ЕКОНОМИКА
ISSN 0350-137X, EISSN 2334-9190, UDK 338 (497,1)
Vol. 68, january-march 2022, № 1
P. 15-30

Batsirai Winmore Mazviona[1]
Gisele Mah[2]
Ireen Choga[3]
North-West University, Faculty of Economic and Management Sciences, South Afrika

ORIGINAL SCIENTIFIC ARTICLE
DOI: 10.5937/ekonomika2201015M
Received: Jun, 28. 2021.
Accepted: November, 04. 2021.

DAY OF THE WEEK EFFECT IN THE SOUTH AFRICAN EQUITY MARKET: A GARCH ANALYSIS

Abstract

Understanding dynamics of daily stock returns provide insight in trading opportunities available in stock markets. The purpose of the study was to examine whether day of the week effect exists in the South African equity market. Daily data from Top 40, All Shares, Basic Materials, Industrials, Consumer Goods, Health Care, Consumer Services, Telecommunications, Financials and Technology indices were collected for period 1995 to 2018. Exponential and threshold generalized auto regressive conditional heteroskedasticity models were employed to analyse day of the week anomaly. Findings of the day of the week for the mean equation revealed a positive Monday effect for aggregate indices namely Top 40 and All shares whilst the sectorial analysis showed a positive Monday effect for Basic materials, Consumer goods, Health care and Telecommunication. Furthermore, the mean equation for day of the week depicted a positive Tuesday effect for Financials sector, positive Wednesday effect for Consumer services sector and Thursday effect for Industrials and Technology sectors. The variance equation highlighted negative Monday effect for Top 40 and All shares as well as Basic materials, Consumer goods, Health care, Consumer services, Telecommunication and Financials sectors. However, Industrials sector indicated a negative Friday effect. The existence of day of the week effect nullifies the efficient market hypothesis in its weak form. In practice, it is recommended that for Mondays investors should invest in Top 40 and All shares, for Tuesday and Wednesday it would be prudent for investors to invest in Financial and Consumer services sectors respectively. Returns for Thursdays are attractive to an investor investing in the Industrial sector. An investor can reduce exposure by diversifying in the Health sector on Monday and in the by Industrial sector on Friday. Unlike previous studies that focussed on aggregate market indices, this study extended the analysis to sectors that constitute the market index.

Key words: *Day of the week, GARCH, EGARCH, TGARCH, Johannesburg Stock Exchange*

JEL classification: C01, C4, C22, C58, G12, G14.

[1] winmoreb@gmail.com, ORCID ID: 0000-0002-6681-6788

[2] Gisele.Mah@nwu.ac.za, ORCID ID: 0000-0002-8729-9935

[3] Ireen.Choga@nwu.ac.za, ORCID ID: 0000-0002-7911-2966

ЕФЕКАТ ДАНА У НЕДЕЉИ НА ЈУЖНОАФРИЧКОМ ТРЖИШТУ АКЦИЈА: A GARCH ANALYSIS

Апстракт

Разумевање динамике дневних приноса акција пружа увид у могућности трговања које су доступне на берзама. Сврха студије је била да се испита да ли ефекат дана у недељи постоји на јужноафричком тржишту акција. Дневни подаци из индекса Top 40, Све акције, Основни материјали, Индустрија, Роба широке потрошње, Здравствена заштита, Потрошачке услуге, Телекомуникације, Финансије и Индекси технологије су прикупљени за период од 1995. до 2018. Експоненцијални и гранични генерализовани ауто-регресивни модели условне хетероскедастичности су коришћени за анализу аномалија дана у недељи. Налази дана у недељи за средњу једначину су открили позитиван ефекат понедељка за агрегатне индексе и то Top 40 и Алл акције, док је секторска анализа показала позитиван ефекат понедељка за Основни материјали, Робу широке потрошње, Здравство и Телекомуникације. Штавише, средња једначина за дан у недељи је приказала позитиван ефекат уторка за сектор финансија, позитиван ефекат среде за сектор потрошачких услуга и ефекат четвртка за сектор индустрије и технологије. Једначина варијансе је истакла негативан ефекат понедељка за Top 40 и све акције, као и за секторе основних материјала, робе широке потрошње, здравства, потрошачких услуга, телекомуникација и финансија. Међутим, сектор индустрије је показао негативан ефекат у петак. Постојање ефекта дана у недељи поништава хипотезу ефикасног тржишта у њеном слабом облику. У пракси се препоручује да понедељком инвеститори улажу у Top 40 и Алл акције, а за уторак и среду би било мудро да инвеститори улажу у сектор финансијских и потрошачких услуга. Приноси за четвртак су атрактивни за инвеститора који улаже у индустријски сектор. Инвеститор може смањити изложеност диверзификацијом у сектору здравства у понедељак и у сектору индустрије у петак. За разлику од претходних студија које су се фокусирале на агрегатне тржишне индексе, ова студија је проширила анализу на секторе који чине тржишни индекс.

Кључне речи: *Дан у недељи, GARCH, EGARCH, TGARCH, Јоханесбуршка берза*

Introduction

Investors aim to earn abnormal profits on their capital invested. Financial market calendar anomalies are one of those possibilities that may provide investors with profitable trades. Theories of market efficiency describing the creation of stock prices laud that investors involved in a market make sound decisions (Fama, 1970). However, in the context of systemic adjustments in stock prices, seasonal trends have been observed and the study of the relationship between stock returns and calendar anomalies is therefore of utmost importance to investors, researchers and finance professionals around the world (Norvaisiene *et al*., 2015; Winkelried & Iberico, 2018). Investors' irrational decisions pertaining to investment

on the stock market is conceived by calendar anomalies inherent in stock price patterns. By identifying calendar anomalies in a stock market, investors are in a position to develop investment tactics that tap into the excess returns as well as the profitable time to purchase or sell stocks (Halari *et al*., 2018; Jebran & Chen, 2017; Tilica & Oprea, 2014). Financial literature has documented different kinds of calendar anomalies observed in advanced and emerging financial markets. Anomalies have been evidenced in the form of day of the week, holiday, turn of the month and January seasonality. The day of the week has been widely studied by researchers.

