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Testing the Weak-Form of Efficient Market Hypothesis and the Day-Of-The-Week Effect in Saudi Stock Exchange: Linear Approach

Abdullah I. Al Ashikh*

The aim of this paper is twofold: first, it investigates the existence of the random walk hypothesis (RWH) by testing the weak-form efficiency in the returns of one of the largest stock markets in the Middle East and North Africa; the Saudi Stock Exchange (SSE), using a set of highly regarded parametric and nonparametric linear serial dependence tests. Second, it investigates the existence of the day-of-the-week effects. The results indicate that the Saudi Stock Exchange (SSE) returns exhibit significant linear serial dependence. The hypothesis of market efficiency has been strongly rejected based on the results from the linearity tests. Thus, a conclusion has been reached that the Saudi stock Exchange is inefficient in the weak-form of the Efficient Market Hypothesis (EMH). The results also show evidence of day-of-the-week effects in the Saudi Stock Exchange, both in mean (returns) and variance (volatility) equation.

JEL Codes: C14, C50, G14 and G15

1. Introduction

Market efficiency has always been the centre of interest in finance and financial economics. It is also one of the most controversial topics in finance literature. The question of whether the financial market is efficient has been widely investigated by researchers, mainly in developed financial markets, over the last three decades. Basically, there are three types of efficiency in market capital that economists are interested in. These types are: allocational efficiency, which means allocating capital resources in a way that participants get the ultimate benefit; operational efficiency, which means that market participants can conduct transactions at fair competitive cost; and informational efficiency, which means securities prices fully reflect all information available in the market. It is important to mention that the degree of allocational efficiency depends mainly on both operational efficiency and informational efficiency.

Generally speaking, most empirical studies on financial market efficiency are concerned with the third type of efficiency; the informational efficiency, based on the fact that financial markets can be informational efficient regardless of whether it is allocational or operational efficient. Theoretically, empirical studies are mostly based on the principle that securities prices follow random walk behaviour, which means that prices cannot be predictable. In finance literature, this is known as the Random Walk Hypothesis (RWH) or, strictly speaking, the Efficient Market Hypothesis (EMH). EMH is based on the idea that asset price in efficient markets reflect all the information available; thus, price behaviour does not

* Abdullah Ibrahim Al Ashikh, Department of Accounting and Finance, Aberdeen Business School, Robert Gordon University, United Kingdom. Email: A.I.H.Al-ashikh@rgu.ac.uk

follow any pattern or trend. Theoretically, market efficiency is supported, so if we fail to reject the hypothesis, that asset's price will behave randomly.

Prior to 1960, technical and fundamental analysis were dominating the financial and investment analysis practices. However, the beginning of modern market efficiency literature is attributed to Samuelson (1965) when he combined the early empirical findings that support the random walk hypothesis, such as Cowles and Jones (1937), and Granger and Morgenstern (1963). According to Dimson and Mussavian (1998), Samuelson developed the theoretical framework of the random walk hypothesis, whereas Bachelier (1900) modelled the formula of random walk in asset prices. Fama (1965) laid the principles of EMH and defined Market Efficiency. Moreover, Roberts (1967) coined the term 'Efficient Market Hypothesis', and also established the classical nomenclature of the three forms of market efficiency information sets (Campbell, Lo, and MacKinlay, 1997). Fama (1970) formalised EMH further and concluded that in efficient markets, prices should 'fully reflect' all information available (Findlay and Williams 2000).

In addition, Fama (1970) stated three conditions which might help or hinder price adjustment to information (market efficiency). First, securities traded without transaction cost. Second, market participants have access to all the relevant information without any cost. Third, agreeing on the implications of current information for the current price and distributions of future prices of each security. Moreover, Fama (1970) formed three classical forms of EMH based on Samuelson's and Roberts' nomenclature work, weak-form; semi strong-form; and the strong-form of EMH.

Calendar anomalies, such as the January effect, the weekend effect and the day-of-the-week effect, have also gained a considerable amount of academic research in developed financial markets. It has been shown that returns of financial assets exhibit systematic patterns at specific times, such as yearly, monthly, weekly or daily. The day-of-the-week effect is one of the most important calendar effects. It has received great attention from researchers and practitioners due to its implications. The existence of the day-of-the-week effect results in average daily returns which are significantly different for each day of the week. Since Fama (1970), the day-of-the-week effect has been documented in many developed financial markets. Such existence is a violation to EMH, that returns should follow random walk.

The aim of this paper is twofold: first, it investigates the existence of the random walk hypothesis (RWH) by testing the weak-form efficiency in the returns of the Saudi Stock Exchange (SSE). Second, it aims to shed light on the existence of the day-of-the-week effects. The existence of the day-of-the-week effect would be in favour of rejecting EMH, that asset returns follow random walk.

Since most research papers are devoted to developed countries with well-organized stock markets, this paper will attempt to be a contribution to the limited literature on the emerging stock markets in general and the Saudi market in particular. In addition, the finding of this thesis will contribute to future research on SSE by adding further insight into the dynamics of this market.

The paper is organised in five sections as follows: the first two sections give a brief introduction and an overview of the literature on EMH and the day-of-the-week effect; section three describes the research methodology and selected data; section four provides the empirical results of the study; and finally, section five presents the conclusion of the study.

2. Literature Review

2.1 Weak-form of the Efficient Market Hypothesis

The test of the weak-form of EMH is concerned with the predictability power of historical prices or returns. Therefore, in order to test the weak-form of EMH we need to examine whether there are changes of security prices or returns featuring random walk behaviour. There are a number of studies devoted to examining the validity of the weak-form of EMH in both developed and emerging markets.

In developed markets, Fama (1965) empirically examined 30 stocks listed in the Dow Jones Industrial Average (AJDIA) from 1956 to 1962. The finding suggests small positive correlation which was statistically not different from zero and the run test supports the findings where the number of runs was less than expected. Fama concluded the efficiency of (AJDIA) in the weak-form. Solink (1973) conducted a thorough study on eight different European markets and had similar results. Other early studies used serial correlation and run tests, showing the same result as the latter, such as Cowles (1960), Osborne (1959, 1962), Cootner (1962), and Fama and Blume (1966). Recent papers include variance ratio test for assessing market efficiency such as Lo and MacKinlay (1988), and Lee (1992). In the UK, Al-Loughani and Chappel (1997) tested the validity of the weak-form on FTSE 30 index using a number of tests and the results rejected the random walk hypothesis. Worthington and Higgs (2004) examined 16 developed markets and four emerging markets for random walk and their findings showed that the random walk hypothesis was not rejected in the developed major European markets, whereas the hypothesis was rejected in all the selected emerging markets.

The validity of random walk hypothesis has been tested in less mature markets. Laurence (1986) tested the weak-form efficiency in the Kuala Lumpur Stock Exchange (KLSE) and the Stock Exchange of Singapore (SES), using both auto-correlation and run tests. The results concluded that both markets are not efficient in the weak-form. On the contrary, a study conducted by Barnes (1986) on the Kuala Lumpur Stock Exchange (KLSE) concluded that the market is efficient in the weak-form. Urrutia (1995) applied variance ratio and the runs test on four Latin American markets. The variance ratio results rejected the random walk hypothesis for all four markets, whereas this was not the case based on the runs test results. Similarly, Ojah and Karemera (1999) conducted the same tests on the same four markets and the results confirmed Urrutia findings. In Asia, a number of studies were concerned with testing the weak-form of the EMH, such as Chang et al. (1996); Poshakwale (1996); Liu et al. (1997); Tas and Dursonoglu (2005); and Hassan et al. (2006).

