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Modelling of Daily Price Volatility of South Africa Property Stock Market Using GARCH Analysis

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Abstract

The study examined the volatility of the daily market price of listed property stocks on the Johannesburg Stock Exchange (JSE) for a 10-year period (2008-2017). The study used daily prices from January 2, 2008, to December 29, 2017, of twelve quoted property companies out of the twenty-seven listed on the Johannesburg Stock Exchange (SA REIT Association, 2020). The study computed the average daily price of the twelve selected property stocks. The analysis used it as a proxy for the daily market price for the property stock market. The study modelled SA-REIT market price volatility using generalised autoregressive conditional heteroskedasticity (GARCH 1, 1). The GARCH model reported that the previous day's information of both the daily market price (ARCH term) and the volatility (GARCH term) have a positive and significant ($p<.05$) effect on the current day's daily market price volatility in the property stock market. The result of the model implies that investment in the property stock market is strongly driven by positive news on daily prices than a negative shock; meaning that South African property investors are more sensitive and exhibit a sharp response to good news on the daily market price than bad news when thinking of investing in listed property company shares on Johannesburg Stock Exchange.

***Keywords**: GARCH, property stock, stock market, volatility, model*

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1. Introduction

While the stock market is geared towards wealth creation, investors are more confused and lose confidence in the investment potentials of the stock market and, by extension, listed property stock and property company shares amidst market volatility. Prior studies have linked volatility to the occurrence of the unexpected swing of events in the stock market (Hanousek, Kocenda & Kutan, 2008; Mitra, Iyer & Joseph, 2015; Mashamba & Magweva, 2019, Trivedi et al., 2021). Early studies, including Shiller (1990), explained that increasing striking events in the stock market have been happening for time immemorial. Still, the concern about unexpected events started gaining the attention of market experts and academicians following the stock market crash on October 19, 1987.

In recent times, Quoreshi, Uddin & Jienwatcharamongkhol (2019) expressed that the reoccurrence of unpredictable events associated with high-level volatility has continued to pose a threat to investment goals and property stock market potential. Generally, volatility measures the variability of price or expected returns to its mean value. A high volatile stock implies that the price moves significantly up and down around the average price per time. Mamtha and Srinivasan (2016) explained that volatility clustering in stock price means a period of prolonged low volatility for a period that is followed by prolonged high volatility for another in the same series. The author attributed the main feature of volatility clustering as meaning collections of small and large fluctuations in stock prices sequentially following one another.

During the volatile marker period, the stock prices behave irrationally, fluctuate and make market predictions less significant. In some cases, the fundamental and technical analyses are difficult to prove, and a large number of participants are left with uncertain market conditions. The changes in the volatility clustering contribute to heightened stock market risk and uncertainty. Lahaye, Laurent & Neely (2009) and Haritha & Rishad (2020) stressed that rapid fluctuations in stock price have resultant effects on investors' trust, confidence and volume of trading activities in the general stock market. Meanwhile, the fluctuation of the stock price amidst a volatile market period is attributable to factors that include economic factors, market news and investment sentiments (Ramanthan & Gopalakrishan, 2013; Mamtha & Srinivasan, 2016; Haritha & Rishad, 2020). Engle & Rangel (2008) concluded that emerging stock markets are characterised by higher volatility of unpredicted events compared to developed markets. However, the volatility of stock price has been modelled by authors in different global markets (Cavalcante & Assaf, 2002; Mondher, Chaker & Ezzeddine, 2005; Quoreshi, Uddin & Jienwatcharamongkhol, 2019 and Quoreshi & Mollah, 2019). Trivedi et al. (2021) posited that volatility modelling in the stock market helps market participants such as investors, investment/financial analysts and fund managers to predict the possibility of great risk loss and the opportunity of higher return during unpredictable market conditions.

2. Literature Review

2.1 Stock Exchange Market and Volatility Pattern

In real estate economics, risk management, finance and investment literature, several studies have examined the relationship between volatility and the stock market and its attendance implications. Some of the studies in recent decades include Samanta (2010), Wang, Tianyi & Huang (2012), Abbas, Khan & Shah (2013), Bhowmik (2013), Issam, Achraf & Boujelbene (2013), Gospodinov & Jamali (2014), Li & Giles (2015), Mitra, Iyer & Joseph (2015), Ghufran, Awan, Khakwani & Qureshi (2016), Sehgal & Garg (2016), Chung, Fung & Shilling (2016), Melo-Velandia (2017), Olbrys & Majewska (2017), Hussain, Murthy & Singh (2019), Quoreshi, Uddin & Jienwatcharamongkhol (2019), Saranya (2019) and Trivedi et al. (2021).

The findings from these studies have shown a different behavioural pattern of volatility in stock markets owing to the peculiarities of local stock markets and varying degrees of physical, social, economic and political development. Chung, Fung & Shilling (2016) concluded that despite the extensive studies, the relationship between the stock market and volatility is still subject to debate. Mitra, Iyer & Joseph (2015) examined the characteristics of volatility transmission in 10 international stock markets — Australia, Brazil, China, Egypt, China, Egypt, France, India, Israel, Japan, the United Kingdom and the United States. The study's primary aim is to capture volatility's spill-over effect during crisis and non-crisis economic periods. To achieve this, the study reviewed a period spanning over 20 years, i.e., from January 1995 – December 2014 (a total observation period of 3,465 days), with data obtained from the Bloomberg Database. Statistical evidence of spill-over volatility was observed during crisis and post-crisis economies and described the volatility pattern among the observed international stock markets as non-random.

Ghufran, Awan, Khakwani & Qureshi (2016) study addressed the causes of volatility in the Karachi stock exchange market in Pakistan. The study examined the volatility pattern of the KSE index and the prominent causes. The authors observed the clustered nature of the KSE index market volatility over the reviewed period. The authors identified the political situation and investors' herd behaviour as the most prominent causes of volatility in the Pakistan stock market. Sehgal & Garg (2016) analysed the cross-sectional volatility of stock markets in the BRIICKS (Brazil, Russia, India, Indonesia, China, South Korea, and South Africa) economies. The study investigated the systematic and unsystematic variation in expected stock returns due to stock exposure to market volatility in the regions. The authors found that systematic volatility showed low stock returns in Brazil, South Korea and Russia with a significant negative risk premium. While unsystematic volatility exhibited high returns with negative risk premium in all the BRIICKS countries except China. Olbrys & Majewska (2017) studied the largest European stock markets (the United Kingdom, France and Germany) to examine the asymmetry effects of market volatility. The authors employed EGARCH to analyse the log form of daily percentage changes in London FTSE100, Paris CAC40 and Frankfurt DAX stock indices for the period from 2007 to February 2009. The study found statistical evidence of asymmetrical volatility in the European stock markets but the degree varied with time. The authors concluded that European stock markets were more responsive to bad news than good news.

