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Testing Weak Form Efficiency: Empirical Evidence from Selected World Stock Markets

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Abstract

Efficient Market Hypothesis, which asserts that returns of a stock market are unpredictable from previous price changes, is of the interest to many researchers and practitioners in the financial studies. There has been extensive research in this area since its inception in 1970, in testing weak form efficiency by several parametric and non-parametric tests. These studies conducted in individual stock markets or small group of markets. However, these studies yield different results of time varying and method specific. In this context, this study aims at examining the weak form efficiency of selected stock markets in the world by employing both parametric and nonparametric tests by considering the daily returns of the stock indices of twenty four selected countries comprises of nine developed, ten emerging and five frontier markets during the period 2000 to 2018. The results of this study observes that the most of the stock markets exhibit weak form inefficiency except few developed markets.

Key Words: Market returns, Weak-form efficiency, parametric tests, Non parametric tests, World stock markets

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1. Introduction:

The efficiency of stock markets is one of the core concepts of financial economics and it has significant practical implications. If the markets are efficient, the stock prices are unpredictable and it is not feasible to gain abnormal returns. Since the prices reflect rational and fundamental factors, it also implies that the resources are allocated efficiently. The concept of efficiency was introduced by Fama (1970), which states that, the stock market is said to be efficient, if prices always fully reflect all the available information. Similarly, Kolb and Rodriguez (1992) describe the efficient stock market as a market, in which the price changes reflect the economic value of the information and prices adjust quickly after the arrival of the new information. Therefore, the efficient markets exhibit transparent price discovery process such that prices accurately reflect the trade-off between the relative risk and potential returns associated with the stock. Strong (2003) points that stock markets are kept reasonably efficient because of the huge number of market players who are quick to take advantage of security mispricing. This implies that market efficiency is related to the quality of information analysis by stock market players, which are instantaneously reflected in stock prices. Thus, the investors cannot gain abnormal profits by using available information.

The concept of efficiency and random walk has very significant role in trading strategies of investors, fund managers, policy makers, capital markets, asset pricing models, and consequently economic and financial development as a whole. Trading strategies may differ when the prices follow random walk process. Random walks are crucial in formulation of rational expectations models and testing of efficiency of stock market. A market with random walk process shows that equities are being appropriately priced at an equilibrium level, whereas the absence of a random walk reveals distortions in the pricing of assets and risk. This has important effects in the allocation of capital within an economy and hence overall economic development. (Worthington and Higgs, 2006).

Besides reflecting full information, a stock market is said to be efficient if it provides basic functions of price transparency, price discovery, reduced transaction costs and exchange regulation, which strengthen the confidence of investors. Price transparency ensures that all the participants of the stock market have access to a neutral reference price. Price discovery confirms that the market forces of demand and supply are reflected in the stock prices. Reduced transaction costs are the results from the centralized market place, the stock exchange and its easy access to the market players. Exchange regulation involves ensuring safety and soundness of the trading system and working towards growth and development of the market (Kalu, 2017)

Fama (1970) categorized the market efficiency in three forms as, weak form efficient, semi-strong form and strong form. In the weak form efficient markets, the asset prices fully reflect all the information contained in the historical prices. In semi-strong form, the prices reflect all the information from the historical prices as well as all the publicly available information. In the strong form, the asset prices fully reflect all the available information, i.e. both public as well as private information. In case of strong form, any kind of information is inadequate to obtain abnormal profit. If the market is semi-strong form efficient, neither technical nor fundamental analysis can help the investors in decision-making. There have been different opinions regarding the efficiency of the stock markets and large number of studies tested all the three types of EMH and majority of them invalidated the strong form and semi-strong forms of EMH that are not supported by financial data. Later on opinions have been split regarding weak form of EMH, which includes random walk theory as well (Titan, 2015).

There exists several studies in examining the hypotheses in various markets. Early empirical studies on developed stock markets found support for weak form efficiency based on low degree of serial correlation and transaction costs observed in the series (Kendal, 1953; Cootner, 1962; Fama, 1965). These studies generally agree that stock price changes are random and that past prices are not useful in predicting future price changes particularly after transaction costs have been taken into consideration. Some recent studies that support weak form efficiency in the markets are, for example, Metghalchi et.al. (2005) for US stock markets, Narayan and Smyth (2006), for fifteen European stock markets, Hasanoy and Omagy (2007) for the stock markets of Bulgaria, Hungary, and Slovakia, Lim et.al. (2013) for China, Tong et. al. (2014) for Australia, Konak and Şeker (2014) for United Kingdom, Erdem and Ulucak (2016) for G7 countries, Plihal (2016) for Germany, Seddigi and Yoon (2018) for South Korea.