In Saudi Arabia, most empirical findings suggested that the SSE is inefficient in the weak-form. Yet, some studies have found evidence of efficiency. A study by Bulter and Malikah (1992) examined the market efficiency of the Saudi and Kuwaiti stock markets from 1985 to 1989, using serial correlation and run tests on individual daily stock returns. The findings concluded that both markets were inefficient in the weak-form, since the results showed high evidence of serial correlation in both markets. Similarly, a number of studies have concluded that inefficiency existed in some GCC stock markets, such as Ebid (1990) in the United Arab Emirates stock market, Nourredine (1998) in the SSE and Al-Loughani (1995) in the Kuwaiti stock market. Moreover, a recent study conducted by Elango and Hussein (2008) examined the random walk hypothesis using run tests in the six GCC countries during the period of 2001 to 2006. Their results indicated that the hypothesis of weak-form efficiency was rejected in all GCC stock markets. More recently, Onour (2009) tested the weak-form efficiency on the SSE using unit root tests and variance ratio. The findings of the tests reject the hypothesis of random walk behaviour at all levels of stock prices.

On the other hand, a few studies showed some evidence of efficiency among the Arab stock markets. A study by Dahel and Labbas (1999) examined the Saudi Arabia, Bahrain, Oman and Kuwait stock markets for efficiency using auto-correlation, variance ratio and run tests. Their results suggested that these markets were efficient in the weak-form as the random walk hypothesis could not be rejected. In addition, Abraham et al (2002) examined three major GCC stock markets, Saudi, Kuwait and Bahrain, using variance ratio and runs tests. The initial results indicated a rejection to the random walk hypotheses in all three markets. However, after taking into consideration possible infrequent trading, they applied a correction to the index using Beveridge and Nelson's (1981) decomposition index returns. As a result, they failed to reject the random walk hypotheses in Saudi and Bahrain stock markets, whereas it was rejected in the Kuwaiti market.

Since they are characterised by small size, thin trade and lack of regulations, emerging markets have always been perceived as inefficient in the literature of market efficiency. However, the contrasting results of weak-form market efficiency in Saudi and Arab's markets is not surprising, as the developed and other developing markets showed the same contrasting of results mentioned earlier.

2.2 The Day-of-the-Week Effect

A number of studies have also recorded the presence of the day-of-the-week effect in the financial literature. In the USA, Cross (1973) examined the day-of-the-week effect on the S&P 500 returns between 1953 to 1977. His results showed that Monday average mean return was lower than average returns of other days of the week. Similarly, studies by French (1980), Gibbons and Hess (1981), Lakonishok and Levi (1982), Keim and Stambaugh (1984) and Rogalski (1984) showed evidence of day-of-the-week variance in stock returns. Other studies such as Cornel (1985), and Dyl and Maberly (1986) demonstrated the present of day-of-the-week effect patterns in the US Treasury bill, bond, and futures markets, similar to the patterns of equity markets.

Calendar anomalies have also been detected in other world markets. Jaffe and Westerfield (1985) examined four advanced markets, Australia, Canada, Japan and the UK, for the weekend effect. Their results showed the existence of weekend effect in all four markets. Also, the lowest mean return seems to be found on Tuesday for the Japan and Australia markets, which is a contrast to the early findings of the US market. In line with this, studies by Solnik and Bousquet (1990) on the Paris stock exchange; Barone (1990) on Italian stock market; and Agrawal and Tandon (1994) in eighteen other countries' stock markets showed the existence of day-of-the-week effect at different levels.

The previous findings of studies, in fact, contradicted the hypothesis of calendar time or diffusion process, which implies that Monday's return is equivalent to three day returns with value equal to three times the value of other weekdays. Therefore, researchers attempted to explain these seasonal patterns by examining different factors such as measurement errors (Gibbons and Hess 1981; Keim and Stambaugh, 1984); trading delay and settlement differences (Lakonishok and Levi, 1982; Jaffer and Westerfield, 1985); trading and non- trading periods (Rogalski, 1984); timing of corporate news releases (penman, 1987; Damodaran, 1989; Harvey and Huang, 1991); and time zone differences (Jaffer and Westerfield, 1985).

Using Generalized Auto-regressive Conditional Heteroscedasticity (GARCH) Models, an increasing number of studies have investigated the time series behaviour of equity returns in terms of volatility. Since the focus of the previous studies has been on the seasonal patterns of the mean returns, the following studies have used variations of GARCH models to examine patterns in the volatility of asset returns. In developed markets, Kiymaz and Berument (2003) studied five stock markets, Canada, Germany, Japan, the UK and the US, for the day-of-the-week effect using GARCH models to account for volatility and volume. They found that Monday's returns for Canada, Japan, and the UK are the lowest and significantly negative, whereas the returns of Germany and the US are negative on Mondays and Thursdays, but insignificant. Also, the highest volatility is observed on Mondays for Germany and Japan, on Thursdays for the UK, and on Fridays for Canada and the US. The lowest volatility, however, appears on Mondays for Canada and Tuesdays for others. Apolinario et al. (2006) examined major European stock markets for the day-of-the-week effect and found an absence of its existence in most of the markets returns. In addition, they applied symmetric and asymmetric models and found evidence of day-of-the-week effect in the volatility. On the contrary, Chukwuogor-Ndu (2006) found evidence of the day-of-the-week effect in both returns and volatility in most of the European stock markets.

Evidence of the day-of-the-week effect has also been documented in emerging markets. Balaban (1995) reported the existence of the day-of-the-week effect in the Istanbul Securities Exchange between 1988 and 1994. His findings supported the findings of Agrawal and Tandon's (1994) work, where the lowest and negative returns occurred on Tuesdays, whereas the highest and positive returns occurred on Fridays. Also, the highest volatility appeared on Mondays, while Fridays' returns exhibited the lowest volatility. In addition, he observed that the direction and magnitude of the day-of-the-week effect changes over yeas. Alexakis and Xanthakis (1995) examined the Athens stock exchange for the day-of-the-week effect before and after the structural changes in the market. The results showed that before the structural changes the returns exhibited patterns different to the one observed in the major world markets, whilst after the changes returns seemed to follow the same pattern that Mondays returns are significantly low and negative, and higher returns occurred on Fridays. Similarly, a number of studies have shown evidence of day-of-the-week effect, such as Poshakwale (1996) in Bombay Stock Exchange; Mookerjee and Yu (1999) in Shanghai and Shenzhen Securities Exchanges; and Brooks and Persand (2001) in five Southeast Asian markets: South Korea, Malaysia, the Philippines, Taiwan and Thailand.

