Day-of-the-week effect in the Nigerian Stock Market Returns and Volatility: Does the Distributional Assumptions Influence Disappearance?

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Abstract:

This study assesses the influence of error distributional assumption on appearance or disappearance of day-of-the-week effects in returns and volatility using the Nigerian stock exchange (NSE-30). The Gaussian, Student-t, and the Generalized error distribution were incorporated in the GARCH (2,1) and EGARCH (2,1) models. Result reveals that day-of-the-week effects are sensitive to error distribution. Our finding also shows that evidence of good or bad news in volatility does not only depend on the asymmetric model but also the choice of the error distribution. Thus, this study will provide adequate knowledge to policy makers, investors and researchers about day-of-the-week effect in stock markets.

Key words: Stock; GARCH; Disappearance; Day-of-the-week; Model.

JEL classification: C22, G12, C12.

1 Introduction

Day-of-the-week effect in the Nigeria stock exchange market has been widely studied and documented in finance literature. In develop market, studies by Cross (1973), French (1980), Gibbons and Hess (1981), Berment et al (2007), Basher and Sadorsky (2006), Brooks and Persand (2001), Charles (2010), Kein and Stambangh (1984) etc, demonstrated that there are differences in distribution of stock returns and volatility for each day-of-the-week. Researchers that have also investigated whether these anomalies exist in developing market, particularly the Nigerian stock exchange includes; Umar (2013), Chipili (2012), Osazevbaru and Oboreh (2014), Oladayo (2015), Alagidele (2008), Ajibola (2014) etc. Due to volatility behavior of the stock prices, majority of these researchers have investigated this daily anomaly using the non-linear model of either the generalized autoregressive conditional heteroskedasticity (GARCH) or the exponential generalized autoregressive conditional heteroskedasticity (EGARCH) model.

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Fast growing numbers of researchers (Charles (2010), Saadi et. al (2006)) etc with empirical evidence have supported the argument that the day-of-the-week anomalies are nothing but a fiction, imagination and inadequate application of methodology. Saadi noted that evidence of the day-of-the-week effect is not robust to a GRACH model with normal, student-t, GED or the double exponential error distribution. Because Nigerian Stock Exchange serves as the second largest financial centre in sub-Saharan Africa, the third largest stock exchange in Africa by capitalization and the largest market in West Africa. With this, most researchers have investigated the day-of-the-week in mean and/or volatility under different distributional assumptions. But will these error distributions show consistencies or otherwise if mounted on the same model? To answer this question is the central objective of this study which is to investigate whether the appearance or disappearance of the day-of-the-week effects varies under different error distributional assumption. The remainder of this paper is organized as follows; Section 2 contains a brief review of history and development of the Nigeria stock exchange. Section 3 presents a review of literature on day-of-the-week effect. Section 4 deals with the preliminary analysis of data and methodology used in the study. Section 5 discuses the application of data to the various models as well as the empirical results of the application. Section 6 draws conclusion as well as appropriate recommendation.

2 Literature review of related studies

There are many literatures on the day-of-the-week effects in the Nigeria Stock Market. Some include; Ajobola and Nwakanma (2014), how investigated market anomalies using 140 listed companies in the Nigeria equity market. They employed both the parametric and non-parametric methodology. Using the normal error distribution assumption with GARCH and TGARCH model, they concluded that there is a significant market anomaly in the Nigeria stock exchange. Other non-parametric methods used are the Lilliefors, Crammer-Von-mises, and the Anderson-Darling tests.

