underlying interest. For equity options, the underlying instrument is a stock, exchange-traded fund (ETF), or similar product. The contract itself is very precise. It establishes a specific price, called the strike price, at which the contract may be exercised, or acted on. And it has an expiration date. The buyer pays a *premium* to the seller for this right. The contract also obligates the seller or writer to meet the terms of delivery if the contract right is exercised by the holder. Options come in two varieties, calls and puts. An option which conveys the right to buy something at a specific price is called a call; an option which conveys the right to sell something at a specific price is called a put. Importantly, studies have shown that call options move in the same direction as the underlying asset, while put options move in opposite direction with the underlying asset. Options can play a variety of roles. For example, it can be used for income purposes. Or it may be used to protect (hedge) the value of an existing asset or assets from a market downturn. No one objective is better than another but defining ones objective helps narrow the choice of appropriate strategies to choose in trading options.

2.3 Empirical Literature

Most empirical studies in this area focus on the appropriateness of volatility models for option pricing and thus engage in high statistical, mathematical and econometric processes to either improve or to prove the supremacy of their models over others. The study of reference usually is the Black-Scholes (1973) option pricing formula. Eventually, they use some data to test the efficacy of their models. Such studies may include: Poterba and Summers (1984), Lo and MacKinlay (1989), Chow and Denning (1993), Wright (2000), Anderson et al (2001), Whang and Kim (2003), Kim (2006), Chen and Deo (2006), as well as Chun Liu and Maheu (2008).

However, to situate the present study, we find similar objectives in the works of Anderson et al. (1999)

Who exploit direct model-free measures of daily equity return volatility and correlation obtained from high-frequency intraday transaction prices on individual stocks in the Dow Jones Industrial Average over a five-year period to confirm, solidify and extend existing characterizations of stock return volatility and correlation. They found that the unconditional distributions of the variances and covariances for all thirty stocks are leptokurtic and highly skewed to the right, while the logarithmic standard deviations and correlations all appear approximately Gaussian. In the same study also, they found that the distributions returns scaled by the realized standard deviations are also Gaussian and that the realized logarithmic standard deviations and correlations all show strong dependence and appear to be well described by long-memory processes.

Charles and Darn´e (2008) more appropriately reflect the thinking and objective of the present study and indeed provide a substantial literature on the methodology (variance ratios test) that is adopted by this study. They review the recent developments in the field of the variance ratio (VR) tests of the random walk and martingale hypotheses. In particular, they present the conventional individual and multiple VR tests as well as their improved modifications based on power-transformed statistics, rank and sign tests, subsampling and bootstrap methods, among others. They examine the weak-form efficiency for five emerging markets in Latin America, including Argentina, Brazil, Chile, Ecuador and Mexico and use daily market prices spanning 03 August 1993 to 22 May 2007. Their results show that stock returns calculated as the first differences in the logs of the stock price indices are all leptokurtic as might be expected from daily stock returns. They report that three series (Argentina, Brazil and Ecuador) were skewed. They found that Argentina, Brazil, Chile and Mexican markets follow rejecting the Random Walk Hypothesis and, consequently conclude that these markets are not weak-form efficient.

Koutmos (2012) which dealt with "Time Varying Behavior of Stock Prices, Volatility Dynamics and Beta Risk in Industry Sector Indices of the Shanghai stock Exchange" capture similar objectives like the present study. Koutmos (2012) used data on the industry sector indices which comprise the Shanghai Stock Exchange and consists of a total of ten industries that are important to China's livelihood: Energy, materials, industrials, consumer discretionary, consumer staples, healthcare, financials, information technology, telecommunications, and utilities, respectively. According to the study which utilized daily Stock prices for a sample period for all sectors including the Shanghai Stock Exchange 180 (SSE 180) market index that ranges from January 9, 2009 to June 15, 2012 for a total of 830 observations.The study reports that the SSE 180 has a mean return of 0.0302%, and that Skewness and kurtosis measures indicate that the return series are generally negatively skewed and leptokurtic. Furthermore the study found that the Anderson-Darling test statistic show that the respective return series depart from the general characteristics of a normal distribution. Thus the study applied EGARCH and report that there was no statistically reliable evidence of volatility asymmetry.

Ajao and Wemambu's (2012) "Volatility Estimation and Stock Price Prediction in the Nigerian Stock Market" also reflect some perspectives of the present study. They use month end stock prices of four major companies from the period January 2005 to December, 2009 and made use of the Autoregressive Conditional heteroskedasticity (ARCH) to estimate and find out the presence of volatility. Their study found the presence of volatility in all the four stock prices used. Again, their results revealed that out of the four companies, only two companies' stock prices were predicted by volatility in their stock prices, while past stock prices predicted current stock prices implying that the market does not follow a random walk.

