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Volatility patterns of stock prices

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A B S T R A C T

Research on stock exchange markets is essential to stock market investors as it offers sensitivities to risk management. This research investigates the patterns of the volatility of stock market prices in ten African stock markets. We estimated the dynamic GARCH model of Engle using the method of maximum likelihood estimation. Daily time series from January 1, 2021 to December 30, 2022, were obtained from African Stock (Securities) Exchange database. The findings established the existence of a normally distributed Senegalese stock market as against time-varying volatility of stock prices in Nigeria, Ghana, Mali, Burkina Faso, Togo, Niger Republic, Benin Republic, Ivory Coast, and Gambian. Hence, the likelihood that an asset or stock is being overpriced (overvalued) or underpriced (undervalued) in the Senegal stock market is low. It is therefore easier for stock traders and investors in Senegal to pick entry and exit points. Unfortunately, this cannot be said of the investors in stock markets of other countries. In effect, the closing price of a stock is most often heavily deviated with significant outliers. This further infers that variations of stock prices in these markets are very wide, heavy, and unpredicted. Hence, it is a case of the volatility of volatilities.

1. Introduction

In the framework of economic globalization, mainly after the effect of the current international financial crunch, the stock market has witnessed special uncertainties. This volatility rises unpredictability and risk in the stock market affects its functioning. To control for this doubt, it is possible to accurately estimate the volatility of a particular stock index. At the same time, because the stock market has a strong position in the international economy, the favorable growth of the stock market has become the focus of attention. So, to size the volatility of a stock index, it is necessary to know the theoretical and literary significance of the volatility.

Volatility is a fundamental feature of financial markets. This is openly associated with market doubt that affects the investment behavior of companies and individuals. Studying the volatility of returns on financial assets is one of the main problems of contemporary financial study, and this variation is regularly defined and measured by the deviation of the yield on financial assets. But it is difficult to predict perfect market volatility, although there are many different models and methods, they do not all work for all stock markets. This is why financial scientists and analysts face such difficulty in predicting market profitability and volatility. Traditional econometric models often assume that the deviation is stationary, that is, constant over various periods. Accurately measuring revenue volatility is directly related to portfolio selection accuracy, risk management effectiveness, and asset price stability. However, the growth of empirical research on the development of financial theory suggests that this assumption is unfounded. In addition, asset price volatility is one of the most common aspects of financial economics. Understanding volatility is a big encounter for stockholders.

Financial market volatility is primarily imitated in expected future asset value deviations. Volatility denotes in this research uncertainty about the impending price of an asset. The doubt of this measurement is commonly categorized by deviation or standard deviation. Currently, there are two key explanations for the relationship between these two factors in science:

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leverage and the instability feedback hypothesis. Leverage usually means bad news, and a fall in stock prices leads to the increased leverage, which in turn raises stock volatility. On the contrary, volatility is weakening. Volatility feedback can easily be defined as the volatility of a security. This inevitably leads to increased risk in the future. Several factors influence stock exchange price fluctuations. First, the influence of financial policy on the stock market is enormous. A weaker monetary procedure has been implemented for a year increasing the growth potential of stock indexes. On the other hand, if a relatively strict monetary policy is affected within a year, the stock index is likely to fall. Second, there is the influence of interest rate liberalization on risk-free rates. Looking at the world's foremost capital markets, changes in risk-free rates are more correlated with current stock markets. Overall, as interest rates continue to grow, risk-free rates rise, as well as the value of money invested in the stock market. As a result, the economy will steadily recover during the period of dividend reform, and the stock market is anticipated to improve its yield on investment.

Volatility tends to influence price movements unpredictably, but not all changes are bad. At the same time, financial market volatility has a straight effect on macroeconomics and financial firmness. Governments around the world often take potential economic risks seriously. Therefore, the study of financial market volatility has always been the emphasis of financial economists and financiers. Most of today's literature has examined several features of the stock market, such as the volatility control consequence, short-term volatility, the GARCH outcome, and so on, but few researchers believe that the short-term recollection of the GARCH model is often zero for sampling. In describing the cropped tail, it is often assumed that the ideal condition is normally distributed, but this perfect condition often is not confirmed.

When GARCH models are used to examine and predict yield volatility, the choice of the ideal variables for predicting is important because the relevant vital conditions will be given for a good solution. The stable method fits perfectly. Several findings have shown that the unaffected model can provide diverse outcomes when it is used with diverse ideas. Therefore, another major resolve of reviewing this work is to review studies that use accuracy-oriented predictive modeling as a standard from a practical standpoint. The researchers estimated small prediction errors, specifically, as estimated by mean absolute deviation (MAD), mean square error (RMSE), mean absolute error (MAE), and error mean squares (MSE), which is not essentially understood as capital gains. Others point out that predictions are not required to be exact according to the NMSE (normalized mean square error). This means that the search for the lowest interest rate on the original mean squared error is not highly profitable; in other words, the relationship between these two factors is not linear.

Stock market research is very vital to investors as it offers insights into risk management. Hence, enhanced empirical knowledge and comprehension of the interconnectedness of capital markets in different nations can be used to diversify risk for higher returns (Bakar, & Masih 2014). This work affords fresh insights into how to model and assess the level of financial market integration in African countries. Examining the integration of monetary markets is vital because of its devastating effects on the economy worldwide, in particular on long-term asset distribution, asset evaluation, valuation, monetary and fiscal policy-making, and ultimately risk management (Kaminski, & Reinhardt 1999). Due to the current international financial crunch, the study of the interrelationships of international markets is becoming a fertile area of research.

This research adds to the literature on the volatility of stock prices, in general, and in particular, how precisely the variances of assets prices are distributed in ten African stock markets namely, Nigeria, Ghana Mali, Burkina Faso, Senegal, Togo, Niger Republic, Benin Republic, Ivory Coast, and the Gambian stock markets. Two forms of distributions were used to evaluate the Z-statistic of the GARCH model, the Normal Gaussian distribution (histogram), and the linear graph for the cutoff point to capture patterns of stock prices over time in ten selected African stock markets taking into account temporal asymmetries in both volatility and correlation. Accordingly, the paper is of great significance as it extrapolates the implications of the statistical distributions of stock markets. By investigating the presence or otherwise of regularities, the appropriate statistical distribution for the various foreign exchange rate markets covered in this study was established.

In line with the research objective, investors and asset traders in the above-mentioned markets were by this study advised to take caution when evaluating a level of return by considering the statistical distribution regarding the trend of asset prices against time particularly when it is the case that investors can experience widespread and heavier variations beyond three standard deviations from the mean price. The present work uses a universal autoregressive conditional variance model (GARCH (1, 1)) to probe the patterns of the volatility of stock market prices of ten African stock markets which include, Nigeria, Ghana Mali, Burkina Faso, Senegal, Togo, Niger Republic, Benin Republic, Ivory Coast, and the Gambia stock markets. Next section 2, is a review of the literature. The methodology of the study is in section 3, a discussion of results in section 4, and 5 is the conclusion.

