CBN Journal of Applied Statistics (JAS)

Volume 7 | Number 1 Article 14

6-2016

Day-of-the-week Anomaly: An illusion or a Reality? Evidence from Naira/Dollar Exchange Rates

Osarumwense Osabuohien-Irabor
Ambrose Alli University, Ekpoma

Day-of-the-week Anomaly: An illusion or a Reality? Evidence from Naira/Dollar Exchange Rates

Osarumwense Osabuohien-Irabor[1]

This study examines the day-of-the-week effect in the Nigerian foreign exchange market (Naira against the US dollars), its volatility as well as the asymmetric effects, for the period of 12th May 2009 to 12th June, 2015. The empirical results of GARCH-t(1,1), EGARCH-t(1,1), GJR-GARCH-t(1,1), IGARCH and the OLS methodology shows that the detection of the day-of-the-week effect is influenced by the choice of the volatility model applied. Similarly, the highest or lowest volatility market day goes with the influence of these models. Thus this study clearly support the argument of Charles (2010), that, the days of the week anomalies lies on the choice of model specified.

Keywords: GARCH, Day-of-the-week, volatility, exchange rate, returns

JEL Classification: C32, G10, G14

1.0 Introduction

Day-of-the-week effect refers to situations where the returns for certain days of the week constantly offer higher returns, while the opposite is true for other days – see (Keim and Stambaugh(1984), Lakonishok and Smidt(1988), Barone (1990), Aggarwal and Tandon,(1994)). It is believed that investigation of the day of the week effect will provide investors the necessary information to adjust their portfolio, depending on the abnormality of the calendar effect (Basher and Sadorsky (2006)). This means an investor could buy stock during the abnormal low returns days and sell in days of abnormally high return. Many researchers have used different Non-linear model from the GARCH family with different error distribution to investigate this anomaly. While other researchers use the standard OLS regression with dummies to check the significance and equality of mean returns, but without adhering to financial time series properties of the data (Gibbons and Hess (1981), French (1980) etc). The use of the OLS regression approach may give indication of the presence or absence of some specific anomalies, including misspecification effect that could lead to poor assumption and spurious conclusions of results. This renders this "so-called" anomaly invalid and spurious as the degree of

[1]Mathematics/Statistics Department Ambrose Alli University, Ekpoma, Nigeria
UniversitiSains Malaysia, Malaysia, Dept of Statistics osabuohien247@gmail.com, osabuohienosa@aauekpoma.edu.ng

leptokurtosis in the error distribution influences the results of statistical significance of the week day dummy effects.

However, Saadi et al (2006) with empirical investigation, considered the day-of-the-week effect "concept" as imaginary. Reason being the failure of various researchers to fully explain the methodology employed and as a result they are induced in finding cause(s) of an effect that may not exist. To buttress this, while Connolly (1989, 1991) and Chang et al (1993) found evidence of Monday effect for the U.S. stock market, Peiro (1994), investigating the day-of-the-week effect in New York, Tokyo, London, Paris, Frankfurt and Madrid's stock markets, found contrary results different from Connolly and Chang. Aggrawal et al (2003) also find contrary evidence of results to earlier researchers.

Just like the empirical research of Chia et al (2006), Alagidele and Panagiotidis (2006) also employed the symmetric and asymmetric volatility estimates to investigate the day-of-the-week effects in the Ghana stock market. But unfortunately, they drew conclusions on the presence of the day-of-the-week effects in the Ghana stock market using only the TGARCH model while other models used in the study contradict their findings. Researchers in large numbers have settled for the use of the exponential GARCH model (Umar (2013), Berument (2007), Chipili (2012), etc) with different error distribution. Their reason perhaps is based on the fact that EGARCH model does not require the non-negativity condition and allows for the capturing of asymmetric characteristics of data. This makes it perform better than the "vanilla" GARCH model and the linear paradigm which other researchers have adopted – see (Tangjitprom (2011), Alagidele (2013), Rayhman (2009), Kiymaz and Berument (2003), McGowan, Jr., and Ibrihim (2009), Davidson and Peker (1996), Foo and Kok (2000)) etc

Furthermore, Charles (2010), kicked against the "concept" of calendar anomalies, arguing that the detection of the day-of-the-week effect depends on the choice of the volatility model used by the researcher. Based on this conflicting analysis on whether the "concept" of day-of-the-week is factual, imaginary, illusion or induced, this study attempts to investigate further by using the standard OLS regression approach and the time-varying symmetric and asymmetric GARCH models. The essence is to ascertain whether these methods, particularly the time-varying models results, are consistent. The remainder of this paper is organized as follows; Section 2 presents a review of literature on day of the week effect. Section 3 deals with preliminary analysis of data and methodology used. Section 4 discusses the application of data to the various models as well as the empirical results of the application. Section 5 draws conclusion as well as the policy implication of the results.

2.0 Literature Review f Related Studies

After the first calendar effect detected by Field (1931), who investigated the pattern of the Dow Jone industrial average from 1915 to 1930, to ascertain whether the conventional Wall Street wisdom was true. For the 717 weekend data he studied, he discovered that Saturday's prices tend to rise in $.10 higher than the weekly days. Since then, large volumes of empirical work on seasonal anomalies have been observed in various markets around the world. Many of these empirical researches of day-of-the-week effect are majorly in stock markets, but with different methodology and conflicting conclusions from different researchers around the world. Amid this various contradictions, very little or no empirical evidence has been discussed on this anomaly for the Nigerian foreign exchange market using either the OLS approach or the GARCH frame-work. Therefore, this study attempt to fill this gap and also investigate if truly the "concept" of day-of-the-week effect truly exist in Nigerian foreign exchange market, judging from numerous empirical investigation or a mere academic exercise to give an economic explanation an "effect" that may be illusion or imaginary.

Apart from Olowe (2011), who investigated the day-of-the-week effect in the Nigerian foreign exchange market using GJR-GARCH(1,1) and GARCH(1,1) models, to the best of our knowledge, no other works on the Nigeria foreign exchange market has been documented in the literature. The empirical results revealed the absence of the day-of-the-week effect in the mean returns but support the presence of the day-of-the-week effect in the volatility of returns of the Nigerian foreign exchange market. Study also revealed that the GARCH (1,1) model fits the Nigerian foreign exchange data than the GJR-GARCH model. Absence of leverage effect in the Nigerian foreign exchange market was another finding of the work. Other prominent researchers on Day-of-the-Week effect in Africa context include Agathee (2008), Aly et al. (2004), Chukwogur (2008) and Tachiwon (2010).