Umar, (2013), investigated the day-of-the-week effects for the Nigerian and South African equity markets for over pre-liberalization and post-liberalization periods. The exponential generalized autoregressive conditional heteroskedasticity (EGARCH) model was used to estimate the day-of-the-week effect both in the mean and variance equations. Evidence of day-of-the-week effect was found in both the mean and variance equation for the Nigeria and South African equity markets. Osazevbaru and Oboreh (2014) also investigated the Nigerian stock market anomalies using the OLS methods and the GARCH model under the normal error distribution assumption with data spanning from January 1995 to December 2009. They found anomaly in the Nigerian stock market for Monday effects. Using one hundred and sixty-seven (167) stocks all share index listed on the Nigerian stock market (NSE-ASI) between the period of 2004 and 2014, the January and Monday effects found no significant evidence in January and day-of-the-week effects. Olowe (2014) also investigated day-of-the-week effects in the Nigerian foreign exchange market using the GARCH and GJR-GARCH models under the normal error distributional assumption for period of January 2nd 2002 to March 13th 2009. Although the results failed to support the presence of the day-of-the-week in the FOREX rate returns, but there was evidence of the effects in the volatility. The GARCH model was found to fit better than the GJR-GARCH model for the data used.

Other extensive studies that have investigated the day-of-the-week anomalies for different stock markets around the world include but not limited to; Al-Mutairi (2010) found evidence of presence of the day-of-the-week effect in Kuwait stock exchange. His findings show that Saturday returns were positive and higher than other days of the week except for Wednesday, suggesting that Kuwait stock market is inefficient. Rozeff & Kinney (1976) in their study of the New York Stock Exchange found that seasonal patterns were present in the New York Stock Exchange Price Index. They found that average returns in January were seven times that of the average returns of the other eleven months. Gultekin & Gultekin (1983), using both parametric and non-parametric methods, found statistical evidence of January effect in thirteen out of the seventeen stock markets of the industrialized countries studied. Kiymaz and Berument (2003), investigated the day-of-the-week effect on the volatility of major stock market indexes for the period of 1988 through 2002. They found that the day-of-the-week effect is present in both return and volatility equations. They found volatility occurs highest on Monday for Germany and Japan and on Friday for Canada and the United States, while on Thursday for the United Kingdom (UK). Claessens et. al, (1995) examined the seasonal effect for many emerging countries and found that only few countries showed evidence for January effect like Republic of Korea, Turkey, and Mexico. However, many countries had shown the abnormal return in other months besides January (e.g., April in Brazil, October in Argentina and Chile, December in Pakistan, etc.).

3 Materials and methods

3.1 Preliminary analysis of data

The historical daily price data of the Nigerian stock exchange for top thirty leading companies (NSE-30) from 31st May 2011 to May 2nd 2015 was used. Table 1 shows that daily stock returns have daily weekly average positive return of about 15%, and 3% for all days' data. There is high excess kurtosis and skewness indicating that the series is non-symmetric with higher peak and fatter tails than the normal distribution. Initial findings show that daily returns are not normally distributed. They are leptokurtic and skewed. The return in each day (R_t) are expressed and calculated as the first logarithmic difference of the series in percentage, given as;

$$R_t = 100\ X\ \log[Stock\ P_t\ /\ Stock\ P_{t-1}] \tag{1}$$

Where P_t and P_{t-1} are prices of stock for current and previous days respectively.

Tab. 1: Summary Statistics for NSE-30 Returns

Observations	Monday	Tuesday	Wednesday	Thursday	Friday	All Days
Panel A:						
Sample Mean	0.1569	0.1455	0.1473	0.1504	0.1530	0.0305
Std.Derivation	2.8436	2.7879	3.0298	3.1957	3.0474	0.9997
Skewness	-0.3324	-0.3241	0.6729	0.6640	-0.2240	0.3049
Kurtosis (excess)	4.5779	2.8774	8.9740	8.4962	5.5073	7.7739
Jarque-Bera	181.8982	73.9497	699.9414	628.5729	259.5237	2594.3739
	[0.0000]*	[0.0000]*	[0.0000]*	[0.0000]*	[0.0000]*	[0.0000]*
Minimum	-12.6690	-10.6345	-11.9434	-13.0649	-13.0291	-4.6307
Maximum	11.9792	9.9695	17.4267	18.3274	13.5327	8.4238

Source: Author's computation from www.investing.com & www.quandl.com.