Early work on day of the week anomaly in developed markets such as the US equity market demonstrated that trading on Mondays and Fridays resulted in negative and positive stock returns respectively (Lakonishok & Levi, 1982). Apart from Monday exhibiting lowest returns, it was found to be associated with low trading activities for institutional investors (Lakonishok & Maberly, 1990; Ülküa & Rogers, 2018). Kohers *et al*. (2004) confirmed day of the week effect in US, UK, Japan, France, Germany, Canada, Italy, Netherlands, Switzerland, Hong Kong, and Australia stock markets. Ajayi et al. (2004) found evidence of day of the week effect in Croatia, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, Russia, Slovakia and Slovenia equity markets. Day of the week anomaly was proved in Greece, France, Finland, Ireland, Italy and Switzerland equity markets (Charles, 2010). Recent studies in US, China and Canada equity markets have exhibited the day of the week anomaly (Vasileiou, 2017; Zhang *et al*., 2017). Day of the week effect is also apparent in developing stock markets for example its existence has been found in Turkey (Oguzsoy & Guven, 2003), Argentina, Brazil, Chile, Colombia, Mexico and Peru (Winkelried & Iberico, 2018), Thailand, India, Taiwan, Philippines, South Korea, Malaysia and Indonesia (Choudhry, 2000). Other developing stock market provided contradictory evidence for instance in Pakistan Nishat and Mustafa, (2002) found no day of the week anomaly. Kaur (2004) demonstrated no day of the week effect in Indian equity market.

Past day of the week studies in South Africa for instance Coutts and Sheikh (2002); Loffe (2008) have focussed on the ordinary least squares (OLS) to examine the relationship between stock returns and trading days of the week in financial markets. The OLS approach ignores the fact that day of the week seasonality may exist in volatility. The generalised autoregressive conditional heteroscedasticity (GARCH) class models have been applied to capture both the effect of day of the week on returns and volatility. Plimsoll *et al*. (2013) day of the week anomaly analysis utilised the GARCH model but could not account for leverage effects and their attention was on aggregate equity market returns. Chinzara and Slyper (2013) employed the exponential GARCH (EGARCH) and threshold GARCH (TGARCH) models for examining day of the week anomaly using aggregate equity market indices.

Given the existence of anomalies in documented in literature, investors face an investment decision challenge of devising profitable anomaly strategy. Failure to have an investment strategy may result in poor investment performance (Pompian, 2012). Therefore, this study sought to examine whether the day of the week anomaly is present on the Johannesburg stock exchange (JSE). Precisely, the EGARCH and TGARCH are used to estimate the relationship between returns and trading days of the week. The EGARCH and TGARCH models are able to address issues of volatility clustering, leverage effects, heteroscedasticity and autocorrelation (Francq & Zakoïan, 2010). The rest of the article

include a literature review section, followed by methodology which provide the methods employed in the study. Next, the empirical findings and discussions for day of the week are summarised and the study end with conclusions and recommendations.

Literature review

Perspectives in day of the week seasonality are rooted in the famous efficient market hypothesis theory. In particular, the weak form efficiency relates well with the daily returns patterns. According to Fama (1970) weak form efficiency is when security prices in a financial market fully reflect all the historical information such as prices and volume changes. If a financial market is weak form efficient then it is impossible for market participants to earn abnormal returns and statistically it means there are no traces of linear or non-linear dependencies in the security returns series (Fama, 1970). The implication of the weak form efficiency is that no trading days should have return and risk that is significantly different from other trading days. However, empirical evidence that tested the effect of stock trading days on returns and risk have provided mixed results.

Charles (2010) examined daily seasonality in Greece, France, Finland, Ireland, Italy and Switzerland equity markets using stock indices data covering the period 1987-2007. The returns and volatility were modelled as a function of Monday, Tuesday, Wednesday, Thursday and Friday. The mean equations indicated negative Monday, positive Monday, Thursday and Friday effects on returns. The volatility equation illustrated a positive Monday, Thursday and Friday as well as negative Tuesday and Thursday effects on volatility. The study unveiled that Monday, Thursday and Thursday effects were prevalent in the studied markets.

Alt *et al*. (2011) studied the day of the week anomaly in the UK, US and Germany equity markets from 1970 to 2008. The returns dependent variable was predicted by Monday, Tuesday, Wednesday, Thursday and Friday dummy variables. Negative Monday effect on returns was observed. The study advised that there was Monday effect (1970-1980) for US and Germany equity markets, which disappeared in 1990s and 2000s.

Asteriou and Begiazi (2013) examined the day of the week anomaly in real estate investment trusts (REITs). The REITs data for the US market spanned from 2000 to 2012. The link between REITs return and independent variables namely Monday, Tuesday, Wednesday, Thursday and Friday were investigated. The results revealed that Friday variable was significantly positive in the mean and volatility equations. The study advised that investors for REITs dislike bad news and the day of the week effect does not influence their behaviour.

Tilica and Oprea (2014) analysed daily seasonal patterns in the Romanian stock exchange utilising the stock indices data covering the period 2005-2011. The returns were estimated as a function of world market risk, Monday, Tuesday, Wednesday, Thursday and Friday variables. Friday was found to have a positive and higher mean return as compared to other trading days. Authors recommended that investors can take advantage of the Friday effect to obtain abnormal returns.

Kumar and Pathak (2016) investigated the day of the week anomaly in the foreign exchange market focussing on the United States dollar, Euro, British pound, Japanese yen against the Indian rupee for years 1999-2014. Monday, Tuesday and Wednesday

have positive and higher returns while Thursdays and Fridays have negative and lower returns. The results indicate that day of the week anomalies are present in the foreign exchange market. However, the authors argue that these have disappeared post 2008 and investors may not make meaningful profits.