Saadi et al(2006) demonstrated that the day-of-the-week effect in logarithmic changes in Canadian dollar per U.S. dollar foreign exchange rate are not robust to GARCH model with normal, student-t, GED or double exponential error distribution respectively. In addition, they remarked that the day-of-the-week effect in conditional variance, disappears completely when account for autocorrelation, heteroskedasticity and non-normality are made. The study concluded that day-of-the-week-effect in return and conditional variance is artifact of using inadequate methodology. Jaffe and Westerfield (1985) in another study, investigated the Canadian, Australian, Japanese and UK markets with a large dataset spanning from 1950-1983, and found daily variations in the returns significant. They found the mean returns for the US, UK and Canadian markets to be negative on Mondays, but recorded lowest returns on Tuesdays for the Japanese and Australian market.

Chipili (2012) investigated the existence of the day of the week effect in the logarithmic first difference of the spot Kwacha/US dollar exchange rate. Results from EGARCH specification with different error distributional assumption (normal, student-t, and GED) reveal the presence of the day-of-the-week-effect in volatility of returns in K/USD exchange rate but weak support for calendar anomalies in returns.

Berument et al (2007) assesses the day-of-the-week effect of the daily depreciation of the Turkey Lira (TL) against the U.S. dollar and its volatility. Their empirical finding suggests that Thursday and Mondays are associated with higher and lower depreciation rates respectively. Their results show that the day-of-the-week effect is present in the mean and volatility specifications of the Turkish foreign exchange market. Balaban et al (2001) used a GJR-GARCH frame work to test daily stock return for 19 countries and found a significant day of the week on volatility for 8 countries. McFarland, Pettit, and Sung (1982) in their earliest studies, investigated the day-of-the-week effect in foreign exchange markets. They observed that the distribution of price changes particularly on Mondays was quite different from the price changes on other days of the week. This indicates negative price changes on Fridays and positive price changes on Mondays which negates the general findings of the weekend effect in the equity markets.

Using the GARCH family models from a forecast framework, Charles (2010) investigated empirically the impact of the day-of-the-week effect in major international stock markets, and concluded that the choice of the volatility model appears to play an important role in detecting the day-of-the-week effects on volatility. This is because the result differs with different model used. He also noted that asymmetry effect does not seem to influence the seasonal effect.

Other studies on day-of-the-week effect using exchange rate data includes; Hsieh (1988), who examined the statistical property of daily exchange rate of five different foreign exchange markets, reveals differences in mean and variance across the day-of-the-week. Bessembinder (1994) investigated day-of-the-week effect in the foreign exchange market and found that bid-ask spreads in the spot and forward market are higher on Fridays and prior to holidays. Aydogan and Booth (2003), in a study of the Turkish Lira exchange rate, noted the presence of day-of-the-week effect in the currency's daily depreciation over the period, 1986 to 1994.Yamori and Kurihara (2004) assesses the day-of-the-week effect for twenty-nine (29) foreign exchange markets in 1980s and found presence of day-of-the-week effect in almost all markets investigated, an effect that disappeared for almost all 29 countries in the 1990s.

3.0 Methodology

3.1 Model specification

The estimates of the standard OLS regression with dummy variables as used by Brook (2004) in detecting seasonality in returns is by regressing returns on the five daily dummy variables. Using this methodology has two drawbacks. Firstly, errors in the model may be autocorrelated or serial dependence which can result in misleading inferences. Secondly, the drawback is that error variances may not be constant over time. However, in addressing the autocorrelation problem, we can include lagged values of the return variable in the equation. And the variances of errors are allowed to be time dependent to include a conditional heteroskedasticity that captures time variation of variance - an approach in addressing the second drawback in exchange rate returns. The dummy variable trap can be avoided by excluding the dummy variable for a particular day and use as base (Baker et al (2008)), or use the five days dummy variables with exclusion of the constant in the regression model (Berument and Kiymaz's (2001)). Using the later, we have;

$$R_t = \alpha_M M_t + \alpha_T T_t + \alpha_W W_t + \alpha_{TH} TH_t + \alpha_F F_t + \varepsilon_t \quad (1)$$

Where;R_t is the continuously compounded index return on day t, the OLS coefficient of α_M to α_F are the mean returns for Monday through Friday respectively,ε_t is the stochastic term and M_t, T_t, W_t, TH_t and F_t are the dummy variables. $M_t = 1$if t is Monday, 0 otherwise, $T_t = 1$ if t is Tuesday, 0 otherwise, $W_t = 1$ if t is Wednesday, 0 otherwise, $TH_t = 1$ if t is Thursday, 0 otherwise and $F_t = 1$ if t is Friday, 0 otherwise. The presence of day seasonality implies;

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

If the null hypothesis is rejected, then exchange rate returns exhibit some form of daily seasonality. The absence of day-of-the-week effect means that the coefficients for dummy variables are not significantly different from zero, i.e that the return on day *i* is not different from any other days.

The Autoregressive Conditional Heteroskedasticity (ARCH) model of Engle (1982) and Generalized Autoregressive Conditional Heteroskedasticity (GARCH) model of Bollerslev (1986) are today the most popular model among the Non-linear models. It captures the stylized facts such as persistence in returns. In this study, the detection of the presence of day of the week effect in returns and volatility of the Naira/USD is specified in two ways; firstly the specification of days of the week in the mean return and secondly, the specification of both days of the week in both return and volatility. In both specifications, the day-of-the-week dummies were introduced in the mean and variance equations (see Halil(2003), Karolyi (1995), Heieh (1988), Yalcin and Yucel (2006) etc). The GARCH-t(1,1) model specification for this two equations for of day-of-the-week effect is;

Mean equation;

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

$$h_t^2 = V_c + \alpha_1 \varepsilon_{t-1}^2 + \beta h_{t-1}^2 \qquad (3)$$

Variance equation;

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

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

The exponential generalized autoregressive conditional heteroskedasticity (EGARCH) model of Nelson (1991) does not require the condition of non negativity and as such performs better than the GARCH-t (1, 1) model. Since volatility tends to rise in response to bad news and fall in response to good news, capturing the asymmetric characteristics of data with the EGARCH model reveals the leverage effect, which usually indicates the level of response of investors to market news. The structure of EGARCH-t(1,1) model with dummy variables are;