2. Literature review

Market integration is becoming more and more intense due to the increase in international financial dealings between different nations (Rezayat & Yavas, 2006). With the founding of financial markets due to financial liberalization, the stock market downturn, and the renewed currency crisis, the problem of global financial market integration has become relevant, particularly from the perspective of risk management and asset allotment (Bakar, & Masih 2014). The basis of this research is portfolio diversification theory, and financial markets integration/transition theory. Financial market integration was well explained by Menezes et al. (2010) as the degree of a close association between prices and returns, and the causal relationship between them over time.

Many theories attempt to perfect and describe the association's return to international financial markets over time (Al-Rimawi & Kaddumi, 2021; Alzoubi et al., 2021; Endri et al., 2021a). In particular, the results obtained by Al-Rimawi, & Kaddumi, (2021) indicated a significant Amman Stock Exchange performance effect of changes in the rate of economic growth, interest rate, foreign investment, and rate inflation rate. Basing their research problem on short-termism as a consequence of the agency association whereby stock market pressures distort performance, Alzoubi et al., (2021) established that individuals make varying investment decisions due to divergent payout time horizons. Endri et al., (2021b) found negative stock returns effect of exchange rates, return on assets, current ratio, commercial property price index, and debt-to-equity ratio. Only the variable of interest rate impact returns positively.

Kwadwo et al. (2023) reported high volatility with a temporary persistence during covid-19 as well as a significant effect of a positive shock on the unpredictability of the Ghana stock exchange (GSE)'s returns. The authors also found that covid-19 had no harmful effect on the returns of the GSE. Vu et al. (2022) reported a reduction in the effects of covid-19 cases since 2021. Some studies have attributed declining returns from the stock markets, escalating volatilities, liquidity crunch, and bankruptcy, to the covid-19 disease. These researches are, Kamaludin et al., (2021), Baig et al., (2021), Zaremba et al., (2020); Akhtaruzzaman et al. (2021), Anjum and Malik, (2020), and Zhang et al., 2020).

Other studies have attributed significant transmission of risk in the stock market within, and across different markets to the covid-19 pandemic. These studies include Ibrahim et al., 2020; Hassan et al. 2021, Abuzayed et al., (2021), Rizvi et al. 2021, Endri et al. (2021a), Bakry et al., (2021), Özdemir et al. (2021), Devpura et al. (2021), Ewing et al., (2019), Kusumahadi & Permana (2021), Gubareva (2021), Bossman et al., (2022), Huynh et al., (2021), Shen et al., (2022), Al-Awadhi et al., (2020), Ashraf, (2020), Vo and Doan, (2021), Zaremba et al., (2020), Baig et al., (2022), Zhang et al., (2020), Singh et al. 2020a; Liu et al. 2020a, b). Other researchers observed the impact of HIV/Aids, Ebola, and respiratory diseases, pandemic outbreak, natural disasters, politics or political movements, and sports on returns of the stock markets. These studies include, Feng & Li (2022), Daly et al. (2019), Kowalewski and Śpiewanowski (2020), Phan & Narayan (2020), Bahrini & Filfilan (2020), Ichev and Marinč (2018), Singh et al. (2020b), Caporale et al. 2019; Bash and Alsaifi (2019), Tavor and Teitler-Regev (2019), Shanaev and Ghimire (2019) and Buhagiar et al. (2018). In all the studies, negative stock market effects were found. Haroon and Rizvi (2020) reported a negative effect of covid-inducing news on the volatility of the economic sectors. Albulescu (2020) established in China that market volatility was positively influenced by covid-19 cases.

Reinhardt et al. (2003) propose several situations that attempt to explain market incorporation. They point out that the problem of unreasonable investor behavior is one of the biggest factors the economist understands, as it will affect the performance of foreign exchange capital markets and thus increase volatility. Other models are marked as commercial or financial. The most convincing theory is that they argue that this transmission of the phenomenon in the context of partial information is the result of investment broadening globally. The benefits of global broadening have been theoretically proven and empirically confirmed over the years. An unsystematic threat can be significantly abridged by creating a collection of negatively correlated securities. That is, to maximize the return of each unit of risk, it is necessary to include assets that are not highly correlated with each other in the portfolio. Recently, from the international market perspective, connectivity analysis has become of great significance in the optimal distribution and diversification of the Mediterranean portfolio.

Much research has been done on the transition of financial markets (Aloi et al. 2011; Samarakoon 2011; Baker, & Masih 2014). Several scholars have examined the interdependence of different financial markets during a crisis caused by other market shocks. Dooley and Hutchison (2009) discovered in their studies that the financial catastrophe in the United States did not affect emerging markets. Yiun et al. (2010) studied the forces of cross-market ratios in advanced evolving markets and noted that there were important signs of transmission concerning the US and Asian markets throughout the 2007-2009 international crisis. Yuetal et al. (2010) showed that there was no integration between the US and Asian financial markets during the crisis.

Loh (2013) shows that the market has become more integrated, especially the stock market. As reported by Loh and Ding Pu (2012) shows that contagion increases with increasing volatility, along with a decline in the ability of owners to pay debts when they are overdue. Another survey analyzed the stock market of the BRICS country along with the United States. Another interesting discovery was suggested by Ding and Pu (2012), who noted that before the crisis, there was a drastic change in each other's topology, suggesting that market integration and financial markets should be seen in isolation after the global market in the 2007 / 2009 financial crunch. Greater international stock market connectivity will certainly affect other markets. Chiang et al. (2012) argue that financial market liberalization has permitted the Chinese market to merge with the rest of the world and that these restructurings will allow China to expand into worldwide markets. In their research of developing markets, Ahlgren and Antell (2010) found no signs of contagion and no indication of short-term relationships throughout the predicament.

Xu and Hamori (2012) recommend that the correlation between the BRIC stock market and the US reduces both average returns and volatility in market shocks. Croatia, and Petrovski (2013) also endorse similar outcomes, arguing that the decline in stock market shares through a "prolonged" market downturn may be associated with a decline in market capitalization. Analyzing U.S. financial shocks, Samarakun (2011) reports a bilateral but asymmetric interdependence in emerging markets. It is also noted the relationship between markets varies eventually as financial crises occur at different times. Interest rates fluctuate over time through different periods of the financial crisis (Loh 2013). Ozdemir and Chakan (2007) find that there is a major bilateral nonlinear co-integration connection between the U.S. and other markets. There is ample proof that the stock market as whole correlates in relation to price and profitability. Relationships have been revealed to change over time, and this is a strong correlation during crises.