Vasileiou (2017) assessed seasonality in daily returns in the US equity market for 2000-2013 sample data period. The study postulated negative effects on returns for Monday and Wednesday. In recession and growth periods, positive and negative effects on Tuesday, positive Thursday, and negative and positive effects for Friday. The author suggested that day of the week effect is influenced by the economic growth status. The study proffer explanation for conflicting results in the literature. Informed investors constantly exploit the day of the week and hence change it.

Zhang *et al*. (2017) analysed day of the week anomaly in Canada, China and US for period 1990-2016. The day of the week which covered Monday, Tuesday, Wednesday, Thursday and Friday were modelled in the return equation only. The returns for Monday, Tuesday and Friday were found to be different from the rest of trading days in the Chinese stock market. The authors highlighted that the trading day anomalies in China were as a result of investors' response to information released during periods when stock prices are falling. The Monday returns were significantly different from other days in the Chinese equity market. For small and mid-cap Chinese stocks, the day of the week anomaly was more pronounced on Monday and Thursday. The Monday and Tuesday effects were found in the US stock market. However, after 2015 the Monday effect remained whilst the Tuesday effect vanished. In Canada, Tuesday effect was stronger than the Monday effect. The study recommended that day of the week anomaly varies with country.

Jadevicius and Lee (2017) tested the day of the week seasonality in UK REITs in the period 1990-2014. The study modelled the relationship between returns and trading days of the week. Results unveiled a negative effect for Monday and positive effects for Tuesday, Wednesday and Friday. The UK REITs are characterised by market inefficiencies which provide profitable opportunities for investors. The authors alluded that returns vary across the trading week. It was recommended that investors should utilise the day of the week effectively in their trading strategies.

Birru (2018) examined the effect of day of the week on US equity volatility for the period 1963 to 2013. The findings showed positive Monday effect and negative Friday effect on volatility. The author asserted that differences in returns across the week are attributed to psychological factors that affect the behaviour of investors. The results suggested a decreasing investors' mood from Monday to Friday.

Mbanga (2018) investigated the day of the week effect in the Bitcoin, a cryptocurrency from 2011 to 2018. Findings highlighted no Monday effect but only the Friday anomaly. It was observed that the clustering was weaker on Mondays and stronger on Friday. Evidence of price clustering in Bitcoin highlights the different daily patterns in the cryptocurrency market. Fridays were found to be a driver in Bitcoin price clustering. The majority of studies found that day of the week effect was present in developed and developing financial markets. However, there were variations observed for the significant trading days of the week.

Research Design, Methodology, Research Tasks and Hypothesis

The study applies a quantitative approach. The GARCH, EGARCH and TGARCH models are employed to examine day of the week effect on returns and volatility for the Johannesburg stock exchange (JSE). The mean and variance equations for analysing the day of the week effect are adapted from Caporale and Zakirova (2017). We include dummy variables for trading days from Monday to Friday and exclude Saturday in the volatility equations. For specifications purposes an order (1,1) is used for GARCH family models are as follows:

$$R_t = \sum_{i=1}^{5} \alpha_i D_{it} + \epsilon_t \quad (1)$$

$$h_t = a + b\epsilon_{t-1}^2 + ch_{t-1} + \sum_{i=2}^{5} d_i D_{it} \quad (2)$$

D_{it} is a dummy variable equal to one where returns occur in trading day i defined from Monday to Friday otherwise its zero.

The EGARCH model specification for the day of the week is as follows:

$$In(h_t) = a + cIn(h_{t-1}) + f_1 \frac{\epsilon_{t-1}}{\sqrt{h_{t-1}}} + f_2 \frac{|\epsilon_{t-1}|}{\sqrt{h_{t-1}}} + \sum_{i=2}^{5} d_i D_{it} \quad (3)$$

TGARCH model for day of the week:

$$h_t = a + b\epsilon_{t-1}^2 + ch_{t-1} + \gamma\epsilon_{t-1}^2 I_{t-1} + \sum_{i=2}^{5} d_i D_{it} \quad (4)$$

Daily indices data from JSE covers the period 1995 to 2018 and were sourced from IRESS database, a financial data firm. Indices have been used to study calendar anomalies in (Loffe, 2008; Astin, 2015; Du Toit *et al*., 2018). The indices consist of top 40 (J200), all shares (J203), basic materials (J510), industrials (J520), consumer goods (J530), health care (J540), consumer services (J550), telecommunications (J560), financials (J580) and technology (J590). Eviews 10 integrated with R software was used to analyse the data.

The null hypothesis for the study is that the average returns for Monday, Tuesday, Wednesday, Thursday and Friday are equal. The estimation procedures of the GARCH, EGARCH and TGARCH models involved various steps. Firstly, descriptive statistics were computed to have an understanding of the financial characteristics of the data. Secondly normality of data was tested using the Jarque-Bera test. Thirdly, The Augmented-Dickey-Fuller (ADF) test for stationarity were employed. Fourthly, Ljung and Box autocorrelation and ARCH effect tests were employed. Fifthly, non-linearity structure of returns were tested by Keenan tests whereas the Hsieh test assessed whether the source of non-linearity was additive or multiplicative. Sixthly, the GARCH, EGARCH and TGARCH with different orders were estimated with the objective of attaining the best model for the day of the week effect. Seventhly, the best model was estimated and Nyblom test was conducted to assess the stability of parameters over time. The null hypothesis of the Nyblom test is that the estimated parameters are stable over time.

Research results and Discussion

This section looks at the results for day of the week modelling, beginning with the descriptive statistics, followed by tests and model selection and finally estimation of the optimum model.