Mean equation;

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

$$\log(h_t^2) = V_c + \alpha_1 \left|\frac{\varepsilon_{t-1}}{\sqrt{h_{t-1}}}\right| + \beta \log(h_{t-1}) + \gamma \frac{\varepsilon_{t-1}}{h_{t-1}} \quad (5)$$

Variance equation;

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

$$\log(h_t^2) = V_c + \alpha_1 \left|\frac{\varepsilon_{t-1}}{\sqrt{h_{t-1}}}\right| + \beta \log(h_{t-1}) + \gamma \frac{\varepsilon_{t-1}}{h_{t-1}} + V_M M_t + V_T T_t + V_W W_t \cdot$$
$$+ V_{TH} TH_t + V_F F_t \quad (6)$$

The logarithm of the conditional variance is shown on the left-hand side of equation (5) and (6). This implies that the leverage effect is exponential, instead of being quadratic. This guaranteed nonnegative results from the forecasts of the conditional variance.

Glosten-Jagannathan-Runkle (1993) also studied whether positive residuals had the same effect as negative residuals in equation (3). For ε_t, the used the usual specification for the second moment equation. The GJR model also allows for the capturing of the asymmetric characteristics of data. It can be used in investigating day-of-the-week effect given as:

Mean equation;

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

$$h_t^2 = V_c + \alpha_1 \varepsilon_{t-1}^2 + \beta h_{t-1}^2 + \gamma \varepsilon_{t-1}^2 I_{t-1} (7)$$

Variance equation;

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

$$h_t^2 = V_c + \alpha_1\varepsilon_{t-1}^2 + \beta h_{t-1}^2 + \gamma\varepsilon_{t-1}^2 I_{t-1} + V_M M_t + V_T T_t + V_W W_t + V_{TH} TH_t + V_F F_t \quad (8)$$

The Integrated GARCH model was suggested by Nelson (1991). An IGARCH model occurs when the autoregressive part of the GARCH model has a unit root. The primary characteristic of an IGARCH model is that the impact of past squared shocks on is persistent. An IGARCH-t(1,1) model can be written as;

Mean equation;

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

$$h_t^2 = V_c + \alpha_1\varepsilon_{t-1}^2 + \beta h_{t-1}^2 \quad (9)$$

With restriction that $\alpha_1 + \beta = 1$, where $0 \leq \alpha_1 \leq 1$ and $0 \leq \beta \leq 1$

Variance equation;

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

$$h_t^2 = V_c + \alpha_1\varepsilon_{t-1}^2 + \beta h_{t-1}^2 + V_M M_t + V_T T_t + V_W W_t + V_{TH} TH_t + V_F F_t \quad (10)$$

With restriction that $\alpha_1 + \beta = 1$, where $0 \leq \alpha_1 \leq 1$ and $0 \leq \beta \leq 1$

For all the Non-linear models considered, the Student's t-distribution which allow for fatter tails than in a standard normal distribution was used. This is because, the student's t-distribution peak more than the normal distribution and as such, takes into consideration the leptokurtic distribution for the error, than the normal distribution. Just like the stock returns, the exchange rate returns also exhibits thicker tails more than those of the Gaussian distribution.

Relationship among volumes, volatility and price rates of Naira/USD is further used in this study in assessing if truly the day-of-the-week effects really exist. While the exchange rate is regarded as the value of one country's currency in terms of another, the trading volume refers to the daily local turnover in domestic currency per trading days. But unfortunately, getting the official figures of foreign exchange trading volumes per currency is difficult and most times an impossible task. Thus, Pottorff (2014) put it succinctly that "...volume makes a lot of sense in stock market, because the number of offered stock, supply and demand is completely clear for each company's stock, but it is a different story in forex trade… What I am saying is that it is not possible to determine volume in forex market accurately and precisely, simply because forex market is not a centralized market…"

However, the foreign exchange volumes can be interpreted or estimated using indicators to facilitate the interpretation of market situation and other technical analysis over a period of time. One of these volume interpretation indicators which this study rely on, is the accumulation/distributor indicator. The accumulation/distributor indicator is a technical indicator used to determine the accumulative flow of money in and out of asset. It uses and compares the high, low and closing prices of foreign exchange as well as calculating the weighted averages. The annualized volatility of the different days of the week are also computed using; the square root of 252 multiply by the standard deviation of the daily return i.e, $Annualized\ Volatility = \sqrt{252}\ X\ Sd(R)$, Where; $Sd(R)$ = Standard deviation of daily return.

4.0 Results

4.1 Statistical Properties of data

The data used in this study contains the daily foreign exchange rates of Naira/USD obtained from the Bloomberg information network. The full sample period under study is for 1590 numbers of days spanning from 12th May 2009 to 12th of June 2015. Our empirical estimates and analysis used the continuously compounded daily return expressed in logarithmic difference of the series considered in percentage, given as;

$$Return = 100\ X\ \log(EXR\ in\ day\ t / EXR\ in\ day\ t-1) \quad (11)$$

Where EXR denotes exchange rate, t and $t-1$ represents the current and previous day's rate respectively. Table 1 panel A contains the summary of the statistical properties of exchange rate returns for week days and all days. Monday has the highest average return of 0.0989 with the highest deviation on Thursday. The values of average return, standard error and skewness for the entire period of study is smallest with values 0.0197, 0.5836, and 0.2112 respectively compare to values from different days of the exchange rates.

However, all sample of the distribution i.e both week days and all days are positively skewed, indicating that they are non-symmetric. In addition, they all exhibit high level of kurtosis, indicating that these distributions have thicker tail than normal distribution. A normal distribution is not skewed and is defined to have a coefficient of kurtosis of 3. Furthermore, the jarque-Bera test for normality reveals a highly statistically significant deviation of the data from normality. These initial findings show that daily returns are not normally distributed. But they are leptokurtosis and skewed. The independence tests shown in panel B also confirmed the presence of autocorrelation and heteroskedasticity in exchange rate returns.

