The Influence of Foreign Investors on the Efficiency of the Saudi Stock Market

Abdullah Alesmaiel
King Faisal University, Saudi Arabia | e-mail: aalesmaiel@kfu.edu.sa

Suzanne Fifield
University of Dundee, United Kingdom | e-mail: s.g.m.fifield@dundee.ac.uk

Justin Hof
University of Dundee, United Kingdom | e-mail: jhof@dundee.ac.uk

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Abstract

This article examines whether the level of weak-form efficiency of the Saudi stock market increased following liberalization in June 2015 when the market was opened up to foreign institutional investors. The results revealed that most sample companies and the market index did not follow a random walk over the sample period. However, the random walk hypothesis was not rejected after opening the market to foreign investors. This evidence implies that the steps taken by policy-makers to liberalize the Saudi stock market appear to have had a positive impact on the level of market efficiency.

Keywords: Saudi Stock Market, Market Efficiency, Non-parametric Testing, Market Liberalization

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I. Introduction

The Saudi stock market has implemented a number of regulatory changes in the past 20 years. One important change, which took place in June 2015, was opening the market to foreign institutional investors. One of the key objectives of this reform was to enhance market efficiency (CMA, 2015). Todea and Pleşoianu (2013) highlighted three reasons why stock market liberalization is expected to increase market efficiency. First, the participation of foreign investors increases market liquidity, which facilitates arbitrage activity, and thus should lead to faster incorporation of available information into stock prices. Second, as foreign investors require more transparency, domestic companies are expected to supply higher-quality information disclosure, which, in turn, should improve informational efficiency. Finally, sophisticated foreign investors are better than local investors at incorporating global market information (Vo, 2019). According to the theoretical model proposed by Albuquerque et. al. (2009), foreign investors react quickly to new global market information because they have immediate access to it. By contrast, local investors underreact to global news because they know less about it and may lack the necessary analytical skills.

This study aims to investigate the relative efficiency of the Saudi stock market before and after the change in regulation using two statistical tools, namely, the parametric variance ratio test of Lo and MacKinlay (1988) and the nonparametric variance ratio test of Wright (2000). These tools are more powerful than other statistical techniques that were designed to test the random walk hypothesis (RWH), such as the unit root test, the runs test and autoregressive models because they are robust to heteroscedasticity and non-normality1 (Mobarek and Fiorante, 2014; Aye et .al., 2017). This paper contributes to the substantive literature in two ways. First, it investigates the effect of the change in ownership regulation on the pricing efficiency of the Saudi stock market; previous studies have not examined the efficiency of the market after this change. Second, this paper uses disaggregated firm-level data rather than index-level data, which previous studies have tended to use when applying the variance ratio test to data on the Saudi market. Fama (1965) argued that analysing data at the company level gives a clearer picture of efficiency as such data are free from the distortion that arises from the use of index-level data.

The remainder of this paper is organized as follows. Section 2 provides a brief summary of the literature on market liberalisation and stock market efficiency, while Section 3 describes the data used in the analysis. Section 4 details the parametric and non-parametric testing procedures employed in the paper. Section 5 discusses the results and, finally, Section 6 offers a number of concluding observations.

II. Literature Review

In the late 1980s and early 1990s, many emerging countries liberalized their financial markets to enhance and deepen their equity markets and promote economic growth (Henry, 2000; Cajueiro et. al., 2009). As a result, many studies have been conducted to investigate the effect of liberalization on return behaviour and volatility, as well as on market integration and market efficiency (Kawakatsu and Morey, 1999b; Laopodis, 2004; Rejeb and Boughrara, 2013; Graham et. al., 2015; Naghavi et. al., 2018). However, the results of these studies have provided no clear consensus on whether stock market liberalization affects stock market efficiency. Some studies have found that stock market liberalization has not positively affected market efficiency (Groenewold and Ariff, 1998; Kawakatsu and Morey, 1999a, b; Basu et. al., 2000; Maghyereh and Omet, 2002; Laopodis, 2003, 2004; Kim and Shamsuddin, 2008; Graham et. al., 2015), whilst other studies have found that liberalization improves the degree of market efficiency (Kim and Singal, 2000a, b; Fuss, 2005; Fifield and Jetty, 2008; Cajueiro et. al., 2009; Rejeb and Boughrara, 2013; Naghavi and Lau, 2014; Naghavi et. al., 2018).

Most of the studies that have investigated the effect of stock market liberalization on the informational efficiency of emerging stock markets, regardless of their findings, have followed a similar approach, which is to divide the sample period into two subperiods - pre-liberalisation and post-liberalisation - and then compare the level of efficiency before and after liberalization. In addition, previous studies have tended to focus on index-level rather than firm-level data, which could be a serious limitation for two reasons. First, the use of index data may mask the true effect of market liberalization given that, after liberalixation, not all companies in the market become eligible for foreign investment (Lim and Kim, 2011). Second, firm-level data are particularly important to investors as it is not possible, or sometimes very costly, to invest in the index in many emerging stock markets (Blitz and Huij, 2012). Benjelloun and Abdullah (2009), Elton et. al. (2019), Almudhaf and Alhashel (2020), and Zawadzki (2020), found evidence that it was difficult to invest in the market index in emerging stock markets.

For example, Elton et. al. (2019) investigated the performance of 396 passively managed index funds over the period 1994 to 2016 and found that index funds in emerging markets underperformed their underlying indexes more frequently as compared to their developed market counterparts. Furthermore, Almudhaf and Alhashel (2020) and Zawadzki (2020) documented that exchange-traded funds that track stock market indices exhibited higher tracking errors in emerging markets. In

[1] Examining the random walk hypothesis using tests that are not robust to heteroscedasticity and non-normality is problematic since stock market data usually deviate from normality and have time-varying volatilities (Campbell et. al., 1997).

addition, due to the high costs of investing in index funds, Benjelloun and Abdullah (2009) suggested that investors in Saudi Arabia are better off buying individual shares directly from the market as opposed to investing in index funds.