Note: p values are reported in brackets. Statistically significant at 1%, 5% and 10%.

To check for stationarity in the return series, the unit root tests - the Augmented Dickey-Fuller (ADF) and the Kwaitkowski, Phillips, Schmidt and Shin (KPSS) tests are applied to the NSE-30 price index series and return. While the ADF test is used to test for all returns in the stock market under the null hypothesis of a unit root against the hypothesis of stationarity, the KPSS has a null of stationarity of a series around either mean or a linear trend; and the alternative assumes that a series is non-stationary due to presence of a unit root.

The results in Table 2 suggest that the NSE-30 series contain a unit root in level but stationary with no evidence of unit root in the return at 1, 5 and 10 percent level of significance. In other words, the NSE-30 series is integrated of order 1. Therefore, by transforming it in returns, the series will be stationary.

Tab. 2: Unit Root Test

		ADF Test		KPSS Test	
Variables	T-Stat	Crit Value	Test Stat	Crit Value	Lag
Panel A: Series		-3.4372		0.7390*	
NSE-30	-0.7945	-2.8638	14.8915	0.4630**	04
		-2.5680		0.3470***	
Panel B: Return		-3.4372*		0.7390	
NSE-30	-22.4981	-2.8638**	0.2243	0.4630	04
		-2.5680***		0.3470	

Source: Author's computation from www.investing.com & www.quandl.com.

Note: *p* values are reported in brackets. Statistically significant at *1%, **5% and ***10%.

3.2 Model Specification

This study uses the Bollerslev (1986) Generalized Autoregressive Conditional Heteroskedasticity (GARCH) and the Nelson (1991) Exponential Generalized Autoregressive Conditional Heteroskedasticity (EGARCH) models. The GARCH models for the mean and variance equations are;

$$R_t = \alpha_M M_t + \alpha_T T_t + \alpha_W W_t + \alpha_{TH} TH_t + \alpha_F F_t + \varepsilon_t \qquad (2)$$

$$h_t^2 = V_c + \alpha_i \varepsilon_{t-1}^2 + \beta h_{t-1}^2 + V_M M_t + V_T T_t + V_W W_t + V_{TH} TH_t + V_F F_t \qquad (3)$$

Where $V_c \geq 0$, $\alpha_i \geq 0$, $\beta_j \geq 0$ i = 1,2,3…q and j=1,2,3…p

If the sum parameter $\alpha_i + \beta_j < 1$, then equation (3) will be stationary, but if close to 1, the volatility parameter will be more persistent. The coefficients M_t, T_t, W_t, TH_t, and F_t are dummy variables for Monday, Tuesday, Wednesday, Thursday and Friday while α_M, α_T, α_W, α_{TH}, α_F are the estimated coefficient. The dummy variable trap is avoided with the exclusion of the constant in the model (Berument and Kiymaz (2001);

$$H_0 : \alpha_M = \alpha_T \cdots \alpha_F = 0 \quad \text{Vs} \quad H_1 : \alpha \neq 0 \quad \text{for } i = 1,\cdots 5$$

A rejection of the null hypothesis implies the presence of daily seasonality. The equation for the EGARCH model is,

$$R_t = \alpha_M M_t + \alpha_T T_t + \alpha_W W_t + \alpha_{TH} TH_t + \alpha_F F_t + \varepsilon_t \qquad (2'')$$

$$\log(h_t^2) = V_c + \alpha_1 \left|\frac{\varepsilon_{t-1}}{\sqrt{h_{t-1}}}\right| + \beta \log(h_{t-1}) + \gamma \frac{\varepsilon_{t-1}}{h_{t-1}} + V_M M_t + V_T T_t + V_W W_t \cdot + V_{TH} TH_t + V_F F_t \qquad (4)$$

The logarithm of the conditional variance ensures that the forecasts of the conditional variance are stationary and guaranteed to be nonnegative. The EGARCH model also allows the investigation of leverage effect. If $\gamma = 0$, then a positive $(\varepsilon_{t-1}/h_{t-1} > 0)$ has the same magnitude effect as a negative surprise. However, if $-1 < \gamma < 0$, a positive surprise increases volatility less than a negative surprise does, but if $\gamma < -1$, then a positive surprise decreases volatility while a negative surprise increases volatility (Berument et al, (2007)). The standard error coefficients were estimated by the Broyden, Fletcher, Goldfarb, Shanno (BFGS) iteration optimization.