Table 1: Summary Statistics for Exchange Rate Returns

OBSERVATION	MON	TUE	WED	THU	FRI	All
Panel A:						
Sample Mean	0.0989	0.0978	0.0951	0.0954	0.0957	0.0197
Std Deviation	0.8977	0.8961	0.9112	1.0632	0.9333	0.5836
Skewness	1.2575	0.8082	0.9346	0.7734	0.491	0.2112
Kurtosis (excess)	7.3623	4.7389	6.3477	11.798	6.0327	20.9084
Jarque-Bera	799.4944 [0.000]*	331.1417 [0.000]*	578.3731 [0.000]*	1870.1313 [0.000]*	493.4374 [0.000]*	28955.74 [0.000]*
Minimum	-2.703	-3.1626	-2.7903	-5.7994	-4.5709	-6.1723
Maximum	5.735	4.9303	5.3231	6.752	4.8827	6.2856

Panel B: Diagnostics Test Checking

L-B Q(15)	126.8896* [0.0000]	**Difference Sign**	-3.8224* [0.0000]
L-B Q^2 (15)	391.0178* [0.0000]	**Rank Test**	0.3740* [0.7083]
Turning Point	-0.2976* [0.0000]	**ARCH-LM(15)**	47.8047* [0.0000]

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

Fig. 1 and 2 shows the day-of-the-week charts for volumes and prices, and volume and volatility of the Naira/USD exchange rates. In Fig 1, the behavioral patterns shown by buyers in respect to price variation in each day of the week are almost similar, as increase/decrease in prices result in low/high spikes in sales volumes. A detail examination of volumes and volatility relationship in Fig. 2, shows the quantity of buyers to the volatile prices of Naira/USD exchange rate. Although, Tuesdays have very marginal spikes in volume compares to other days, but “statistically” not different from other days, as high and unstable values of exchange rates leads to small or poor volumes of sales. The computed annualized volatility for daily returns in different days of the week are 14.2420%, 14.2394%, 14.5500%, 16.8650% and 14.8283%, while the calculated sample mean of the weighted average volumes indicator are 0.9204, 0.9208, 0.9214, 0.9207 and 0.9205, for Mondays, Tuesdays, Wednesdays, Thursdays and Fridays respectively.

Thursdays being the highest annualized volatility day was expected to correspond to the lowest turnover. That is not the case here. This is inconsistencies and impracticability in the concept of day-of-the-week effects.

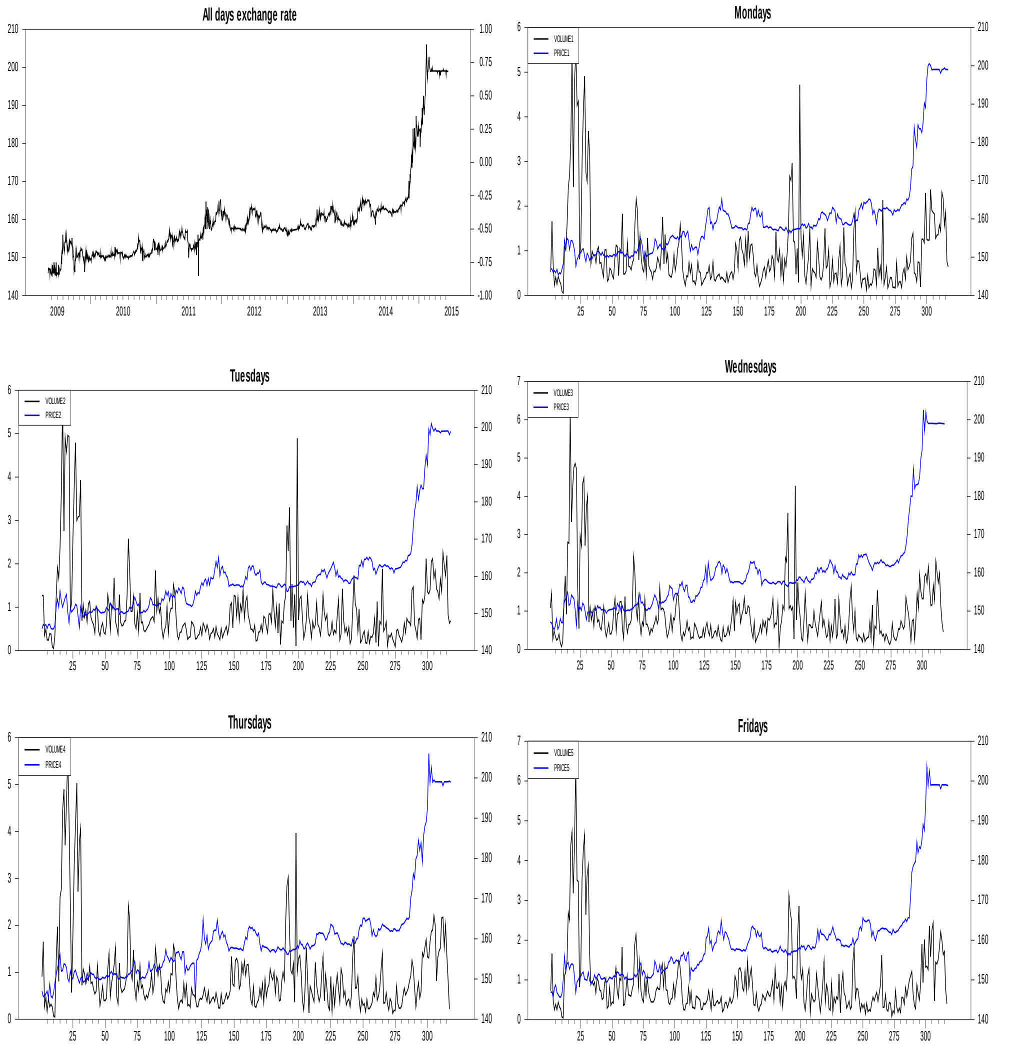

Fig 1: Days-of-the-week Charts for Volumes and Prices of Naira/USD Exchange Rate[2]

[2]The sample period is from 12th May 2009 to 12th June 2015. The number 1,2,3,4 and 5 in the key box represents Mondays, Tuesdays, Wednesdays, Thursdays and Fridays respectively