3. Methodology

As noted by Umoru (2023a,b,c), in financial econometrics, volatility is measured in terms of variance as modeled by ARCH and the GARCH models together with its variants, the T-GARCH, and the E-GARCH models. However, the variance is modeled conditionally on its history as specified:

$$\sigma_t^2 = \gamma_0 + \rho_1\sigma_{t-1}^2 + \rho_2\sigma_{t-2}^2 + \cdots + \rho_k\sigma_{t-k}^2 + \vartheta_1 e_{t-1}^2 + \vartheta_2 e_{t-2}^2 + \cdots + \vartheta_m e_{t-m}^2 \quad (1)$$

where σ_{t-j}^2 for j=1,2…. k are all past period's variance terms as captured by GARCH. The GARCH (1,1) is hereunder stated as follows:

$$\sigma_t^2 vol = \gamma_0 + \rho_1\sigma_{t-1}^2 + \vartheta_1 e_{t-1}^2 \quad (2)$$

The magnitude of the estimated coefficients, namely, ρ_1 and $\vartheta_1$determines the short-run dynamics of the consequential volatility pattern in the GARCH (1,1) model. A greater coefficient of ARCH error is an indication that volatility reacts significantly to stock market movements while such volatility is deemed persistent if the sum of significant coefficients of ARCH and GARCH terms exceeds 1. Similarly, risky volatility is suggested if the coefficient of the ARCH term exceeded the GARCH term given the following conditions (Bollerslev 1986):

Table 1
A Necessary and sufficient condition of the GARCH (1,1) model

Condition	Requirement	Source
$(\sum_{i=1}^{\rho}\rho_i + \sum_{j=1}^{q}\vartheta_j) < 1$	weak stationarity of the GARCH (1, 1) model	Bollerslev (1986)
$E(\log(\vartheta_1 e + \rho_i) < 0$	strict stationarity of the GARCH (1, 1) model	Bollerslev (1986)

Source: Authors calibration

The volatility pattern of stock prices was generated as a conditional variance of stock prices measured by Eq. (3):

$$\sigma_t^2 = \varphi_0 + \rho_1\sigma_{t-1}^2 + \sum_{j=1}^{p}\vartheta_j\hat{e}_{t-j}^2 \quad (3)$$

where σ_t^2 is the conditional variance, that is, the conditional rate of the volatility of the African stock markets and $\hat{u}_{t-1}^2$ depicts information about previous volatility measured as the lagged squared residual term, σ_t^2 is conditional variance, ϑ_1 signifies the ARCH parameters, ρ_1 denotes the GARCH parameter, and σ_{t-1}^2 is the previous forecast error variance. Alternative estimation methods for this study exist, and these include, the ARIMA method, frequency domain approach, impulse response function, VAR_AGARCH estimation approach, Panel Bayesian VAR method of estimation, Structural Panel Bayesian VAR (SPBVAR), and the TS-GARCH and TARCH methods of estimation.

We chose to estimate the dynamic conditional correlation generalized autoregressive conditional heteroscedasticity (DCC-GARCH) model of Engle (2002) using the method of maximum likelihood estimation (MLE) to take advantage of two different forms of distribution. Two forms of distributions were used to evaluate the Z-statistic of the GARCH model, the Normal Gaussian distribution (histogram), and the linear graph for the breakpoint to capture patterns of stock prices over time in ten selected African stock markets taking into account temporal asymmetries in both volatility and correlation, and examines the quadratic dynamics of the financial time-series, to resolve the issue of variable variance. The rationale for Engle's (2002) DCC-GARCH model is because it allows one to obtain possible coefficients of conditional relation of stock prices of the countries under investigation. In this study, the researchers used daily time series data on stock prices from January 1, 2021, to December 30, 2022, for ten African stock markets in Nigeria, Ghana, Mali, Burkina Faso, Senegal, Togo, Niger Republic, Benin Republic, Ivory Coast, and the Gambia. The daily time series were obtained from the African

Stock (Securities) Exchange database. For a sample of 10 African stock markets, we generated a total of 7,300 panel data points for analysis. The sample size requirement for a GARCH model is 1000 data points (Ng & Lam, 2006). With this, an optimal solution is instituted by implementing the maximum likelihood estimation method. Hence, using daily time series data on stock prices from January 1, 2021, to December 30, 2022, for ten African stock markets we generated a total of 7,300-panel data points for analysis. So, even with smaller cross sections of 10 stock markets where data was readily available for this study, the daily frequency of stock prices was sufficiently large to produce over 7000 data points. This plays a significant role in modeling volatility patterns and accordingly justifies the application of the GARCH modeling technique. Data of a minimum of 2-3 years cannot be relied upon to meet data requirements for the application of GARCH models. And indeed, the volatility pattern cannot be accurately measured with just 2 to 3 years of observations. Under the results and discussion, we presented the pattern of the volatility of stock prices for each country, and the ensuing discussion followed. This was necessary to disentangle the different patterns of volatility for each country.

4. Results and discussions

This section is devoted to succinct discussions on volatility patterns of stock price movements in Nigeria, Ghana Mali, Burkina Faso, Senegal, Togo, Niger Republic, Benin Republic, Ivory Coast, and the Gambia stock markets. The Normal Gaussian distribution (histogram), and the linear graph for the cutoff point were deployed to evaluate the Z-statistic of the GARCH model to capture patterns of stock prices over time in ten selected African stock markets taking into account temporal asymmetries in both volatility and correlation.