In a more recent similar study, Hussain, Murthy & Singh (2019) reviewed over forty empirical studies to examine the issues surrounding the volatility of different stock markets across the globe. Some of the volatility issues assessed by the authors include heteroscedasticity, asymmetric effect, risk-return framework, spill-overs and forecasting accuracy. Parts of the major findings were the evidence of a statistically weak interaction between conditional volatility and expected returns. The study noted the significant level of economic development as a determinant of systematic shock among stock market volatility. Quoreshi, Uddin & Jienwatcharamongkhol (2019) expanded the scope of volatility assessment to cover the BRIICKS, the major stock markets including the United States, United Kingdom, Euro Zone and others totalling 35 stock markets across the globe. The study assessed return volatility equity stocks with a major focus on unexpected events during the Eurozone crisis and global financial crises (GFC). The authors used fractionally integrated generalised autoregressive conditional heteroskedasticity (FIGARCH) and found that all the 35 sampled stock markets exhibited long memory in equity stock returns and statistical evidence of intensive contagious (volatility) but at varying degrees across stock markets.

2.2 Volatility of Property Stock Market

The real estate sub-sector of the stock market in developing economies, including South Africa, has received little attention and debate on volatility. Li (2012) posited that incorporating REIT components into the broader stock market has contributed to the exposure of property stock to varying degrees of volatility, attributable to structural changes in market fundamentals, portfolio adjustments and macroeconomic shock. In Australia, Lee (2010) evaluated the effect of volatility dynamics on REIT features with the primary aim of informing investors on the extent to which REITs react to market news. The study analysed the Australian stock index from 2004-2008 and discovered that REITs show a stronger reaction to negative news than positive news in the market. The author concluded that news emanated from the general stock market exhibited a strong influence on REIT features than that news originated from REIT stock.

The work of Li (2012) attempted to identify the effects of market and economic trading activities on equity REIT components such as dividend yield (D.Y.) and return on average equity (ROAE) in the U.S. capital markets. The author analysed U.S. REITs data from 1995 to 2009 and found a higher impact of systematic risk of REIT return volatility in the bull (up) than the bear (down) market periods, but dividend yield and return on average equity were negatively affected. The findings were corroborated by the work of Kawaguchi, Aadu & Shilling (2016). The authors investigated the implication of volatility on equity REIT stock amidst the financial crisis in the US Stock market. The REIT data review period was from October 1985 to October 2012; the study found a significant increase in average equity REIT returns volatility in the pre-and-post Greenspan era due to the leverage effect that was triggered by wealth transfer, from equity to debt, and a declining interest rate.

Fei, Ding & Deng (2010) analysed the dynamic nature of volatility among returns on REITs, stock and direct real estate asset classes. The authors documented the time-vary implication of volatility among the asset class. A strong relationship was noted between stock (S&P) and REITs and the future return of equity REIT and the direct real estate. The authors stated that macroeconomic indicators explain the dynamism in volatility. The work of Chung, Fung, Shilling & Simmons-Mosley (2016) probed the relationship between REIT stock market volatility and expected returns. The author revealed that REIT volatility has a negative relationship with stock returns but exhibited a significant positive relationship with future expected returns. The authors demonstrated a trading potential in REIT implied volatility in the stock market. However, from the reviewed literature, there is empirical evidence of volatility in the global REIT market. Still, there is no conclusive debate on the pattern of the volatility in the REIT market, as its dimensional effects on REIT stock vary from one local market to another, reasons attributed to the difference in the level of market maturity and socioeconomic development.

In Africa, apart from the influence of unique attributes of local market factors on the volatility pattern in the REIT market, there is a dearth of empirical evidence on volatility dynamics and property stocks in the stock market, including the South African property stock market and constitutes a major gap in the literature. The few available studies focus on volatility in the general stock markets. For instance, Emenike & Aleke (2012), Emenike & Okwuchukwu

(2014) worked on volatility in the Nigerian stock market, Ndwiga & Muriu (2016), and Owidi & Mugo-Waweru (2016) investigated the Nairobi securities exchange of Kenya. In the Johannesburg stock exchange of South Africa, Niyitegeka & Tewar (2013) and Mashamba & Magweva (2019) documented stock market volatility. For instance, Uyaebo, Atoi & Usman (2015) explained that the South African stock market has high volatility while the volatility in Nigeria and Kenya is low. Therefore, study on property stock market volatility from an African context becomes imperative owing to the fragility of the market and the need for local and international investors to be informed when thinking of investing in the property stock market, especially in South Africa.

2.3 South Africa Stock Market

The South African stock market is one of the fastest developing markets, and its property sector is the only globally reported sector on the African continent. Akinsomi, Kola, Ndlovu & Motloung (2015) noted that South Africa is the only African country that was represented in the FTSE EPRA/NAREIT and the S&P Global REIT indices. Generally, African stock markets are characterised as fragmented and inefficient (Ntim, 2012). Ncube & Mingiri (2015) posited that African stock markets have been witnessing improvement with a significant level in Egypt and South Africa. However, the strong performance of South African stock indicates its considerable contribution and prominence in the African continent and global property stock market. Generally, the S.A. market is the only African market ranked among transparent markets in 2018 (Global Real Estate Transparent Index 2018).

By extension, S.A. property stock and listed property company shares have recorded significant performance, especially since the introduction of real estate investment trust, where PUL and PUT stocks were listed as REITs in 2013. Between 2014 and 2015, SA REIT capitalisation rose by 43%; by the end of 2015, SA REIT capitalisation was worth R340 billion. As of 2016, nine S.A. REITs were listed among the 100 most empowered companies worldwide. As reported by FTSE Russell (2017), SA-REITs were worth 16.86 million USD, ranked 9th and account for 1.74% of REIT's global market share (SA REIT Association, 2016).

3. Data and Method

The study is econometric and relies solely on published secondary data. The study focussed on the South African stock market with a significant concentration on property stock prices. Daily stock price data from January 2, 2008, to December 29, 2017, of twelve quoted property companies out of the twenty-seven listed on the Johannesburg Stock Exchange (SA REIT Association, 2020). The property stocks were selected based on the mentioned property companies with sufficient published data on daily prices for the period under review. The data were obtained from the JSE published statistical bulletin. The study computed the average daily price of the selected property stocks. The analysis used it as a proxy for the daily market price for the property stock market. The study deployed mean, standard deviation, maximum and minimum analytical tools for descriptive statistics, Augmented Dickey-Fuller (ADF) and Kwiatkowski-Phillips-Schmidt-Shin (KPSS); Jarque-Bera, Breusch-Godfrey LM and Heteroskedasticity tests for unit root, normal distribution, autocorrelation and ARCH effect tests respectively. The diversification benefits and modelling structure of SA-REIT market price volatility were analysed using a correlation matrix and generalised autoregressive conditional heteroskedasticity (GARCH 1, 1), respectively.