Preliminary analysis

Descriptive statistics for JSE's sectorial indices in addition to the Top 40 and All shares indices are presented. The descriptive statistics looks at the mean, standard deviation, skewness, kurtosis and Jarque-Bera normality test results are also explained.

Table 1: Summary statistics of daily series for JSE indices

Variable	Indices	J200	J203	J510	J520	J530	J540	J550	J560	J580	J590
Daily	Mean	0.00039	0.00041	0.00027	0.0004	0.00056	0.0004	0.00053	0.0004	0.00037	0.000275
	Std. Dev.	0.01321	0.01202	0.01693	0.01221	0.01567	0.01336	0.01288	0.02042	0.01276	0.019167
	Skewness	-0.3712	-0.4395	-0.0018	-0.438	0.23876	-0.3056	-0.3331	-0.1575	-0.4387	-0.673301
	Kurtosis	9.13867	9.0863	7.17077	9.52205	8.50191	8.64729	6.96216	9.92434	10.0192	14.53108
	Jarque-Bera	9302.092	9200.25*	4232.147	10535.64	7420.164	7849.906	3927.326	11689.11	12174.15	32790.67*
	Observations	5839	5839	5839	5839	5839	5839	5839	5839	5839	5839

*indicates significant at 1% level of significance. J200=Top 40, J203=All shares, J510= Basic materials, J520=Industrials, J530=Consumer goods, J540=Health care, J550=Consumer services, J560=Telecommunication, J580=Financials and J590=Technology.

Table 1 reveals positive average daily returns for the JSE indices studied with the highest average returns being found in the Consumer goods sector. Based on the standard deviation results, Telecommunication is the riskiest sector. The Consumer goods sector has positive skewness implying more positive values on the distribution tails and the rest of the indices have negative skewness (Cisar & Cisar, 2010; Conrad *et al*., 2013). The daily returns on the JSE are leptokurtic with kurtosis exceeding 3 for all indices which is in contrast with mesokurtic kurtosis that is assumed in an efficient market (Aparicio & Estrada, 1977). A joint test of skewness and kurtosis using the Jarque-Bera tests rejects the null hypothesis that JSE indices returns distribution are normally distributed. Normality test findings contradicts the random walk model of assessing stock market efficiency which assumes the Gaussian distribution but however supports the non-normal distribution of returns (Bachelier, 1900; Fama, 1965; Mishkin & Eakins, 2018).

Table 2: Preliminary tests for GARCH models estimation

Returns	Stationarity	Autocorrelation and ARCH	Nonlinearity	Hsieh	Conclusion
J200	Stationary I(0)	Autocorrelation and ARCH effects	Nonlinear	Multiplicative	GARCH class
J203	Stationary I(0)	Autocorrelation and ARCH effects	Nonlinear	Multiplicative	GARCH class
J510	Stationary I(0)	Autocorrelation and ARCH effects	Nonlinear	Multiplicative	GARCH class
J520	Stationary I(0)	Autocorrelation and ARCH effects	Nonlinear	Multiplicative	GARCH class
J530	Stationary I(0)	Autocorrelation and ARCH effects	Nonlinear	Multiplicative	GARCH class

J540	Stationary I(0)	Autocorrelation and ARCH effects	Nonlinear	Multiplicative	GARCH class
J550	Stationary I(0)	Autocorrelation and ARCH effects	Nonlinear	Multiplicative	GARCH class
J560	Stationary I(0)	Autocorrelation and ARCH effects	Nonlinear	Multiplicative	GARCH class
J580	Stationary I(0)	Autocorrelation and ARCH effects	Nonlinear	Multiplicative	GARCH class
J590	Stationary I(0)	Autocorrelation and ARCH effects	Nonlinear	Multiplicative	GARCH class

J200=Top 40, J203=All shares, J510= Basic materials, J520=Industrials, J530=Consumer goods, J540=Health care, J550=Consumer services, J560=Telecommunication, J580=Financials and J590=Technology.

Stationarity findings in Table 2 were based on the ADF showed that the natural logarithm returns of JSE were stationarity at level. The Ljung and Box autocorrelation and ARCH effect test results for JSE stock returns. The results highlighted significant evidence of autocorrelation and ARCH effects in the residuals at 1% and 5% level of significance. The strong significance of the ARCH effects results implies that it is scientifically justified to use GARCH family models specification because of non-constant variance (Ahmed & Suliman, 2011). The presence of autocorrelation and ARCH implies that modelling of calendar anomalies should incorporate past residuals (Gazda & Výrost, 2003).

The Keenan test revealed that JSE returns have a nonlinear structure, which is a characteristic for financial data (Francq & Zakoïan, 2010; Bisaglia & Gerolimetto, 2014). Furthermore, examining source of non-linearity of a return series of JSE indices using the Hsieh test. The step was crucial in specifying whether the use of GARCH in mean (GARCH-M) or GARCH models not incorporated in mean (Hsieh, 1989). The Hsieh results showed that the number of acceptances were more than the rejections and hence the null hypothesis of a multiplicative source of non-linearity was accepted at the 5% level of significance and it is concluded that GARCH in mean models are irrelevant to model JSE returns.

Table 3: Order selection for GARCH modelling of day of the week anomaly

Returns	Day of the week
J200	EGARCH-t (2,2)
J203	EGARCH-t (2,2)
J510	EGARCH-t (3,2)
J520	TGARCH-t (1,1)
J530	EGARCH-t (3,3)
J540	EGARCH-t (3,1)
J550	EGARCH-t (2,1)
J560	EGARCH-t (2,3)
J580	EGARCH-t (1,3)
J590	TGARCH-t (3,2)

J200=Top 40, J203=All shares, J510= Basic materials, J520=Industrials, J530=Consumer goods, J540=Health care, J550=Consumer services, J560=Telecommunication, J580=Financials and J590=Technology.