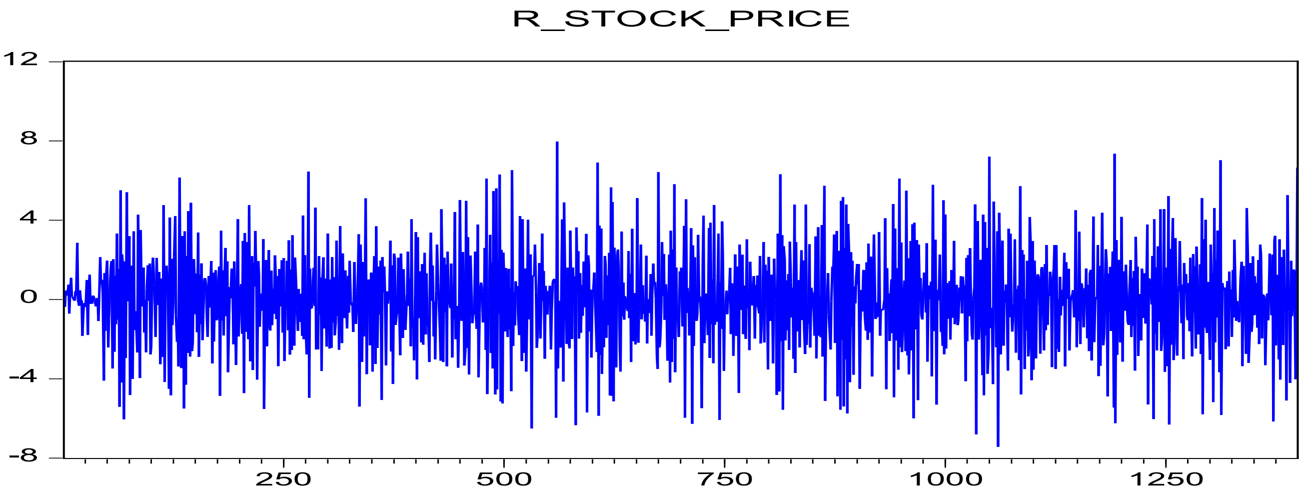
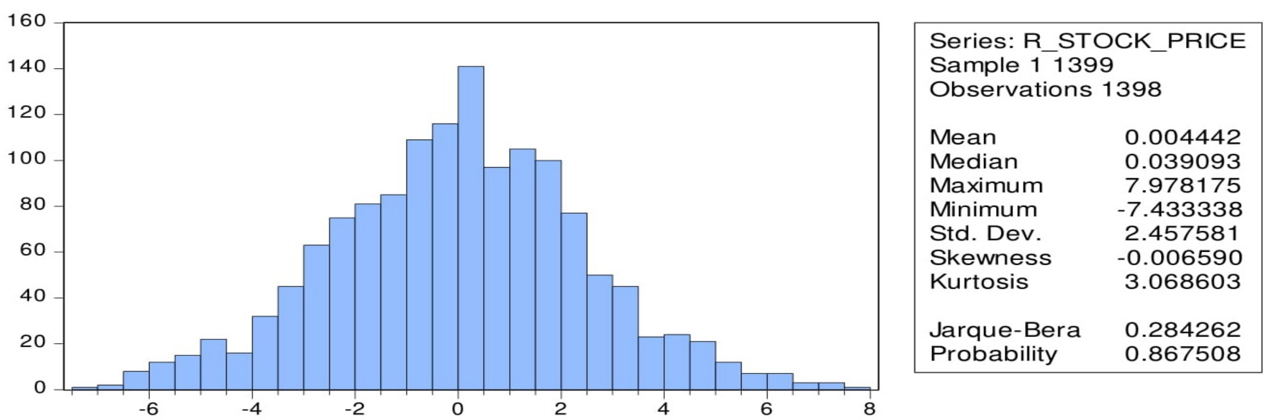


Fig. 1. The pattern of the volatility of stock prices in Nigeria

From the graph, clustering of volatility is evident in the series as stock prices display a tendency to return to a zero average. In effect stock prices in Nigeria exhibits a bunch of volatility. The histogram plot is leptokurtic. It has fat tails which is a strong feature of financial series. High-frequency series often display fat tails. Return of stock exchange is not an exception.



Mean Equation: The dependent variable is *S_Price* and convergence was achieved after 18 iterations.

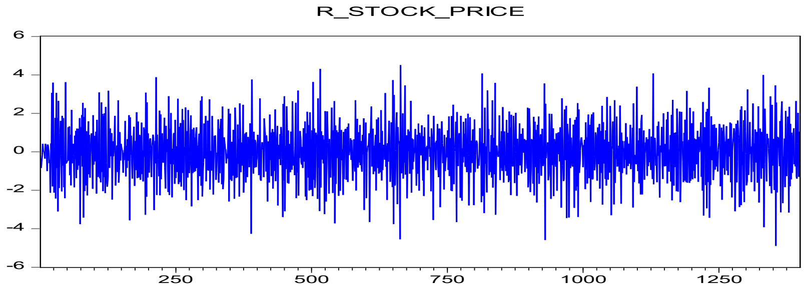
$$S\_Price_t = 0.030649 - 0.552248 S\_Price_{t-1}$$

The coefficient of S_Price_{t-1} is desirable and statistically imperative at a 1 percent level. The average stock yield is 0.030649 and the past values of the stocks considerably forecast the current series.

Variance Equation:

$$\widehat{\sigma_t^2 vol_t} = \underset{(2.70)}{0.118778} + \underset{(55.79)}{0.949}\sigma_t^2 vol_{t-1} + \underset{(2.23)}{0.023}e_{t-1}^2$$

The regression constant, together with GARCH and ARCH coefficients are all significant at the 1 percent level. Regarding time-varying variability coefficient of correlation of conditional deviations that do encounter stability are 0<0.949<1, 0<0.023<1, and 0.972<1. The results confirm the existence of a conditional return that varies with the stock price. The results also show that there is a constant existence of volatility shocks, as the amount of the ARCH and GARCH parameters (0.972). This suggests that the effects of today's shocks are projected to persist for several periods in the future.



Source: Authors calibrations using Eviews 10

Fig. 2. Pattern of the volatility of stock prices in Ghana

From the graph, the volatility clustering of the series is made evident. It shows a period of big change followed by a big change, an era period of small change followed by an era of small change. The clustering of volatility is evident in the series. With regards to the average return, i.e. the series has returned to an average of zero. This series is a real series that shows a bunch of volatility.

Mean Equation: The dependent variable is *S_Price* and convergence was achieved after 20 iterations.

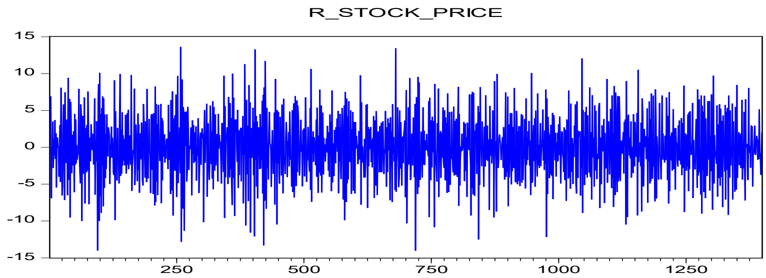
$$S\_Price_t = -0.000369 - 0.505750 S\_Price_{t-1}$$

The average stock yield is 0.000369 and the past values of the stocks significantly forecast the current series.