Table 1: Data Description and Acronym

Listed REITs	Acronym
EMIRA Property Fund Ltd	EMIP
EQUITIES Property Fund	EQUP
FAIRVEST Property Holdings Ltd	FAVT
FORTRESS REIT Ltd	FORT
GROWTHPOINT Properties Ltd.	GRTP
HOSPITALITY Property Fund Ltd	HOSP
HYROP Investment Ltd	HYPR
INTU Property Plc	INTU
INVESTEC Australia Property	INTA
INVESTEC Property Fund Ltd	INTP
OCTODEC Investment Ltd	OCTD
RESILIENT REIT Ltd	RESR
JSE Property Sector	JSE_Prop

3.1 Generalised Autoregressive Conditional Heteroskedasticity (GARCH 1, 1)

GARCH (1, 1) model is specifically developed to perform two primary functions: to model volatility and to forecast future occurrences in the stock market. The model analysis returns two results: the conditional mean equation and conditional variance (volatility) equation in a VAR environment. The conditional mean equation is synonymous with the autoregression analysis modelled after the ARIMA process, while the conditional variance equation (heteroscedastic error term) measures the volatility index (VIX). Thus, the (1, 1) GARCH specification indicates the presence of the ARCH term and GARCH term at the first order of lag length (ARCH 1 and GARCH 1). In a simple term, GARCH (1, 1) is mathematically expressed in equations (i) and (ii) below:

Condition Mean Equation (eqn. i)

$$Y_t = X_t\theta' + \in_t \qquad \text{------------------------- (i)}$$

Condition Variance Equation (eqn. ii)

$$\sigma_t^2 = \omega + \alpha\epsilon_{t-1}^2 + \beta\sigma_{t-1}^2 \qquad \text{------------------- (ii)}$$

From the GARCH (1, 1), the conditional variance equation (volatility) specification could be explained as thus

i) σ_t^2 is current day volatility
ii) ω is the constant term
iii) $\alpha\epsilon_{t-1}^2$ - ARCH term: previous day's information about volatility with coefficient α
iv) $\beta\sigma_{t-1}^2$ – GACH term: Previous day's residual volatility or forecast variance with coefficient β
iv) Significant p-value at a 5% confidence level ($p \leq .05$) indicates the statistically significant effect of the GARCH (1, 1) effects on the series at period t (Y_t).

Therefore, in this study, σ_t^2 is the information on the current day's volatility of the market price of the property stock, $\alpha \neq 0$ is the co-efficient of previous days' information about the stock market price volatilityϵ_{t-1}^2 while $\beta \neq 0$ is the co-efficient of previous days' information about the market price variance or volatility σ_{t-1}^2.

4. Result and Discussion

4.1 Summary of Descriptive Statistics

Table 4.1 presents the summary of descriptive statistics such as mean, standard deviation, and maximum and minimum analyses of the price of the listed property stocks on the JSE stock market for the years under review (2008-2017). Property stocks with an average stock price above R5,000 were HYPR (R7,583.51), RESR (R6,204.58) and INTU (R5,930.38). This category of stocks was also characterised by a high level of risk, as reported by its corresponding standard deviation. For instance, the risk level recorded in the price of RESR is R3,949.27, and the price varies from R1,730 to R15,116, having a range value of R13,386. HYPR has a standard deviation of R3,076, and the price swings between R3,080.46 and R14,143, having a range of R11,062.54. This result implies that the price of the two property stocks experienced turbulence over the reviewed period but at varying levels; the prices of RESR stock experienced rapid fluctuation over a longer period compared to HYPR and made the stock price of RESR to be more risk-prone than HYPR in the property stock market. Other categories of the property stocks with average price and standard deviation such as HOSP (R2,686.99; R1,968.66), GRTP (R2,108; R517.67), OCTD (R1,899.56; R401.14), INTP (R1,469.06; R194.37), FORT (R1,428.30; R234.73), EQUP (R1,417.07; R295.69), INTA (R1,242.90; R122.06) were traded at price above R1,000, with relatively lower risk over the study period. FAVT stock recorded the lowest average price of R134.04, the standard deviation of R34.58, and the prices vary from R70 to R225. This result, for FAVT, could be attributed to many reasons, including low volume of the stock being traded, low patronage and relatively low returns compared to its contemporaries in the market

However, the estimation of the general market (JES_Pr), the mean, stand deviation and price range shows that the average price of traded property stock stood at R2,957.31, risk level (standard deviation) of R544.51 and the market prices range from the least price of R2,035 to the highest price of R4,868.57. The study observed that HYPR (R7,583.51; R3,076); RESR (R6,204.58; R3,949.27), and INTU (R5930.38; R2,649.69) enjoyed higher prices above market price (R2,957.31), but their prices were highly risk-prone. HOSP stock price (R2,686.99) is lesser than the market stock price but has a higher level of risk than the market risk. The associated higher risk level may be due to the influence of the stock-specific characteristics on the stock pricing. In summary, the price of the listed property stock exhibited fluctuations over the reviewed period, as indicated by the standard deviation and range analyses. This result signals the likelihood of price volatility (either short or prolonged or a combination of both) in the property stock.

Table 4.1: Summary of Descriptive Statistics of Property Stock Price on Johannesburg Stock Exchange (JSE) Market

Property Stocks	Descriptive Statistics			
	Mean	**Std. Dev.**	**Max.**	**Min.**
EMIP	1342.64	223.54	1949.00	806.00
EQUP	1417.07	295.69	2205.00	1030.00
FAVT	134.04	34.58	225.00	70.00
FORT	1428.30	234.73	1858.00	940.00
GRTP	2108.34	517.67	3049.00	1090.00
HOSP	2686.99	1968.66	7858.00	595.00
HYPR	7583.51	3076.46	14143.00	3080.46
INTU	5930.38	2649.69	16039.00	3460.00
INTA	1242.90	122.06	1543.00	1021.00
INTP	1469.06	194.37	1879.00	1010.00
OCTD	1899.56	401.14	2852.00	1000.00
RESR	6204.58	3949.27	15116.00	1730.00
JSE_Prop	***2957.31***	***544.51***	***4868.57***	***2035.91***

Note: Standard Deviation (S.D.), Maximum (Max.), Minimum (Min.)