Besides these studies, other empirical studies have tested the efficiency of the Nigerian stock exchange with varying results. Studies that found the NSE to be efficient at some levels include but are not limited to: Samuels and Yacout (1981), Ayadi (1984), Olowe (1999), Okpara (2010), and Mayowa and Osayuwu (2012). While Ekechi (2002) Kalu (2008), Aguegbo, *et al.* (2010), Anoruo and Gil-Alana (2011), Gimba (2012), Adetunji et al (2013) and others say the NSE is not efficient in the weak form. Some of these studies are reported below

Kalu (2008) examines the Weak-Form Efficient Market Hypothesis across time for the Nigerian Stock Exchange (NSE) by hypothesizing Normal Distribution and Random walk in periodic return series. Monthly all share indices of the NSE were examined for three periods including January 1985 to December 1992, January 1993 to December 1999, and January 2000 to December 2007. Their Normality tests were conducted using Skewness, Kurtosis, Kolmogorov-Smirnov, and Q-Q Normal Chart; whereas Random walk was tested using the non-parametric Runs test. Results of the Normality tests show that returns from NSE do not follow normal distribution in all the periods. Runs test results reject the randomness of the return series of the NSE in the periods studied. Overall results from the tests suggest that the NSE is not Weak-Form efficient across the time periods of this study.

Okpara (2010) Analysis of Weak-Form Efficiency on the Nigerian Stock Market: Further Evidence from GARCH Model. This study investigated whether the Nigerian stock market (from the period 1984 to 2006) follows a random walk. He used the Generalized Autoregressive Conditional Hetrosecedasticity (GARCH) and report that the Nigerian stock market follows a random walk and is therefore weak form efficient. Though there were mixed results in his analysis, Okpara (2010) went on to conclude that the Nigerian stock market is weak form efficient and as such no investor can usurp any privileged information to bit the market and make abnormal profit.

Gimba (2012) tested the weak- form efficient market hypothesis using data from the Nigerian stock exchange spanning from 2005 to 2009. Specifically, the tests were for the market index and four individual stocks (First Bank, UBA, Union Bank, Cadbury and Nestle). Using daily and weekly data, the study reports that the empirical findings derived from the autocorrelation tests, Runs test and Variance ratio test for the observed returns conclusively reject the null hypothesis of the existence of a random walk for the market index and four out of the

five selected individual stocks and concluded that the NSE stock market is not efficient in the weak form.
Mayowa and Osayuwu (2012) Tested the Weak Form of Efficient Market Hypothesis in Nigerian Capital Market. The scope of the study consist of all securities traded on the floor of the Nigerian Stock Exchange and the month end value of the All Share Index from 2001 – 2010 constitute the data analyzed. They employ serial correlation analysis to test for independence of successive price movement and the distributive pattern while runs test was used to test for randomness of share price movement. The result of the serial correlation shows that the correlation coefficients did not violate the two-standard error test. Furthermore, they report that the Box-Ljung statistic show that none of the serial correlation coefficients was significant and the Box pierce Q statistics shows that the overall significance of the serial correlation test was poor while the result of the distribution pattern shows that stock price movements are approximately normal. On the basis of these findings, the study conclude that successive price changes of stocks traded on the floor of the Nigerian Capital Market are independent and random therefore, the Nigerian Capital Market is efficient in the weak-form.
Adetunji et al (2013) in their study "Forecasting Movement of the Nigerian Stock Exchange All Share Index using Artificial Neural and Bayesian Networks" made use of daily stock prices; these are the opening price, high price, low price, closing price, volume and the All-Share index of the Nigeria Stock Exchange market. This study is actually a comparative study of the predictive ability of Artificial Neural and Bayesian Networks using the Nigerian stock exchange data. Nevertheless, the conclusion derived from this study is informative regarding the methodology of forecasting NSE. In their words;
"This research work shows the weakness of ANN, in predicting the NSE financial time series because the data collected is not long-term form. The data may not be suitable to better train the ANN system to learn properly. From this work, one could easily infer that not all financial time series can be efficiently predicted by ANN".

3.0 Methodology

3.1 Variance Ratio Test, Wild Bootstrap, Martingale

The variance ratio (VR) statistic has been used widely as a test for the random-walk hypothesis. Lo and MacKinlay (1989) demonstrated that the VR test is more powerful than either the Dickey-Fuller test or the Box-Pierce Q test for several interesting alternatives. Cecchetti and Lam (1994) summarized the advantages of using the VR test. According to Charles and Darn´e (2008) VR tests have been applied to Asian markets (Kim and Shamsuddin, (2008), Eastern European markets (Smith and Ryoo, 2003), African markets (Lagoarde-Segot and Lucey, 2008) and Latin American markets (Chang *et al*., 2004).
We will go ahead and apply variance ratios test using Bootstrap method and refer interested readers to see Charles and Darn´e (2008) for technical and theoretical details on the conventional individual and multiple VR tests as well as their improved modifications based on power-transformed statistics, rank and sign tests, subsampling and bootstrap methods, among others.