Variance Equation:

$$\widehat{\sigma_t^2 vol_t} = \underset{(8.36)}{2.996002} - \underset{(-4.08)}{0.847}\widehat{\sigma_t^2 vol}_{t-1} - \underset{(-0.64)}{0.0106}e_{t-1}^2$$

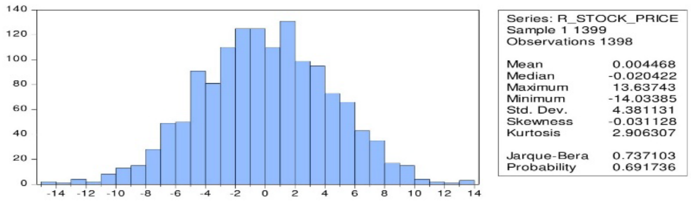
The coefficient of constant variance and GARCH parameter is negative. ARCH coefficient is statistically significant at the 1 percent level, while ARCH is not statistically important at all levels. Time-varying volatility consists of a constant (2.996002), a past value (0.847), and a past error of 0.0106. Therefore, the coefficients of conditional deviations that do meet stability are 0<0.847<1, 0<0.0106<1, and 0.8576<1. The results confirm the existence of a conditional return that varies with stock prices in Nigeria. The results also show that there is a constant existence of volatility shocks, as the ARCH and GARCH coefficients sum is huge. This suggests effects of today's shocks are projected to persist for some periods in the future.



Source: Authors calibrations using Eviews 10

Fig. 3. Pattern of the volatility of stock prices in Mali

From the graph, clustering of volatility is evident in the series such that stock prices have returned to an average of zero. The histogram plot is leptokurtic. It has fat tails which is a strong feature of financial series. High-frequency series often display fat tails. Return of stock exchange is not an exception.



Source: Authors calibrations using Eviews 10

Mean Equation: The dependent variable is *S_Price* and convergence was achieved after 1iteration.

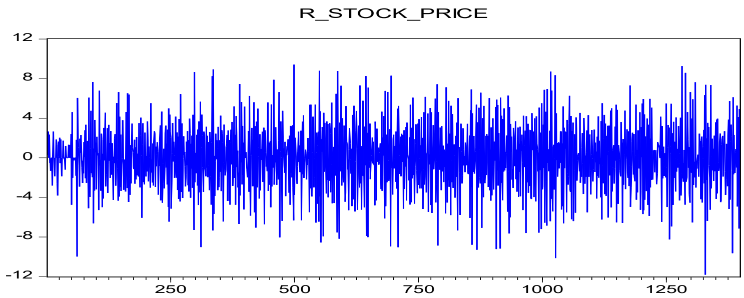
$$S\_price_t = 3.49100 + 1.00000 S\_price_{t-1}$$

The one-period lagged coefficient of stock prices is significant and statistically desirable at the 1 percent level. The average stock yield is 3.49100 and the past values of the stocks significantly predict the current series.

Variance Equation:

$$\widehat{\sigma_t^2 vol_t} = 1.3000 + 0.600\sigma_t^2 \widehat{vol}_{t-1} + 0.1500 e_{t-1}^2$$
$$(1.79) \qquad (2.89) \qquad (0.150)$$

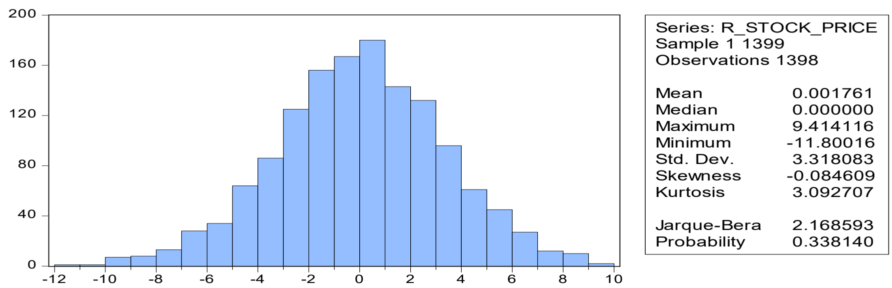
The coefficient of term constant variance, together with the GARCH coefficient are positive, while the ARCH is negative at the statistically essential 1 percent level. The time-varying instability results show a constant of variance equation is 1.30E-34, its past variance was calculated as 0.6, and a past error of 0.15 was calculated as well. The results confirm the existence of a conditional return that varies with the stock price. The results also show that there is a constant existence of volatility shocks, as the amount of the ARCH and GARCH parameters (0.75) is huge. This suggests that the effects of today's shocks are projected to persist for several periods in the future.



Source: Authors calibrations using Eviews 10

Fig. 4. Pattern of the volatility of stock prices in Burkina Faso

From the graph, it is evident volatility clustering of the series. It shows a period of big change followed by a big change, an era of small change followed by an era of small change. The clustering of volatility is evident in the series and stock prices tend to return to a zero average. In effect, stock prices in Burkina Faso show a bunch of volatility.



Source: Authors calibrations using Eviews 10

The histogram plot is leptokurtic. It has fat tails which is a strong feature of financial series. High-frequency series often display fat tails. Return of stock exchange is not an exception.

Mean Equation: The dependent variable is *S_Price* and convergence was achieved after 36 iterations.

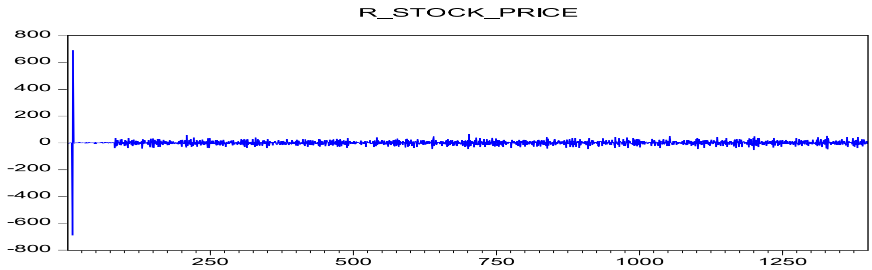
$$S\_Price_t = 0.023924 - 0.483451 S\_Price_{t-1}$$

The one-period lagged coefficient of stock prices is negative and significant at the 1% level. The average stock yield is 0.023924 and the past values of the stocks significantly forecast the current series.