Table 3 delineate the results of running various GARCH class models of p and q ranging from 0 to 3 for day of the week anomaly. The variables p and q represent the

GARCH and ARCH terms respectively. The optimum selection criteria utilised the AIC and SC information criteria through choosing the model with the lowest value (Asteriou & Hall, 2007). The findings on the order for GARCH models are incompatible with parsimonious principle that recommended order (1,1) (Kaur, 2004; Du Toit *et al*., 2018). Of interest, it was noted that order (1,1) was selected as the best for the Industrial sector for TGARCH with studentised distributed residuals. The EGARCH and TGARCH with Student-*t* distributed errors performed best in modelling day of the week effect based on the AIC and SC information criteria. The EGARCH were also applied to model day of the week in US equity market by Vasileiou (2017), in Hong Kong stock market by Chan and Woo (2012), in Ghana by Alagidede and Panagiotidis (2009), Israel by Alberg *et al*. (2008). The TGARCH modelling of daily seasonality in equity market is supported in Vasileiou (2017) for US, Derbali and Hallara (2016) for Tunisia, Charles (2010) for Germany, US, UK and Japan, and Alagidede and Panagiotidis (2009) for Ghana. The next section reports and interprets the findings from estimating the optimum EGARCH and TGARCH models.

Looking at the mean equation in Table 4, the Top 40, All shares, Basic materials, Consumer goods, Health care, Consumer services and Telecommunications indices illustrate a significant positive Monday effect. Only Consumer services and Financials sectors have significant positive Tuesday effect. A significant positive Wednesday effect is only applicable to the Consumer services sector. Thursday effect are positively significant in Top 40, All shares, Consumer services, Telecommunications and Financials indices. No Friday effect was found in the mean equation for the JSE indices.

The findings in Table 4 shows no sign bias for all series which demonstrate the strength of EGARCH to capture asymmetric behaviour in returns of JSE indices which the GARCH is unable to incorporate (Brooks, 2014). The Nyblom test indicates that the estimated parameters in the mean and variance equations for the JSE indices are stable. In the light of the variance equation, there is a significant negative Monday effect for all JSE series. Telecommunications sector demonstrates the greatest reduction in risk when an investor trades a unit of investment on a Monday. The lowest reduction of risk on a Monday is found in Consumer goods sector. Fridays have negative significant effects for Top 40, All shares and Consumer services indices. In comparison, trading on Mondays offers a greatest reduction on risk to investors than Fridays. All JSE series exhibit a phenomenon known as the leverage effect highlighted in Brooks (2014), where a fall in stock returns causes volatility to increase. The volatility-return relationship illustrates that negative information has a greater impact on volatility as compared to positive information of the same magnitude (Brooks, 2014). Investors on the JSE are more sensitive to bad news than good news of equal size. The parameter values of f_2 are significantly positive showing a positive impact on current volatility from shocks emanating from bad news generated on the previous day for the series in Table 4. Likewise, news from the previous two days have a positive magnitude on the current volatility as highlighted by the significant positive parameters values, f_3 for Top 40, All shares, Basic materials, Consumer goods and Telecommunications indices. However, information generated in past 3 days have a negative impact on the current volatility because the estimated f_4 values are negatively significant for Consumer goods and Telecommunications sectors. The sum of c_1, c_2 and c_3 coefficients show that volatility is persistence for the JSE series. For example, Top 40 index has a sum of is about 0.97 implying that past shocks in returns impacts highly on current volatility and continue for a long period (Srinivasan & Kalaivani, 2013; Brooks, 2014).

GARCH modelling results for day of the week

Table 4: EGARCH models results for day of the week

R_t	J200	J203	J510	J530	J540	J550	J560	J580
Mean equation								
α_1	0.001302**	0.001302**	0.001218**	0.001287**	0.000977**	0.001175**	0.000921*	0.000451
α_2	0.000135	0.000243	0.00018	5.86E-07	0.000486	0.001044**	0.000799	0.000861**
α_3	0.000111	0.000173	-0.000152	0.000356	0.000573	0.001208**	9.12E-05	0.000483
α_4	0.000843**	0.000883**	0.00064	0.000542	0.000526	0.001003**	0.000876*	0.000829**
α_5	2.86E-05	0.000221	-0.000323	0.000158	0.000251	0.000361	0.000547	-4.83E-05
Variance equation								
A	-0.433209**	-0.444788**	-0.445582**	-0.102016*	-0.475879**	-0.361765**	-0.48997**	-0.214138**
f_1	-0.117571**	-0.115278**	-0.074898**	-0.029207**	-0.050505**	-0.0646**	-0.033305*	-0.063887**
f_2	0.147035**	0.147549**	0.154284**	0.236833**	0.248739**	0.235122**	0.292693**	0.244217**
f_3	0.096929*	0.102175*	0.146888**	0.03049*			0.144085**	-0.025931
f_4				-0.208013**			-0.137281**	-0.049736
c_1	0.494996**	0.457803**	0.180956	0.723842**	0.610609**	0.564615**	0.090139	0.980312**
c_2	0.477743**	0.514867**	0.315129	0.980101**	0.032058	0.4109**	0.883592**	
c_3			0.48337**	-0.708564**	0.329495**			
d_2	0.025292	0.030481	0.099871	0.049201	0.056075	0.002325	0.06759	-0.089563
d_3	0.102848	0.094564	0.146029	0.043796	-0.011074	0.002239	0.034746	-0.070916
d_4	0.020674	0.029724	0.044806	-0.018019	0.128862	-0.010098	0.073183	-0.133703
d_5	-0.162193*	-0.162911*	-0.077221	0.012219	0.033576	-0.193729*	0.089265	-0.173385
AIC	-6.147672	-6.34312	-5.614728	-5.794269	-6.039671	-6.157577	-5.25356	-6.263238
SC	-6.129389	-6.324837	-5.595302	-5.773701	-6.021387	-6.140436	-5.234134	-6.244955
LL	17964.13	18534.74	16409.2	16934.37	17648.82	17992.05	15354.77	18301.52
SB	1.227	1.1557	0.18321	0.4123	1.1162	0.35037	0.7429	0.59383
NEGSB	1.025	1.2650	0.04455	0.9575	1.3509	1.16464	1.8114	1.31074
POSSB	1.248	0.7857	0.18920	0.4037	0.3121	0.09211	1.0117	0.06009
JE	2.619	2.2524	0.04674	1.1121	2.7066	3.32966	5.1604	1.72166

+ indicates significant Nyblom test at 5% level. * and ** indicates significance at 5% and 1% level respectively. n* denote that normal distributed error is assumed in the model. J200=Top 40, J203=All shares, J510= Basic materials, J530=Consumer goods, J540=Health care, J550=Consumer services, J560=Telecommunication and J580=Financials.