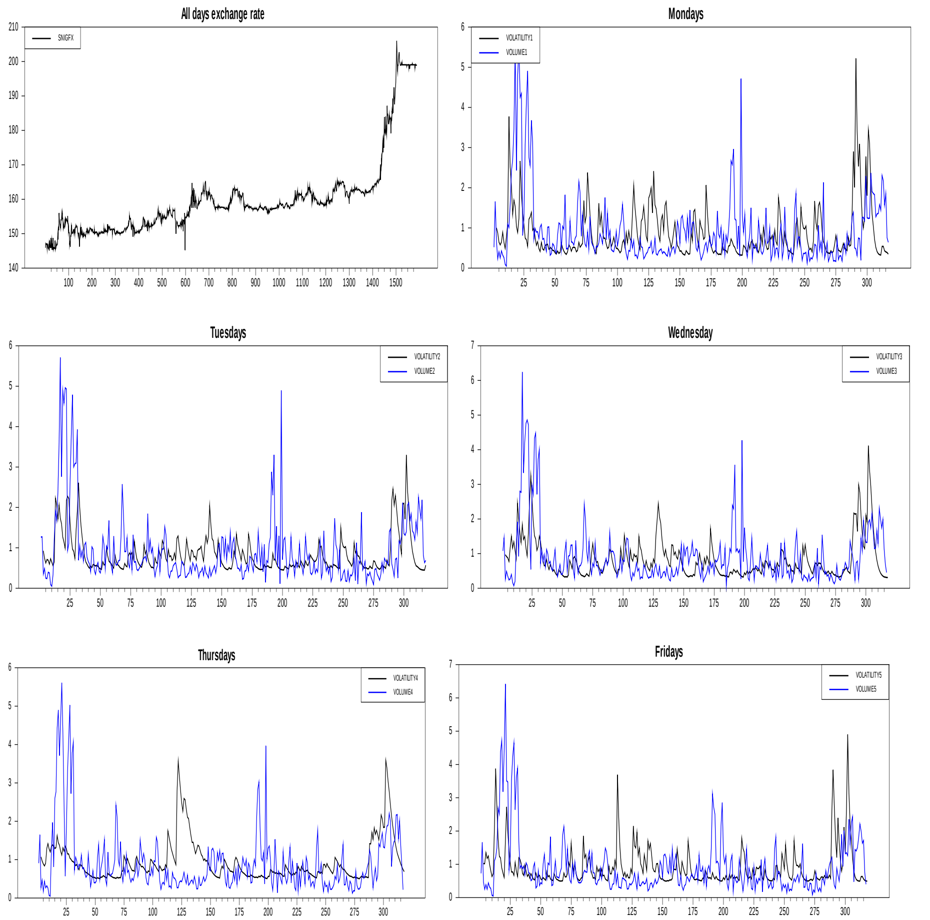

Fig 2: Trading Volumes and Volatility for Naira/USD Exchange Rate[2]

In Table 2, panel A and B examines the stationarity or non stationarity of the daily index and returns of exchange rate data. But because the ADF and PP tests are almost the same, this study used the ADF and the KPSS test for unit root test. In panel A, the non rejection of the null hypothesis of exchange rate series at 1% 5% and 10% is evidence. However, panel B shows no evidence of unit root in exchange rate return. Therefore, the statistical analysis of the exchange rate returns in Table 1 panel A and B, reveals non normality, leptokurtosis and non-constant variance or volatility clustering and serial dependent of exchange rate returns. This means the exchange rate returns favours models that incorporate the ARCH/GARCH models.

Table 2: Unit Root Test

	ADF TEST		KPSS Test		
Variables	**T-Stat.**	**Crit. Value**	**T-Stat.**	**Crit. Value**	**Lag**
Panel A: Series		-3.3472		0.7390*	
EXR	-0.1213	-2.8628	17.835	0.4630**	4
		-2.568		0.3470***	
Panel B: Return		-3.4372*		0.7390	
EXR	-51.7402	-2.8638**	0.2573	0.4630	4
		-2.5680***		0.3470	

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

Table 3 presents the OLS results of the day-of-the-week effect in the Nigerian foreign exchange market from 12th may 2009 to 12 June, 2015. Results reveal that Tuesday estimate of the day of the week is significantly not different from zero. This shows the existence of day of the week effect in the Nigeria foreign exchange market. But this finding is superimposed by the Ljung-Box and the ARCH-LM tests results shown in Table 3 panel B, suggesting the presence of remaining ARCH effect and serial dependence in the model. And as shown, the OLS does not take into account the varying daily volatility of the Nigerian foreign exchange market. This implies that the OLS approach in the detection of day-of-the-week effect is inadequate in modeling the daily returns of the Nigeria foreign exchange market. The estimate of the mean returns and variance equations of (2″), (3) and (4) of the GARCH-t (1,1) model are shown in table 4 and 5. In table 4, it is evidence that there is absence of day-of-the-week effect in return of the Nigerian foreign exchange market when day-of-the-week dummies are present in return. But when these dummies are both introduced in the mean and variance equations, a contradiction occurred. There is Tuesday and Friday effect in the mean while daily anomalies are observed in all days with the exception of Fridays in the variance equation. The diagnostic test result shows that there is no remaining ARCH effect in the estimated GARCH model.

Table 3: Ordinary Least-Squares (OLS) Estimate

VARIABLES	MON	TUE	WED	THU	FRI
Panel A: Exchange Returns					
Coeff.	-0.0001	0.0635***	-0.0166	0.0416	0.0102
Std. Error	0.0327	0.0327	0.0327	0.0327	0.0327
T-Stat.	-0.0042	1.9415	-0.5082	1.2714	0.3123
p-value	[0.9966]	[0.0523]	[0.6113]	[0.2037]	[0.7548]
Panel B: Diagnostics Test Checking					
	S.E. Regression	0.5836		**Arch-LM Test**	**Lags**
	L-B Q(10)	137.0873* [0.000]		116.9190* [0.0000]	05
	L-B Q^2(10)	436.6095* [0.000]		60.3580* [0.0000]	10
	L-B Q(15)	150.1322* [0.000]		40.4990* [0.0000]	15
	L-B Q^2(15)	450.0943* [0.000]		30.6060* [0.0000]	20

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

But the result of the mean return of EGARCH-t(1,1) in Table 4 contradict the results of absence of the day of the week effect in GARCH-t(1,1) model, as the model reveals Monday effect in the Nigerian foreign exchange market. Similarly, in Table 5 results, where the dummies are introduced in the mean and variance equation, (see equation (2″), (5) and (6)), the model strongly support the evidence of the day-of-the-week effect, but with additional anomalies in Tuesdays and Fridays. The estimated coefficient for the leverage effect, $\boldsymbol{\gamma}$, in Table 4 and 5 is negative but statistically different from zero. This suggests that there is no leverage effect in the Nigerian foreign exchange market. The *L-BQ* and *L-BQ*^{2} statistics for 15 lags show no linear or non-linear dependencies for the standardized and square standardized residual for the EGARCH model which means that such effect was successfully captured by our EGARCH-t(1,1) model. Apart from lag 10 of Table 5, the ARCH-LM test also shows insignificance at lags 5, 10, 15 and 20, indicating the non-existence of the ARCH phenomenon.