On the other hand, some studies show evidence of weak-form inefficiency. Tabak (2003) for Brazilian market, Lima and Tabak (2004) for Chinese and Singapore stock markets, Islam et. al (2007) for Thailand, Afego (2012) for Nigerian stock market, Arora (2013) for India, Harrison and Moore (2012) for MENA markets, Owido et. al. (2013) for Kenya stock market, Radikoko,(2014) for Canada, Al-Jafari and Altaee (2011) for Egypt, Said (2015) for Russia, Dutta (2015) for UK, Germany, France and Italy, Singh et. al (2016) for Brazil, Japan, Indian and US markets, Vieito (2016) for Latin American Countries, Almudhaf (2018) for Indonesia.

In spite of extensive research on this topic, the debate continues as these empirical results are not arriving at common conclusions. Most of these studies are confined to a single market or small group of markets. These studies also differ across time for the same market for example (Konak and Şeker, 2014; Dutta, 2015; Erdem and Ulucak, 2016). Therefore, it is clear the there is no consensus among the results of these studies in testing the efficiency of stock markets all over the world. Moreover, after the global financial crisis, 2008, the efficiency testing of the markets gained lot of importance (Su et. al. 2015). Thus, this necessitates the re-examination of market efficiency among all the stocks markets of the world. Hence, this study aims at testing weak from efficiency of selected twenty-four stock markets of the world, comprising nine developed, ten emerging and five frontier markets. This study also uses parametric as well as non-parametric tests to test the efficiency of these twenty-four markets.

The rest of the paper is organized as follows.Section 2 describes the data and methodology. In section 3, we present the empirical results of this study, and finally, the summary and conclusions are given in section 4.

2. Data and Methodology:

2.1. Data:

This section describes the data and methodology of various methods to test the efficient market hypothesis. Here we considered representative markets of three groups viz. developed, emerging and frontier markets as classified by Morgan Stanley Capital International classification (MSCI, 2018; Mallikarjuna and Rao, 2019). Based on the availability of data in open sources and for uniformity, we considered the following markets for the study. The markets in the developed category are Australia (ASX 200), Canada (TSX), France (CAC 40), Germany (DAX), Japan (NIKKEI 225) South Korea (KOSPI), Switzerland (SMI), United Kingdom (FTSE 100), and the United States of America (S&P 500). The markets in the emerging group are Brazil (BOVESPA), China (SSEC), Egypt (EGX 30), India (SENSEX), Indonesia (IDX), Mexico (BMV IPC), Russia (MOEX), South Africa (JSE 40), Thailand (SET), and Turkey (BIST 100). The markets in the frontier category are Argentina (S&P MERVAL), Estonia (TSEG), Kenya (NSE 20), Sri Lanka (CSE AS), and Tunisia (TUNINDEX). The daily closing prices of the selected indices data ranging from 1st January 2001 to 31st December 2018 have been obtained from the website www.investing.com.

The asset returns (R_t) are calculated as:

$$R_t = \frac{(P_t - P_{t-1})}{P_{t-1}} * 100 \qquad 2.1$$

Where, P_t is the price of the asset in the current time period and P_{t-1} is the price of an asset in the previous time period.

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2.2. Methodologies:

In the literature, broadly there are two types of approaches to test the weak form efficiency. First, statistical tests and second, Technical trading rules. Even among the statistical tests, there exists different methods such as serial correlation test, Ljung box test, runs test, Variance ratio test etc. The most frequently used methods by researchers are Ljung box test, Runs test, Hurst exponent and variance ratio test (Camelia, 2012). This study employs two parametric tests (Serial correlation test and Ljung box test) as well as two non-parametric tests (Runs test and Hurst exponent).