3.2 The Wild bootstrap variance ratio test of Martingale Hypothesis

A *martingale* is a stochastic process whose expected value at each step equals its previous realization/observed value. This is the most important process in the general theory of stochastic processes. Its defining characteristic is the so-called *martingale property*: the best prediction for the next realization is the current value of the process.
A stochastic sequence $\{x_n\}$ is called a *martingale* (with respect to itself) if
(a) $E(x_n) < \mu$, and (b) $E(x_{n+1} ê x_1, x_2, \ldots, x_n) = x_n$.
Condition (a) says that at any point in time we require that the expected value of the realization be finite. Condition (b) is the mathematical expression of the martingale property: knowing the past history of the process, our best prediction for one step ahead is the current observation. If the time series of an asset price follows a martingale, then its return is purely non-predictable and investors are unable to make abnormal returns consistently over time.
Let x_t be an asset return at time t, where $t = 1, \ldots, T$. It is assumed that x_t is a realization of the underlying stochastic process X_t, which follows a martingale difference sequence. This means that X_t's are serially uncorrelated, but are allowed to be conditionally or unconditionally heteroskedastic. A formal definition of the martingale difference time series can be found in Lo and MacKinlay (1988; Assumption H*). Given the observed data ($x_1, .., x_T$), the VR statistic is shown below as provided in Kim (2004):

$$VR(X\,;K) = \{\frac{1}{TK} \sum_{t=k}^{T} (x_t + x_{t-1} + \cdots + x_{t-k+1} - k\hat{\mu})^2\} \div \{\frac{1}{T} \sum_{t=1}^{T} (x_t - \hat{\mu})^2\} \quad \ldots\ldots\ldots 1$$

Where $\mu = T^{-1} \sum_{t=1}^{T} x$ following the formula given by Wright (2000). This is an estimator for the unknown population VR, denoted as $V(k)$, which is the ratio of $1/k$ times the variance of k-period return to the variance of one-period return. To test the null hypothesis, $V(k_i) = 1$ for $i = 1, \ldots, l$ against the alternative hypothesis that $V(k_i) \neq 1$ for some i, the statistic of interest considered is

$$MV = \sqrt{T} \max|(VR(x; K_i) - 1)|. \qquad \text{Max } 1 \le I \le l \quad \ldots\ldots\ldots 2$$

This is also the form of the statistic also considered by Whang and Kim (2003) for their subsampling test. The sampling distribution of (2) is unknown and the wild bootstrap is used to approximate its sampling distribution. It can be conducted in three stages as below:

(i) Form a bootstrap sample of *T* observations: $x_t^* = n_t x_t$ (t=1,…,T) where n_t is a random sequence with zero mean and unit variance. (ii) Calculate *MV**, which is the *MV* statistic given in (2) obtained from the bootstrap sample generated in stage (i). (iii) Repeat (i) and (ii) sufficiently many, say *m*, times to form a bootstrap distribution of the test statistic $\{MV^{*j}\}_{j=1}^{m}$. The bootstrap distribution $\{MV^{*j}\}_{j=1}^{m}$ is used to approximate the sampling distribution of the *MV* statistic given in (2). The 100α% critical value of the test can be obtained as the $(1-\alpha)^{th}$ percentile of $\{MV^{*j}\}_{j=1}^{m}$ while the *p*-value of the test can be estimated as the proportion of $\{MV^{*j}\}_{j=1}^{m}$ greater than the *MV* statistic calculated from the original data. In implementing the wild bootstrap, a specific form of n_t should be chosen. It is random weights which ensure that $E(x_t^* \| x_t) = 0$ and $Var(x_t^* \| x_t) = x_t^2$. Note that the conditions $E(n_t) = 0$ and $E(n_t^2) = 1$ are essential for the validity of the wild bootstrap. In this paper, the standard normal distribution is chosen for n_t.

3.3 Data

The data for this study comprise of daily historical closing prices of the Nigerian stock exchange all share index (NSE ASI) and individual equities that make up the Nigerian Stock Exchange 30 Index (NSE30) and cover the period January 2005 to May 2013. Two sources provide our data: the Central Securities Clearing System Plc. and Cashcraft Asset Management Limited. The Central Securities Clearing System (CSCS) Plc. is the Clearing House of the Nigerian Stock market while Cashcraft Asset Management Ltd is a dealing member of the Nigerian Stock Exchange and is registered with the Securities and Exchange Commission as a Broker, Dealers, Issuing House and Fund Managers. The NSE30 index tracks the top 30 companies in terms of market capitalization and liquidity. It is a price index and is weighted by adjusted market capitalization—the number of a company's listed shares, multiplied by the closing price of that company, multiplied by a capping factor. Only fully paid-up common shares are included in the index. The NSE30 members for this study are those equities that make up the index as at end of May 2013. The Nigerian stock exchange maintains an All-Share Index formulated in January 1984 (January 3, 1984 = 100). Only common stocks (ordinary shares) are included in the computation of the index. The index is value-weighted and is computed daily.

To arrive at the data for our analysis, we calculate the daily log relative's returns of the respective firms and NSE ASI and from these compute their monthly and three month moving volatilities using Microsoft Excel. Black & Scholes (1973) assumed that financial asset prices are random variables that are log normally distributed. Therefore, returns to financial assets, the relative price changes are usually measured by taking the differences between the logarithmic prices. The log relative returns are mathematically defined by the equation:

$$\mu_i = In(S_i) - In(S_{i-1}) = In(\frac{S_i}{S_{i-1}}) \quad \ldots\ldots\ldots\ldots \quad 3$$

Where S_i is the stock price at the end of the *i* -th interval and $\ln(S_i)$ is the natural logarithmic function. We also assume that there are *n* stock prices in our sample.