There is evidence of volatility persistence for the JSE indices indicating that past volatility of returns affects current volatility (Paolella, 2019). The Nyblom tests for estimated GARCH effect parameters are unstable for Top 40, All shares and Telecommunications indices showing time sensitivity of the parameters. A negative Friday effect was found for Top 40 and All shares indices in variance equation. A negative Tuesday, Wednesday, Thursday and Friday effects as well as a positive and unstable Monday effect was found in the Financials sector. The leverage effect is present as illustrated by the positive gamma parameter, γ for all JSE indices. The mean equations for Top 40, All shares indices have a positive Monday and Thursday effects. Monday effects are displayed in Basic materials, Consumer goods and Health care sectors. It is observed that Consumer services sector has positive effects for all trading days whilst the Financials has Monday, Tuesday and Thursday effects.

Table 5: TGARCH models results for day of the week

R_t	J520	J590
Mean equation		
α_1	0.000729*	0.000718*
α_2	0.00065	0.000451
α_3	0.000334	0.000833**
α_4	0.00092**	0.000907**
α_5	0.000323	0.000499
Variance equation		
a	1.24E-05**+	2.14E-06+
b_1	0.052029**	0.240646**
γ	0.078779**+	0.002737**
b_2		-0.238398**
c_1	0.883479**	1.24759**
c_2		0.072294
c_3		-0.323715**
d_2	-1.12E-05	-1.73E-06
d_3	-5.81E-06	-3.81E-06
d_4	-1.04E-05	-5.14E-06
d_5	-1.69E-05*	7.20E-07
AIC	-6.233252	-5.602572
SC	-6.217254	-5.583146
LL	18211.98	16373.71
SB	0.2538	1.8401
NEGSB	3.7969**	1.1756
POSSB	0.5828	0.8516
JE	18.3392**	3.5711

+ indicates significant Nyblom test at 5% level. * and ** indicates significance at 5% and 1% level respectively. n* denote that normal distributed error is assumed in the model. J520=Industrials and J590=Technology.

Table 5 reports the day of the week effect results for TGARCH models for Industrials and Technology sectors. In the light of the mean equation, there is positive and significant Monday and Thursday effects for Industrials and Technology sectors. Additionally, the Technology sector has positive and significant Wednesday effect. The returns are much attractive on Thursday for Industrials and Technology sectors as compared to other significant trading days. The coefficient for the Monday effect is unstable as revealed by the Nyblom test and hence can change over time.

The mean equation for Industrials sector has a positive Monday and Thursday effects. The volatility equation depicted a positive Monday and negative Friday effect for the Industrials sector. Technology sector revealed Monday, Wednesday and Thursday effects in the mean equation. The AIC, SC and LL justified the use of Student-*t* distributed errors in TGARCH models for day of the week anomaly (Paolella, 2019). Negative, positive and joint sign bias are present in the returns of JSE indices.

The results shed light on the day of the week effect on the JSE. Daily seasonality in equity markets has now become a stylised fact for financial securities as highlighted by empirical evidence (Zhang *et al*., 2017). Vasileiou (2017) found that EGARCH with Student-*t* distributed errors was a better model than TGARCH in the US stock market and significant positive Tuesday and Thursday effects in the mean equation which was also present on the JSE. In contrast, Jebran and Chen (2017) in the Islamic equity market found negative Tuesday and Thursday effects in the variance equation of a GARCH model, and negative Monday and positive Friday effects in the mean equation. The study results agree with Derbali and Hallara (2016) findings in Tunisia stock market for positive Thursday and Wednesday effects for the EGARCH and TGARCH models. Similar with the South Africa equity market, Chan and Woo (2012) found positive Monday in the mean equation and negative Friday in the variance equation for the Hong Kong, however investors' returns on Monday are aligned to the risk reflected in the volatility equation, the only exception is Industrials sector. The positive Monday effect displayed in variance equation for the Industrials sector tallies with findings in Charles (2010) for Germany, UK and Japan equity markets, Alagidede and Panagiotidis (2009) in Ghana stock market, and Alberg *et al*. (2008) for Israel equity market. JSE indices has negative Monday effect in the variance equation with the exception of Industrials and Financials sectors, the results are supported by Charles (2010) for US equities.

On the local platform, results of day of the week appear to be consistent with Du Toit *et al.* (2018) in some aspects for instance a positive Monday effect on all sectorial JSE indices, positive Monday to Thursday effects for Consumer services sector. Positive Monday effects obtained are in contrast with negative Monday effects obtained in Darrat *et al*. (2013) which disappeared after 2008. Inconsistently, Ndako (2013) found negative Monday effect in mean equation and positive Friday effect in variance equations for pre-liberalisation whereas for post-liberalisation it was positive Thursday and Friday effects. Current findings paint a totally different picture with Ndako's results.

The Monday and Thursday effects on the JSE is attributed to the current settlement process, a T+3 that is when one trades on Monday, the cycle ends on a Thursday for the transaction (Chen *et al*., 2001). A reverse Monday effect is noted and the investors' mood are different across the sectors (Birru, 2018). For Top 40, All shares, Consumer services, Telecommunications and Financials indices, investors' mood declines in the trading week Monday to Thursday and the mood increases for Industrials and Technology sectors.