2.2 (a). Serial correlation

Serial correlation or autocorrelation (ACF) is one of the statistical tools used for measuring the dependence of a variable on its own past values. In other words, this test measures the relationship between the stock return in the current period and its value in the previous period, which is defined as:

$$\rho_k = \frac{\sum_{t=1=k}^{n} (r_t - \bar{r})}{\sum_{t-1}^{n} (r_t - \bar{r})^2} \qquad 2.2$$

where ρ_k is the serial correlation coefficient of daily returns of lag k ; n is the number of observations; r_t is the stock return over period t; r_{t-k} is the stock return over period *t-k*; is the mean of stock returns, and k is the lag of the period. The series of ACF values are presented in graphical form, called correlogram. The presence of serial correlation can be observed from the correlogram, in which, ACF values exceeding the critical values indicate the presence of serial correlation in the data. The critical values at 5% level of significance at any given lag *d (d≠0)* are calculates as:

$$\pm \frac{1.96}{\sqrt{T-d}} \qquad 2.3$$

Where, T is the sample size.

2.2 (b). Ljung-Box test

In addition, to test the joint hypothesis that all correlations are simultaneously equal to zero, the study used the Ljung-Box Q-statistic (1978) as a variant of Box-Pierce's Q statistic (Q), which is as follows:

$$Q_{LB} = n(n+2) \sum_{j=1}^{h} \frac{\rho^2(j)}{n-j} \qquad 2.4$$

Where, n is the sample size, $\rho(j)$ is the autocorrelation at lag j, and h is the number of lags being tested. Under the null hypothesis of zero autocorrelation at the first k autocorrelations ($\rho_1 = \rho_2 = \rho_3 \dots = \rho_k$), the Q-statistic is distributed as a chi-square with degrees of freedom equal to the number of autocorrelation (k). If the Q-statistic is significantly different from 0, this indicates that the series is serially correlated. Such a result would allow rejecting the null hypothesis that returns are independent (Guidi et. al., 2010).

2.2 (c). Runs Test:

The runs test is used to measure the independence of a series price change, which belongs to a non-parametric test. The non-parametric runs test is valid as a tool to measure the price returns randomness. The null hypothesis for a runs test is that the series of returns are temporal independent, which means weak form efficiency. Therefore, if this series of returns follows a random walk, the expected number of runs (m) should be close to the observed number of runs (R). The following equation is conducted to estimate the expected number of runs (m):

$$m = \frac{N(N+1) - \sum_{i=1}^{3} N_i^2}{N} \qquad 2.5$$

Where N represents the observations number, i denotes the sign of plus, minus and no change, and ni is the total amount of changes for each kind of sign. If the number of observations is larger (>30), the expected number of runs will be normally distributed approximately with a standard deviation σ_m, which can be estimated as follows:

$$\sigma_m = \left[\frac{\sum_{i=1}^{3} n_i^2 \left[\sum_{i=1}^{3} n_i^2 + N(N+1) - 2N\sum_{i=1}^{3} n_i^3 - N^3\right]}{N^2(N-1)}\right]^{\frac{1}{2}} \qquad 2.6$$

Then, a runs test can be conducted by using standard normal Z-statistic as follows:

$$Z = \frac{R - M \pm 0.5}{\sigma_m} \sim N(0,1) \qquad 2.7$$

Where R denotes the actual number of runs and 0.5 denotes the continuity adjustment. According to Abraham et al. (2002), a positive Z-value will be obtained if the actual number of runs is larger than the expected number of runs; contrarily, when the actual number is below the expected one, a negative Z-value will be obtained.

2.2 (d). Hurst Exponent:

The Hurst Exponent helps in determining the dependencies in a time series data. The following are the steps involved in measuring Hurst Exponent:

First the whole time series is fragmented into various shorter series of length as $n = N, \frac{N}{2}, \frac{N}{4}, \ldots.$ where n refers to the initial times series data and N, N/2, N/4, refer to fragmented or shorter time series data. The next step is to calculate the mean for each of the shorter series i.e.

$$m = \frac{1}{n}\sum_{i=1}^{n} X_i \qquad 2.8$$

Where, X_i is the daily index returns. Then a series of mean adjusted returns Y_i should be generated:

$Y_t = X_t - m$ where $t = 1, 2, 3, \ldots .n$

After obtaining the mean adjusted returns, the cumulative deviations series (Z) should be estimated:

$Z_t = \sum_{i=1}^{t} Y_i$ where $t = 1, 2, \ldots .n$

Next, the range series (R) is estimated. Range is the difference is obtained by finding the difference between the highest and lowest values of the cumulative deviation.