3.4 Historical Volatility

The historical volatility is the volatility of a series of stock prices where we look back over the historical price path of the particular stock. The historical volatility estimate as measured by standard deviation is thus given by:

$$\sigma = (\sqrt{\frac{1}{n-1}) \sum_{i=1}^{n} (u_i - \bar{u})^2} \quad \ldots\ldots\ldots\ldots \quad 4$$

Where $\bar{u}$ is the mean defined by; $\bar{u} = \frac{1}{n}\sum_{j=1}^{n} u_j$. u_i was defined in Equation (4). σ in Equation (4) gives the estimated volatility per interval. To enable us to compare volatilities for different interval lengths we express volatility in annual terms. To do this we scale this estimate with an annualization factor (normalizing constant) *h* which is the number of intervals per annum such that:

$\sigma_{an} = \sigma^* \sqrt{h}$. ……………………………………………………..5

If daily data is used the interval is one trading day and we use *h* = 252, if the interval is a week, *h* = 52 and *h* = 12 for monthly data. Thus, given a series of daily log relative returns, we estimate the monthly and three month moving historical volatilities of a firm as implemented in Microsoft Excel by the following formula:

σ_{an} =STDEV{Log(r_t): Log(r_n)}*SQRT(252) ………………………………… 6

Where t is the first observation through n the last observation. We then form monthly and three month moving volatility series and use these in our descriptive statistics and in our variance ratio tests applying the Bootstrap method to see if the volatilities contain information that can be used to predict future volatilities of the assets in our study. We observe that we should be modeling realized implied volatility of option prices since we allude to option trading. But we are not blessed with such data since there is yet to be options in the NSE. However, we note that in a paper prior to their seminal one, *Black & Scholes* gave more insight into the variance rate of return. There they stated that they estimated the instantaneous variance from the historical series of daily stock prices. They thus defined volatility as the amount of variability in the returns of the underlying asset. *Black & Scholes* determined what is today known as the historical volatility and used that as a proxy for the expected volatility in the future (Kotzé, 2005).

4.0 Analysis and Results

Table 1 presents summary statistics for the NSE ASI and NSE30 Index equities' monthly volatilities. Apart from Glaxosmith that show a long left tail distribution, all the other equities are positively skewed. Three stocks – Glaxosmith, Nigerian Breweries and Stanbic bank have kurtosis (3.1838, 3.1756, 3.3359) and Jarque Bera Prob. statistics (0.7615, 0.2151, 0.6555) respectively that approximate that of a normal distribution. All other stocks including the NSE ASI are leptokurtic and have Jarque Bera statistics that indicate strong conditional heteroscedasticity. Using the standard deviation statistics, UBN is the most volatile (risky) while Nigerian Breweries is the least volatile. In general all the NSE30 Index equities are more volatile than the NSE ASI. Higher volatility estimates reflect greater expected fluctuations (in either direction) in underlying price levels. This expectation generally results in higher option premiums. Therefore, given the standard deviation of the NSE30 Index equities monthly volatilities, option traders may be better off writing/buying options on these equities than the NSE ASI which is comparably the least volatile. However, ETI, JBERGER, SKYEBANK, TOTAL, and UBN, present more interesting volatility statistics that investors may look out for in writing options in the NSE. These five securities require further investigation as their standard deviations are greater than their mean volatilities. For us, we did not observe any negative values for these equities neither did we observe any pronounced outliers to account for this.

Table 1: Descriptive statistics of monthly volatility of NSE30 Index Equities and NSE ASI

Equity	Mean	Standard Dev.	Skewness	Kurtosis	Jarque-Bera	Probability	Observations
ACCESS	0.46376	0.458529	6.807267	58.15989	12239.38	0	91
ASHAKACEM	0.477012	0.248776	3.762328	23.404	1970.599	0	100
CADBURY	0.422374	0.175839	0.592659	5.023504	22.91478	0.000011	100
DANGCEM	0.289488	0.167866	1.377265	5.409089	17.2969	0.000175	31
DANGFLOUR	0.496379	0.252895	1.746315	9.676293	149.0248	0	63
DANGSUGAR	0.447597	0.200239	0.996044	5.116461	26.04746	0.000002	74
DIAMOND	0.416243	0.250227	1.031594	7.799231	108.0204	0	95
ETI	0.461055	0.679083	5.905203	42.74596	5730.758	0	80
FBNH	0.412654	0.291621	3.752431	25.77957	2396.798	0	100
FCMB	0.369408	0.23589	1.057961	8.658442	152.0629	0	100
FIDELITY	0.39754	0.278119	1.059653	6.099697	56.39832	0	96
FLOURMILL	0.393479	0.229189	1.730573	8.350172	169.1828	0	100
GLAXOSMITH	0.423277	0.176164	-0.15574	3.183805	0.545033	0.761461*	100
GUARANTY	0.408986	0.220454	1.891517	7.393579	140.062	0	100
GUINNESS	0.301844	0.153158	1.261726	6.003552	64.1214	0	100
INTBREW	0.497009	0.260802	1.22113	8.549074	98.01829	0	64
JBERGER	0.454936	0.547797	6.924882	57.60501	13223.01	0	100
MOBIL	0.318062	0.205001	0.689683	4.16983	13.62979	0.001097	100
NB	0.355357	0.136723	0.420315	3.175684	3.073022	0.21513*	100
NESTLE	0.322584	0.201346	1.615577	8.292769	160.224	0	100
PZ	0.423673	0.276583	2.590385	14.85373	697.2975	0	100
SKYEBANK	0.481048	0.536327	5.758325	44.93574	6855.744	0	87
STANBIC1	0.420522	0.249771	0.832325	3.355886	0.845167	0.655351*	7