4.2 Correlation Analysis to Measure Diversification Benefits

The study conducted a correlation analysis of the property stocks to examine their level of diversification benefits in the property stock market, and the results were presented in Table 4.2. According to Modern Portfolio Theory, Markowitz (1952) expressed that a negative correlation coefficient above 70% (>-0.70) indicates a strong diversification relationship and 30% (<-0.3) and below means a weak diversification relationship. As indicated in Table 4.2, a strong negative correlation coefficient was observed between paired property stock: EQUP-INTU (-0.809). Paired property stock of EMIP-HOSP (-0.685), FORT-INTU (-0.676), EMIP-EQUP (-0.648) and EMIP-INTA (-0.632) showed a moderate correlation relationship, while a very weak correlation coefficient was observed between paired property stock price of AVGP-EMIP (-0.071), EMIP-FAVT (-0.068), and FORT-OCTD (-0.011). This result signals good diversification benefits, especially between EQUP and INTU stocks. This means that the price of the two stocks moves in the opposite direction; the rise/fall in the price of EQUP stock is strongly associated with the fall/rise in INTU stock which signals diversification benefit in the paired property stocks the investor can leverage to achieving optimal diversification benefits in the asset. The correlation coefficient with a positive sign showed poor diversification; therefore, the study reveals paired property stock types for optimal performance amidst instability in the property stock market.

Table 4.2: Correlation Analysis to Measure the Diversification benefits among the property Stocks in the market

	EMIP	EQUP	FAVT	FORT	GRTP	HOSP	HYPR	INTA	INTP	INTU	OCTD	RESR
EMIP	1											
EQUP	-0.648	1										
FAVT	-0.068	0.659	1									
FORT	-0.268	0.653	0.470	1								
GRTP	0.509	-0.135	0.298	0.336	1							
HOSP	-0.685	0.354	-0.041	0.322	-0.339	1						
HYPR	0.030	0.337	0.467	0.195	0.290	-0.209	1					
INTA	-0.632	0.543	0.136	0.134	-0.342	0.261	0.465	1				
INTP	0.443	0.080	0.524	0.427	0.748	-0.310	0.227	-0.353	1			
INTU	0.747	-0.809	-0.463	-0.676	0.025	-0.551	-0.099	-0.437	-0.140	1		
OCTD	0.702	-0.323	0.300	-0.011	0.591	-0.396	0.355	-0.329	0.555	0.390	1	
RESR	-0.373	0.721	0.482	0.291	-0.170	0.002	0.654	0.662	-0.163	-0.326	-0.172	1

4.3 Unit Root Test for the Stationary of the Data Series

In Table 4.3, the study investigated the data series' stationary status (unit root) as a pre-conditional test for time series data. Two different unit root tests, i.e., Augmented Dickey-Fuller (ADF) and Kwiatkowski-Phillips-Schmidt-Shin (KPSS), were conducted at a 5% level of significance. The tests' results complement one another to substantiate the stationary status of the data series. As shown in the Table, the ADF test rejected the null hypothesis of the presence of unit root in favour of stationarity of the data as the p-value in all cases were greater than the 5% significant level ($p > 0.05$) at the first order of lag I(1) for the listed property stocks. The complementary KPSS test exhibited a similar result. The calculated t-stat values of all the listed property stocks were lower than the critical value (CV) at 5%, indicating no unit root in the series. The rejection of the presence of the unit root test by KPSS further ascertained the stationarity of the data series over the study period, suggesting that the data series are fit and suitable for model estimation in a VAR environment.

Table 4.3: Unit Root Tests of the Listed Property Stock Price

Property Stock	Augmented Dickey-Fuller				Kwiatkowski-Phillips-Schmidt-Shin			
	I(0)		I(1)		I(1)			
	t-stat	Sig	t-stat	Sig	1%	5%	10%	t-stat
EMIP	-2.1617	0.2207	-50.0832	0.0001	0.7390	0.4630	0.3470	0.0756
EQUP	-0.0584	0.9518	-35.3734	0.0000	0.7390	0.4630	0.3470	0.1667
FAVT	-1.5437	0.5113	-23.269	0.0000	0.7390	0.4630	0.3470	0.0274
FORT	-1.4816	0.5430	-38.5552	0.0000	0.7390	0.4630	0.3470	0.0266
GRTP	-1.2159	0.6698	-52.8970	0.0001	0.7390	0.4630	0.3470	0.0474
HOSP	-2.3516	0.1559	-39.6324	0.0000	0.7390	0.4630	0.3470	0.2744
HYPR	-0.5915	0.8701	-32.4577	0.0000	0.7390	0.4630	0.3470	0.0601
INTU	-3.3776	0.0119	-48.3953	0.0001	0.7390	0.4630	0.3470	0.4372
INTA	-2.3052	0.1705	-26.2878	0.0000	0.7390	0.4630	0.3470	0.3394
INTP	-1.6616	0.4507	-35.3525	0.0000	0.7390	0.4630	0.3470	0.0944
OCTD	-2.0857	0.2506	-33.4328	0.0000	0.7390	0.4630	0.3470	0.0702
RESR	1.0635	0.9973	-52.8210	0.0001	0.7390	0.4630	0.3470	0.3905

4.4 Residual Diagnostics Tests of Series for GARCH (1, 1) Model

The suitability of the data series for computing the GARCH model is of utmost concern in this type of study. To ascertain this, the study conducted residual diagnostics tests such as autocorrelation, heteroskedasticity, and normality tests to verify the presence of ARCH effects which are the preconditioned requirement for computing the GARCH model. The results of the residual diagnostic tests are presented in Table 4.4. The results of the tests showed that the price of the selected property stocks was strongly characterised by ARCH effects as reported by the p-value of the observed R-square (Obs*R-squared) of the Lagrangian multiplier (L.M.) autocorrelation and heteroskedasticity tests ($p>0.05$). The result of the ARCH effect characterised by the price of the property stocks indicates that the residual of the series exhibited an irregular pattern of variance, clustering the price volatility nature of the property stocks and the variance of the series error term moved in a non-linear pattern. However, the result of randomness in the variance of series error term further suggests the appropriateness of the GARCH model for estimating and modelling the price volatility in the property stock market. However, the Jarque-Bera test on a normal distribution of the property stock price for the reviewed period reports the non-linear distribution of the property stock price as indicated by the significant p-value ($p<0.05$). The non-conformity of time series data with normal distribution is expected since the distribution of the time-varying series is characterised by clustering of price and random movement.