Groenewold and Ariff (1998) studied a sample of six developed and four emerging markets to evaluate the effect of liberalisation on informational efficiency. Specifically, the authors carried out unit root and variance ratio tests before and after the process of market liberalisation using daily closing values for share indexes over the period 1980 to 1992. Unexpectedly, the results suggested that the predictability of emerging stock markets had increased after liberalization, thus indicating that the markets were less efficient. One explanation of this counter-intuitive finding may be the change in the degree of integration of the sample markets. That is, opening a market to foreign investors exposes it more to global factors as it shifts the market from being segmented to being integrated with international markets (Umutlu et. al., 2010). This high degree of integration may increase the predictability of stock prices.

Furthermore, Kawakatsu and Morey (1999b) conducted a similar study on nine emerging markets that were liberalized in the late 1980s and early 1990s. Using monthly data from 1976 to 1997, the authors tested the usefulness of past price data in predicting future share prices by making use of a first-order autoregressive model. Their results showed there was no significant change in the behavior of stock prices before or after liberalization, indicating that the sample stock markets were efficient even prior to the liberalization date. The authors suggested that investors seemed to start behaving rationally prior to market opening because liberalization was announced well in advance of the actual liberalisation date.

Upon studying individual markets, Maghyereh and Omet (2002) and Laopodis (2004) found similar conclusions to the aforementioned studies. Specifically, Maghyereh and Omet (2002) examined the Jordanian stock market and found that stock market efficiency had not improved after liberalization, while Laopodis (2004) examined the Greek stock market during the sample period from January 1985 to December 2001. The author tested for autocorrelation in dollar-equivalent and local currency returns and found that the Greek stock market was weak form efficient even before any liberalization announcement was made.

More recently, Graham et. al. (2015) presented additional evidence that capital market liberalization and market integration do not necessarily lead to improvements in informational efficiency. Utilizing various types of variance ratio tests, Graham et. al. (2015) studied the Icelandic stock market during contrasting periods of financial market openness and found that the market was relatively less efficient during the period of free capital flows. Furthermore, Kim and Shamsuddin (2008) tested the weak form of the EMH using multiple variance ratio tests and weekly data for nine Asian markets for the period from January 1990 to April 2005. Their results indicated that stock market liberalization did not improve the efficiency of the Indonesian, Malaysian and Filipino markets. However, their results did indicate that market efficiency depends on the level of stock market development as well as on having good corporate governance provisions.

Laopodis (2004) referred to the importance and difficulty of identifying appropriate opening dates when evaluating the impact of stock market liberalization on the degree of market efficiency. According to the author, there are two main reasons why it is important and difficult to specify such dates. First, liberalization is a gradual process; countries usually start the liberalization process by allowing foreign investors to participate only through mutual funds and then they may allow them to directly invest in the market but with some restrictions, such as having a minimum level of funds invested. Further restrictions on foreign investors may gradually be removed over time. Thus, the process of liberalization sometimes takes years to be fully implemented, making it difficult to select a starting date. Second, and as previously mentioned, the impact of liberalization could start before the actual liberalisation takes place. That is, after the announcement, investors anticipate the impact of liberalisation on stock market returns and behave accordingly.

Using regression models, Naghavi and Lau (2014) and Naghavi et. al. (2018) attempted to explain the relationship between market efficiency and stock market liberalization for 27 emerging markets that had different levels of institutional development. For instance, Naghavi and Lau (2014) performed a regression analysis using the variance ratio as the dependent variable, and stock market liberalization, measured as the ratio of capital flows to GDP, as the independent variable. They also controlled for trade openness and the level of institutional development. Their results showed that the informational efficiency of stock markets was not affected by financial liberalization for countries with a low level of institutional development, whilst market efficiency appeared to be positively impacted by liberalization in countries with a high level of institutional development. The authors concluded that, in order to reap the benefits of stock market liberalization, emerging countries need to have strong institutions.

Kim and Singal (2000) supported the finding that market liberalization has a positive impact on market efficiency. They applied the variance ratio test of Lo and MacKinlay (1988) to 18 emerging markets covering the period 1976 to 1996. They found that the benefits associated with international portfolio equity flows were likely to outweigh any perceived risks (increased volatility of stock returns) as the sample markets exhibited lower serial correlation after liberalization. The authors concluded that the decrease in the predictability of returns in these markets suggested an improvement in market efficiency which, in turn, should lead to improved asset allocation.

In a study of the Athens Stock Exchange, Cajueiro et. al. (2009) applied the Hurst exponent using a more recent data sample from January 1987 to April 2005. Their main findings were in favor of market efficiency and suggested that, after liberalization, stock markets may evolve and converge to become more mature. More recently, Rejeb and Boughrara (2013) provided evidence in favor of a positive relationship between market liberalization and efficiency. They studied 13 emerging markets from January 1986 to December 2008 and found that financial market liberalization not only improved

market efficiency, but also minimized the probability of a crisis2.

In conclusion, the findings from previous studies on this issue are somewhat inconclusive. Some studies have found that stock market efficiency did not improve after liberalization, while other studies have documented evidence of positive effects on market efficiency after liberalization. In addition, a number of studies have concluded that stock markets are efficient even before liberalization. Overall, the variation in results indicates that the effect of stock market liberalization on informational efficiency may depend upon the level of stock market development.