$R_t = \max(Z_1, Z_2, \ldots Z_n) - \min(Z_1, Z_2 \ldots .Z_n)$ here $t = 1, 2, 3, \ldots .n$

Then standard deviation (S) should be calculated for each of the divided series

$$S_t = \sqrt{\frac{1}{t}\sum_{i=1}^{t}(X_i - m)^2} \text{ and } t = 1, 2, \ldots .n \qquad 2.9$$

Finally, we can determine the Hurst Exponent by dividing R(t) by S(t)

$$(R/S)_t = \frac{R_t}{S_t} \text{ where } t = 1, 2, \ldots n \qquad 2.10$$

Then the E(R/S) is obtained by taking the simple mean of all the shorter series of length n.

Hurst established following relation for R/S:

$$E\left(\frac{R}{S}\right) = C^* n^H \text{ as } n \to \infty \qquad 2.11$$

In the above equation, R/S indicates rescaled range, $c = constant$ and $H = Hurst\ Exponent$

The above equation (2.11) can be converted into linear relation by using log on both sides and Hurst exponent can be estimated for the linear equation by using ordinary least square method.

$$\log(R/S)_n = \log C + H \log n \qquad 2.12$$

The slope obtained by estimating the above equation is the Hurst Exponent and its value varies from 0 to 1.

If the value of H is close to 0.5, it indicates that series is in Brownian motion and the market can be said to exhibit weak form efficiency. If the value of H is in the range of 0 to 0.5, then the data is said to have anti-persistent behaviour. This phenomenon is also called as mean reversion which means that future values tend to return to long run mean value. The mean reversion strengthens as H approaches 0. A value of H between 0.5 and 1 indicates persistent behaviour and implies that there is strong trend in the data. The trend could be either decreasing or increasing, which means that the markets are weak form inefficient and are predictable.

3. Empirical Results:

In this section, we present the empirical results including, descriptive statistics, and the results of Ljung-Box test, Runs test and Hurst exponent for the stock returns of developed, emerging and frontier markets.

3.1. Descriptive Statistics of the Stock Returns

First, we present the summary statistics of returns of market indices such as mean, standard deviation, skewness, kurtosis and JB test in table 1 for developed, emerging and frontier stock markets and from this table, we can observe that, the mean returns in all the markets are positive, which indicates overall positive investment returns during the period of study. The kurtosis values of the returns series of all the markets are observed to be greater than three revealing that all the series are leptokurtic, i.e thick tails, which is a common phenomenon of stock returns. The Jarque-Bera test shows that the series are non-normally distributed. All these statistics confirm the stylized facts of financial time series observed in globally (Cont, 2001; Humala, 2013; Mallikarjuna et al., 2017).

3.2. Results of Efficiency Tests

The results of the parametric tests, i.e., serial correlation and Ljung-Box tests for lags 1, 5 and 10 are presented in the table 2, table 3 and table 4, for developed, emerging, and frontier markets respectively. From these tables we can observe that the autocorrelation coefficients are significant for almost all the markets at different lags among developed, emerging and frontier markets, this canbe observed from the correlograms of the developed, emerging and frontier markets frim the figures 1 (a), 1(b) and 1(c)

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respectively. The Q statistic from the Ljung-Box test is greater than ± 1.96 at 5% level of significance for all the markets in developed markets group at lags 1, 5 and 10, except for Canada and Germany at first lag. In case of emerging markets, the Q- Statistic is significant in eight markets, except Brazil and Turkey. As far as frontier markets are concerned, we can understand that all the markets are weak form inefficient, they do not follow random walk.

The non-parametric tests i.e., runs test and Hurst exponent were performed in all the markets and the results are presented in table-5. Considering the results of runs test at 5% level of significance, the results show that, the p-values of France and Germany are less than the 0.05 in developed markets. Among emerging markets, Egypt, India, Indonesia, Mexico and Thailand are less than the p-value. In case of frontier markets, all the markets are less than 0.05, rejecting the null hypothesis of weak for efficiency, which shows that all these markets are weak form inefficient. Australia, Canada, Japan, South Korea, Switzerland, UK and US from developed markets are weak form efficient. Brazil, China, Russia, South Africa and Turkey in emerging markets are weak form efficient.