The day of the week dummies in mean return in the GJR-GARCH model clearly supports GARCH-t(1,1) model of none existence of day-of-the-week effect in mean return equation as shown in Table 4. But the dummies in the variance equation of panel B Table 5, reveals otherwise. However, panel C of Table 4 and 5 show no evidence of serial dependence and existence of ARCH effect. And just like the EGARCH-t(1,1) model, the GJR-GARCH-t(1,1) model also shows the non existence of the leverage effect in the Nigerian foreign exchange market.

Table 4: Day-of-the-week Effect in Return Equation

	GARCH-t(1,1)	EGARCH-t(1,1)	GJR-GARCH-t(1,1)	IGARCH-t(1,1)
Panel A: Returns				
Monday	-0.0194 [0.4957]	0.0150* [0.0000]	-0.0074 [0.7885]	-0.0057 [0.5757]
Tuesday	0.8977 [0.6825]	0.0167 [0.6723]	-0.0018 [0.9530]	0.0331 [0.4734]
Wednesday	-0.0372 [0.2722]	-0.0399 [0.3720]	-0.0286 [0.2806]	-0.0458 [0.2886]
Thursday	0.0115 [0.6509]	0.0142 [0.1011]	0.0132 [0.5508]	0.0159 [0.6384]
Friday	0.0111 [0.7168]	0.0132 [0.5371]	0.0148 [0.6011]	0.0005 [0.9871]
Panel B: Volatility				
V	0.1327* [0.0000]	-0.6949* [0.0023]	0.2254 [0.7104]	0.0157** [0.0171]
α	0.7515* [0.0000]	0.6254* [0.0000]	4.0128 [0.7131]	0.2471* [0.0000]
β	-0.0394* [0.0025]	0.8469* [0.0000]	0.3825** [0.0135]	0.7528* [0.0000]
γ		-0.0255 [0.6969]	-0.6633 [0.7968]	
Panel C: Diagnostics Test Checking				
Log-Likelihood	-227.9765	-223.2229	-213.8357	-248.7216
L-B Q(15)	0.4707 [0.9999]	1.3783 [0.9979]	1.2915 [0.9984]	1.1623 [0.9989]
L-BQ^2(15)	0.2542 [0.9999]	0.8562 [0.9990]	1.4038 [0.9941]	3.9799 [0.8589]
ARCH-LM (5)	0.3000 [0.9124]	0.8630 [0.5065]	0.7840 [0.5621]	1.2600 [0.2813]
ARCH-LM(10)	0.6380 [0.7812]	0.7880 [0.6400]	1.1610 [0.3167]	0.7370 [0.6897]
ARCH-LM(15)	0.4650 [0.9564]	0.9090 [0.5544]	1.1230 [0.3347]	0.8910 [0.5750]
ARCH-LM(20)	0.7350 [0.7881]	1.2850 [0.1877]	1.6560 [0.1403]	0.7590 [0.7619]
BDS TEST	0.2207 [0.8253]	-0.3442 [0.7306]	-1.0667 [0.2861]	-0.8091 [0.4184]

*P values are reported in brackets. Statistically significance at *1%, **5% and ***10%*

It is note-worthy that our empirical results of GARCH-t (1,1) and GJR-GARCH-t (1,1) supports the findings of Olowe (2011) of the disappearance of the day-of-the-week effect in mean return equation but appears in the variance equation, absence of leverage effects in the Nigerian foreign exchange rate market as well as the better performance of the GARCH-t (1,1) model compare to the GJR-GARCH-t (1,1) model. But these findings contradict the results from other models used in this study.

In the mean equation, the IGARCH-t (1,1) model also show no day-of-the-week effect, but finds the existence of this effect in the variance equation when the Nigeria foreign exchange market data was applied. Similarly, panel C of Table 4 and 5 reveal the adequacy of IGARCH-t (1,1) model. In addition, our empirical evidence shows that the IGARCH-t (1,1) model seems to be the best performing model among the sets of model used in this study when day-of-the-week dummies are put in the mean equations. But unfortunately, has poor performing ability in the variance equation.

The *BDS* test (after the initials of W. A. Brock, W. Dechert and J. Scheinkman) developed by Brock, et al (1996), to detects the nonlinear serial dependence in time series. As shown in panel C, Table 4 and 5, the *BDS* uses the null hypothesis of independent and identically distributed (IID) to test for the presence of non linear dependence, strongly confirmed the absence of non linear innovation in our tested models. However, in panel B of Table 4 and 5 of the four Non-linear models in this study, shows that the coefficient of α_i and β_i are positive and statistically significant indicating that the Nigerian foreign exchange markets current volatility is affected by its past volatility. This also shows the stability of variances in the models. However, just like the appearance and disappearance of the day-of-the-week effect varies with model, the lowest and/or highest volatility days also depend on the choice of the model applied. In the OLS method, Tuesdays and Wednesdays has the highest and lowest volatility days, while the Non-linear GARCH family model has different days, particularly in the variance equations. Wednesdays and Tuesdays seem to be consistent in the mean equation in all the models used including the OLS method, but the GJR-GARCH-t model has different days (Fridays) for high volatility days.