III. Data and Descriptive Statistics

The data used in this paper consist of daily closing prices of the main market index and 100 companies that are traded on the main Saudi stock market. The sample period spans the time from 1st January 2008 to 31st December 20173. This period was analyzed to include as many companies as possible whilst, at the same time, having a long enough time period to investigate the effect of market opening on informational efficiency. After eliminating all non-trading days (weekends and holidays), the sample period consisted of 2,497 trading days. The data were obtained mainly from the Tadawul website and checked against data from Datastream. The share prices employed in this study were adjusted for stock dividends, stock splits and share issues.

However, in order to ensure consistency with a majority of previous studies, the share prices used in this analysis were not adjusted for cash dividends. Mills and Coutts (1995) reviewed the literature on cash dividends and concluded that any biases caused by the exclusion of cash dividends was negligible. In addition, the omission of dividends is unlikely to alter the results as many companies in the Saudi stock market tended not to distribute any dividends during the sample period (Tadawul, 2021). Unlike many previous studies, thin trading was not considered a problem for the current study; all 100 companies traded almost every day4.

In order to investigate the impact of opening the market to foreign investors on the pricing efficiency of the Saudi stock market, the sample period was divided into two subsample periods. The first subsample period (pre-period) covers the time before this change in regulation - that is, from 1st January 2008 to 14th June 2015, while the second subsample period (post-period) covers the time after the regulatory change, from 15th June 2015 to 31st December 2017. This approach of comparing efficiency measures in two subperiods is commonly used in the literature to test the effect of market liberalisation (Laopodis, 2004; Fifield and Jetty, 2008; Ulici and Nistor, 2011; Graham et al., 2015).

Logged returns for the market index and each company were calculated according to the following formula:

$$R_{it} = ln\left(\frac{P_t}{P_{t-1}}\right) \quad (1)$$

where R_{it} is the daily return of stock i on day t, P_t and P_{t-1} are the closing prices of stock i on day t and day $t-1$ respectively, and ln is the natural logarithm.

Table 1 presents descriptive statistics of the data for the full sample period and the two subsample periods. In particular, the mean (Mean), the standard deviation (SD), the minimum (Min), the maximum (Max), skewness (Skew), kurtosis (Kurt) and the Jarque-Bera (JB) test statistic were calculated for the daily return series as described by Equation (1). The table shows that although the market index and the sample companies earned negative mean daily returns before and after the regulatory change, the returns in the pre-period were higher than that in the post-period. For instance, the average return of the market index was -0.01% in the pre-period, and it decreased to -0.05 in the post-liberalization period. This noticeable decrease in the average return after market liberalization can be attributed to the fact that, in the post-liberalization period, the local economy was negatively affected by low oil prices (Kinninmont, 2017; SAMA, 2017).

Table 1: Descriptive Statistics for Daily Returns

Market Index	Mean	SD	Min	Max	Skew	Kurt	JB
Full	-0.0002	0.0139	-0.1033	0.0909	-0.8867***	14.0***	12819.1***
Pre	-0.0001	0.0145	-0.1033	0.0909	-0.9601***	14.5***	10506.5***
Post	-0.0005	0.0121	-0.0710	0.0712	-0.5125***	9.2***	1034.2***
Companies	**Mean**	**SD**	**Min**	**Max**	**Skew**	**Kurt**	**JB**
Full	-0.0002	0.0151	-0.1026	0.0931	-1.3556***	13.0***	11210.0***
Pre	-0.0001	0.0152	-0.1026	0.0931	-1.3694***	14.1***	10095.3***
Post	-0.0007	0.0145	-0.0785	0.0707	-1.3202***	9.2***	1185.0***

Note: This table reports descriptive statistics for the market index, and the average of 100 sample companies for the full sample period and two subsample periods. The full period spans the time from 1st January 2008 to 31st December 2017, while the pre-and post-periods cover the periods before and after the change in regulation on 15th June 2015. SD indicates the standard deviation of the return series. Min and Max indicate the minimum and maximum returns, respectively. Skew is the Kendall-Stuart measure of skewness, and Kurt is the Kendall-Stuart measure of kurtosis. JB refers to the Jarque-Bera test for normality. *** indicates significance at the one per cent level.

In addition, Table 1 shows that the volatility in the pre-period was higher as compared to the post-period,

[2] Rejeb and Boughrara (2013) estimated a treatment effect model to empirically analyze the three-dimensional relationship between informational efficiency, stock market liberalization and financial crises. The results showed that there was a significantly negative relationship between market liberalization and financial crisis, and this relationship was present regardless of the type of crisis considered. The results also showed that stock market liberalization tended to increase the informational efficiency of the sample markets.

[3] There was a total of 179 companies listed on the Saudi stock market as of 31st December 2017. A total of 71 companies were excluded from the final sample because they were listed after the start date of the analysis. In addition, another eight companies were excluded from the sample as trading of their shares was suspended at some point during the sample period. Suspension durations varied widely between companies and ranged from 13 to 1,043 days. Reasons for suspended trading included failure to announce financial statements within the specified period, exceeding the pre-determined limit of losses for a company to be traded on the exchange and a lack of accurate information about the company.

[4] The daily trading volume for stocks included in the analysis showed that 88 out of the 100 companies traded on 100.0% of the trading days over the sample period. For the remaining companies, shares were traded on at least 99.5% of the trading days.

indicating that the market became less volatile after liberalization. Specifically, following the change in regulation, the standard deviation of the market index decreased from 1.45 to 1.21%. This reduction in volatility after the regulatory change is also reflected in the difference between the minimum and maximum values in each period; the difference between these values was lower in the post-period than in the pre-period. Previous studies have found mixed results concerning the changes in stock return volatility following market liberalization (Kawakatsu and Morey, 1999; Fuss, 2005; Ahmed, 2016; Sharif, 2019). For example, Kawakatsu and Morey (1999) found an increase in volatility after stock market liberalization in five out of the nine markets examined.