Table 4.4: Residual Diagnostics Tests

Property Stock	Breusch-Godfrey LM Test: Autocorrelation Test		Heteroskedasticity Test ARCH Effect		Jarque-Bera Normality Test	
	Obs*R-squared	Probability	Obs*R-squared	Probability	Coefficient	Probability
EMIP	2480.77	0.0000	2453.68	0.0000	10200.11	0.0000
EQUP	878.95	0.0000	873.00	0.0000	11169.01	0.0000
FAVT	2465.87	0.0000	2385.85	0.0000	22657.43	0.0000
FORT	2030.44	0.0000	2017.41	0.0000	11135.38	0.0000
GRTP	2489.89	0.0000	2450.23	0.0000	3961.42	0.0000
HOSP	2489.51	0.0000	2478.93	0.0000	84248.8	0.0000
HYPR	2494.17	0.0000	2469.08	0.0000	6521.463	0.0000
INTU	2480.98	0.0000	2480.32	0.0000	40296.01	0.0000
INTA	886.51	0.0000	107.18	0.0000	9047.894	0.0000
INTP	1639.71	0.0000	1616.59	0.0000	142724.4	0.0000
OCTD	2472.36	0.0000	2374.88	0.0000	35639.40	0.0000
RESR	2496.42	0.0000	2484.69	0.0000	2317.154	0.0000

4.5 Volatility of Market Price of Property Stock on JSE

Having verified and ascertained the selected property stocks' fitness and suitability to model the market price volatility on JES, the study computed the average price of the selected property stocks as a proxy for the market price of the property stocks. It analysed the volatility of the residual error term of the market price by GARCH (1, 1). The analysis results are presented in graphical illustrations (Figure 1 and Figure 2 below). The value on the x-axis measures days of trading activities of property stock on JSE (January 2, 2008, to December 29, 2017, i.e. 2,499 observations). The daily trading price (excluding Saturdays and Sundays) have an interval of 100 unit, starting from trading day 1 in 2008 to the last trading day in 2017; meaning that year 2008 represent 0, the year 2009 represents 100, the year 2010 represents 200 and up to 2016 and 2017 representing 800 and 900 unit respectively. The y-axis calibrated the fluctuations in the market price of property stocks through positive and negative swings, especially for the volatility index (VIX) in the residual error term of the series (Fig.2). For the lines on the graph, the actual line (red) represents the trend in the market prices (movement of price in property stocks market), the fitted line (green) measures trend in the conditional mean-variance while the residue line (blue) measures trend in the conditional variance (volatility) in the residual (error terms) of the series.

However, to better understand the trend in the volatility pattern of the price of property stock market, the study computed the residual estimates (volatility) of the series, and the analysis was presented in Fig. 2.

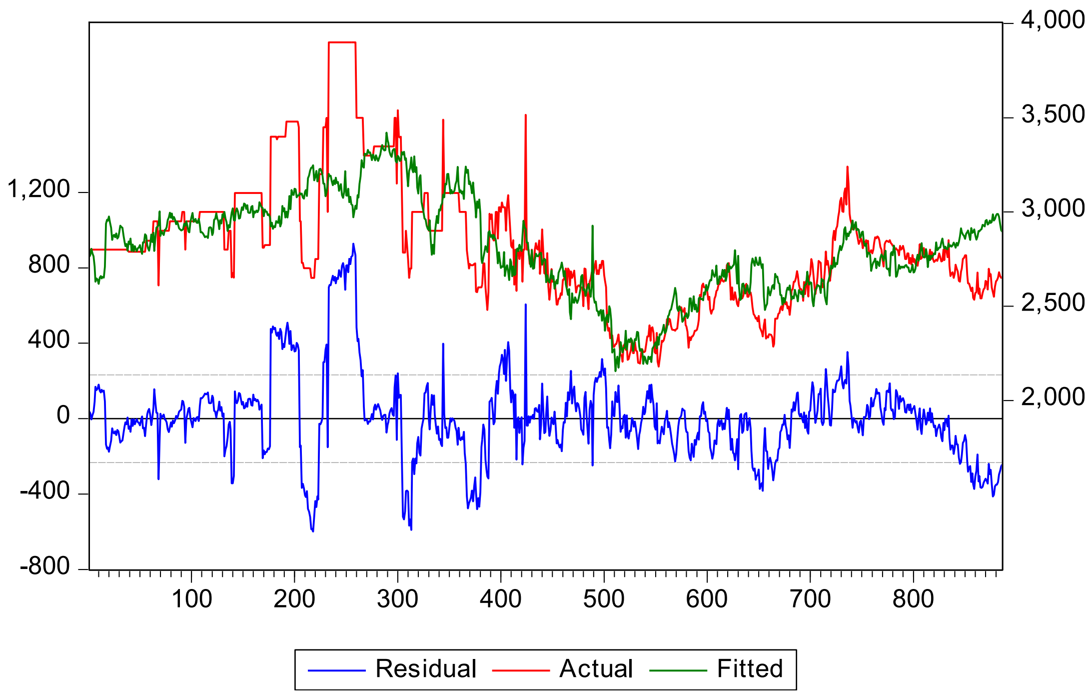

Figure 1: Actual, Fitted and Residual Estimates of the Data Series (2008-

As empirically evidenced from the graphical illustration in Fig. 2, the market price of property stocks on JES experienced turbulence as the price swung up and down frequently over the study period in a mixed pattern (high and low levels of volatility). The market price volatility started low from 2008 till the end of 2010. Prolonged high volatility set in; as the market price began to experience high fluctuations between 2010 and 2012, with the noticeable high volatility occurrence between 2010 and 2011. Sharp market price fluctuations were also recorded from 2011 to early 2012 but at a relatively lower rate compared to high occurrences in previous years. Thereafter, the market price began to experience prolonged low volatility, especially from mid-2013 to late 2017. By implication, it means that the market price of property stock on JSE experienced both low and high prolonged volatility. The up and down market price swings signal the reactions of property stock investors/breakers to the stock market's technical, fundamental news/pronouncement and sentiment. The evidence of volatility in the S.A. property stock market is a reflection of what was obtained in the listed property stock markets across the globe (Olbrys & Majewska, 2017; Hussain, Murthy & Singh, 2019; Quoreshi, Uddin & Jienwatcharamongkhol, 2019; Saranya, 2019; Trivedi et al., 2021). The authors demonstrated the evidence of volatility in the property stock market with varying dimensional effects across the globe. However, the high volatility level in the property stock market price sends caution of risk-prone investment in property stocks in the volatile trading period.