Since the use of the GARCH models is prevalent in developed markets, some studies in emerging markets have also applied it in the analysis of the day-of-the-week effect to control differences in both returns and volatility. Choudhry (2000) examined seven Asian emerging markets using GARCH models and reported the presence of the day-of-the-week effect in both returns and conditional volatility in all of the seven markets. Also, he attributed the existence of the day-of-the-week effect in the volatility to the timing of information arrival on each day. Al-Loughani and Chappell (2001) tested the day-of-the-week effect in Kuwait Stock Exchange (KSE) using nonlinear GARCH (1,1) to better explain data and allow for identification and modelling the day-of-the-week effect. They observed that returns are higher in the first day of the trading week of KSE, which is in contrast to most of the findings in Western markets. Nath and Dalvi (2005) reported the presence of the day-of-the-week effect on Wednesday and Friday returns of the Indian stock market. However, after introducing the rolling settlement in 2002, the effect disappeared on Wednesdays, but remains for Fridays' returns.

Saudi Arabia Stock Exchange, however, received relatively little attention in regard to calendar anomalies. Seyyed and Al-hajji (2005) examined patterns of returns and volatility during the Muslim Holy Month of Ramadan in the SSE using the GARCH model. They observed systematic patterns of declining volatility due to a decline in trading activity during this month. More recently, Ariss et al. (2011) investigated the day-of-the-week effect and the Holy Month of Ramadan in the GCC stock markets, including Saudi, using ordinary least square (OLS). They revealed that returns are significantly positive on Wednesdays, which is the last trading day of the week in the GCC. Ulussever et al. (2011) examined the day-of-the-week effect in the SSE using the same method of Al-Loughani and Chappell (2001), nonlinear GARCH (1,1). They showed that mean returns were significantly different from zero and followed different processes, which supported of the day-of-the-week effect existence. There are also some studies which examined the day-of-the-week effect in other Arab emerging markets, such as Egypt (Aly et. al., 2004), Jordan (Al-Rjoub, 2004) and UAE (Al-Khazali, 2008). Nevertheless, the results are varied for each country.

3. The Methodology, Models and Data

3.1 Data

To investigate the effectiveness of all linear statistical models in examining EMH, a sample has been chosen from the Saudi Stock Exchange. Samuelson (1998) claimed that the efficient markets hypothesis works much better for individual stocks than it does for the aggregate stock market index. Therefore, individual and sectoral price indices, beside the aggregate price index, have been included in the study sample. The constituents of the sample size include:

- Tadawul All-Shares Index (TASI)
- Banks and Finance Services Index (BFSI)
- Saudi Arabia Basic Industries (SABIC)
- Saudi Telecommunication Company (STC)
- Savola Group (SAVOLA)

The reason of including the index of banks and financial services is that SSE, as an emerging market, is dominated by banks. Therefore, the banks index is significant to the study even though it includes different banks with different structures, e.g. Islamic and Conventional banks. SABIC , STC and SAVOLA have also been included in the sample since they have a significant influence in the market and they represent their sector with a long listed period. Other stocks have not been included either because they were newly listed or because their historical data were not available.

Unlike Western markets, the Saudi Stock Exchange (SSE) operates from Saturday to Wednesday, where Thursdays and Fridays are the official weekend. The data collected included the daily closing stock prices for all of the constituents with different sample periods due to the data availability. This data was obtained from DataStream. The data set consists of: the daily closing of Tadawul All-Shares Index (TASI) from 31 December 1999 to 1 January 2010 with a total of 2661 daily observations; the daily closing of Saudi Tadawul Banks and financial services (TDWBANK) from 19 April 2007 to 1 January 2010 with a total of 707 daily observations; the daily closing adjusted price of Saudi Arabia Basic Industries (SABIC) from 13 April 2000 to 1 January 2010 with a total of 2537 daily observations; the daily closing adjusted price of Saudi Telecommunication Company (STC) from 3 October 2005 to 1 January 2010 with a total of 1110 daily observations; and the daily closing adjusted price of Savola Group from 4 July 2003 to 1 January 2010 with a total of 1696 daily observations.

For each series, the first difference of the natural logarithm was computed using the continuously compounded returns formula:

$$R_t = \ln\left(\frac{p_t}{p_{t-1}}\right) * 100 \qquad (1)$$

3.2 Study Hypotheses

The purpose of this paper is, first, to examine the random walk hypothesis (RWH) by testing the weak-form efficiency in the SSE returns. Therefore, the first hypothesis to be tested is:

H_0: Saudi Stock Market returns follow random walk, thus weak-form efficient.
H_1: Saudi Stock Market returns do not follow random walk, thus weak-form inefficient.

Secondly, this paper examines the existence of calendar anomalies by testing the day-of-the-week effects in the returns of the Saudi Stock Exchange. Thus, the hypothesis is:

H_0: Saudi Stock Market has no difference in returns between the days of the week.
H_1: Saudi Stock Market has difference in returns between the days of the week.

In order to examine the first hypotheses, three standard tests from the literature of linearity have been used in this study, including Auto-correlation Function (ACF) test, Ljung-Box Q statistic test, and the runs test. The purpose of choosing these tests is due to their reputation and extensive use within the literature of market efficiency. For the second hypothesis, a regression model with dummy variables has been used to examine the day-of-the-week effect in the SSE index returns using OLS and GARCH (1,1) models.

Unlike previous papers, this study applies three well known unit root tests on each series of constitutes before conducting the tests for linear serial dependence, in order to avoid any possible spurious regression that might involve in the serial dependence tests. The unit root tests, which have been used to examine the stationary on the series, are: Augmented Dickey and Fuller (ADF) test (1981); Phillips and Perron (PP) test (1988); and Kwiatkowski, Phillips, Schmidt, and Shin (KPSS) test (1992). As mentioned earlier, emerging markets are characterised by thin or infrequent trading, therefore the study uses a long time period in order to avoid such possible bias. In fact, this will expect to reduce non-trading bias (Lo and MacKinlay, 1988) and increase the test power of random walk (Taylor, 1986).

3.3 Tests for Linear Serial Dependence

3.3.1 Autocorrelation Function Test

As noted from the literature review, serial correlation is one of the most commonly used tests for randomness. According to Campbell et al. (1997), auto-correlation coefficient is a natural time series extension of the correlation coefficient between two random variables, x and y. Auto-correlation coefficient ρ_k; therefore, measure the correlation degree between current stock return r_t and the return r_{t-k} which separated by *k* lags. It can be computed using serial correlation coefficient model:

$$\rho(k) = \frac{Cov(r_t, r_{t-k})}{\sqrt{Var(r_t)}\,\sqrt{Var(r_{t-k})}} = \frac{E[(r_t - \mu)(r_{t-k} - \mu)]}{E[(r_t - \mu)^2]} \qquad (2)$$

$\rho(k)$ Autocorrelation coefficient of time series.
r_t The return at time *t*
r_{t-k} The return after *k* lags.
$Cov(r_t, r_{t-k})$ The covariance between the two returns.
$Var(r_t)$, $Var(r_{t-k})$ the variance on returns over time period (*t, t-k*).