In addition, varying returns reflect some incorporation of information being processed during the trading week (Nishat & Mustafa, 2002). The positive Monday suggests that investors act upon information in weekly reports and process it during the weekend and this drive pressure of securities on Monday and thereby increasing their yields (Zhang *et al*., 2017).

The findings of day of the week effect invalidate the EMH. The observed trading days returns on the JSE are not equal and therefore investors can make use of past information on returns and volatility to gain profitable trades. Investors can buy securities on any other day then sell on Monday when the return is higher. Trading on a Monday and Friday reduces uncertainty in returns.

Conclusion

The study endeavoured to test whether day of the week effect existed on the JSE. The relationship between returns and trading days of the week was estimated using the EGARCH and TGARCH models. In modelling for the day of the week, the Top 40, All Shares, Basic materials, Consumer goods, Health care, Consumer services, Telecommunications and Financials utilised EGARCH with Student-*t* distributed errors. Industrials and Technology sectors were modelled by TGARCH with Student-*t* distributed errors. The aggregate indices, namely Top 40 and All Shares revealed a positive Monday effect in the mean equation. The mean equation for the sectoral analysis of the day of the week anomaly showed a positive Monday effect for Basic materials, Consumer goods, Health care and Telecommunications in the mean equation. The Financials sector depicted a positive Tuesday effect, and a positive Wednesday effect was observed in the Consumer services sector. The Industrials and Technology sectors had positive Thursday effects. Monday effect is highest in aggregate indices, namely the Top 40 and All Shares of the JSE. The highest Tuesday and Wednesday effects were found in the Financials and Consumer services sectors respectively, whilst the Industrials sector had the greatest Thursday effect.

Looking at the variance equation, the aggregate indices, symbolised by the Top 40 and All Shares revealed a negative Monday effect. The sectoral indices, namely Basic materials, Consumer goods, Health care, Consumer services, Telecommunications, and Financials, indicated a negative Monday effect. The Industrials sector highlighted a negative Friday effect.

Based on EGARCH and TGARCH model findings for modelling the day of the week anomaly, an investor should invest in aggregate indices, namely the Top 40 and All Shares, as these provide the highest Monday returns compared to investing in specific sectors. The investment in the Top 40 and All Shares will involve constructing an index fund that mimics performance of the said aggregate indices on Mondays. For Tuesday and Wednesdays, it would be prudent for investors to invest in the Financial and Consumer services sector respectively, as they offer the largest returns for the corresponding trading days. On Thursdays, an investor has to be invested in the Industrials sector to earn abnormal returns. An investor can reduce exposure by diversifying in the Health sector on Monday and in the Industrials sector on Friday. The study is limited to South Africa equity market and suggestion for further studies may include the use of panel GARCH methods.

References

Alagidede, P. & Panagiotidis, T. 2009. Calendar anomalies in the Ghana stock exchange. *Journal of Emerging Market Finance*, 8(1):1–23.

Alberg, D., Shalit. H. & Yosef, R. 2008. Estimating stock market volatility using asymmetric GARCH models. *Applied Financial Economics*, 18(15):1201-1208.

Alt, R., Fortin, I. & Weinberger, S. 2011. The Monday effect revisited: An alternative testing approach. *Journal of Empirical Finance*, 18(2011):447–460.

Ahmed, A.E.M. & Suliman, S.Z. 2011.Modeling stock market volatility using GARCH models evidence from Sudan. *International Journal of Business and Social Science,* 2(23):114-128.

Ajayi, R.A., Mehdian, S. & Perry, M.J. 2004. The day of the week effect in stock returns: Further evidence from Eastern European emerging markets. *Emerging Markets Finance & Trade*, 40(4):53-62.

Aparicio, F. & Estrada, J. 1997. Empirical distribution of stock returns: Scandinavian securities markets, 1990-95. http://web.iese.edu/jestrada/PDF/Research/Others/DSRSSM Date of access: 19 May 2018.

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

Astin, A. J. L. 2015. Analysis of calendar effects and market anomalies on the Johannesburg stock exchange.Masters Thesis.Nelson Mandela Metropolitan University.

Bachelier, L. 1900. Theorie de la speculation. *Annales Scientifiques de l'E´cole Normale Supe´rieure Se´r*. 3(17):21–86.

Birru, J. 2018. Day of the week and the cross-section of returns. *Journal of Financial Economics*, 130(1):182–214.

Bisaglia, L. & Gerolimetto, M. 2014. Testing for (non)linearity in economic time series: a Monte Carlo comparison. *Quaderni Di Statistica*, 16:5-32.

Brooks, C. 2014. *Introductory econometrics for finance*. 3rd ed. Cambridge: Cambridge University Press.

Caporale, G. M. & Zakirova, V. 2017. Calendar anomalies in the Russian stock market. *Russian Journal of Economics*, 3(2017):101–108.

Chan, H.L. & Woo, K. 2012. Day of the week effect on the return and conditional variance of the H-shares index in Hong Kong. *Applied Economics Letters*, 19(3):243-249.

Charles, A. 2010. Does the day of the week effect on volatility improve the volatility forecasts? *Applied Economics Letters*, 17(3):257-262.

Chen, G., Kwok, C.C.Y. & Rui, O.M. 2001. The day-of-the-week regularity in the stock markets of China. *Journal of Multinational Financial Management*, 11(2001):139–163.

Chinzara, Z. & Slyper, S. 2013. Volatility and anomalies in the Johannesburg securities exchange daily returns. *The South African Financial Markets Journal*, 17:1-16.

Choudhry, T. 2000. Day of the week effect in emerging Asian stock markets: Evidence from the GARCH model, *Applied Financial Economics*, 10(3):235-242.