TOTAL	0.374884	0.665667	8.641851	82.3126	27455.06	0	100
UACN	0.382142	0.18822	0.976628	5.774222	47.96465	0	100
UBA	0.46959	0.36216	3.772307	25.65913	2376.49	0	100
UBN	0.581958	1.337207	9.088	87.8149	31036.23	0	99
UNILEVER	0.423434	0.212199	2.395911	14.18284	616.7393	0	100
WAPCO	0.391358	0.3146	4.837114	36.41432	5042.114	0	100
ZENITH	0.341712	0.244823	2.834187	17.98557	1080.269	0	101
NSEASI	0.152394	0.086676	1.456955	5.011222	51.18822	0	98

***The** Jarque-Bera statistics indicate that the monthly volatilities of these assets are normally distributed

In Table 2, we observe that the three month moving volatility statistics of the NSE30 Index equities and the NSE ASI follow similar characteristics as their monthly volatilities. However, three more stocks – Dangote Sugar, Dangote cement, and Mobil join Glaxosmith, Nigerian Breweries and Stanbic bank and indicate kurtosis and Jarque Bera Prob. statistics that approximate that of a normal distribution. One other difference is that the standard deviations of the three month moving volatility statistics have lower values indicating reduced deviations from the mean.

Table 2: Descriptive statistics of 3 month moving volatility of NSE30 Index Equities and NSE ASI

Equity	Mean	Standard Dev.	Skewness	Kurtosis	Jarque-Bera	Probability	Observations
ACCESS	0.492331	0.25531	2.950166	13.85623	566.1572	0	89
ASHAKACEM	0.50448	0.194519	2.44702	9.900381	298.1954	0	100
CADBURY	0.438676	0.121794	-0.24079	4.216058	7.127952	0.028326	100
DANGCEM	0.299727	0.121356	0.829484	2.950625	3.328488	0.189334*	29
DANGFLOUR	0.543844	0.185765	0.914119	4.315333	12.89273	0.001586	61
DANGSUGAR	0.470538	0.129288	0.249458	2.954021	0.753096	0.686226*	72
DIAMOND	0.450784	0.203437	-0.15551	4.294691	6.870218	0.032222	93
ETI	0.544827	0.629596	3.376135	14.79794	600.5497	0	78
FBNH	0.447581	0.236244	2.577689	12.22972	465.6901	0	100
FCMB3	0.392637	0.202325	0.166874	5.021157	17.13556	0.00019	98
FIDELITY	0.42452	0.235963	0.412822	4.47514	11.19276	0.003711	94
FLOURMILL	0.417755	0.190467	0.924773	4.418444	22.63669	0.000012	100
GLAXOSMITH	0.437378	0.125739	-0.07589	2.227027	2.585519	0.274512*	100
GUARANTY	0.43063	0.16523	1.166501	3.955907	26.48605	0.000002	100
GUINNESS	0.317826	0.118146	1.068936	4.317405	26.27521	0.000002	100
INTBREW	0.540462	0.17625	0.867941	4.339195	12.41738	0.002012	62
JBERGER	0.523151	0.472388	3.981911	19.6185	1414.988	0	100
MOBIL	0.349035	0.159593	0.234012	2.409135	2.367366	0.306149*	100
NB	0.367827	0.092855	0.474285	3.007165	3.749318	0.153407*	100
NESTLE	0.34035	0.159655	0.622977	3.705783	8.372996	0.015199	98
PZ	0.43878	0.21151	1.256725	7.001653	93.04442	0	100
SKYEBANK	0.539588	0.41391	2.751422	13.1708	473.6147	0	85
TOTAL	0.440994	0.644403	5.03637	28.03133	3033.448	0	100
STANBIC	0.502429	0.175066	-0.32597	1.256628	0.721744	0.697068*	5
UACN	0.390869	0.13781	-0.31349	4.165359	7.296524	0.026036	100
UBA	0.513546	0.284532	2.158903	10.29099	299.1748	0	100
UBN	0.720109	1.090071	5.047145	30.29912	3494.439	0	99

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UNILEVER	0.431066	0.141848	0.916863	4.571747	24.30391	0.000005	100
WAPCO	0.42134	0.256679	2.709999	12.91653	532.1413	0	100
ZENITH	0.370124	0.205982	1.779849	8.256735	169.6157	0	101
NSEASI	0.161594	0.072744	0.949214	3.23836	14.64339	0.000661	96

***The** Jarque-Bera statistics indicate that the 3month moving volatilities of these assets are normally distributed. Figure 1, 2 and 3 show the graphical distribution of the monthly and three month moving volatilities of the NSE ASI and the NSE30 Index equities. Financial analysts, looking at plots of daily returns such as in Figure 1, 2 & 3, notice that the amplitude of the returns varies over time and describe this as "volatility clustering" (Engle, 2001). A marked difference between the two figures however, is that the time part of the volatilities are more discernable for the three month moving volatilities than for the monthly.