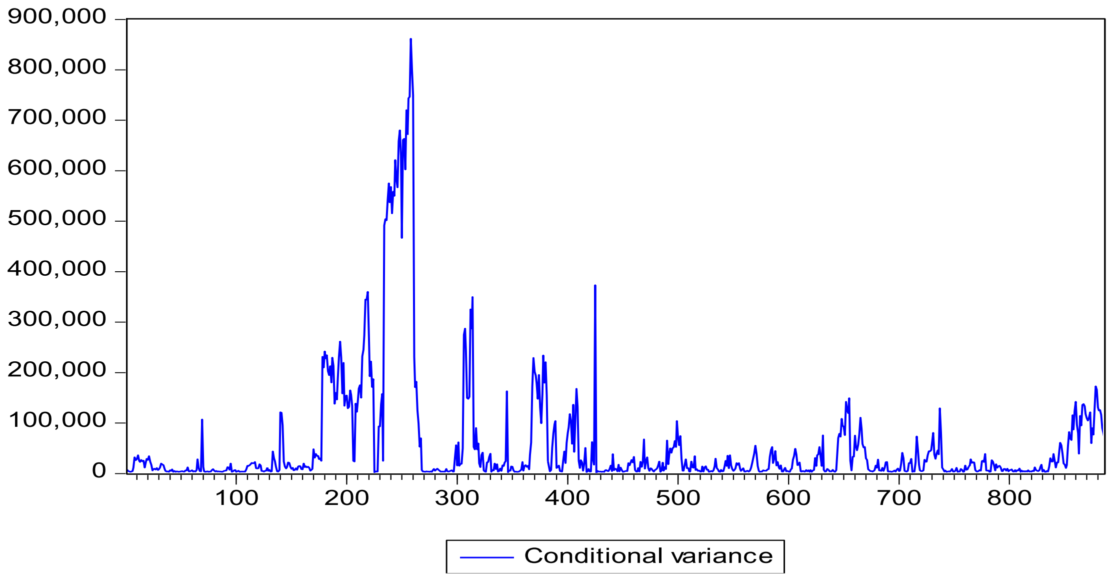

Figure 2: Market Price Volatility of Property Stock

However, evidence of volatility in property stock price on the JSE market aligns with extant studies that have identified volatility patterns characterised by general property stock market and, by extension, property stock in different countries: For example, in Australia (Lee, 2010), India (Ramanathan & Gopalakrishnan, 2013; Ghufran, Awan, Khakwani & Qureshi, 2016; Saranya, 2019). European stock markets and BRIICKS regions (Sehgal & Garg, 2016; Majewska, 2017; Kawaguchi, Aadu & Shilling, 2016; Quoreshi, Uddin & Jienwatcharamongkhol, 2019). Local studies, including Uyaebo, Atoi & Usman (2015), Ndwiga & Muriu (2016) and Mashamba & Magweva (2019), have documented the evidence of volatility in Nigeria, Kenya and South Africa's general stock exchange market. On the attributable causes, Ramanthan & Gopalakrishan (2013), Mamtha & Srinivasan (2016), Ghufran, Awan, Khakwani and Qureshi (2016) noted that the prominent effect of stock-specific information, public information, economic indicators such as inflation, interest and exchange rates being the prominent, market strength, i.e. size, volume traded and peers, herd behaviour and market sentiment, demand-supply interplay, speculations and uncertainty of the future prices on stock price volatility but at varying degree across countries.

Meanwhile, the reviewed period (2007-2017) saw a series of events in the S.A. industry, the JSE and the global financial market, which can be linked to the dynamics in the volatility pattern in the prices of S.A. REITs. For instance, the spill-over effects of the global financial crisis of 2008-2009, which put financial stress on the global financial market with the worst hit on nations' capital markets, could be a significant contributor to the dynamic in the price volatility experienced by the SA REIT market due to the level of exposure and integration to the global financial market. Also, the micro-economic policy of JSE, the announcement, disclosure and news on economic policy and market regulations could be a driving force that shapes the trading pattern in the market rather than underlying market parameters. Another factor to be considered is the SA REIT transition regime in the year 2013, where the S.A. property unit trust (PUT) and property loan stock (PLS) were upgraded to REIT firms. The consequential effects of the transition period appear to cause changes in the S.A. property stock market, which could be significantly linked to volatility in the REIT share prices in the short run. Also, concern about the market noise, sentiment, information bias and irrational behaviour of the market participants cannot be underrated in the REITs market over the reviewed period, where people based their trading activities on emotion rather than facts and becomes a threat to stability in the REIT market.

4.6 Price Volatility Model of Property Stock Market on JES

In Table 4.5, the study modelled the volatility pattern of the market price using GARCH (1, 1) analysis at first-order lag and a 5% level of significant specifications. The result of the analysis showed that the resid(-1) and the GARCH(-1) have a p-value of 0.000 and 0.0085, respectively which are less than a 5% level of confidence ($p<0.05$). The result of the positive and significant ($p<0.05$) of the ARCH term (resid) and GARCH evidenced the considerable effects of information on historical market price and variance on the property stock market volatility. The resid(-1) representing the ARCH effect is the previous day's market price information about volatility. At the same time, the GARCH (-1) reports the previous day's residual volatility in the property stock (see eqn. viii). This means that both the previous day's information on the market price and the associated risk (variance) significantly influence the property stock market. For example, good news/information on historical performance in the price of property stock strongly influences market volatility. For instance, an announcement on the increase in the dividend pay-out, favourable economic parameters, market incentives etc., drives trading activities in the bull market, boosts investors' confidence in the stock market and influences volatility in the stock market.

By implication, it means that investment in property stock on JSE is driven by good news rather than negative shock. The result is, on the one hand, in agreement with some extent, literature; on the other hand, it opposed the findings of other studies reported in different property stock markets. This study corroborates the findings of Gopal, Mahalakshmi & Thiyagaraja (2019), that document the direct positive influence of volatility on future price stock in the New York Stock Exchange (NYSE) market. But this contradicts the findings of Chung, Fung, Shilling & Simmons-Mosley (2016), Sehgal & Garg (2016), Olbrys & Majewska (2017) and Mamtha & Srinivasan (2016), that reported the faster response of investors to bad news than the good news in the general stock market. However, Simmons-Mosley (2016) reported a negative relationship between REIT volatility and stock returns.

Table 4.5 Price Volatility Model of Property Stock Market on JES

Variable	Coefficient	Std. Error	z-Statistic	Probability
C	285.5508	59.46454	4.802036	0.0000
RESID(-1)^2	0.873473	0.120069	7.274757	0.0000
GARCH(-1)	0.144308	0.054805	2.633130	0.0085

Dependent variable market price residue (H_t), Significant level at 5%

$$JSE\_Prop_{Vol} = 285.55 + 0.87\epsilon_{t-1}^2 + 0.144\sigma_{t-1}^2 \quad \text{------------------ eqn. (viii)}$$

5. Conclusion and Recommendations

The study examined the volatility pattern characterised by the daily market price of property stock on the Johannesburg Stock Exchange (JSE). This was done to document and model the volatility pattern of the daily price of the property stock market. The study analysed the ten years (January 2, 2008, to December 29, 2017) daily price of property stock, which was obtained from JSE published statistical bulletin using the GARCH (1, 1) model. The study computed the average daily price of the selected (12) property stocks and was used as a proxy for daily market price in the analysis. The analysis showed that the daily market price of property stock is characterised by autocorrelation and ARCH effects. Still, the series was not normally distributed over the study period. The study documents the evidence of volatility in the daily market price of the property stock characterised by prolonged high and low clustering patterns. The GARCH model reported a positive (direct) and significant effect of previous days' information on the current day market price volatility, meaning that trading activities in S.A. property stock are driven by good news such as bonuses, incentives, and tax holidays etc. The evidence of volatility in the S.A. property stock market aligns with previous studies across different property stock markets (Fei, Ding & Deng, 2010; Li, 2012; Aadu & Shilling, 2016; Trivedi et al., 202). While the result of the direct relationship between the property stock and volatility pattern in S.A. property stock agrees with the findings of Gopal, Mahalakshmi & Thiyagaraja (2019) in the New York stock market, but Chung, Fung, Shilling & Simmons-Mosley (2016) reported a negative relationship between REIT volatility and stock returns. The practical implication of this result is that investors need to take caution in a volatile market driven by unfavourable market news but could bring opportunities to earn higher returns in a market anomaly triggered by good news, especially in the short run. We advise the market participants, investment/financial analysts and fund managers to give attention to the pattern of volatility in the property stock market. At the same time, the regulatory bodies and policymakers are required to embark on regulations/policies that encourage stability and boost the trading activities in the property stock market.