Table-1. Descriptive Statistics of Developed, Emerging and Frontier Markets

	Stock Market	Mean	Standard Deviation	Skewness	Kurtosis	Jarque Bera Test	ARCH - LM Test
Developed Markets	Australia	0.016900	0.981318	-0.366178	8.451780	5732.678 (0.00000)	1064.3 (0.00000)
	Canada	0.016719	1.043102	-0.466783	13.58932	21277.95 (0.00000)	1419.3 (0.00000)
	France	0.005790	1.429676	0.141474	8.712746	6275.928 (0.00000)	828.34 (0.00000)
	Germany	0.021703	1.475373	0.097060	8.111260	4987.257 (0.00000)	873.68 (0.00000)
	Japan	0.019562	1.501151	-0.211389	9.413287	7642.163 (0.00000)	1081.2 (0.00000)
	South Korea	0.040316	1.384506	-0.350392	9.724636	8473.831 (0.00000)	720.95 (0.00000)
	Switzerland	0.007731	1.174780	-0.012284	10.18851	9766.624 (0.00000)	1034.6 (0.00000)
	UK	0.009243	1.171826	-0.004334	9.918071	9061.453 (0.00000)	1081.7 (0.00000)
	US	0.020694	1.147998	-0.089045	12.10219	15630.08 (0.00000)	1309.3 (0.00000)
Emerging Markets	Brazil	0.055547	1.769091	0.075096	7.347967	3439.261 (0.00000)	1064.8 (0.00000)
	China	0.016499	1.585054	-0.218775	7.684998	4025.909 (0.00000)	422.28 (0.00000)

	Egypt	0.079649	1.658833	-0.121416	13.15053	18891.65 (0.00000)	506.16 (0.00000)
	India	0.059777	1.414324	0.120611	12.83913	17795.20 (0.00000)	515.88 (0.00000)
	Indonesia	0.070676	1.326156	-0.501572	9.570707	8083.189 (0.00000)	597.36 (0.00000)
	Mexico	0.051820	1.213204	0.153714	9.356521	7644.352 (0.00000)	785.27 (0.00000)
	Russia	0.082735	1.965327	0.370012	24.33804	85492.66 (0.00000)	738.93 (0.00000)
	South Africa	0.047609	1.298747	0.036830	6.299922	2044.612 (0.00000)	901.03 (0.00000)
	Thailand	0.047775	1.263998	-0.520070	13.23751	19417.31 (0.00000)	633.39 (0.00000)
	Turkey	0.069655	1.973356	-0.037463	9.689365	8426.657 (0.00000)	761.13 (0.00000)
Frontier Markets	**Argentina**	0.120985	2.162861	0.018419	7.202958	3230.709 (0.00000)	716.33 (0.00000)
	Estonia	0.052646	1.036820	0.316893	14.29612	24406.12 (0.00000)	413.54 (0.00000)
	Kenya	0.012726	0.831383	0.555709	15.16038	28057.55 (0.00000)	1115.2 (0.00000)
	Tunisia	0.035152	1.292467	0.603647	20.46153	59408.84 (0.00000)	223.91 (0.00000)
	Sri Lanka	0.066494	1.128874	0.993308	43.75095	300319.2 (0.00000)	1151.6 (0.00000)

From the results of Hurst exponent, among developed markets, France, Japan and UK are found to be weak form efficient, since the *H* value is below 0.5, rest of the markets viz. Australia, Canada, Germany, Japan, South Korea, Switzerland and US are weak form inefficient. In case of emerging markets, and frontier markets, all the markets exhibit weak form inefficiency. Our findings from the efficiency tests are consistent with majority of the studies in the literature (see for example, Arora 2013; Hamid et. al. 2017; Malafeyev, et. al, 2017)

The results from Runs test and Hurst Exponent tests are little contrast with the results of serial correlation test and Ljung-Box tests. Although the results from these methods are not uniform, the Hurst exponent method is considered as more appropriate since it is non-parametric and based on non-linear relation for determining market efficiency (Camelia, 2012). Therefore, according to the Hurst exponent method, except France, Japan and UK, all the markets considered for the study are weak form inefficient, and they do not follow random walk process. So, the future movements of emerging markets and frontier markets are predictable and the investors can employ various technical analysis and fundamental analysis tools to gain profits from these markets.

Some of the previous studies found the developed markets as weak form efficient, for example, Tong et. al. (2014) found that the stock market of Australia exhibits weak form efficiency, Konak and Şeker (2014) revealed that the United Kingdom confirms EMH, Erdem and Ulucak (2016) show the presence of efficiency in the markets of G7 countries, and Yoon (2018) found weak form efficiency in South Korea. However, this study found only France, Japan and UK are weak form efficient.