Table 5: Day-of-the-week Effects in Returns and Volayility Equations

	GARCH-t(1,1)	EGARCH-t(1,1)	GJR-GARCH-t(1,1)	IGARCH-t(1,1)
Panel A: Returns				
Monday	0.0084 [0.1355]	-0.0218* [0.0000]	0.0039* [0.0025]	-0.0140* [0.0021]
Tuesday	-0.0340* [0.0066]	-0.0192*** [0.0590]	-0.0224* [0.0000]	-0.0008 [0.8717]
Wednesday	-0.0658 [0.2722]	-0.0302 [0.2507]	-0.0333* [0.0000]	-0.0104 [0.1910]
Thursday	-0.0105 [0.3454]	0.0349 [0.1133]	0.0423* [0.0000]	0.0079 [0.1116]
Friday	0.1019* [0.0000]	0.0138*** [0.0761]	-0.0026 [0.1273]	0.0001 [0.9847]
Panel B: Volatility				
V	0.1732* [0.0000]	0.0498* [0.0000]	0.1074* [0.0000]	0.0776* [0.0000]
α	0.2098* [0.0000]	0.8103* [0.0000]	0.3901* [0.0000]	0.6073* [0.0000]
β	0.0265* [0.0025]	0.6836* [0.0000]	0.2717* [0.0000]	0.3926* [0.0000]
γ		-0.0621 [0.3851]	0.1586 [0.1265]	
Monday	-0.0459* [0.0000]	-0.3247** [0.0491]	-0.0462* [0.0000]	-0.0353* [0.0000]
Tuesday	-0.0078* [0.0000]	0.4214** [0.0157]	0.0647* [0.0000]	0.0093*** [0.0726]
Wednesday	-0.0131* [0.0000]	-0.1037 [0.5860]	0.0328* [0.0098]	0.0757* [0.0000]
Thursday	0.0079* [0.0001]	-0.3898* [0.1011]	0.0441* [0.0000]	-0.0421* [0.0000]
Friday	0.0018 [0.2689]	-0.0227 [0.8853]	0.0182 [0.2745]	-0.0360* [0.0000]
Panel C: Diagnostics Test Checking				
Log-Likelihood	-236.2171	-216.6666	-213.8014	-248.7216
L-B Q(15)	0.5270 [0.9999]	3.4468 [0.9439]	2.9963 [1.0000]	21.7968* [0.0095]
L-BQ^2(15)	0.4850 [0.9998]	20.9896* [0.0072]	0.0702 [1.0000]	12.3805 [0.1350]
ARCH-LM (5)	0.7780 [0.9124]	0.4500 [0.8134]	0.3460 [0.8845]	0.4960 [0.7788]
ARCH-LM(10)	1.2700 [0.2466]	1.6680*** [0.0875]	1.2450 [0.2616]	1.8180 [03569]
ARCH-LM(15)	0.9050 [0.5594]	1.2800 [0.2138]	0.8650 [0.6039]	1.4870 [0.1086]
ARCH-LM(20)	1.0890 [0.3605]	1.9180 [0.2115]	1.7740** [0.0230]	1.6230 [0.1468]
BDS TEST	0.1686 [0.8660]	0.3313 [0.7403]	1.1763 [0.2394]	-0.6407 [0.5216]

*P values are reported in brackets. Statistically significance at *1%, **5% and ***10%*

5.0 Discussion

This study examines the existence of a daily pattern of calendar anomalies in the Nigerian foreign exchange market using the standard least square (OLS), GARCH-t(1,1), EGARCH-t(1,1), GJR-GARCH-t(1,1) and the IGARCH-t(1,1) model. The evidence presented in this study suggests that; (1) The assertion that bad news increases volatility more than good news does not hold in the Nigerian foreign exchange market. Thus, there is no difference between good news and bad news in the Nigeria foreign exchange market. (2) The standard OLS method is inadequate in the modeling of the Nigerian foreign exchange market, because errors in the model may be autocorrelated resulting in misleading inferences. (3) The inconsistencies of results from the various models, empirical analysis of volatility and volumes as well as the graphical analysis used in this study, supports the assertion of Charles (2010) that the detection of the day-of-the-week effect is being influence by the choice of the model applied is the novelty of this study. Thus, the “concept” of day-of-the-week effect does not apply to the Nigerian foreign exchange market.

6.0 References

Agathee, U. S. (2008). **“**Day-of-the-week Effects: Evidence from the Stock Exchange of Mauritius (SEM)” *International Research Journal of Finance and Economics* 17, 8-14

Aggarwal, A. and K. Tandon (1994). “Anomalies or illusions? Evidence from Stock Markets in Eighteen Countries. *Journal of International Money and Finance* 13, 83-106.

Aggarwal, R., & Rivoli, P. (1989). “Seasonal and Day-of-the-week Effects in four Emerging stock Markets”. *Financial Review*, 24, 541-550.

Alagidele, P. and Panagiotidis T.(2006). “Calendar Anomalies in the Ghana Stock Exchange”. Discussion paper series, Dept Economics Loughborough University, WP 2006 -13

Alagidede, P. (2013). Month of the year and Pre-holiday Effects in African Stock Markets. *Sajems* NS 16. No 1.

Aly, H., Mehdian, S. and Perry, M. (2004). “An Analysis of the Day-of-the-week Effects in the Egyptian Stock Market”, *International Journal of Business*, 9, pp**:** 301-308.

Aydogan, K., and Booth, G., (2003). “Calendar Anomalies in the Turkish Foreign Exchange Markets”. *Appl. Finan. Econ*. 13, 353–360.

Baker, H., Rahman, A. and Saadi, S. (2008). “The Day-of-the-week Effect and Conditional Volatility: Sensitivity of Error Distributional Assumptions”.*Review of Financial Economics* 17: 280-295.

Balaban,E., Bayar A., and Kan. O.B. (2001). “Stock Returns, Seasonality and Asymmetric Conditional Volatility in world Equity Markets”. *Applied Economics letter* 8, 263 – 268

Barone, E. (1990). “The Italian Stock Market: Efficiency and Calendar Anomalies”. *Journal of Banking and Finance* 14, 483-510.

Basher, S. A. and Sadorsky P. (2006). “Day-of-the-week Effect in Emerging Stock Markets”.*Applied Economics Letters* 13, 621-628.

Berument, H., Coskun, M. N. and A. Sahin (2007). “Day-of-the-week Effect on the Foreign Exchange Market Volatility: Evidence from Turkey”. *Research in International Business and Finance* 21, 87-97.

Berument, H., and Kiymaz, H. (2001). “The Day-of-the-week Effect on Stock Market Volatility” *Journal of Economics and Finance* 25: 181−193.