If the series has no significant serial dependence that means stock returns are following random walk. However, evidence of significant serial correlation in stock returns would be a clear contradiction to the efficient market hypothesis since past stock returns information are able to justify significant amount of the variation in returns. In addition, significant serial correlation increases the predictability power, where future returns can be predicted from past returns. Auto-correlation coefficient, under the null hypothesis of random walk, will not be significantly different from zero.

$H_0: \hat{p}_k = 0$
$H_1: \hat{p}_k \neq 0$

Serial correlation can be estimated using the sample auto-correlation coefficient at lag k:

$$\hat{p}_k = \frac{\sum_{t-1}^{n-k}(R_t - \bar{R})(R_{t-k} - \bar{R})}{\sum_{t-1}^{n}(R_t - \bar{R})^2} \quad (3)$$

To determine whether auto-correlation coefficient is different from zero, the value of autocorrelation coefficient at each lag will be compared with a band at 95% confidence interval: $\pm 1.96 \times 1/\sqrt{T}$ where T is the number of observations[i]. If the value of auto-correlation coefficient $\hat{p}_k$ at a given lag falls outside this band, then it is significant which implies rejecting the null hypothesis that the value of coefficient is zero.

3.3.2 Ljung-Box Q-Statistic Test

Ljung-Box Q-statistic test (1978) is an originated from the portmanteau Box-Pierce Q-statistic test (1970). This test examines the overall randomness of a series based on selected lags. Literally, it tests the joint hypothesis that all auto-correlation coefficients are simultaneously equal to zero.

$$\rho_1 = \rho_2 = \cdots = \rho_k = 0 \quad (4)$$

According to Campbell et al. (1997), testing for random walk hypothesis, Q-statistic has power against many alternative hypotheses since RWH implies that all auto-correlations are zero. Q_k is asymptotically Chi-Squared (x^2), thus the null hypothesis of no significant auto-correlation will be rejected if the value of Q_k exceeds the appropriate value in Chi-Squared table with m degree of freedom. The rejection of the null hypothesis indicates accepting an alternative that at least one auto-correlation is not zero (Enders, 2004). Box-Pierce Q test (1970) is defined as:

$$Q_k = N \sum_{k=1}^{m} \rho^2(k) \quad (5)$$

Where N is the sample size, m is the maximum lag length and $\rho^2(k)$ is the auto-correlation coefficient at lag k.

For short samples, this test shows weak performance. Therefore Ljung and Box (1978) suggested modifying the old test using finite-sample correction, denoted as QLB. The new test provides improved statistic that yielded a better fit to both short and large samples. QLB computes thus:

$$QLB_k = N(N+2)\sum_{k-1}^{m} \frac{\hat{p}_k^{\,2}}{(N-k)} \qquad (6)$$

Where $\hat{p}_k$ is the sample auto-correlation coefficient at lag k which takes the values from 1 to 12 lags, and N is the sample size.

3.3.3 Runs Test

In the literature of serial dependence, run tests are one of the most standard non-parametric tests used for examining serial dependence of time series. The mechanism of a run test is that the number of sequences of consecutive positive and negative returns, or runs, is tabulated and compared against its sampling distribution under the random walk hypothesis (Campbell et al. 1997). Unlike most linear tests, a runs test is powerful in non-normally distributed series, since it does not require returns to be normally distributed. For non-normal distributed returns, a runs test can be used as an alternative test for deducting serial dependence.

As will be shown later in table 1, normality has been rejected for all samples as indicated by the results of Jarque-Bera's test of normality. Therefore, serial dependence might be deduced using a runs test more than it does using auto-correlation. Assigning equal weight to each change, the direction of consecutive changes can be identified according to the position of return changes to the mean return. For instance, if the return is greater than the mean, the changes will be positive; if it less than the mean, the changes will be negative; and zero when return is equal to the mean (Worthington and Higgs, 2004). For daily returns, the run is a sequence of days when stock returns change in the same direction. The runs test implies that the series is random if the number of actual runs in the series is equal to the expected number of runs. Therefore, in order to perform a runs test we should compare the actual runs (r) with the expected number of runs (N) using the following mean:

$$\mu = E(r) = \frac{N+2N_a N_b}{N} \qquad (7)$$

Where r is the actual runs, N is number of observations, and N_a and N_b are the number of observations above and below the mean. For large observations, the expected number of runs is normally distributed under the null hypothesis so that successive returns are independent. The standard deviation σ_r of runs is specified as:

$$\sigma = \left[\frac{2N_a N_b(2N_a N_b - N)}{N^2(N-1)}\right]^{1/2} \qquad (8)$$

Since the independence null hypothesis implies that actual runs are not significantly different from expected number of runs, positive serial correlation will result if the actual runs is less than what is expected (-Z). Conversely, negative serial correlation will appear if the actual runs are greater than the expected number of runs (+Z). The existence of positive serial correlation would be a violation to the random walk, since there is a positive dependence in the stock returns. The standard normal Z-statistic can be computed as:

$$Z = \frac{r - \mu}{\sigma}, \ \ Z \sim N(0,1) \qquad (9)$$

3.4 Tests for day-of-the-Week Effect

Calendar anomalies, such as the day-of-the-week effect, in stock market returns lead to a violation of the random walk hypothesis. To investigate the day-of-the-week effect, the study uses the following regression model to regress the returns of Saudi Tadawul All-Shares Index (TASI) on five daily dummy variables using the standard Ordinary Least Square (OLS):

$$R_t = c + \gamma_S D_{St} + \gamma_M D_{Mt} + \gamma_T D_{Tt} + \gamma_W D_{Wt} + \varepsilon_t \qquad (10)$$

Where R_t is the return of TASI at time *t*, D_S, D_M, D_T and D_W are the binary dummy variables for Sunday, Monday, Tuesday and Wednesday, respectively (i.e. $D_S = 1$, if day *t* is a Sunday, Zero otherwise, etc) and ε_t is the stochastic error term. The coefficients γ_S, γ_M, γ_T and γ_W are the average deviations between the sample mean return of Saturday and the sample mean return of the corresponding day. In order to avoid the dummy variable trap, the study removes Saturday's dummy variable from the regression model (10). The regression model is run over the whole period to test whether there are any returns statistically notably different from Zero at any day of the week. The hypothesis of the day-of-the-week effect is to be tested as:

$$H_0: c = \gamma_S = \gamma_M = \gamma_T = \gamma_W = 0 \qquad (11)$$

If the hypothesis of the day-of-the-week effect, that is, coefficients that are not significantly different from Zero (i.e. no day-of-the-week effect), is rejected, that implies that at least one of the five sample mean returns is not equal to the others. Thus, the day-of-the-week effect existence will be confirmed if at least one of the dummy variable coefficients is statistically significant. The hypothesis is tested by standard t statistics. Unsurprisingly, the test statistic values of the linear model are meaningless if the assumptions of OLS, that error terms and variances are constant across time, are violated. According to Chang et al. (1993), the assumptions of multiple linear regressions are more likely to be violated by daily stock returns. In addition, the use of the OLS method has two downsides. First, the possible existence of auto-correlated errors in the model may result in misleading inferences. Second, variances of errors may not be constant across time. Therefore, the study diverts to use the GARCH model in order to overcome OLS drawbacks. Following Kiymaz and Berument (2003), the auto-correlation problem has been addressed by introducing lagged values of the return variable into the model as follows:

$$R_t = c + \gamma_S D_{St} + \gamma_M D_{Mt} + \gamma_T D_{Tt} + \gamma_W D_{Wt} + \sum_{I=i}^{n} \alpha_i R_{t-i} + \varepsilon_t \qquad (12)$$

Where R_{t-i} is lagged values of the TASI returns and n is the lag order[ii]. For variances of error problems, the GARCH model used allows time dependence in variances of errors to include a conditional Heteroescedasticity that captures time variation of variance in stock returns.