In few studies, the results of different methods were contradicting, for example, (Li and Li, 2016) used runs test and variance ratio tests to check the efficiency and found mixed results and found different results from these two methods. Saeedi et. al (2014) also provided contradicting results from serial correlation, runs test and Augmented Dickey Fuller tests. Borges (2010) employed Runs test and variance ratio test for six European markets, namely, France, Germany, Greece, Portugal, Spain and UK and found mixed results, however, the author found that Germany to be more efficient compared to other markets. Worthington and Higgs (2006) employed serial correlation, unit root tests and variance ratio tests for ten emerging markets and five developed markets and found mixed results from these models. Camelia et. al(2017) tested the weak form efficiency in nine emerging markets and three developed markets by using entropy, runs test, and Hurst Exponent and found contrasting results. Variations in the results happen when different methods are employed to test efficiency. This contradiction echoes the past literature and highlights the potential reason for the paradox (Chancharat and Valadkhani, 2007).

Table 2. Results of Autocorrelation and Ljung-Box Tests for Developed Markets

Lag/ Market	Australia		Canada		France		Germany		Japan	
	ACF	LB test	ACF	LB test	ACF	LB test	ACF	LB test	ACF	LB test
1	-0.033	5.2476 (0.02198)	-0.014	0.95145 (0.3294)	-0.027	3.5987 (0.05782)	-0.015	0.98174 (0.3218)	-0.040	6.9353 (0.008451)
5	-0.002	14.007 (0.01557)	-0.065	29.751 (1.651e-05)	-0.063	44.139 (2.17e-08)	-0.060	21.933 (0.0005392)	-0.015	13.233 (0.02129)
10	0.003	20.063 (0.02866)	0.023	42.133 (7.102e-06)	-0.026	59.596 (4.322e-09)	-0.025	30.841 (0.0006234)	0.026	19.621 (0.03305)
Lag/ Market	**South Korea**		**Switzerland**		**UK**		**US**			
	ACF	LB test	ACF	LB test	ACF	LB test	ACF	LB test		
1	0.022	2.3113 (0.1284)	0.024	2.8084 (0.09377)	-0.042	8.6151 (0.003334)	-0.040	7.7963 (0.005235)		
5	-0.036	14.831 (0.01111)	-0.073	49.373 (1.862e-09)	-0.052	63.649 (2.136e-12)	-0.041	34.171 (2.202e-06)		
10	0.001	17.456 (0.06487)	-0.008	69.356 (5.904e-11)	-0.020	76.029 (2.999e-12)	0.012	41.597 (8.843e-06)		

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Table 3. Results of Autocorrelation and Ljung-Box Tests for Emerging Markets

Lag/ Market	Brazil		China		Egypt		India		Indonesia	
	ACF	LB test	ACF	LB test	ACF	LB test	ACF	LB test	ACF	LB test
1	0.004	0.091744 (0.762)	0.021	2.0835 (0.1489)	0.183	154.98 (<2.2e-16)	0.067	20.961 (4.687e-06)	0.102	48.673 (3.025e-12)
5	0.003	14.517 (0.01264)	-0.005	18.947 (0.001966)	0.009	168.02 (<2.2e-16)	-0.029	30.842 (1.006e-05)	-0.007	52.402 (4.462e-10)
10	0.026	23.07 (0.01049)	-0.003	35.032 (0.0001233)	0.030	181.88 (< 2.2e-16)	0.022	39.341 (2.212e-05)	0.014	60.765 (2.596e-09)
Lag/ Market	**Mexico**		**Russia**		**South Africa**		**Thailand**		**Turkey**	
	ACF	LB test	ACF	LB test	ACF	LB test	ACF	LB test	ACF	LB test
1	0.095	43.373 (4.524e-11)	0.039	7.1383 (0.007546)	0.023	2.4592 (0.1168)	0.033	5.1943 (0.02266)	0.006	0.17412 (0.6765)
5	-0.033	63.038 (2.858e-12)	0.015	16.259 (0.006142)	-0.044	28.852 (2.479e-05)	-0.002	21.256 (0.0007245)	-0.016	4.9057 (0.4275)
10	-0.008	69.81 (4.824e-11)	-0.020	21.799 (0.01616)	-0.011	34.674 (0.0001419)	0.038	37.943 (3.882e-05)	0.055	35.71 (9.44e-05)

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Table 4. Results of Autocorrelation and Ljung-Box Tests for Frontier Markets