Variance Equation:

$$\underset{(76.9)}{\sigma_t^2 vol = 0.048755} + \underset{(1614.63)}{1.003\sigma_t^2 vol} - \underset{(13.39)}{0.0084 e_{t-1}^2}$$

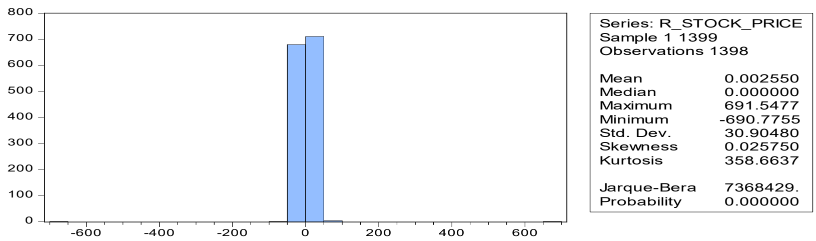
The intercept and the GARCH coefficients are positively useful, while the ARCH is negative at the statistically important 1% level. The time-varying instability results show a constant of variance equation is 0.048755, its past variance was calculated as 1.003, and a past error of 0.0084 was calculated as well. The results confirm the existence of a conditional return that varies with the stock price. The results also show that there is a constant existence of volatility shocks, as the amount of the ARCH and GARCH parameters (1.0084) is huge. This suggests effects of today's shocks are projected to persist for some periods in the future.



Source: Authors calibrations using Eviews 10

Fig. 5. Pattern of the volatility of stock prices in Senegal

The graph shows the period of constant mean and variance. Volatility clustering is evident in the series.



Source: Authors calibrations using Eviews 10

The histogram plot shows that there is a uniform distribution of the series over a long period. It has constant volatility. The results of Table 1 depict the mean and variance equations for Togo.

Table 1

The results of the mean and variance

Mean Equation				
Variable	Coefficient	Std. Error	z-Statistics	Prob.
C	0.010214	0.128262	0.079633	0.9365
R_STOCK_PRICE(-1)	-0.492172	0.023584	-20.86913	0.0000
Variance Equation				
C	0.255145	0.045837	5.566312	0.0000
RESID(-1)^2	0.017538	0.006645	2.639308	0.0083
GRACH(-1)	0.973736	0.007037	138.3781	0.0000

Source: Authors' estimations using Eviews 10

Mean Equation: The dependent variable is R_STOCK_PRICE and convergence was achieved after 140 iterations.

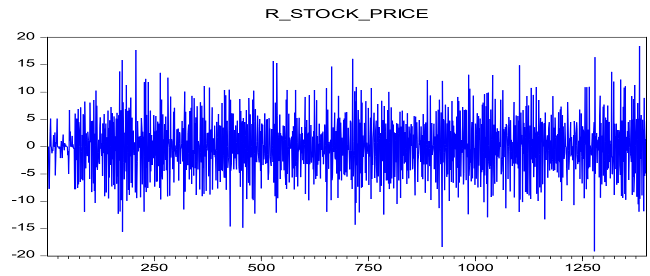
$$S\_Price_t = -0.010214 - 0.492172 S\_Price_{t-1}$$

The one-period lagged coefficient of stock prices is negative and significant at the 1% level. The average stock yield is 0.010214 and the past values of the stocks significantly forecast the current series.

Variance Equation:

$$\widehat{\sigma_t^2 vol_t} = 0.255145 + 0.973736\widehat{\sigma_t^2 vol_{t-1}} + 0.017538e_{t-1}^2$$
$$(5.566312) \quad (138.3781) \qquad (2.639308)$$

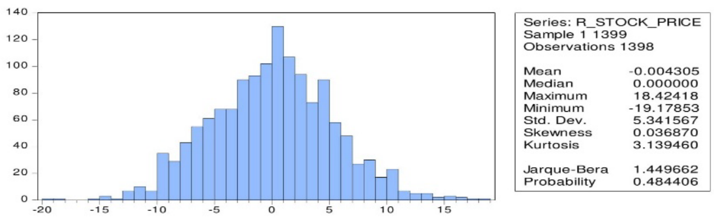
The intercept and the GARCH coefficients are positively constructive, while the ARCH is desirable at the statistically significant 1 percent level. The time-varying instability results show a constant of variance equation is 0.255145, its past variance was calculated as 0.973736, and a past error of 0.017538 was calculated as well. The results confirm the existence of a conditional return that varies with the stock price. The results also show that there is a constant existence of volatility shocks, as the ARCH and GARCH coefficients sum is huge. This suggests effects of today's shocks are projected to persist for some periods in the future.



Source: Authors calibrations using Eviews 10

Fig. 6. Pattern of the volatility of stock prices in Togo

From the graph, the clustering of volatility is evident in the series. In terms of the average return, i.e. the series has returned to an average of zero. This series is a real series that shows a bunch of volatility.



Source: Authors calibrations using Eviews 10

Mean Equation: The dependent variable is *S_Price* and convergence was achieved after 11 iterations.

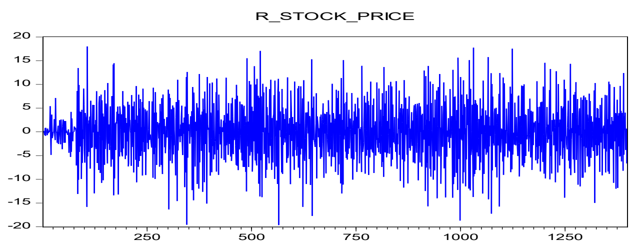
$$S\_Price_t = -0.021856 - 0.512519S\_Price_{t-1}$$

The one-period lagged coefficient of stock prices is negative and considerably significant at the 1% level. The average stock yield is 0.021856 and the past values of the stocks significantly forecast the current series.

Variance Equation:

$$\widehat{\sigma_t^2 vol_t} = 5.471125 + 0.671\widehat{\sigma_t^2 vol_{t-1}} + 0.070e_{t-1}^2$$
$$(1.94) \quad (4.47) \qquad (2.45)$$

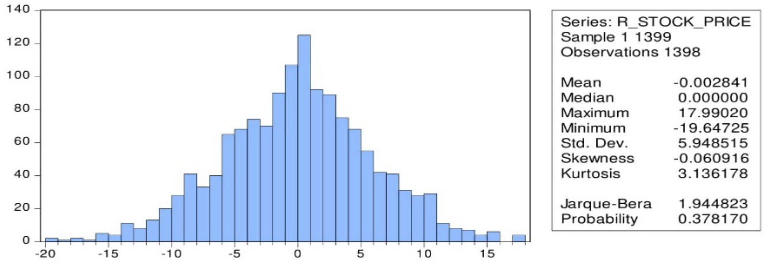
The coefficients of the intercept and the GARCH terms are positive in sign, while the ARCH is negative at the statistically significant 1% level. The GARCH coefficient is significant at 1% level. The results confirm the existence of a conditional return that varies with the stock price. The results also show that there is a constant existence of volatility shocks. This suggests effects of today's shocks are projected to persist for some periods in the future.



Source: Authors calibrations using Eviews 10

Fig. 7. Pattern of the volatility of stock prices in Niger Republic

From the graph, clustering of volatility is evident in the series, with a tendency to revert to zero. The histogram plot is leptokurtic. It has fat tails which is a strong feature of financial series. High-frequency series often display fat tails.