To model for conditional variances, Engle (1982) developed a model that allows expected volatility of return change with the squared lagged values of the error terms from the previous periods. Engle's Autoregressive Conditional Heteroescedasticity model (ARCH (*q*)):

$$\sigma_t^2 = \alpha_0 + \alpha_1 u_{t-1}^2 \qquad (13)$$

Bollerslev (1986) developed generalised version of the ARCH model that allows the conditional variance to be dependent upon previous own lags and thus a function of lagged values of both u_t^2 and σ_t^2 :

$$\sigma_t^2 = \alpha_0 + \alpha_1 u_{t-1}^2 + \beta\sigma_{t-1}^2 \qquad (14)$$

Where the α_0 is long-term average value, $\alpha_1 u_{t-1}^2$ is the volatility during the previous period and $\beta\sigma_{t-1}^2$ the fitted variance from the various period.The GARCH model is less likely to breach non-negativity constrains since it is more parsimonious and avoids over-fitting. Also, theGARCH model offers a more flexible framework that captures many dynamic structures of conditional variance. The study considers various models in order to examine the day-of-the-week effect in both returns and variance equations. The first model consists of the following equations:

$$R_t = c + \gamma_S D_{St} + \gamma_M D_{Mt} + \gamma_T D_{Tt} + \gamma_W D_{Wt} + \sum_{I=i}^{n} \alpha_i R_{t-i} + \varepsilon_t \qquad (12)$$

$$\sigma_t^2 = \alpha_0 + \alpha_1 u_{t-1}^2 + \beta\sigma_{t-1}^2 \qquad (14)$$

The second model incorporates the day-of-the-week effect in both mean and variance equations to model the conditional volatility of the stock returns.

$$R_t = c + \gamma_S D_{St} + \gamma_M D_{Mt} + \gamma_T D_{Tt} + \gamma_W D_{Wt} + \sum_{I=i}^{n} \alpha_i R_{t-i} + \varepsilon_t \qquad (12)$$

$$\sigma_t^2 = \alpha_0 + \gamma_S D_{St} + \gamma_M D_{Mt} + \gamma_T D_{Tt} + \gamma_W D_{Wt} + \alpha_1 u_{t-1}^2 + \beta\sigma_{t-1}^2 \qquad (15)$$

The study applies Bollerslev and Wooldridge's (1992) Quasi-Maximum Likelihood Estimation (QMLE) method on both models in order to avoid the problem of misspecification of the likelihood function in estimating parameters.

4. Empirical Results

4.1 Preliminary Statistics

Preliminary analysis was performed before applying the tests of linear dependence in order to get an insight into the important features of the series returns. Table 1 reports a summary of the preliminary statistics for the return series of each constituent. As can be seen from the table, the entire sample has the same stylised characteristics. All the series are Leptokurtic, since the value of Kurtosis for all are greater than the value for standard normal distribution's leptokurtosis 3. Moreover, asymmetry can be found in every series, as their Skewness values are different from zero. Given the previous features, Jarque-Bera's test statistic, which is a test of whether the series distribution is normal, is strongly significant for all constituents, which implies that normality is rejected even at 1% significance level. These results conform to the consensus that equity market returns are non-normally distributed.

Table 1: Preliminary Statistics for the Selected Sample

	TASI	BFSI	SABIC	STC	SAVOLA
Mean	0.0425	-0.0338	0.0555	-0.1007	0.0574
Median	0.0834	0.0000	0.0000	0.0000	0.0000
Maximum	16.3995	8.7312	27.0238	12.8531	20.8169
Minimum	-11.6816	-10.2834	-32.9730	-13.7653	-25.0981
Std. Dev.	1.7054	2.0004	2.6923	2.4363	3.1737
Skewness	-0.5438	-0.1517	-1.2467	-0.3971	-0.5286
Kurtosis	14.0516	8.3743	27.1584	8.6781	14.3005
Jarque-Bera	13411.2500*	852.3583*	62326.8700*	1518.9520*	9097.8940*
Probability	0.0000	0.0000	0.0000	0.0000	0.0000
Sum	110.9077	-23.8890	140.6313	-111.6550	97.3056
Sum Sq. Dev.	7587.5570	2821.0040	18374.4400	6576.6970	17062.1200
Observations	2610	706	2536	1109	1695

*, ** and *** denote significance at 1%, 5% and 10% level, respectively

4.2 Unit Root Tests

Unit root tests have always been confused with tests for the random walk hypothesis. A number of studies, as mention in the above literature, have used unit root tests to examine the random walk hypotheses. Even though the null hypothesis of unit root means the series is random, unit root tests should not be used to examine random walk hypothesis since the focus of these tests are not on the predictability as it is under the random walk hypothesis. To support this argument, Campbell et al. (1997) stated that 'tests of unit roots are clearly not designed to detect predictability, but are in fact insensitive to it by construction'. Based on this argument, the use of unit root tests in this study will examine the stationary of the time series of each constitutes before conducting the tests of linearity.

In order to apply unit root tests, optimal lag length should be first determined. Hannan and Quinn (1979) information criterion (HQIC) have been used to select the optimal lag length in ADF unit root test. According to the study conducted by Liew (2004), who examined the performance of some commonly used selection criteria, HQIC outperformed other selection criteria with large samples of 120 observations and above. In this study, all the series of the constituents in the sample are relatively large, 700 observations and above. On the other hand, Newey-West (1994) used Bartlett Kernel on PP and KPSS unit root tests to select the bandwidth, since it recommended it in their literature.

The null hypothesis of ADF and PP unit root tests is that the time series has unit root (not stationary), and the alternative hypothesis is that the series is stationary. Therefore, to have stationary series test statistics of ADF and PP should be significant. Conversely, the null hypothesis of KPSS is that that the series is stationary, and the alternative is that the time series has unit root (not stationary). In this case, stationary series should have insignificant KPSS test statistics. Table 2 reports the resulting test statistics of unit root tests ADF, PP and KPSS. The unit root tests were employed on the first difference of the natural logarithm of each series, with constant term and no time trend. Table 3 presents test critical values in all significant levels. Form the tables, ADF and PP unit tests resulted with strong evidence of stationary in all series at one, five and ten percent significant levels. Similarly, KPSS unit root test gave strong evidence of stationary for all series at one, five and ten percent significant levels, apart from TASI and SAVOLA, where they showed significance at the ten percent level[iii]. Generally speaking, one would conclude that returns in Saudi Stock Market are stationary.