Finally, the table reveals that the returns of the market index and the sample companies were highly non-normal in both periods, a property that is commonly found in stock market data (Hull and McGroarty, 2014; Seif et. al., 2017). Specifically, all return series are negatively skewed suggesting that they are more likely to have negative extreme values than positive extreme values. The return series are also leptokurtic, implying fatter tails. As a consequence of these characteristics, the Jarque-Bera test rejected the null hypothesis of normally distributed data at the one per cent level for all return series considered. Overall, the descriptive statistics suggest that the results of parametric tests of the Efficient Market Hypothesis (EMH), such as the Lo-MacKinlay variance ratio test, should be used with caution as these tests are designed for normally distributed data. When the data are not normally distributed, non-parametric techniques, such as Wright's (2000) variance ratio test, are more suitable for testing weak form efficiency.

IV. Method

This study employs the Lo-MacKinlay variance ratio test and Wright's rank and sign variance ratio tests to examine whether the Saudi stock market is characterized by a random walk following the opening of the stock market to foreign investors. According to the RWH, the variance of random walk increments must linearly increase with the time interval (AlKhazali, 2011). The variance ratio test of Lo and MacKinlay (1988, 1989) is based on this central idea of a random walk. The test compares the variance of stock returns over different intervals to determine if they behave randomly. More precisely, Lo and MacKinlay proposed that if a stock's return follows a random walk, the variance of the q-period return is q times the variance of the one-period return. For example, if a stock's return follows a random walk, the variance of its five-day return will be five times as large as the variance of its daily return. Therefore, if $\{y_t\}$ denotes a time series consisting of T observations $y_1, \dots, y_T$ of asset returns, then the Lo-MacKinlay variance ratio at lag q is defined as:

$$VR(q) = \frac{\sigma^2(q)}{\sigma^2(1)} \tag{2}$$

where $\sigma^2(q)$ is $\frac{1}{q}$ the variance of the q-period return, $\sigma^2(1)$ is the variance of the first period return, and q is the number of days of the difference interval. If the time series of returns follow a random walk, then the value of $VR(q)$ should be equal to one for all time horizons q. By contrast, if the time series are positively (negatively) autocorrelated, the value of $VR(q)$ should be larger (smaller) than one. Following Lo and MacKinlay (1988, 1989), the variance of the q-period return, $\sigma^2(q)$, and the variance of the first period, $\sigma^2(1)$, are computed as follows:

$$\sigma^2(q) = \frac{1}{Tq}\sum_{t=q}^{T}\left(y_t + \cdots + y_{t-q+1} - q\hat{\mu}\right)^2 \tag{3}$$

and:

$$\sigma^2(1) = \frac{1}{T}\sum_{t=1}^{T}(y_t - \hat{\mu})^2 \tag{4}$$

where:

$$\hat{\mu} = \frac{1}{T}\sum_{t=1}^{T} y_t \tag{5}$$

Lo and MacKinlay (1988) developed two statistics (M_1 and M_2) to test the null hypothesis of the random walk. The first statistic, M_1, was mainly designed to test the random walk that assumes homoscedastic increments (Campbell et. al., 1997) and is given by:

$$M_1(q) = \frac{VR(q) - 1}{[\emptyset(q)]^{\frac{1}{2}}} \sim N(0,1) \tag{6}$$

where

$$\emptyset(q) = \frac{2(2q-1)(q-1)}{3qT} \tag{7}$$

Under homoscedasticity, the volatility of stock returns is assumed to be constant over time, which often does not hold in practice. Indeed, the volatility of stock returns fluctuates over time, and this can lead to misleading conclusions about the EMH when the M_1 measure is considered (Charles and Darne, 2009). Thus, Lo and MacKinlay (1988) developed a second test statistic, M_2, which tests the type of the RWH that assumes the increments are subject to heteroscedasticity (Mobarek and Fiorante, 2014). This test statistic is computed as:

$$M_2(q) = \frac{VR(q) - 1}{[\emptyset^*(q)]^{\frac{1}{2}}} \sim N(0,1) \tag{8}$$

where:

$$\emptyset^*(q) = \sum_{j=1}^{q-1}\left[\frac{2(q-j)}{q}\right]^2 \hat{\delta}(j) \tag{9}$$

and:

$$\hat{\delta}(j) = \frac{\left[\sum_{t=j+1}^{T}(y_t - \hat{\mu})^2 \left(y_{t-j} - \hat{\mu}\right)^2\right]}{[\sum_{t=1}^{T}(y_t - \hat{\mu})^2]^2} \tag{10}$$

A potential limitation of Lo and MacKinlay's (1988) variance ratio test is that it assumes stock returns are normally distributed. This assumption is usually violated in stock returns, especially in emerging markets such as the Saudi stock market (Abdmoulah, 2010; Al-Ajmi and Kim, 2012; Charfeddine and Khediri, 2016). Therefore, Wright (2000) attempted to overcome this limitation by introducing a more powerful test than that proposed by Lo and MacKinlay (1988). Specifically, Wright (2000) introduced a nonparametric variance ratio test that is based on the ranks and signs of the returns. In the rank-based variance ratio test, the time series (stock returns) used in the Lo-MacKinlay tests are substituted

with ranks of the time series, in order to obtain the test statistics R_1 and R_2. These test statistics are defined as:

$$R_1 = \left(\frac{\frac{1}{Tq}\sum_{t=q}^{T}\left(r_{1t} + \cdots + r_{1t-q+1}\right)^2}{\frac{1}{T}\sum_{t=1}^{T} r_{1t}^2} - 1 \right) \times \emptyset(q)^{-1/2} \quad (11)$$

and

$$R_2 = \left(\frac{\frac{1}{Tq}\sum_{t=q}^{T}\left(r_{2t} + \cdots + r_{2t-q+1}\right)^2}{\frac{1}{T}\sum_{t=1}^{T} r_{2t}^2} - 1 \right) \times \emptyset(q)^{-1/2} \quad (12)$$