Bessembinder, H. (1994). “Bid–ask Spreads in the interbank foreign exchange Markets”. *Journal of Financial Economics*, 35, 317–348.

Bollerslev, T. (1986). “Generalised Autoregressive Conditional Heteroscedasticity” *Journal of Econometrics*, 31, 307-27.

Brock, W.A., Dechert, W. and Scheinkman, H and LeBaron, B. (1996). “A Test for Independence Based on the Correlation Dimension”. *Econometric Reviews*, 15, 197-235.

Brooks, C. (2004). “Introductory Econometrics for finance (6th edition)” The United Kingdom: Cambridge University press.

Chang, E., Pinegar, M., and Ravichandran, R. (1993). “International Evidence on the Robustness of the Day-of-the week effect”. *Journal of Financial and Quantitative Analysis*, 28,497–513.

Charles, A. (2010). “The Day-of-the-week Effect on the Volatility”. The Role of the Asymmetry. *European Journal of Operational Research* 202, 143-152.

Chia,. R.C.1. Liew.,V. K. S., Syed K.W. and Syed A.W.(2007). “Calendar Anomalies in the Malaysian Stock Market”. MPRA Paper No. 516.

Chipili, J.M. (2012). “Day-of-the-week Effect in Returns and Volatility of the Kwacha/Us Dollar Exchange Rate. Authorised for Distribution by

Director-Financial Markets as working Paper WP/01/2012, Bank of Zambia.

Chukwuogor, C. (2008) “An Econometric Analysis of African Stock Market: Annual Returns Analysis, Day-of-the-Week Effect and Volatility of Returns” *International Research Journal of Finance and Economics* 14, 370-378

Connolly, R. (1989). “An Examination of the Robustness of the Weekend Effect”. Journal of Financial And Quantitative Analysis 24: 133-169.

Connolly, R.A. (1991). “A Posterior odds Analysis of the Weekend Effect”. *Journal of Econometrics*, no.49, pp. 51−104

Davidson, S., and Peker, A. (1996). “Malaysian Evidence on the Robustness of the Day-of-the-week Effect”. *Capital Markets Review*, 4(2), 15–29.

Engle, R. (1982). “Autoregressive Conditional Heteroscedasticity with Estimates of the Varianceof United Kingdom Inflation. *Econometrica*, 987–1007.

Fields, M. J. (1931). “Stock Prices: A Problem in Verification”. *Journal of Business*, 7, 415-418.

Foo, M.W. and Kok, K.L. (2000). “Seasonal Anomalies of Stocks on the Kuala Lumpur Stock Exchange Second Board”. *Capital Market Review*, 8, 123 – 145.

French, K. (1980). “Stock Returns and the weekend Effect”. *Journal of Financial Economics*, 8,pp. 55-69

Gibbons, M., and Hess, P. (1981). “Day-of-the-week Effects and asset Returns”. *Journal of Business*, 54, 579–596.

Glosten, L.R. R. Jagannathan and Runkle D. (1993). “On the Relation between the Expected Value and the Volatility of the Nominal Excess Return on Stocks”. *Journal of Finance*. 48, 1779-1801.

Hsieh, D. A. (1988). “The Statistical Properties of daily Foreign Exchange Rates 1974–1983”. *Journal of International Economics*, 24, 129–145.

Jaffe, J. andWesterfield, R.(1985). “The Week-end Effect in Common Stock Returns: The International Evidence”. *Journal of Finance*, vol. 40, nro 2, 433-454

Karolyi, A. G. (1995). "A Multivariate GARCH model of International transmission of Stock Returns and Volatility: The Case of the United States and Canada". *Journal of Business and Economic Statistics*, 13, 11–25.

Kiymaz, H. and Berument H. (2003). "The Day-of-the-week Effect on Stock Market Volatility and Volume: International Evidence". *Review of Financial Economics* 12, 363-380.

McGowan, Jr., C. B., and Ibrihim, I. (2009). "An Analysis of the Day-of-the-week Effect in the Russian Stock Market". *International Business & Economics Research Journal*, *8*(9), 25-30.

Keim D. and Stambaugh F. (1984). "A Further Investigation of Weekend Effects in Stock Returns". *Journal of Finance* 39: 819-840.

Lakonishok, J. and Smidt S. (1988). "Are seasonal anomalies real? A ninety-year perspective". *Review of Financial Studies,* 1, 403-25.

Nelson, D.B. (1991). "Conditional Heteroskedasticity in Asset Returns: A New Approach". *Econometrica*, 59, 347 – 370.

Olowe R.A. (2011). "Exchange Rate Volatility, Global Financial Crisis and the Day-of-the-week Effect". *KJBM* Vol. 3 Issue No. 3

Peiró, A. (1994). "Daily Seasonality in Stock Returns: Further International Evidence". *Economics Letters*, 45, 227-232

Pottorff, C. (20014). "Forex Volume Indicators Interpretation". **(http://www.fxkeys.com/forex-volume-indicators-interpretation**)

Rahman M. L. (2009). "Stock Market Anomaly: Day-of-the-week Effect in Dhaka Stock Exchange". *International Journal of Business and Management* Vol 5, No 5

Saadi, S., Rahman, A. and L. Chourou (2006). "Day-of-the-week in Returns and Conditional Volatility: A Fact or Fiction? Evidence from Spot CAD/USD Foreign Exchange Rates". 6th Global Conference on Business and Economics, October 15-17, Gutman Conference Centre, USA.

Tachiwou, A. M. (2010). "Day-of-the-week Effects in West African Regional Stock Market". *International Journal of Economics and Finance* 4, 167-173

Tangjitprom N. (2011). "The Calendar Anomalies of Stock Return in Thailand". *Journal of Modern Accounting and Auditing.* Vol. 7, No. 6, 565-577.

Umar B. N. (2013). "The Day-of-the-week Effect on Stock Market Returns and Volatility: Evidence from Nigeria and South Africa". MPRA Paper No. 48076.

Yalcin, Y. and Yucel E.M. (2006) "The Day-of-the-week Effect on Stock Market Volatility and Return: Evidence from Emerging Markets" *Czech journal of Economics and Finance*, 56,pp. 258-27

Yamori, N. and Kurihara Y. (2004). "The Day-of-the-week Effect in Foreign Exchange Markets: Multi-Currency Evidence". *Research in International Business and Finance* 18, 51-57.