Table 2: Unit Root Test Statistics

	ADF	PP	KPSS
TASI	-23.160*	-48.408*	0.425***
BFSI	-16.311*	-23.738*	0.108
SABIC	-27.419*	-53.855*	0.260
STC	-24.982*	-30.986*	0.050
SAVOLA	-17.934*	-40.208*	0.433***

*, ** and *** denote significance at 1%, 5% and 10% level, respectively.

Table 3: Unit Root Test critical values

	significant level	Test critical values				
		TASI	BFSI	SABIC	STC	SAVOLA
ADF	1%	-3.433	-3.439	-3.433	-3.436	-3.434
	5%	-2.862	-2.865	-2.862	-2.864	-2.863
	10%	-2.567	-2.569	-2.567	-2.568	-2.568
PP	1%	-3.433	-3.439	-3.433	-3.436	-3.434
	5%	-2.862	-2.865	-2.862	-2.864	-2.863
	10%	-2.567	-2.569	-2.567	-2.568	-2.568
KPSS	1%	0.739	0.739	0.739	0.739	0.739
	5%	0.463	0.463	0.463	0.463	0.463
	10%	0.347	0.347	0.347	0.347	0.347

4.3 Linear Serial Dependence Tests Results

4.3.1 Autocorrelation Coefficients and Q-Statistics

The result of the first twelve sample auto-correlation coefficients and Ljung-Box Q-statistic for each return series (unfiltered returns) of the sample constituents are reported in Table 4. The results indicate that there is strong evidence of positive first-order correlation (except SABIC where it is negative), hence the null hypothesis of no first-order serial dependence has been rejected for the entire sample apart from SAVOLA. As can be seen from the table, there is weak evidence of negative correlation and it seems that all series have relatively the same pattern of the correlation sign. As known, positive auto-correlation is generally against market efficiency since it means that the return can be predictable in the short term. On the other hand, negative auto-correlation may indicate that returns are mean reverting. Therefore, based on our result one might say that the Saudi Stock Market exhibits momentous effect, more than it is characterised by mean reverting behaviour. The ACF statistics show a strong serial correlation in the first 8 lags for all series returns, except SABIC where it is just at the first lag. For the aggregate index, TASI, three of the auto-correlation coefficients were rejected at the 1% significant level, whereas with STC, most of the auto-correlation coefficients rejected at higher significant levels. Generally speaking, the auto-correlation test results in table 4 indicate a strong evidence of serial correlation, and hence evidence of linear dependence in the SSE.

Table 4: Autocorrelation Coefficients and Ljung-Box Q-Statistics in Daily Saudi Stock Market Returns (Unfiltered Returns)

	TASI		BFSI		SABIC		STC		SAVOLA	
	AC	Q	AC	Q	AC	Q	AC	Q	AC	Q
Lags										
1	0.055*	7.850*	0.115*	9.304*	-0.042**	4.391*	0.069**	5.229*	0.023	0.892*
2	-0.028	9.927*	0.089**	14.923*	0.018	5.176*	-0.091*	14.528*	-0.027	2.111*
3	0.038**	13.659*	0.031	15.590*	0.070*	17.493*	-0.019	14.942*	0.021	2.859*
4	0.072*	27.057*	-0.009	15.642*	0.007	17.606*	0.041	16.826*	0.042***	5.921*
5	-0.024	28.510*	0.004	15.657*	-0.003	17.632*	-0.049***	19.508*	-0.003	5.938*
6	-0.053*	35.935*	-0.091**	21.600*	-0.022	18.815*	-0.051***	22.358*	-0.100*	22.980*
7	0.022	37.176*	-0.056	23.857*	-0.001	18.816*	0.013	22.534*	-0.023	23.890*
8	0.034***	40.270*	0.077**	28.058*	0.019	19.753*	0.051***	25.426*	0.064*	30.879*
9	0.000	40.270*	0.004	28.067*	0.019	20.707*	0.016	25.714*	-0.005	30.929*
10	-0.006	40.369*	-0.042	29.327*	0.016	21.389*	-0.064**	30.331*	-0.005	30.9718
11	0.005	40.443*	0.057	31.678*	-0.002	21.397*	-0.007	30.380*	-0.020	31.669*
12	0.023	41.811*	0.013	31.794*	0.036**	24.736*	0.030	31.360*	0.071*	40.267*

*, ** and *** denote significance at 1%, 5% and 10% level, respectively. The rejection is based on what have been described in the methodology (See appendix 2 for the band).

In addition, Ljung-Box Q statistics indicate evidence of possible dependence in the first and higher moments of the return distributions. The Ljung-Box Q statistics for the first twelve lags rejected the null hypothesis at even one percent significant level for the entire sample series. To sum up, ACFs show strong evidence of serial correlation and it is also supported with Ljung-Box Q statistical findings. We can confidently say that the null hypothesis of no serial correlation is rejected in the Saudi Stock Market, which is consistent with the previous findings of the studies in emerging markets mentioned in the literature review.

4.3.2 Runs Test Results

The result of the runs test for all sample constituents is reported in Table 5. As can be noted from the table, the Z-statistics of the runs test of serial independence are significant at the one percent level, apart from SABIC and SAVOLA, where they are significant at the five percent level. The significant negative Z-values for the returns indicate that the actual number of runs is less than the expected number of runs under the null hypothesis that returns are independent. In our case, the null hypothesis of returns independence has been rejected for the entire sample which implies that there is linear dependence in SSE. These findings are consistent with the previous findings of auto-correlation tests, showing that the Saudi Stock Market does not follow random walk. Furthermore, the negative Z-values, where the expected number of runs is significantly higher than actual number of runs, imply that there is positive correlation the daily return of the SSE which already has been proven by the auto-correlation test.

Table 5: Runs Test for the Saudi Stock Market

	Obs (N)	N (above)	N (below)	Actual Runs R	Expected Run m	Standard Deviation	Z	P-Value
TASI	2610	1579	1031	1129.00	1248.47	24.41	-4.89*	0.0001
BFSI	706	360	346	321.00	353.86	13.27	-2.48**	0.0133
SABIC	2536	1434	1102	1146.00	1247.27	24.74	-4.09*	0.0001
STC	1109	611	498	491.00	549.74	16.47	-3.57*	0.0004
SAVOLA	1695	1014	681	772.00	815.79	19.78	-2.21**	0.0269

***, ** and *** denote significance at 1%, 5% and 10% level, respectively.**

To sum up, ACF and Ljung-Box Q-statistics tests have concluded that there is strong evidence of serial correlation in the returns of the Saudi market. In addition, the non-parametric runs test has also given strong evidence of serial dependence for the entire sample. There is consensus between ACF and runs tests that the returns in Saudi Stock Market are positively correlated. Moreover, there is a strong presence of first order in all of the series besides a significantly higher degree of serial correlation as shown by ACF. Consequently, the null hypothesis that the daily stock returns of the Saudi market are linear serial independence has been rejected at individual; sectoral; and aggregate levels, and thus we reject the weak-form efficient market hypothesis. These findings validate Samuelson's (1998) claim that the efficient markets hypothesis works much better for individual stocks than it does for the aggregate stock market index.