In order to account for excess kurtosis, this study assumed the three main distributional assumption — the Gaussian, the student-t and the generalized error distribution (GED). Rahman et al (2013) states the Gaussian distribution, symmetric distribution with density function given as,

$$f(x)=\frac{1}{\sqrt{2\pi\sigma^2}}e^{-(x-\mu)^2/\sigma^2} \tag{5}$$

Where μ is the mean value, and σ^2 is the variance of the stochastic variable. The standard Gaussian distribution considers the mean value $\mu = 0$ and variance $\sigma^2 = 1$. Although the Guassian distribution possess the leptokurtic property, but this property is not enough to explain the leptokurtosis property found in most of the financial data. Another error distributional assumption used in this study is the student-t distribution which takes into account the leptokurtic distribution for the error, with density function given as;

$$f(x)=\frac{\Gamma[(v+1)/2]}{\sqrt{v\pi[v/2](1+x^2/2)^{(v+1)/2}}} \tag{6}$$

Where v is the degree of freedom $(v > 2)$. If v tend to ∞, the student-t distribution converges to the Gaussian distribution. The implied kurtosis of the student-t distribution is $k = (6/v-4)+3$ for all $v > 4$. In addition to the Gaussian and the student-t distribution, this study also used the generalized error distribution (GED). The GED is a symmetric distribution and platykurtic with density function;

$$f(x)=\frac{ve^{\frac{1}{2}\left|\frac{x}{\lambda}\right|}}{\lambda 2^{(v+1)/v}\Gamma\frac{1}{v}} \tag{7}$$

Where $\Gamma(\cdot)$ is the gamma function and $\lambda = [(2^{-2/v}\Gamma\left(\frac{1}{v}\right))/\Gamma\left(\frac{3}{v}\right)]^{\frac{1}{2}}$. If the parameter v has the value 2 it become standardized normal and so the distribution reduces to normal distribution. The implied kurtosis of the GED is, $\Gamma\left(\frac{1}{v}\right)\Gamma\left(\frac{5}{v}\right)/\Gamma\left(\frac{3}{v}\right)^2$. Although the GED distribution may be better able to capture peaks, it is far worse for capturing fat tails.

4 Empirical results and discussions

Tables 3 and 4 report the estimate of the specifications in equations (2), (2″), (3) and (4) under the three distributional assumptions. In other to capture more autocorrelation, more lagged values (second lagged) of the NSE-30 prices are included in the variance equation for both the GARCH (2,1) and EGARCH (2,1) models. There is disappearance of day-of-the-week dummies in the mean when the GARCH (2,1) and EGARCH (2,1) models are used under the Gaussian distribution. But with the GARCH (2,1) model, day-of-the-week effects are observed when the day-of-the-week dummies are present in the volatility equation. In the variance equation, the EGARCH (2,1) model also showed absence of day-of-the-week effect.

And just like under the Gaussian distribution, the EGARCH (2,1) model under the student-t distribution also causes disappearance of the day-of-the-week dummies in both the mean and the variance equation. However, the coefficient of the day-of-the-week dummies in the GARCH (2,1) model under the student-t distribution shows anomaly in both returns and volatility. The GARCH (2, 1) model under the generalized error distribution (GED) shows presence of the day-of-the-week effect in both in mean and variance equations, there is appearance of day-of-the-week effect in the mean model, and disappearance in the variance equation when the EGARCH (2, 1) model is use. In summary, there is inconsistencies and sensitivity in the day-of-the-week effect under different error distributional assumption in the GARCH (2,1) and EAGRCH (2,1) model using the NSE-30.