Reference

Abbas, Q., Khan, S. & Shah, S. Z. A. (2013). Volatility transmission in regional Asian stock markets. *Emerging Markets Review*, 16(3): 66–77.

Abdalla, S. Z. S. & Winker, P. (2012). Modelling stock market volatility using univariate GARCH models: evidence from Sudan and Egypt *International Journal of Economics and Finance* 4(8), 161–176

Abken, P. A. & Nandi, S. (1996). Options and volatility. *Economic Review,* 21-35.

Adeniji S. O. (2016). An empirical investigation of the relationship between stock market prices volatility and macroeconomic variables' volatility in Nigeria. *European Journal of Academic Essays,* 2(11): 1-12

Akinsomi, O., Kola, K., Ndlovu, T. & Motloung, M. (2016). The performance of the broad based black economic empowerment compliant listed property firms in South Africa. *Journal of Property Investment and Finance,* 34(1): 3-26

Aliyu, S.U.R., (2011). Does inflation have an impact on stock returns and volatility? Evidence from Nigeria and Ghana. *Applied Financial Economics,* 22(6): 427–435.

Amita, B. (2004). *Stock return volatility patterns in India.* India Habitat Centre, New Delhi. India Council for Research on International Economic Relations.

Asteriou, D. & Begiazi, K. (2013). Modelling of daily REIT returns and volatility. *Journal of property Investment and Finance,* 31(6): 589-601.

Bera, A. K. & Higgins, M. L. (1993). ARCH models: properties, estimation and testing. *Journal of Economic Survey*, 7: 305-362.

Bhowmik, D. (2013). Stock market volatility: an evaluation. *International Journal of Scientific and Research Publications,* 3(10): 1-18.

Bollerslev T. & Mikkelsen, O. H. (1996). Modelling and pricing long memory in stock market volatility. *Journal of Econometrics* 73: 151-184.

Coffie, W. (2015). Measuring volatility persistence and risk in southern and east African stock markets. *International Journal of Economics and Business Research,* 9(1): 23–36.

Choi, Ki-Hong, C., Zhu-Hua J., Kang,S. H, & Seong-Min, Y. (2012). Relationship between trading volume and asymmetric volatility in the Korean stock market. *Modern Economy*, 3: 584-589.

Chung, R., Fung, S., Shilling, D. J. & Simmons–Mosley, X. T. (2016). REIT stock market volatility and expected returns. *Real Estate Economics,* 1–28

Dimitrios, D. & Theodore, S. (2011). A semi-parametric approach is a relationship between stock returns and volatility in the seventeen largest international stock markets. *Modern Economy*, 2(1): 1–8.

Emenike, K. O. & Aleke, S.F., (2012). Modelling asymmetric volatility in the Nigerian stock exchange. *European Journal of Business and Management,* 4(12): 52–59

Emenike, K. O. & Okwuchukwu, O. (2014). Stock market return volatility and macroeconomic variables in Nigeria. *International Journal of Empirical Finance*, 2(2): 75 – 82.

Engle, R. F. & Rangel, J. G. (2008) The Spline-GARCH Model for Low-Frequency Volatility and Its Global Macroeconomic Causes. *Review of Financial Studies*, 21(3), 1187-1222.

Fei, P., Ding, L. & Deng, Y. (2010). *Correlation and volatility dynamics in REIT returns: performance and portfolio considerations.* IRES Working Paper Series IRES2010-002

Floros, C. (2008). Modelling volatility using GARCH models: evidence from Egypt and Israel. *Middle Eastern Finance and Economics*, 2: 31-41.

Ghufran B., Awan, M. H, Khakwani, K. A, & Qureshi A. M. (2016). What causes stock market volatility in Pakistan? Evidence from the field. *Economics Research International*, 1-9.

Global Real Estate Transparent Index (2018). *Transparency: Data, disclosure and disruption*. Jones Lang LaSalle, LaSalle Investment Management. www.jll.com

Gopal, N., Mahalakshmi, S. & Thiyagarajan, S. (2019). The consequence of volatility index on stock market returns. *Journal of Stock and Forex Trading Research* 7(1): 1-6

Gospodinov, N. & Jamali, I. (2014). The response of stock market volatility to futures-based measures of monetary policy shocks. *International Review of Economics and Finance*, http://dx.doi.org/10.1016/j.iref.2014.11.001

Hanousek, J., Kocenda, E. & Kutan, A. M., (2008). *The reaction of asset prices to macroeconomic announcements in new E.U. markets: evidence from intraday data.* CERGE-EI, Czech Republic. http://ssrn.com/abstract=1113089

Haritha P. H. & Rishad, A. (2020). An empirical examination of investor sentiment and stock market volatility: evidence from India. *Financial Innovation* 6(34) 1-15 https://doi.org/10.1186/s40854-020-00198-x

Higgins, D. & Ng, B. (2009). Australian securitised property funds: an examination of their risk-adjusted performance. *Journal of Property Investment and Finance,* 27(4) 404-412.

Hussain, S, Murthy, K. V. B. & Singh, A. K. (2019). Stock market volatility: a review of the empirical literature. *Journal of Management,* 7(1): 96-105.

Issam, C., Achraf, G. and Boujelbene, Y. (2013). Volatility spill-over and channels transmission during subprime crisis: an empirical study of USA stock market and other developed stock markets. *Journal of Applied Economic Sciences*, 1: 7-21.

Jorge, C. & Assaf, A. (2002). *Long-range dependence in the returns and volatility of the Brazilian stock market.* Working paper Rio de Janeiro, Banco Nacional do Desenvolvimiento.

Joulin, A., Lefevre, A., Grunberg, D. & Bouchaud, J. P. (2008). *Stock price jumps: news and volume play a minor role.* http://arxiv.org/abs/0803.1769.