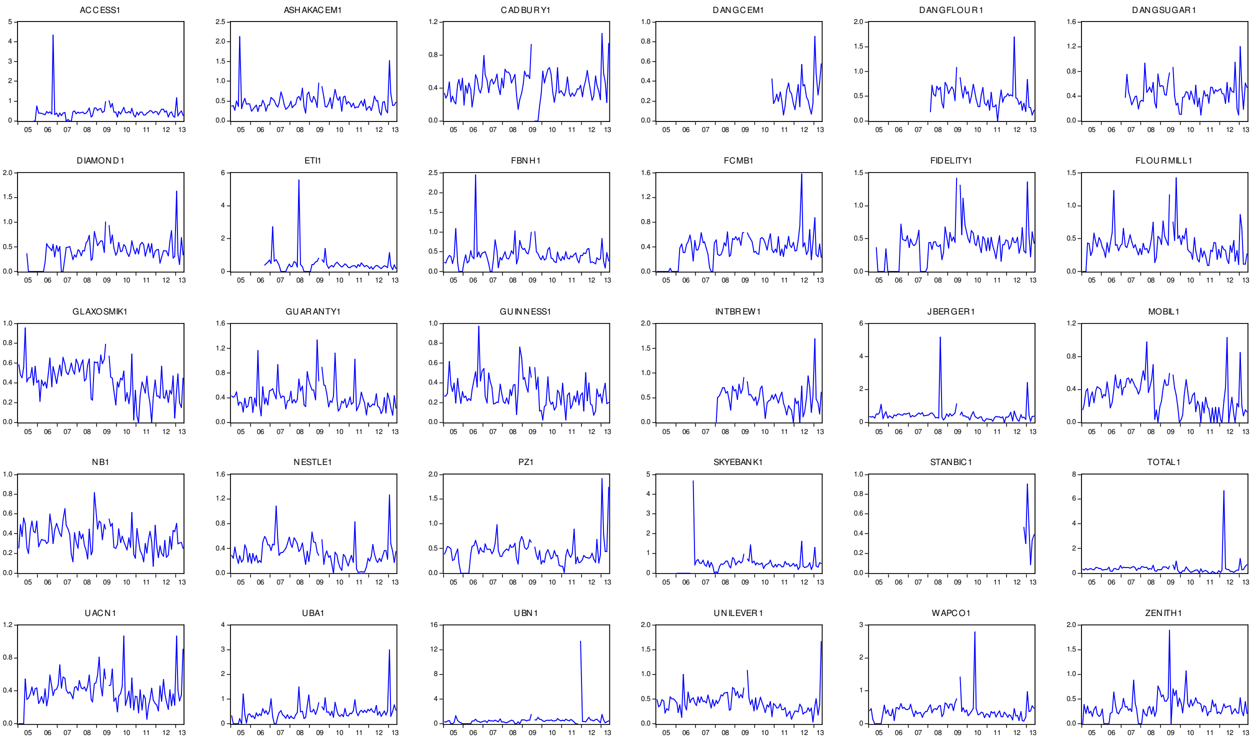

Fig.1 Graph of monthly volatilities of NSE30 Index Equities

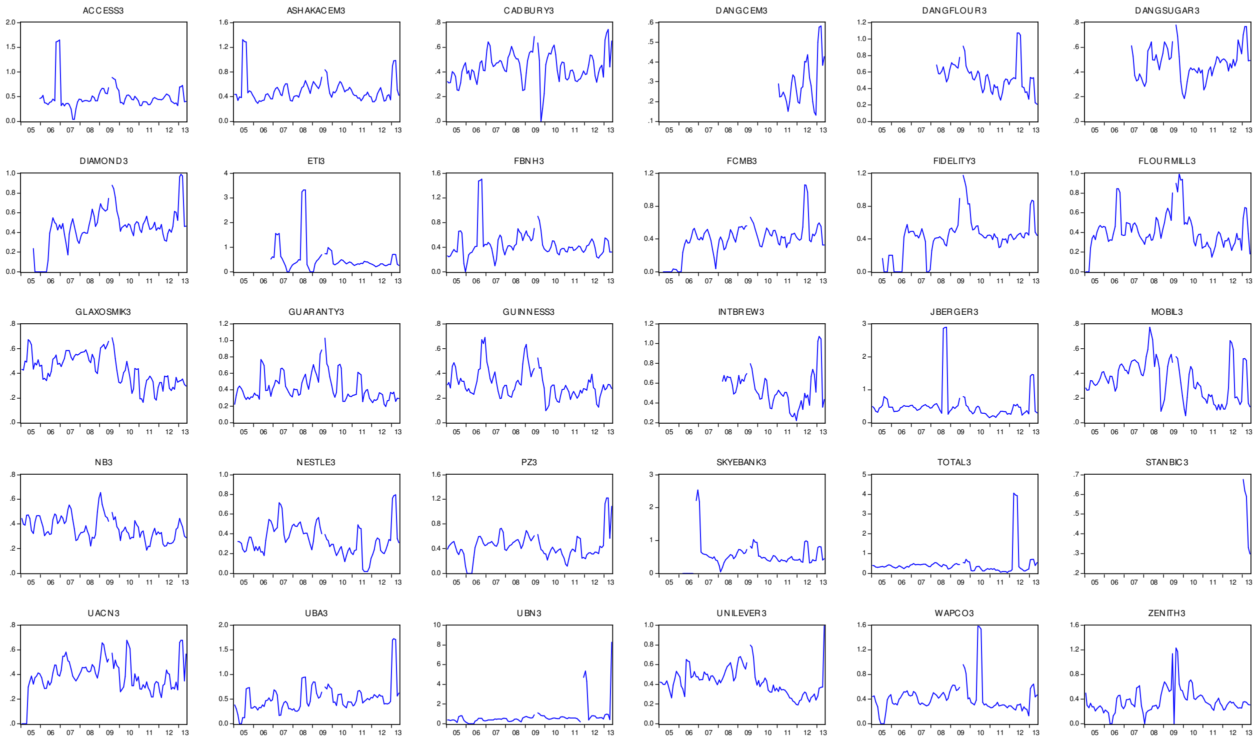

Fig.2 Graph of 3 month moving volatilities of NSE30 Index Equities

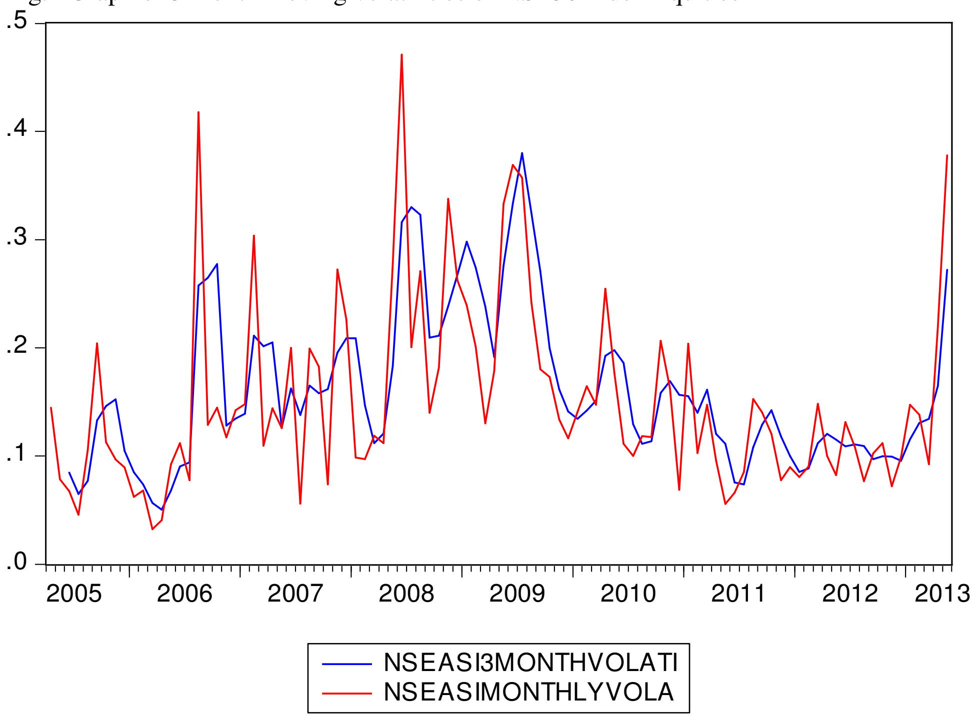

Fig. 3 Graph of monthly and three month moving volatilities of the NSE ASI

To test the information efficiency of the historical volatilities of the NSE ASI and the NSE30 Index equities, we hypothesized using the Null Hypotheses that: Log NSE ASI volatility and Log NSE30 Equities' volatilities are martingales and employ Variance Ratio Wild Bootstrap Joint Tests to evaluate the statistical significance . The specifications were set for Exponential random walk and Use heteroskedastic robust S.E. to allow for heteroskedasticity in the Wild bootstrap (with the two-point distribution, 1000 replications, the Knuth generator, and a seed for the random number generator using e-views 7.0 default settings specified in the Options section). The variances were computed assuming zero mean and use biased variance estimates and Lags specified as grid: min=2, max=16, step=1.