4.4 Day-of-the-Week Effect Results

Table 6 presents descriptive statistics for the TASI all days returns and for each trading day of the week. Examining the characteristics displayed in Table 6 shows that in the overall average daily returns for TASI, all days and each trading day are positive. In addition, the values of mean returns for each day of the week are noticeably close to each other. Nonetheless, the highest returns occur on Sundays (0.213742) whereas the lowest returns are observed on Mondays (0.211995) and also pronounced on Tuesdays (0.211994). The table also reports Skewness and excess Kurtosis for the TASI all day returns and for each day of the week. All the returns are asymmetric, since all distributions are negatively skewed. Moreover, all the week days' returns exhibit high level of kurtosis, which means the distributions have fatter tails then normal distribution (i.e. Leptokurtosis). For all week days, test statistics the Jarque-Bera test are strongly significant, which implies that normality is rejected at even 1%, on top of the negative skewed and leptokurtosis.

Table 6: Summary Statistics for TASI Daily Rate of Returns

	TASI All days	Saturday	Sunday	Monday	Tuesday	Wednesday
Mean	0.0425	0.212467	0.213742	0.211995	0.211994	0.212616
Median	0.0834	0.592267	0.616953	0.572992	0.447702	0.496265
Maximum	16.3995	15.5363	14.66933	16.00592	11.18132	11.54351
Minimum	-11.6816	-24.8982	-18.5983	-23.2211	-25.9024	-25.2381
Std. Dev.	1.7054	4.088336	3.926072	4.107624	3.896932	4.117327
Skewness	-0.5438	-1.58825	-1.12535	-1.25041	-1.63616	-1.90758
Kurtosis	14.0516	10.18698	6.964296	8.552675	10.41026	11.66859
Jarque-Bera	13411.2500*	1342.909*	451.1268*	805.0815*	1424.502*	1947.236*
Probability	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Sum	110.9077	110.9077	111.3593	110.4492	110.4489	110.7729
Sum Sq. Dev.	7587.5570	8708.25	8015.302	8773.739	7896.759	8815.239
Observations	2610	522	521	521	521	521

*, ** and *** denote significance at 1%, 5% and 10% level, respectively.

4.4.1 Ordinary Least Square (OLS) Results

Table 7 reports the regression results of the OLS method for the day-of-the-week effects in the TASI returns using dummy variables[iv]. The first column displays the constant and dummy variables for each day of the week. The second through sixth columns contain coefficient, standard error, t-statistics and probability, respectively. The results form Table 7, indicating that Saudi Stock Market Index (TASI) exhibits significant day-of-the-week effect. The estimated regression coefficient for Saturdays' dummy variable (0.001331) is positive (highest) and statistically significant at the 10% level, whereas regression coefficient for Sundays' dummy variable (-0.002234) is negative (lowest) and statistically significant at the 5% level. The last trading day, Wednesdays' coefficient (-0.000193) is negative but strongly insignificant and the same case for Mondays and Tuesdays. The finding of high returns for the TASI on Saturdays supports the hypothesis of calendar time or diffusion process that Monday's (in our case Saturday's) return is equivalent to three day returns with a value equal to three times the value of other weekdays. Also, the finding of high returns on Saturdays is in line with the finding of some of the studies in the day-of-the-week effect literature (see Al-Loughani and Chappell, 2001), whereas the negative of the last trading day of the week, Wednesday, is contrary to some of the studies (e.g. Ariss et al., 2011), although it is not significant. The results confirm that there are significant differences between the mean returns of Saturdays and each other trading days, thus the null hypothesis of the day-of-the-week effect is rejected. Hence, the existence of the day-of-the-week effect in TASI returns is supported, which violates the random walk hypothesis. Nonetheless, given the non-normality distribution of the returns, the finding might be suspected. Therefore, the study applies nonlinear GARCH to analyse the day-of-the-week effect.

Table 7: OLS Results of Day-of-the-Week Effect for TASI Daily Rate of Returns

Variable	Coefficient	Standard Error	T-Statistic	Probability
Constant (Saturday)	0.001331	0.000746	1.784172***	0.0745
Sunday	-0.002234	0.001055	-2.117181**	0.0343
Monday	-0.000455	0.001055	-0.43153	0.6661
Tuesday	-0.001648	0.001055	-1.562349	0.1183
Wednesday	-0.000193	0.001055	-0.183034	0.8548

R-squared	0.002646	**Mean dependent variable**	0.000425
Adjusted R-squared	0.001114	**S.D. dependent variable**	0.017054
S.E. of regression	0.017044	**Akaike info criterion**	-5.304122
Sum squared residual	0.756748	**Schwarz criterion**	-5.292882
Log likelihood	6926.879	**Durbin-Watson stat**	1.887287

*, ** and *** denote significance at 1%, 5% and 10% level, respectively.

4.4.2 Generalized Autoregressive Conditional Heteroescedasticity (GARCH) model Results

Table 8 reports the regression estimates of the GARCH (1,1) model for the day-of-the-week effects in the TASI mean returns equation. As mentioned earlier, lagged values of the returns variable is included into the return equation in order to avoid the auto-correlation problem. Also, the QMLE method was used on both models in order to avoid misspecification problem. The results in Table 8 suggest that Saturdays' returns are still the highest since the regression coefficient (0.001055) is positive and strongly significant at even the 1% level. However, Wednesdays' returns are positive, but still insignificant. The rest of the week days are negative and statistically insignificant. The lagged returns value is significant which indicates that the auto-correlation problem is solved. The sum of the lagged squared error (ARCH) and the lagged conditional variance (GARCH) coefficients is unity (1.01), which implies that conditional variance is highly persistent. The constant term coefficient of the conditional variance equation is significant. The ARCH coefficient is positive and significant with z-value of 6.9521, which indicates that returns on a particular day are influenced by returns on the previous day for the same period. In other words, high returns today results in high returns on the following day. The GARCH coefficient is also positive and significant with z-value of 54.181. This also implies that if the errors are positive in a day, it will result in positive errors on the following day. The null hypothesis of the day-of-the-week effect is rejected using the likelihood ratio (7788.456), which means that the results are statistically significant.

The study also incorporates the day-of-the-week effect into the conditional variance of returns equation by modifying the GARCH model in order to detect the existence of the day-of-the-week effect in TASI volatility. This is done by including the dummy variables for each day into the conditional variance equation as in equation (15); excluding the dummy variable of Saturdays to avoid the so-called dummy variable trap. The results of the

GARCH (1, 1) model for the day-of-the-week effects in both mean and conditional variance equations are reported in Table 9.

The following results are observed: the coefficient for Saturdays' dummy variable (0.002628) is positive and strongly significant at the 1% level. The estimated coefficients of Sundays, Mondays and Tuesdays are negative and statistically significant at the 5% level. However, the last trading day coefficient (Wednesdays) is still negative, but statistically insignificant. In addition, the highest volatility occurs on Saturdays (0.00022) and is statistically significant, whereas the lowest volatility occurs on Tuesdays and Wednesdays (-0.00024) and is also significant. The constant term and the slope terms coefficients are positive and significant, except for ARCH insignificance, indicating that conditional variance non-negativity constraints are satisfied. The finding clearly suggests that the day-of-the-week effect is existent in stock market return volatility of the emerging markets. The null hypothesis that there is no day-of -the-week effect in the conditional variance equation has been rejected by the likelihood ratio test (7519.589). Therefore, the study confirms the presence of the day-of-the-week effect in both mean and variance equations.