where the standardized ranks r_{1t} and r_{2t} are given by:

$$r_{1t} = \frac{\left(r\left(y_t - \frac{T+1}{2}\right)\right)}{\sqrt{\frac{(T-1)(T+1)}{12}}} \quad (13)$$

and:

$$r_{2t} = \Phi^{-1}\frac{r(y_t)}{(T+1)} \quad (14)$$

where $\emptyset(q)$ is defined in Equation (8), $r(y_t)$ is the rank of y_t among $y_1, \cdots, y_T$, and Φ^{-1} is the inverse of the standard normal cumulative distribution function. Wright (2000) also constructed a nonparametric variance ratio test using the signs of the returns instead of the ranks. In this sign-based variance ratio test, the stock returns used in the Lo-MacKinlay tests are substituted with signs of the stock returns in order to obtain the test statistics S_1 and S_2. This study does not consider S_2 as it is inferior to S_1. In particular, the results of Wright (2000)'s Monte Carlo simulations showed that S_1 has better size and power properties than S_2. The test statistic S_1 is defined as:

$$S_1 = \left(\frac{\frac{1}{TK}\sum_{t=k}^{T}(s_t + \cdots + s_{t-k+1})^2}{\frac{1}{T}\sum_{t=1}^{T} s_t^2} - 1 \right) \times \emptyset(q)^{-\frac{1}{2}} \quad (15)$$

where $\emptyset(q)$ is defined in Equation [7], $s_t = 2u(y_t, 0)$, and

$$u(y_t, 0) = \begin{cases} 0.5 & \text{if } y_t > 0, \\ -0.5 & \text{otherwise,} \end{cases}$$

V. Results

The null hypothesis that the market index and the sample companies follow a random walk was tested using the variance ratio tests described in the previous section. Following Fifield and Jetty (2008), AlKhazali (2011) and Jamaani and Roca (2015), the ratio was calculated for lags of 2, 4, 8 and 16 days, with the one-day return used as a base.

Parametric Variance Ratio Test

The results of the Lo-MacKinlay parametric variance ratio test for the market index return and the returns of the 100 companies are reported in Tables 2 and 3, respectively. The left panels of Tables 2 and 3 (M_1) report the results under the assumption of homoscedasticity, while the right panels (M_2) show the results under the assumption of heteroscedasticity. The M_1 market index results for the full sample show that the variance ratios are larger than one for all lags selected, indicating a positive correlation between returns.

Table 2: Parametric Variance Ratio Test Results: Market Index

Period	M_1				M_2			
	$q=2$	$q=4$	$q=8$	$q=16$	$q=2$	$q=4$	$q=8$	$q=16$
Full	1.12	1.22	1.26	1.22	1.12	1.22	1.26	1.22
	(6.01)***	(5.86)***	(4.32)***	(2.48)**	(2.96)***	(2.68)***	(2.04)**	(1.26)
Pre	1.13	1.21	1.22	1.17	1.13	1.21	1.22	1.17
	(5.45)***	(4.95)***	(3.27)***	(1.63)	(2.77)***	(2.29)**	(1.56)	(0.83)
Post	1.09	1.24	1.39	1.42	1.09	1.24	1.39	1.42
	(2.32)**	(3.25)***	(3.31)***	(2.40)**	(1.04)	(1.48)	(1.66)*	(1.38)

Note: This table shows the Lo and Mackinlay parametric variance ratio tests for daily Saudi stock market returns for the three sample periods. The full period spans the time from 1st January 2008 to 31st December 2017, while the pre-and post-periods cover the periods before and after the change in regulation on 15th June 2015. The main row in each period reports the variance ratios, with test statistics given in parentheses. The test statistic M_1 assumes homoscedasticity while the test statistic M_2 assumes heteroscedasticity. *, **, and *** indicate statistical significance at the ten, five and one per cent levels, respectively.

Table 3: Parametric Variance Ratio Test Results: Individual Companies

Period	M_1				M_2			
	$q=2$	$q=4$	$q=8$	$q=16$	$q=2$	$q=4$	$q=8$	$q=16$
Full	77.0	62.0	34.0	19.0	24.0	11.0	5.0	5.0
	84.0	72.0	49.0	27.0	48.0	29.0	17.0	7.0
	90.0	78.0	57.0	33.0	64.0	47.0	27.0	12.0
Pre	59.0	45.0	21.0	15.0	14.0	6.0	3.0	2.0
	72.0	55.0	34.0	24.0	35.0	17.0	9.0	5.0
	73.0	59.0	42.0	29.0	49.0	34.0	15.0	9.0
Post	42.0	43.0	36.0	21.0	6.0	11.0	11.0	4.0
	58.0	58.0	54.0	37.0	22.0	25.0	24.0	16.0
	70.0	70.0	64.0	44.0	35.0	36.0	33.0	25.0

Note: This table gives the results for the percentage of companies for which the null hypothesis of no autocorrelation was rejected for the three sample periods. The variance ratio test statistic M_1 assumes homoscedasticity, while the test statistic M_2 assumes heteroscedasticity. The full period spans the time from 1st January 2008 to 31st December 2017, while the pre-and post-periods cover the periods before and after the change in regulation on 15th June 2015. The first row of each period presents the percentage of firms that rejected the null at the one per cent level, while the second and third rows for each period report the percentages at the five and ten per cent levels, respectively.