Source: Authors calibrations using Eviews 10

Mean Equation: The dependent variable is *S_Price* and convergence was achieved after 19 iterations.

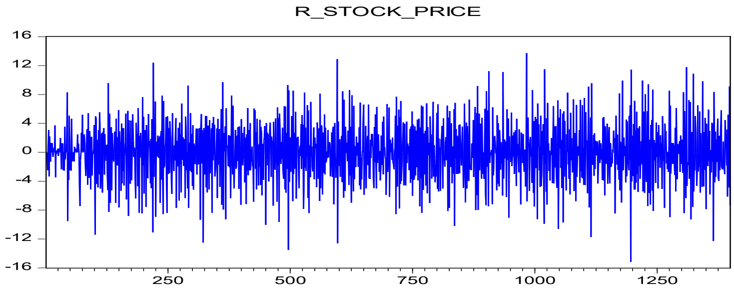
$$S\_Price_t \ = 0.010214 - 0.492172S\_Price_{t-1}$$

The one-period lagged coefficient of stock prices is negative and significant at the 1 percent level. The average stock yield is 0.010214 and the past values of the stocks significantly predict the current series.

Variance Equation:

$$\widehat{\sigma_t^2 vol_t} \ = \underset{(5.57)}{0.255145} + \underset{(138.38)}{0.973736}\sigma_t^2 vol_{t-1} \ + \underset{(2.64)}{0.017538}e_{t-1}^2$$

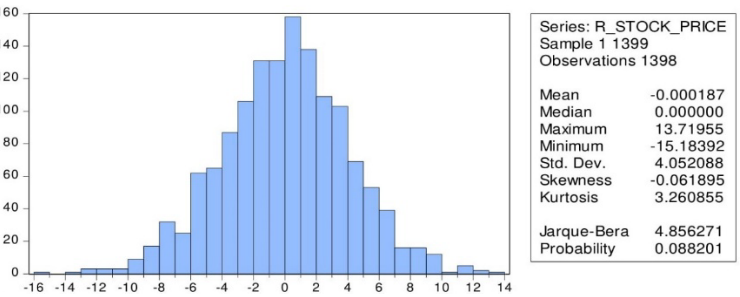
The intercept and the GARCH coefficients are had positive sign while the ARCH term is negative at the statistically important 1% level. We these results, we have established the existence of a conditional return that varies with the stock price. The results also show that there is a constant existence of volatility shocks, as the ARCH and GARCH coefficients sum is significant. This suggests effects of today's shocks are projected to persist for some periods in the future.



Source: Authors calibrations using Eviews 10

Fig. 8. Pattern of the volatility of stock prices in the Benin Republic

From the graph, clustering of volatility is evident in the series and the distribution of stock prices is highly leptokurtic.



Source: Authors calibrations using Eviews 10

Mean Equation: The dependent variable is *S_Price* and convergence was achieved after 16 iterations.

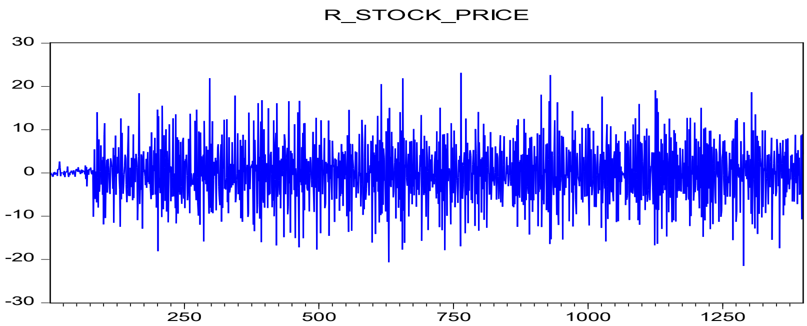
$$S\_Price_t \ = 98.24954 - 0.024737S\_Price_{t-1}$$

The one-period lagged coefficient of stock prices is significant at the 1 percent level. The average stock yield is 98.24954 and the past values of the stocks significantly predict the current series.

Variance Equation:

$$\widehat{\sigma_t^2 vol_t} = 9.052556 - 0.144159\sigma_t^2 \widehat{vol}_{t-1} + 0.065556e_{t-1}^2$$
$$(2.74) \qquad (-0.37) \qquad (2.10)$$

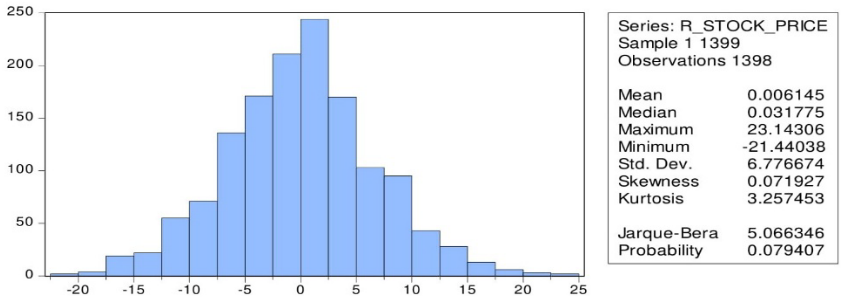
The intercept and the GARCH coefficients are both positive in sign, while the ARCH is negative at the statistically important 1 percent level. It also provides the outcomes of the GARCH model. The results confirm the existence of a conditional return that varies with the stock price since 0<0.144159<1, 0<0.065556<1, and 0.209715<1. The results also show that there is a constant existence of lesser volatility shocks as portrayed by a low sum of 0.2. Nevertheless, the consequence of today's shocks remains in the prediction of variance for several eras in the future. This suggests that the effects of today’s shocks are projected to persist for some periods in the future.



Source: Authors calibrations using Eviews 10

Fig. 9. Pattern of the volatility of stock prices in Ivory Coast

From the graph, it is evident that there is volatility clustering of stock prices and the distribution is leptokurtic.



Source: Authors calibrations using Eviews 10

Mean Equation: The dependent variable is S_Price and convergence was achieved after 49 iterations.

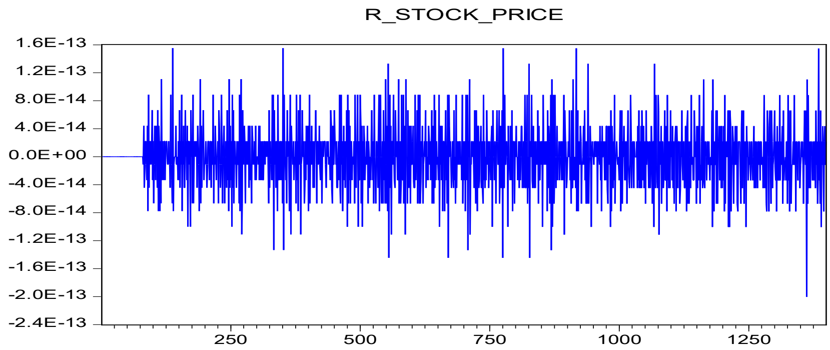
$$S\_Price_t = 0.035396 - 0.482983S\_Price_{t-1}$$

The one-period lagged coefficient of stock prices is desirable and statistically significant at the 1 percent level. The average stock return is 0.0035396 and the previous values of the stocks significantly forecast the current series.