However, the estimated coefficient for the leverage effect in EGARCH (2,1) model under the three distributional assumptions (Gaussian, student-t and GED) are negative but statistically significant under the GED distribution. If γ is negative and statistically significant, it suggests that negative unanticipated changes in the NSE-30 introduces more changes in the conditional variance than positive unanticipated change does. The coefficient of β_j for both lagged are less than 1, and this satisfies the non-explosiveness of the conditional variance. Our study shows that the GARCH (2,1) and EGARCH (2,1) model fit better under the student-t and GED distributions respectively.

Again as shown in both panel B, Table 3 and 4, the asymmetry models seem to cause a disappearance in the variance equations. The highest and lowest volatility days also varies in line with the different error distribution and model applied. In order to assess the robustness of our specification, we provided a set of robustness statistics. These tests are the Ljung-Box autocorrelation test for lag 10, the ARCH-LM test for lags 5, 10 and 20, and the Brock, Dechert and Scheinkman (BDS) test.

Tab. 3: Daily day-of-the-week in return and volatility with GARCH model

	GARCH	CARCH-t	GARCH-GED
Panel A: Returns			
Monday	-0.0156	-0.0045**	-0.0036
	[0.3099]	[0.0461]	[0.4997]
Tuesday	-0.0336	-0.0369**	-0.0412*
	[0.1438]	[0.0197]	[0.0000]
Wednesday	-0.0227	-0.0161	-0.0091
	[0.2916]	[0.2748]	[0.3288]
Thursday	0.0012	0.0028	0.0019
	[0.9537]	[0.3177]	[0.7236]
Friday	0.0075	0.0005	-0.0050
	[0.2581]	[0.7529]	[0.3002]
Panel B: Volatility			
V_C	0.3228*	0.3046*	0.1113*
	[0.0000]	[0.0000]	[0.0075]
α	0.1402*	0.2193*	0.1782*
	[0.0000]	[0.0000]	[0.0026]
β *{1}*	0.0731*	0.1235*	0.0582
	[0.0000]	[0.0000]	[0.3337]
β *{2}*	0.1757*	0.1276*	0.5858*
	[0.0000]	[0.0000]	[0.0000]
Monday	0.0353*	-0.0136*	0.0028
	[0.0000]	[0.0000]	[0.9380]
Tuesday	-0.0379*	-0.0170*	-0.0522*
	[0.0000]	[0.0000]	[0.0000]
Wednesday	0.0585*	0.0243*	0.0295*
	[0.0000]	[0.0000]	[0.0000]
Thursday	0.0528*	0.0470*	0.0698***
	[0.0000]	[0.0000]	[0.0589]
Friday	-0.0722*	-0.0247*	-0.0388
	[0.0000]	[0.0000]	[0.4588]
Panel C: Diagnostics test checking			
Log-Likelihood	-214.4401	-215.3077	-213.8616
LBQ (10)	1.4440	0.0965	5.8243
	[0.9991]	[1.0000]	[0.7573]
LBQ^2 *(10)*	0.0619	0.0651	0.6383
	[1.0000]	[1.0000]	[0.9996]
ARCH-LM (10)	2.8120***	3.3500**	2.0960
	[0.0670]	[0.0340]	[0.2610]
ARCH-LM (15)	2.3060	2.8930	2.1930***
	[0.2466]	[0.4230]	[0.0612]
ARCH-LM (20)	1.7700	2.2460	1.7100
	[0.1378]	[0.2920]	[0.1552]
BDS Test	-0.4790	-0.1855	-0.2816
	[0.6318]	[0.8528]	[0.7782]

Source: Author's computation from www.investing.com & www.quandl.com.

Note: *p* values are reported in brackets. Statistically significant at *1%, **5% and ***10%.