Table 3 show the Chow-Denning joint test statistics and bootstrap *p*-values for the null hypothesis that the Log NSE ASI volatility and Log NSE30 Equities' volatilities are martingales

Table 3: Variance Ratio Bootstrap Joint Tests Results. Null Hypotheses: Log NSE ASI volatility and Log NSE30 Equities volatility are martingales

	one month volatility stats			3 month mov volatility stats		
Firm ID	max |z|	Prob.		max |z|	Prob.	
ACCESS	1.773379	0.1730		1.344714	0.5290	
ASHAKA	2.845458	0.0070*		1.960792	0.2110	
CADBURY	8.362535	0.0320*		1.206641	0.7440	
DANGCEM	1.774652	0.1460		2.024245	0.0930	
DANGFLOUR	1.139695	0.4560		2.144654	0.2080	
DANGSUGAR	3.061108	0.0020*		2.011561	0.1520	
DIAMOND	3.012676	0.2650		2.545697	0.6520	
ETI	1.766868	0.2930		2.216405	0.0070*	
FBNH	1.587791	0.2860		1.065838	0.4500	
FCMB	1.617059	0.1670		1.419654	0.4070	
FIDELITY	1.948437	0.2200		1.937003	0.5170	
FLOURMILL	5.251805	0.2130		7.972644	0.2790	
GLAXOSMITH	1.667346	0.1380		2.120118	0.0810	
GUARANTY	3.549767	0.0000*		2.746704	0.0340*	
GUINNESS	2.567425	0.0120*		1.841705	0.1710	
INTBREW	1.773219	0.1640		2.482835	0.0800	
JBERGER	1.501319	0.1390		2.321128	0.1110	
MOBIL	3.307724	0.0110*		1.912414	0.1340	
NB	3.312974	0.0020*		1.849395	0.1850	
NESTLE	1.300959	0.2770		1.756773	0.1130	
PZ	1.566514	0.3390		1.562716	0.1600	
SKYEBANK	0.849759	0.8360		18.44194	0.0000*	
STANBIC	1.479165	0.2850		1.640876	0.5880	
TOTAL	2.213728	0.0630		1.301982	0.5340	
UACN	4.620823	0.2480		10.58347	0.2820	
UBA	1.880408	0.2110		1.240399	0.4670	
UBN	1.650788	0.3480		1.355317	0.7200	
UNILEVER	2.697282	0.0190*		2.802789	0.3300	
WAPCO	2.357077	0.2080		1.540442	0.1810	
ZENITH	2.040881	0.1780		1.673552	0.7734	
NSE ASI	3.037588	0.0130*		2.303527	0.0910	

Table 3 show Chow-Denning maximum |z| statistic obtained using the studentized maximum modulus (SMM) with infinite degrees of freedom and the approximate *p*-values
*Indicate significance at 5% level

The Chow-Denning maximum |z| statistic obtained using the studentized maximum modulus (SMM) with infinite degrees of freedom and the approximate *p*-values show that for the monthly volatilities, Ashakacem, Cadbury, Dangote sugar, Guaranty bank, Guinness, Mobil, Nigerian Breweries, Unilever, as well as the NSE ASI generally reject the null hypothesis that the log of their monthly volatilities are martingales. Consequently, it is impossible to conclude on the weak-form efficiency for these assets. On the other hand, the rest of NSE30 Equities failed to reject the null hypothesis that the logs of their volatilities are martingales.

For the three month moving volatilities, three equities (ETI, Guaranty Bank, and Skye Bank), strongly reject the null of a martingale while the NSE ASI and the rest of the NSE30 Index equities failed to reject the null hypothesis that the log of their three month moving volatilities are martingales.

5. 0 Conclusions

This paper examined the characteristics of volatilities in the Nigerian stock exchange and their prospects for option trading. Also, the paper tested the information efficiency of the historical volatilities of the NSE ASI and NSE30 Index equities using the Null Hypotheses that: Log NSE ASI volatility and Log NSE30 Equities' volatilities are martingales and employ Variance Ratio Wild Bootstrap Joint Tests to evaluate the statistical significance. The study found that Apart from Glaxosmith that show a long left tail distribution, all the other equities are positively skewed. Three stocks – Glaxosmith, Nigerian Breweries and Stanbic bank have kurtosis

and Jarque Bera Prob. statistics that approximate that of a normal distribution. All other stocks including the NSE ASI are leptokurtic and have Jarque Bera statistics that indicate strong conditional heteroscedasticity. Using the standard deviation statistics, UBN was found to be the most volatile (risky) while Nigerian Breweries was the least volatile. In general all the NSE30 Index equities were more volatile than the NSE ASI.
For the test of the information efficiency of the historical volatilities of the NSE ASI and the NSE30 Index equities based on the Chow-Denning maximum |z| statistic obtained using the studentized maximum modulus (SMM) with infinite degrees of freedom and the approximate *p*-values the study show that for the monthly volatilities, Ashskacem, Cadbury, Dangote sugar, Guaranty bank, Guinness, Mobil, Nigerian Breweries, Unilever, as well as the NSE ASI generally reject the null hypothesis that the log of their monthly volatilities are martingales while the rest of NSE30 Equities failed to reject the null hypothesis that the logs of their volatilities are martingales.
For the three month moving volatilities, the study show that three equities (ETI, Guaranty Bank, and Skye Bank), strongly reject the null of a martingale while the NSE ASI and the rest of the NSE30 Index equities failed to reject the null hypothesis that the log of their three month moving volatilities are martingales.
Given the standard. deviation of the NSE30 Index equities monthly and three month moving volatilities, option traders may be better off writing/buying options on these equities than the NSE ASI which is comparably the least volatile. As for whether investors can rely on past volatility information on the NSE ASI and NSE30 Index equities, the results are mixed and therefore depends on the particular asset of interest.

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