Table 8: GARCH (1, 1) Results of Day-of-the-Week Effect for TASI Daily Rate of Returns

Variable	Coefficient	Standard Error	Z-Statistic	Probability
Constant (Saturday)	0.001055	0.000363	2.903173*	0.0037
Sunday	-0.000524	0.000743	-0.705552	0.4805
Monday	-9.76E-05	0.000582	-0.167733	0.8668
Tuesday	-0.000254	0.000528	-0.481881	0.6299
Wednesday	0.000284	0.00056	0.50653	0.6125
Lagged Return	0.049967	0.022792	2.192278**	0.0284
		Variance Equation		
Constant	2.05E-06	5.66E-07	3.629865	0.0003
ARCH(1)	0.142279	0.020466	6.952112*	0.0000
GARCH(1)	0.865174	0.015968	54.1811*	0.0000
R-squared	0.004873	**Mean dependent variable**		0.000426
Adjusted R-squared	0.001807	**S.D. dependent variable**		0.017067
S.E. of regression	0.017051	**Akaike info criterion**		-5.970419
Sum squared residual	0.755058	**Schwarz criterion**		-5.950162
Log likelihood	7788.456	**Durbin-Watson stat**		1.888018

*, ** and *** denote significance at 1%, 5% and 10% level, respectively.

Table 9: GARCH (1, 1) Results of Day-of-the-Week Effect for TASI Daily Rate of Returns with Day-of-the-Week Effect in Variance Equation

Variable	Coefficient	Standard Error	Z-Statistic	Probability
Constant (Saturday)	0.002628	0.000716	3.66874*	0.0002
Sunday	-0.001974	0.000985	-2.005268**	0.0449
Monday	-0.002319	0.001035	-2.241293**	0.025
Tuesday	-0.001863	0.000901	-2.066602**	0.0388
Wednesday	-0.001188	0.00113	-1.051046	0.2932
Lagged Return	0.068015	0.032097	2.119045**	0.0341
		Variance Equation		
Constant	0.000221	3.08E-05	7.170763	0.0000
ARCH(1)	0.224343	0.163078	1.375673	0.1689
GARCH(1)	0.593192	0.307217	1.930856	0.0535
Sunday	-0.00022**	9.33E-05	-2.361018	0.0182
Monday	-0.000153***	8.28E-05	-1.844351	0.0651
Tuesday	-0.00024*	7.25E-05	-3.306289	0.0009
Wednesday	-0.000235*	6.85E-05	-3.423944	0.0006
R-squared	0.003848	**Mean dependent variable**		0.000426
Adjusted R-squared	-0.000762	**S.D. dependent variable**		0.017067
S.E. of regression	0.017073	**Akaike info criterion**		-5.761004
Sum squared residual	0.755836	**Schwarz criterion**		-5.731744
Log likelihood	7519.589	**Durbin-Watson stat**		1.886421

*, ** and *** denote significance at 1%, 5% and 10% level, respectively

5. Summary and Conclusions

The weak-form efficiency has been widely investigated in both developed and developing markets. Also, the day-of-the-week effect has been extensively documented in both equity and non-equity markets. This paper examines the existence of the random walk hypothesis (RWH) by testing the weak-form efficiency in the Saudi Stock Exchange (SSE) returns using parametric and nonparametric linear tests. In addition, it examines one of the calendar anomalies in capital returns, the day-of-the-week-effect, using standard Ordinary Least Square (OLS) and the GARCH model. The data includes the daily close price of Saudi index (TASI), Bank index and three companies in order to investigate Samuelson's dictum that the efficient markets hypothesis works much better for individual stocks than it does for the aggregate stock market index.

The results obtained from the linear serial dependence tests indicate that linear dependence is existed in the Saudi market returns. Thus, based on the first hypothesis of this study we would say that the null hypothesis has been rejected, and we concluded that the SSE is not weak-form efficient. However, the existing or rejection of linear serial dependence does not necessarily mean that nonlinearity exists. According to Hsieh (1989), 'The earlier evidences of rejection of linear dependence are not sufficient to prove independence in view of non-normality of series'. Therefore, nonlinearity ought to be investigated in the returns of the SSE. Market efficiency has significant implications for both investors and authorities. Since the EMH is not held in the Saudi market, investors might doubt the strategy 'hold-the-market' and adopt the 'beat-the-market' strategy. Authorities, however, should adopt the policy of increased market interventions rather than decrease it.

The empirical results of the OLS and GARCH (1, 1) models indicate the presence of the day-of-the-week effect in the SSE in both mean (returns) and variance (volatility) equation. The patterns of the day-of-the-week effect in returns and volatility might be exploited by investors to generate abnormal profits through adapting trading strategies that take into account such predictable patterns. Since the null hypothesis of no day-of-the-week-effect is rejected from the results of OLS and GARCH model, the second hypothesis of the study that Saudi Stock Market has no difference in returns between the days of the week is rejected. Hence, the SSE is inefficient since the day-of-the-week anomaly contradict the efficient markets hypothesis. Numbers of empirical studies have suggested the main factors behind the existence of seasonal patterns in returns and volatility. Such factors include measurement errors; trading delay and settlement differences; and non- trading periods, timing of corporate news releases and time zone differences.

Unlike developed Western markets, the returns of the Saudi markets are high on the first trading day of the week, which supports the hypothesis of calendar time. In addition, the lowest volatility in Saudi markets occurs on Tuesdays and Wednesdays (last trading days of the week), thus this finding refutes the public information release hypothesis suggested by Harvey and Huang (1991). Since the Saudi market is inefficient and the day-of-the-week effect exists, investors may have the opportunity to adjust their portfolios to account for the regularity in returns and volatility to make abnormal returns. Nonetheless, the Saudi Stock Market needs to be studied further with different samples, time series, and other tests to verify market efficiency and day-of-the-week effect.

Endnotes

[i] See appendix 1 for band values

[ii] n is determined by Akaike's (1974) information criterion (AIC) that eliminates autocorrelation in the residual term.

[iii] To ensure stationary, the unit root DF-GLS test has been conducted on TASI and SAVOLA using HQIC, and gave similar result as ADF and PP tests (see appendix 2 for details)

[iv] The study estimates OLS using Newey and West (1987) estimator to correct for Hetroscedasticity and autocorrelation.

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Appendices

Appendix 1: Autocorrelation Coefficient Band

	TASI	BFSI	SABIC	STC	SAVOLA
1% level	0.05	0.0967	0.051	0.0772	0.0624
5% level	0.038	0.0738	0.0389	0.0589	0.0476
10% level	0.032	0.062	0.033	0.049	0.040

Appendix 2: Unit Root DF-GLS Test for TASI and SAVOLA

	DF-GLS	
	TASI	**SAVOLA**
Test statistics	-23.134*	-13.828*
significant level		
1%	-2.566	-2.566
5%	-1.941	-1.941
10%	-1.617	-1.617

*, ** and *** denote significance at 1%, 5% and 10% level, respectively.