Tab. 4: Daily day-of-the-week in return and volatility with EGARCH model

	EGARCH	EGARCH-t	EGARCH-GED
Panel A: Returns			
Monday	-0.0170	-0.0150	0.0045
	[0.6828]	[0.7201]	[0.2710]
Tuesday	-0.0472	-0.0191	-0.0118*
	[0.1163]	[0.4712]	[0.0025]
Wednesday	-0.0046	-0.0407	0.0196*
	[0.9316]	[0.3845]	[0.0000]
Thursday	-0.0058	0.0294	0.0003**
	[0.9186]	[0.5492]	[0.0292]
Friday	0.0113	-0.0085	-0.0081*
	[0.8452]	[0.8808]	[0.0000]
Panel B: Volatility			
V_C	-0.3353**	-0.3170**	0.9072*
	[0.0262]	[0.0405]	[0.0000]
α	0.2369***	0.3003***	0.9237*
	[0.0836]	[0.0822]	[0.0000]
β {1}	0.3736*	0.5748*	-0.1151
	[0.0000]	[0.0091]	[0.3041]
β {2}	0.4456*	0.2896	
	[0.0000]	[0.1542]	
γ	-0.0724	-0.0978	-0.3245*
	[0.2586]	[0.2361]	[0.0029]
Monday	0.0828	-0.0307	-0.0313
	[0.3670]	[0.8240]	[0.5730]
Tuesday	-0.0327	-0.0512	-0.0496
	[0.7043]	[0.6613]	[0.4281]
Wednesday	0.0002	0.0540	0.0351
	[0.9987]	[0.8380]	[0.4685]
Thursday	0.1946	0.2645	0.0560
	[0.2672]	[0.2262]	[0.2595]
Friday	-0.1845	-0.1871	-0.0495
	[0.1830]	[0.3317]	[0.3381]
Panel C: Diagnostics test checking			
Log-Likelihood	-214.9065	-215.4644	-260.3812
LBQ (10)	1.7717	3.5289	0.3289
	[0.9945]	[0.9396]	[1.0000]
LBQ^2(10)	22.9640	26.6530	15.3554***
	[0.1534]	[0.2379]	[0.0525]
ARCH-LM (10)	2.0250	1.7260***	2.2920
	[0.4330]	[0.0778]	[0.1147]
ARCH-LM (15)	1.6610***	1.4020	2.1070
	[0.0628]	[0.1509]	[0.1115]
ARCH-LM (20)	1.2670	1.1350	1.8490
	[0.2079]	[0.3193]	[0.2331]
BDS Test	0.1309	0.7629	0.1462
	[0.8958]	[0.4454]	[0.8837]

Source: Author's computation from www.investing.com & www.quandl.com.
Note: *p* values are reported in brackets. Statistically significant at *1%, **5% and ***10%.

The p-values of these tests shown in panel C tables 3 and 4 cannot reject the null hypothesis that they are statistically significant at conventional 1%, 5% and 10%. Therefore, our robustness tests result supports and confirms the validity of our models specification.

5 Conclusion

This study assesses comprehensively the day-of-the-week in the Nigeria stock exchange (NSE-30) in returns and volatility, under the three main error distributional assumptions for the period of May 31st 2011 to May 2nd 2015. The GARCH (2,1) and EAGRCH (2,1) models are used to capture the volatility clustering effect as well as the leverage effects. However, the evidence presented in this study reveals that; (1) The day-of-the-week in the Nigeria stock exchange (NSE-30) in returns and volatility is sensitive to the distributional assumptions. Our empirical evidence shows that the day-of-the-week anomalies vary depending on the assumption made on returns and variance. In other words, the idea of day-of-the-week effect in the Nigerian stock market is not real as error distributional assumption influences the appearance or disappearance of calendar effects. Therefore, academic researchers, investors, policy makers etc, investigating the relationship between the Nigerian stock exchange prices and returns or variance should take into consideration the error distributional assumption. (2) The asymmetry does not seem to influence the appearance or disappearance of the seasonal effects. In addition, our results indicate that the asymmetric effects as a result of the leverage effect also depend on the choice of the model used.

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