Lag/ Market	**Argentina**		**Estonia**		**Kenya**		**Sri Lanka**		**Tunisia**	
	ACF	LB test	ACF	LB test	ACF	LB test	ACF	LB test	ACF	LB test
1	0.059	15.937 (6.547e-05)	0.140	89.429 (< 2.2e-16)	0.377	642.35 (< 2.2e-16)	0.176	133.52 (< 2.2e-16)	-0.140	87.305 (< 2.2e-16)
5	-0.025	23.893 (0.0002277)	0.052	123.38 (< 2.2e-16)	0.005	991.55 (< 2.2e-16)	0.008	146.24 (< 2.2e-16)	0.002	94.706 (< 2.2e-16)
10	0.013	35.654 (9.65e-05)	0.061	177.15 (< 2.2e-16)	0.016	1000.9 (< 2.2e-16)	0.031	158.68 (< 2.2e-16)	0.020	101.41 (<2.2e-16)

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Figure 1 (a). Correlograms for Returns of Developed Markets

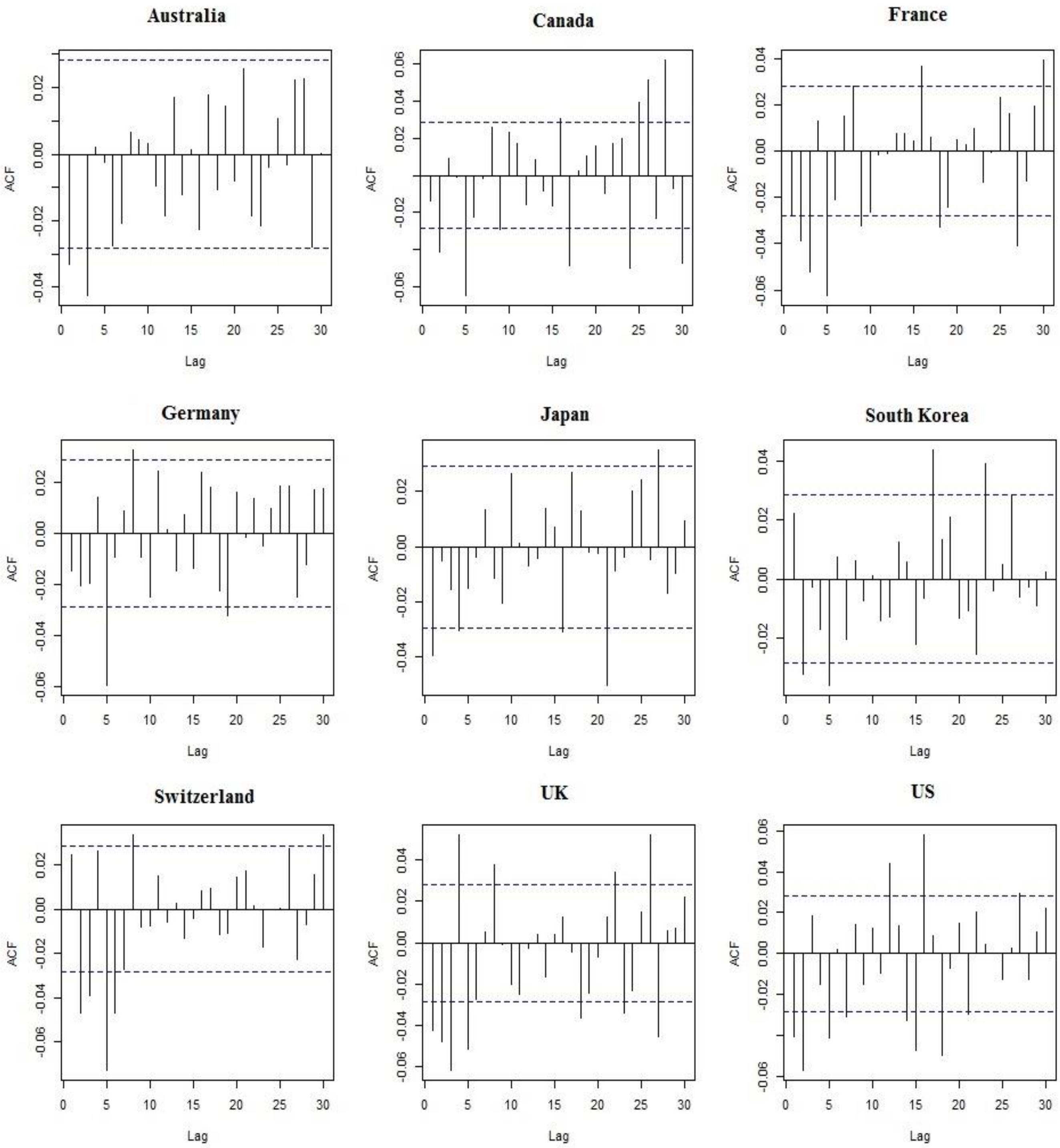

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Figure 1 (b). Correlograms for Returns of Emerging Markets