Cisar, P. & Cisar, S.M. 2010. Skewness and kurtosis in function of selection of network traffic distribution. *Acta Polytechnica Hungarica*, 7(2):95-106.

Conrad, J., Dittmar, R.F. & Ghysels, E. 2013. Ex ante skewness and expected stock returns. *The Journal of Finance*, 68(1):85-124.

Coutts, J. A. & Sheikh, M. A. 2002. The anomalies that aren't there: the weekend, January and pre-holiday effects on the all gold index on the Johannesburg stock exchange 1987-1997. *Applied Financial Economics*, 12(12):863-871.

Darrat, A. F., Li, B. & Chung, R. 2013. Seasonal anomalies: A closer look at the Johannesburg stock exchange. *Contemporary Management Research*, 9(2):155-168.

Derbali, A. & Hallara. 2016. Day of the week effect on the Tunisian stock market return and volatility. *Cogent Business & Management*, 3(2016):1-12.

Du Toit, E., Hall, J.H. & Pradhan, R.P. 2018. The day of the week effect: South African stock market indices. *African Journal of Economic and Management Studies*, 9(2):197-212.

Fama, E. 1965. Random walks in stock market prices. *Financial Analysts Journal*, 21(5):55-59.

Fama, E. F. 1970. Efficient capital markets: A review of theory and empirical work. *The Journal of Finance*, 25(2):383-417.

Francq, C. & Zakoïan, J.M. 2010. GARCH models: Structure, statistical inference and financial applications. West Sussex: Wiley.

Gazda, V. & Výrost, T. 2003. Application of GARCH models in forecasting the volatility of the Slovak share index (SAX). *BIATEC*, 11(2):17-21.

Halari, A., Helliar, C., Power, D.M. & Tantisantiwong, N. 2018. Taking advantage of Ramadan and January in Muslim countries. The Quarterly Review of Economics and Finance xxx(2018):xxx–xxx.

Hsieh, D.A. 1989. Testing for non-linearity dependence in daily foreign exchange rate. *Journal of Business*, 62:339-368.

Jadevicius, A. & Lee, S. 2017. UK REITs don't like Mondays. *Journal of Property Investment & Finance*, 35(1):58-74.

Jebran, K. & Chen, S. 2017. Examining anomalies in Islamic equity market of Pakistan. *Journal of Sustainable Finance & Investment*, 7(3):275-289.

Kaur, H. 2004. Time varying volatility in the Indian stock market. *Vikalpa*, 29(4):25-42.

Kohers, G., Kohers, N., Pandey, V. & Kohers, T. 2004. The disappearing day of the week effect in the world's largest equity markets. *Applied Economics Letters*, 11(3):167-171.

Kumar, S. & Pathak, R. 2016. Do the calendar anomalies still exist? Evidence from Indian currency market. *Managerial Finance*, 42(2):136-150.

Lakonishok, J. & Levi, M. 1982. Weekend effects on stock returns: A note. *The Journal of Finance*, 37(3):883-889.

Lakonishok, J. & Maberly, E. 1990. The weekend effect: Trading patterns of individual and institutional investors. *The Journal of Finance*, 45(1):231-243.

Loffe, S. 2008. The Day of the Week Effect on the JSE Securities Exchange since 1994.Masters Thesis. University of the Witwatersrand.

Mbanga, C.L. 2018. The day of the week pattern of price clustering in Bitcoin. *Applied Economics Letters*, DOI: 10.1080/13504851.2018.1497844.

Mishkin, F.S. & Eakins, S.G. 2018. *Financial markets and institutions*. 9th ed. Harlow: Pearson Education.

Ndako, U.B. 2013. The day of the week effect on stock market returns and volatility: Evidence from Nigeria and South Africa. *MPRA,* paper no. 48076.

Nishat, M. & Mustafa, K. 2002. Anomalies in Karachi Stock Market: Day of the week effect. *The Bangladesh Development Studies*, 28(3):55-64.

Norvaisiene, R., Stankeviciene, J. & Lakstutiene, A. 2015. Seasonality in the Baltic stock markets. *Procedia-Social and Behavioural Sciences,* 213(2015):468-473.

Oguzsoy, C.B. & Guven, S. 2003. Stock returns and the day of the week effect in Istanbul Stock Exchange. *Applied Economics,* 35(8):959-971.

Paolella, M.S. 2019. *Linear models and time-series analysis regression, ANOVA, ARMA and GARCH*. New Jersey: John Wiley & Sons.

Plimsoll, J., Saban, B., Spheris, A. &Rajaratnam, K. 2013. The day of the week effect: An analysis of the Johannesburg stock exchange top 40 firms. *International Business & Economics Research Journal*, 12(3):319-330.

Pompian, M.M. 2012. *Behavioral finance and investor types: managing behavior to make better investment decisions*. New Jersey: John Wiley & Sons.

Srinivasan P. & Kalaivani, M. 2013. Day-of-the-week effects in the Indian stock market. *MPRA,* paper No. 46805.

Tilica, E.V. & Oprea, D. 2014. Seasonality in the Romanian stock market: The day of the week effect. *Procedia Economics and Finance*, 15(2014):704-710.

Ülküa, N. & Rogers, M. 2018. Who drives the Monday effect? *Journal of Economic Behavior and Organization*, 148 (C):46–65.

Vasileiou, E. 2017. Calendar anomalies in stock markets during financial crisis: The S&P 500 case. (*In* Haciog˘lu, U. & Dinc¸er, H., *ed*. Global financial crisis and its ramifications on capital markets: Opportunities and threats in volatile economic conditions. Cham: Springer. p. 493-506).

Winkelried, D. & Iberico, L.A. 2018. Calendar effects in Latin American stock markets. *Emprical Economics,*54(3):1215-1235.

Zhang, J., Lai, Y. & Lin, J. 2017. The day of the week effects of stock markets in different countries. *Finance Research Letters*, 20(2017):47–62.