The variance ratios of the market index range between 1.12 and 1.26% and are statistically significant at the one per cent level for three lags and at the five per cent level for one lag. Furthermore, the company results of M_1 for the full sample also indicate positive serial correlation; the companies' variance ratios at lag 2 are significantly larger than one at the five per cent level for 84.0% of the sample companies. This non-random behavior for the market index and the sample companies implies that,

under the assumption of homoscedasticity, the Saudi stock market is not weak form efficient. Overall, the results corroborate those documented by AlKhazali (2011), Bley (2011) and Jamaani and Roca (2015) who found that, under the hypothesis of homoscedasticity, Saudi stock returns do not follow a random walk.

The M_1 results also show that the RWH is rejected before and after the date of opening the market to foreign investors. For example, the null hypothesis is rejected for the market index in three out of the four lags in the pre-opening period and in all lags in the post-opening period, suggesting the change in regulation did not increase the informational efficiency of the Saudi stock market. This finding is consistent with those of Fuss (2005) and Ulici and Nistor (2011) who found that the estimated variance ratio tests, under the assumption of homoscedasticity, were statistically significant in the pre- and post-liberalisation periods for the majority of their sample markets. For instance, Fuss (2005) found that the random walk hypothesis was rejected before and after stock market liberalization in Indonesia, the Philippines, Taiwan, and Thailand; the variance ratios for all markets and lags were significantly different from one at the five per cent level. The evidence from the company results of M_1 seem to support this finding; the null hypothesis for more than half of the companies is rejected at the five per cent level for lags 2 and 4 in both subperiods. For instance, the variance ratios for lag 4 are significantly different from one at the five per cent level for 55.0 and 58.0% of the companies in the pre- and post-opening periods, respectively. Thus, these results indicate that the participation of international investors in the market appears to have had no impact on the efficiency of the Saudi stock market.

However, due to the time-varying volatility that usually characterizes stock market data the above results may not be robust. The presence of heteroscedasticity may lead to a higher rejection of the random walk hypothesis. Thus, an inspection of the M_2 results is necessary to make inferences about the RWH and market efficiency. In general, the M_2 results show fewer rejections of the RWH for the market index as well as the sample companies. For example, the market index variance ratios for the full period are larger than one for three lags using M_2, as opposed to four lags using M_1. Moreover, the magnitude of the M_2 statistics are smaller than those for M_1. They range from 1.26 to 2.96, while the M_1 statistics range from 2.48 to 6.01, indicating the significance of rejection is weaker for M_2. Furthermore, the results for individual firms also show that the rejection of the null hypothesis of a random walk for some firms is not robust to heteroscedasticity.

For instance, the percentage of companies that rejected the null hypothesis for lag 2 at the five per cent level decreases from 84.0% for M_1 to 48.0% for M_2. However, although these findings for the entire period indicate that some of the rejections of the RWH were due to changing variances (heteroscedasticity) rather than autocorrelation, support for weak form inefficiency is still strong. Although this study employs higher frequency data than that of previous studies, and covers a period where the Saudi stock market was characterized as a liquid market, the results are in line with those reported by Abraham et. al. (2002) and AlKhazali (2011). One possible reason for the positive autocorrelation can be attributed to the gradual information diffusion process in small firms. Small-capitalised firms tend to trade less frequently traded than large capitalized firms. They also tend to have lower analyst coverage (Hong et. al., 2000). This, in turn, means information is incorporated into the share prices of small firms at a slower speed. This slow incorporation of information for some small firms causes positive autocorrelation in the market index[5].

However, the M_2 results for the pre- and post-opening periods reveal a different picture as compared to that given by the M_1 results. The M_2 results show that most of the variance ratio tests fail to reject the random walk hypothesis after the change in regulation. The market index variance ratios are significantly larger than one at two lags for the pre-period, while they are larger than one at only one lag for the post-period. In addition, the variance ratios of the individual companies at lag 2 reject the RWH at the five per cent level in only 22.0% of the companies for the post-period, as opposed to 35.0% for the pre-period. This result indicates that opening the market to foreign institutional investors has positively impacted the efficiency of the Saudi stock market, providing some support to the findings of Kim and Singal (2000) and Fuss (2005). Laopodis (2004) also used the Lo-MacKinlay heteroscedastic variance ratio test to investigate how the Greek stock market behaved after liberalization, but he documented results that are inconsistent with those reported here. That is, Laopodis (2004) found that the Greek stock market was efficient before and after allowing for the participation of foreign investors.

Nonparametric Variance Ratio Test

Parametric techniques employed to test the random walk hypothesis require stock returns to be normally distributed. Thus, using the parametric Lo-MacKinlay variance ratio test to examine the random walk behavior of the Saudi stock market suffers from a critical limitation. As reported in Section 3, the returns of the Saudi stock market are not normally distributed. To overcome this limitation, the nonparametric Wright's rank and sign variance ratio tests, which are robust to the violation of the normality assumption, were conducted. The results of these tests are reported in Tables 4 and 5. Specifically, Table 4 shows the estimates of the variance ratios and their associated tests statistics, R_1, R_2 and S_1, for the market index, while Table 5 displays the percentage of companies where the null hypothesis of a random walk at three different levels of significance are rejected. An inspection of the tables reveals a number of points.

First, stock returns in the full period do not follow a random walk as the market index variance ratios are significantly larger than one for all test statistics considered and at all lags selected. The variance ratios for the full period range from 1.07 to 1.26, while their corresponding test statistics range from 2.36 to 6.06, which implies that the daily returns are positively autocorrelated. In view of equations (11) and (12), variance ratios at lag 2 are approximately equivalent to the first-order autocorrelation plus one; hence, using a base observation interval of two days, the R_1 variance ratio of 1.12 indicates that the first-order autocorrelation for daily

[5] As of December 2017, there was a total of 179 companies listed on the Saudi stock. The market capitalization was below $500 million for 58.1% of these companies, between $500 million and $5,000 million for 31.8% of the companies, and above $5,000 million for 10.0% of the companies.

returns is nearly 12.0%. The company analysis confirms the points that emerge from the market index analysis as the RWH is rejected for a high proportion of the sample companies. For example, at the five per cent level of significance, the null hypothesis is rejected by 59.0% of the companies using R_1 and 73.0% using R_2. Such findings suggest that trends were present in the share prices examined, indicating that the Saudi stock market was weak form inefficient. Despite the focus on company-level data and the use of a recent time period, the results of this study are consistent with the results documented by Al-Khazali et. al. (2007), AlKhazali (2011), Bley (2011) and Jamaani and Roca (2015). One plausible explanation for this lack of efficiency is the irrationality of investors. For example, investors in the Saudi stock market may under- or over-react to the arrival of new information, causing share prices to have predictable patterns.