Kawaguchi, Y., Sa-Aadu, J. & Shilling, D. J. (2016). REIT stock price volatility and the effects of leverage. *Real Estate Economics,* 1-38

Lahaye, J., Laurent, S. & Neely, C. J. (2009). Jumps, cojumps and macro announcements. *Journal of Applied Econometrics*, 26(6): 1-33

Lee, L.C. (2010). *An examination of volatility dynamics in Australian REIT futures* [Paper presentation]. The 16th Pacific Rim Real Estate Society Conference, Wellington, New Zealand, 24th-27th January 1- 42

Lee, C. L. & Hwa, T. K. (2008). *Securitised real estate in a mixed-asset portfolio: the case of Malaysia* [Paper presentation]. The 14th Pacific Rim Real Estate Society Conference, Kuala Lumpur, Malaysia, 21-23 January

Li, L. (2012), *The determinants of REIT volatility Graaskamp Centre for real estate.* Wisconsin School of Business, University of Wisconsin- Madison, 975 University Avenue Madison, WI 53706

Li, Y. & Giles, D. E. (2015). Modelling volatility spill-over effects between developed stock markets and Asian emerging stock markets. *International Journal of Finance and Economics*, 20: 155-177.

Manabu, A. & Unite, A. (2008). The relationship between stock return volatility and trading volume: the case of the Philippines. *Applied Financial Economics*, 18(16): 1333-1341

Mashamba, T. & Magweva, R., (2019). Dynamic volatility behaviour of stock markets in southern Africa. *Journal of Economic and Financial Sciences* 12(1): 396.

Melo-Velandia, F. (2017). Stock market volatility spill-overs: evidence for Latin America. *Finance Research Letters* 20: 207–16.

Mitra, A., Iyer, V & Joseph, A. (2015). Characterising the volatility transmission across international stock markets. *Theoretical Economics Letters,* 5: 571-583

NAREIT (2020). *Economic contribution of REITs in the United States in 2018*. EY Building a better working world. National Association of Real Estate Investment Trusts, United States of America http://www.reit.com

NAREIT (2016). *Global real estate investing*. National Association of Real Estate Investment Trusts, United States of America. http://www.reit.com

Ndwiga, D. & Muriu, P.W. (2016). Stock returns and volatility in an emerging equity market. Evidence from Kenya. *European Scientific Journal,* 12(4): 79–98.

Ncube, G. & Mingiri, F. K. (2015). Stock market integration in Africa: the case of the Johannesburg stock exchange and selected African countries. *International Business and Economics Research Journal,* 14(2): 367-386

Newell, G., & Peng, H. (2012). The significance and performance of Japan REITs in a mixed-asset portfolio. *Pacific Rim Property Research Journal,* 18(1): 21-34.

Niyitegeka, O. & Tewar, D. D., (2013). Volatility clustering at the Johannesburg stock exchange: investigation and analysis. *Mediterranean Journal of Social Sciences,* 4(14): 621–626

Ntim, C. G. (2012). Why African stock markets should formally harmonise and integrate their operations. *African Review of Economics and Finance,* 4 (1): 1-18

Ogum, G., Beer, F. & Nouyrigat, G. (2005). Emerging equity market volatility: an empirical investigation of markets in Kenya and Nigeria. *Journal of African Business,* 6(2): 139–154.

Mamtha, D. & Srinivasan, S. K. (2016). Stock market volatility: conceptual perspective through literature survey. *Mediterranean Journal of Social Sciences,* 7(1): 208-212 Doi:10.5901/mjss.2016.v7n1p208

Okonkwo, J. J. (2019). Volatility of stock return and selected macroeconomic variables: evidence from Nigeria Stock Exchange. *International Journal of Academic Research in Business and Social Sciences*, 9(6): 185–201.

Olaleye, A A, & Ekemode, B. (2014). Integration between real estate equity and non-real estate equity. *Journal Property Investment and Finance,* 32(3): 244-255.

Olbrys, J. & Majewska, E. (2017). Asymmetry effects in volatility on the EGARCH-based approach. *Quantitative Finance and Economics,* 1(4): 411-427.

Owidi, O.H. & Mugo-Waweru, F., (2016) analysis of asymmetric and persistence in stock return volatility in the Nairobi securities exchange market phases. *Journal of Finance and Economics,* 4(3): 63–73.

Quoreshi, S., A. M. M., Uddin, R. & Jienwatcharamongkhol, V. (2019). Equity market contagion in return volatility during Euro Zone and global financial crises: evidence from FIMACH model. *Journal of Risk and Financial Management,* 12(94): 1-8.

Ramanathan & Gopalakrishnan (2013). Volatility in Indian stock market: a study of post and pre-recession period. *Name International Journal of Management Research* 3(1): 2250-20076.

SA REIT Association (2016). *Real estate investment trusts (REITs) shine among the JSE's most empowered companies*. http://www.sareit.com/news-302.php.

Samanta, G. P. (2010). *Stock market return, volatility and future output growth: some observations relating to the Indian economy*. Assistant Advisor, NSE.

Saranya P. B. (2019). Impact and the relationship between volatility index on select equity index: an analysis. *Asian Journal of Research in Social Sciences and Humanities,* 9(5): 13-21.

Sehgal, S. & Garg, V. (2016). Cross-sectional volatility and stock returns: evidence for emerging markets. *The Journal for Decision Makers,* 41(3): 234–246

Shegal, S. Garg, V. & Deisting, F. (2012). Relationship between cross-sectional volatility and stock returns: evidence from India. *International Management and Financial Innovation*: 9(2): 90-99

Shiller, J. R. (1990). Market volatility and investor behaviour. *The American Economic Review,* 80(2): 58-62

Trivedi, J. Afjal, M., Spulbar, C, Birau, R, Inumula, M. K. & Pradhan, S. (2021) Modeling emerging stock market volatility using asymmetric GARCH family models: An empirical case study for BSE Ltd. (formerly known as Bombay Stock Exchange) of India, *Revista de Științe Politics. Revue des Sciences Politiques*, 70(2021) 167 – 176

Uyaebo, O. S., Atoi, N. V. & Usman, F. (2015). Nigeria stock market volatility in comparison with some countries: application of asymmetric GARCH models. *CBN Journal of Applied Statistics,* 6(2): 133-160

Wang, T. & Zhuo, H. (2012). The relationship between volatility and trading volume in the Chinese stock market: a volatility decomposition perspective. *Annals of Economics and Finance,*13(1):211-236

Rajni, M. & Mahendra, R. (2007). Measuring stock market volatility in an emerging economy. *International Research Journal of Finance and Economics,* 8:126-133

Zakaria, Z. & Shamsuddin, S. (2012). Empirical evidence on the relationship between stock market volatility and macroeconomics volatility in Malaysia. *Journal of Business Studies Quarterly,* 4(2): 61-71.