Variance Equation:

$$\widehat{\sigma_t^2 vol_t} = 0.082092 + 0.964\sigma_t^2 \widehat{vol}_{t-1} + 0.036e_{t-1}^2$$
$$(7.09) \qquad (169.78) \qquad (6.35)$$

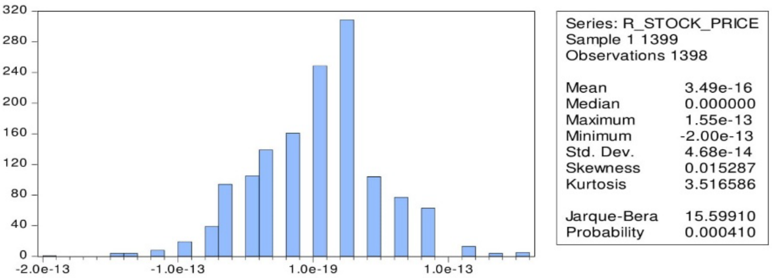
The constant and the GARCH coefficient are positive, while the ARCH is negative at the statistically important 1 percent level. The results confirm the existence of a conditional return that varies with the stock price given the conditions that 0<0.964<1, 0<0.036<1, and 1. The results also show that there is a constant existence of volatility shocks, as the ARCH and GARCH coefficients sum is huge. This upholds the effects of today’s shocks are projected to persist for several periods in the future.



Source: Authors calibrations using Eviews 10

Fig. 10. Pattern of the volatility of stock prices in Gambia

From the graph, the volatility clustering of the series is highly evident.



Source: Authors calibrations using Eviews 10

The histogram plot is normally distributed with high-frequency series that often display fat tails.

Mean Equation: The dependent variable is *S_Price* and convergence was achieved after iteration.

$$S\_Price_t = 5.19(E-16) + 0.508688S\_Price_{t-1}$$

The one-period lagged coefficient of stock prices is desirable and significant at the 1 percent level. The average stock return is 5.19E-16 and the past values of the stocks significantly forecast the current series.

Variance Equation:

$$\underset{(0.785507)}{\sigma_t^2 vol_t = 1.06(E-27)} + \underset{(1.238675)}{0.600\sigma_t^2 vol_{t-1}} - \underset{(0.826118)}{0.150e_{t-1}^2}$$

The constant and the GARCH coefficient are both positive, while the ARCH is negative at the statistically significant 1% level. This gives the outcomes of the GARCH model. Gambian stock market results suggest that stock yields fluctuate over time. The results also show that there is a constant existence of instability shocks, as the amount of the ARCH and GARCH parameters is huge and the conditions 0<0.6<1, 0<0.15<1, and 0.75<1 are fulfilled by the Gambian stock market accordingly.

In terms of empirical research findings, the distribution of stock prices in Africa exhibits wider tails. This is an indication of a greater likelihood of extreme patterns of the volatility of stock prices in African markets. In effect, the closing price of a stock is most often heavily deviated with significant outliers. More importantly, stock price movements in Nigerian, Ghana, Mali, Burkina Faso, Togo, Niger Republic, Benin Republic, Ivory Coast, and Gambian stock markets had most often exceeded three standard deviations beyond the mean as against the expectations of market participants. This further infers that variations of stock prices in these markets are very wide, heavy, and unpredictable. Hence, it is a case of the volatility of volatilities. In effect, investors and asset traders in the above-mentioned markets are notified by this study that stock price distributions have fat tails, with more than three kurtosis. Only in the Senegal stock market, we found constant stock price volatility as against time-varying volatility of stock prices in Nigeria, Ghana, Mali, Burkina Faso, Togo, Niger Republic, Benin Republic, Ivory Coast, and Gambian. This could be pointing to the fact that stock pricing is 0.68, 0.95, and 0.997 standard deviations above average and 0.68, 0.95, and 0.997 standard deviations below average respectively in the Senegalese market. Hence, the likelihood that an asset or stock is being overpriced (overvalued) or underpriced (undervalued) in the Senegal stock market is low. It is therefore easier for stock traders and investors in Senegal to pick entry and exit points. Unfortunately, this cannot be said of the investors in Nigerian, Ghana, Mali, Burkina Faso, Togo, Niger Republic, Benin Republic, Ivory Coast, and Gambian stock markets.

5. Conclusion

The paper pulls its conclusions from the fluctuations in correlation coefficients of the ten African countries' stock markets. To size the potential of the patterns of variation, ten West African countries' stock markets were investigated using the GARCH (1, 1) approach. The findings established the existence of a normally distributed Senegalese stock market but a time-varying conditional stock price in Nigerian, Ghana, Mali, Burkina Faso, Togo, Niger Republic, Benin Republic, Ivory Coast, Gambian stock such that the variance of stock prices in aforesaid stock markets follows a leptokurtic distribution. The outcome also indicates that volatilities are non-stationary, as signified by an enormous amount of significant ARCH and GARCH parameters. The volatility clustering of stock prices is highly noticeable. With this pattern of volatility whereby asset prices are at times, extremely low and extremely high, risk-averse stock market investors could take caution when evaluating an asset or level of return by considering the statistical distribution regarding the trend of asset prices against time particularly when it is the case that investors can experience widespread and heavier variations beyond three standard deviations from the mean price. This could manifest in the enormous potential of extremely low stock returns. Going forward, therefore, African investors are advised to consider the statistical distribution associated with different stocks or assets before investment.

Considering the smaller sample of stock exchange markets covered in this research as a result of data availability, the research findings could be deemed preliminary. That is the limitation confronting the study. Therefore, studies of a larger sample should be engaged through the use of DGARCH estimates. The originality of the study is highlighted by its empirical finding that the variance of stock prices in Nigeria, Ghana, Mali, Burkina Faso, Togo, Niger Republic, Benin Republic, Ivory Coast, and Gambian stock markets is highly leptokurtic while that of Senegal is normally distributed. The further implied value of this research is in its unraveling that though the instability of stock prices manifests in the Senegalese market, the market reverts to calmness over time. The Senegalese stock market is characterized by mean reversion.

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