Another plausible explanation for the finding of market inefficiency relates to the dominance of noise traders who tend to buy when share prices rise and sell when share prices fall (Park and Irwin, 2007). Such trend-chasing behavior is not fully justified by news or fundamental factors and, in the absence of arbitragers, this behavior leads share prices to rise or fall further, causing positive autocorrelation.

Table 4: Non-Parametric Variance Ratio Test Results: Market Index

Period	R_1				R_2				S_1			
	$q=2$	$q=4$	$q=8$	$q=16$	$q=2$	$q=4$	$q=8$	$q=16$	$q=2$	$q=4$	$q=8$	$q=16$
Full	1.12	1.22	1.26	1.22	1.12	1.22	1.26	1.21	1.07	1.14	1.18	1.22
	(5.93)***	(5.76)***	(4.38)***	(2.54)***	(6.06)***	(5.93)***	(4.39)***	(2.36)**	(3.68)***	(3.76)***	(3.02)**	(2.54)*
Pre	1.11	1.20	1.23	1.19	1.12	1.21	1.22	1.15	1.08	1.15	1.22	1.35
	(4.94)***	(4.67)***	(3.39)***	(1.88)*	(5.21)***	(4.77)***	(3.23)***	(1.50)	(3.24)***	(3.52)***	(3.28)***	(3.40)***
Post	1.12	1.24	1.30	1.19	1.12	1.26	1.38	1.33	1.07	1.10	1.02	0.81
	(3.13)***	(3.19)***	(2.53)**	(1.11)	(3.02)***	(3.56)***	(3.21)***	(1.88)*	(1.71)*	(1.32)	(0.13)	(-1.07)

Note: This table shows the results from conducting Wright's non-parametric variance ratio test using daily stock market returns data for Saudi stock market for the three sample periods. The full period spans the time from 1st January 2008 to 31st December 2017, while the pre-and post-periods cover the periods before and after the change in regulation on 15th June 2015. The main row in each period reports the variance ratios, with test statistics given in parentheses. *, **, and *** indicate statistical significance at the ten, five and one per cent levels, respectively.

Second, the predictability of stock returns altered after the change in regulation. In particular, the variance ratio tests for the market index are significantly larger than one in 11 cases in the pre-opening period as opposed to eight cases in the post-opening period. This reduction in the predictability of returns implies that there was an improvement in market efficiency after allowing foreign institutional investors to participate in the market. One reason that may explain the improvement in efficiency after stock market liberalization is that international investors are faster and better at incorporating global news into share prices. This result is in line with Fifield and Jetty (2008) who found that, when using the nonparametric variance ratio test, the B-share Chinese market had become more informationally efficient in the post-deregulation period. However, this result is not in line with Graham et. al. (2015), who presented evidence against weak form efficiency for the Icelandic stock market during periods when foreign capital restrictions were relaxed. The contradictory findings of these studies are possibly due to the result of differences in the levels of stock market development. Kim and Shamsuddin (2008) suggested that the relationship between stock market liberalization and market efficiency depends on factors such as market depth and breadth as well as on having good corporate governance provisions.

By contrast, the variance ratio tests for the individual companies yield a somewhat different conclusion. Specifically, the companies whose variance ratios did not equal one in the post-opening period are, in most cases, higher than those in the pre-opening period. For example, the percentage of companies that reject the RWH (assuming the R_1 measure and a five per cent significance level) increases from 42.0% in the pre-period to 53.0% in the post-period. The variation in results between market index and individual companies is consistent with Lo and MacKinlay (1988) who suggested that it is difficult to detect statistically significant predictability for returns of individual firms because such returns contain firm specific noise (Campbell et. al., 1997).

Third, an analysis of the results across the three different measures shows that there is no material difference between the conclusions drawn from the R_1 and R_2 test results; both measures show that the variance ratios are significantly larger than one for the market index for the full period and both subperiods. This result also holds for the individual companies; in general, the differences between measures R_1 and R_2 in terms of the number of companies that reject the null hypothesis are small. Nevertheless, there are considerable differences in outcomes between the rank-based measures and the sign-based measure. Specifically, the test results for R_1 and R_2 rejected the random walk after liberalization, while the test results for S_1 did not. Belaire-Franch and Opong (2005) claimed that the sign-based measure is more powerful than the R_1 and R_2 measures in the presence of heteroscedasticity, and thus the S_1 test may be more robust statistically6. This provides additional support for the non-rejection of the RWH for the Saudi stock market in the post-opening period.

[6] In his empirical testing, Wright (2000) showed that tests based on ranks are robust under the assumption of homoscedasticity while the tests based on signs are robust to many forms of conditional heteroscedasticity.

Table 5: Non-Parametric Variance Ratio Test Results: Individual Companies

Period	R_1				R_2				S_1			
	$q=2$	$q=4$	$q=8$	$q=16$	$q=2$	$q=4$	$q=8$	$q=16$	$q=2$	$q=4$	$q=8$	$q=16$
Full	44.0	33.0	18.0	13.0	62.0	44.0	23.0	15.0	22.0	20.0	17.0	18.0
	59.0	41.0	31.0	19.0	73.0	58.0	46.0	24.0	44.0	38.0	40.0	37.0
	67.0	54.0	42.0	26.0	76.0	62.0	55.0	28.0	49.0	48.0	50.0	46.0
Pre	25.0	17.0	10.0	7.0	44.0	27.0	14.0	8.0	10.0	9.0	8.0	10.0
	42.0	28.0	17.0	13.0	57.0	39.0	22.0	20.0	30.0	23.0	25.0	23.0
	53.0	35.0	25.0	23.0	62.0	46.0	32.0	27.0	39.0	36.0	36.0	31.0
Post	30.0	31.0	20.0	12.0	34.0	34.0	26.0	14.0	10.0	11.0	8.0	9.0
	53.0	44.0	33.0	17.0	49.0	47.0	40.0	20.0	24.0	29.0	22.0	22.0
	59.0	55.0	41.0	22.0	62.0	59.0	50.0	25.0	38.0	41.0	31.0	27.0

Note: This table gives the percentage of companies where the null hypothesis of no autocorrelation was rejected for the three sample periods at three different significance levels. The full period spans the time from 1st January 2008 to 31st December 2017, while the pre-and post-periods cover the periods before and after the change in regulation on 15th June 2015. The first row of each period presents the percentage of firms where the null hypothesis was rejected at the one per cent level, while the second and third rows for each period show the percentages at the five and ten per cent levels, respectively.

Finally, the magnitude of the test statistics declines with the number of lags (q) considered, which indicates that the rejection of the RWH becomes weaker when the variances of longer holding periods are considered. More importantly, this result holds when company-level data are considered. That is, the percentage of companies that reject the RWH using the rank-based measures decreases as the number of lags (q) increases in all three periods, a result that is in line with Fifield and Jetty (2008). An exception to this generalization is the R_1 results for the post-period at the one per cent level; the percentage of companies that reject the null hypothesis at the one per cent level increases from 30.0% for lag 2 to 31.0% for lag 4.

Overall, the results of the parametric and nonparametric variance ratio tests in this study indicate that the EMH does not hold in the Saudi stock market. These results support conclusions drawn from previous literature about the efficiency of the Saudi stock market, such as Abraham et. al. (2002), Al-Khazali et. al. (2007) and Jamaani and Roca (2015). In addition, the results suggest that the market became more informationally efficient after opening the market to foreign institutional investors. The test results for M_2 and S_1 supported the non-rejection of the RWH in the post-opening period. These results are consistent with some previous studies that investigated the effect of stock market opening using the variance ratio tests and other tests of the random walk (Kim and Singal, 2000; Fuss, 2005; Cajueiro et. al., 2009; Ulici and Nistor, 2011; Rejeb and Boughrara, 2013) However, the substantive literature has not always documented a positive impact of stock market liberalization on market efficiency (Groenewold and Ariff, 1998; Maghyereh and Omet, 2002; Kim and Shamsuddin, 2008; Naghavi et. al., 2018). The difference in results between this study and some previous studies suggests that the relationship between stock market opening and informational efficiency may be country-specific.

VI. Conclusion

This paper has examined the behavior of the Saudi stock market using the parametric variance ratio test of Lo and MacKinlay (1988) as well as the nonparametric variance ratio test of Wright (2000). Employing these statistically robust techniques and using market- and firm-level data over the ten-year period 2008-2017, this paper provides new empirical evidence on the weak form of the EMH for the Saudi stock market. In addition, the paper investigated, for the first time, the impact of opening the market to foreign institutional investors on market efficiency. To do so, the paper divided the whole sample period into two subperiods based on the market opening date and then compared the level of efficiency in the pre-opening period with the post-opening period. The analysis conducted in this paper revealed several key findings.

First, the analysis of the descriptive statistics suggested that the average daily return for the market index and the sample companies were highly skewed and leptokurtic implying the need to use nonparametric techniques, such as Wright's (2000) variance ratio test, when testing weak form efficiency. Second, the results from the parametric variance ratio test suggested that the RWH was rejected for the market index and the sample companies, providing evidence against weak form efficiency. This result supports previous studies that have employed various statistical tests to examine the informational efficiency of the Saudi stock market (Butler and Malaikah, 1992; Abraham et. al., 2002; Bley, 2011; Al-Ajmi and Kim, 2012; Niemczak and Smith, 2013; Jamaani and Roca, 2015). The variance ratios were significantly larger than one for most lags used. The rejection of the random walk hypothesis was also robust to heteroscedasticity.

Third, the use of the nonparametric variance ratio test provided further evidence against weak form efficiency in the Saudi stock market; the results for R_1, R_2 and S_1 rejected the random walk hypothesis for all lags selected. This lack of efficiency can be explained by the dominance of irrational investors in the market who tend to trade based on noise rather than information. Finally, and most importantly, opening the stock market to international investors seemed to positively impact the efficiency of the Saudi stock market. The results of the M_2 measure, which is robust to heteroscedasticity, and the S_1 measure, which is robust to non-normality, failed to reject the RWH in the post-opening period for most lags.

Although this study provided evidence of an improvement in market efficiency during the post-opening period, this finding needs to be interpreted with care. The post-opening time period considered in this investigation spans the time from June 2015 to December 2017. This relatively short period of two-and-a-half years might not be long enough to fully understand the impact of stock market liberalization on market efficiency. The restrictions on foreign investment in some countries are lifted gradually and this means the process of stock market liberalisation can take years to be fully implemented. Therefore, future work may usefully investigate the impact of stock market liberalization by considering a longer time period. In order to provide a better understanding of the relationship between market liberalization and market efficiency, future studies could

also compare the share price behavior of companies whose shares are held by international investors to the behavior of companies whose shares are neglected by the global community.

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