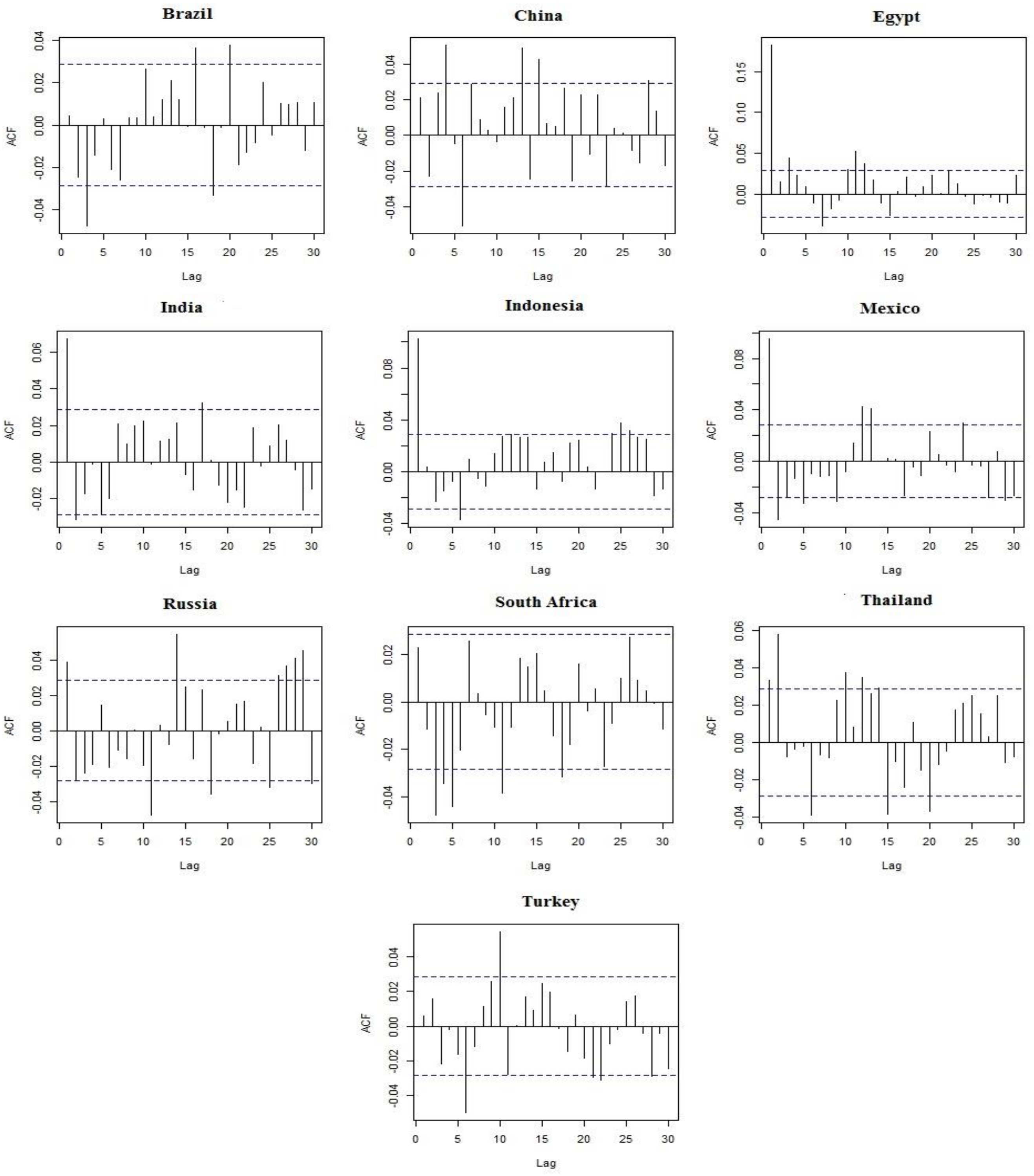

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Figure 1 (c). Correlograms for Returns of Frontier Markets

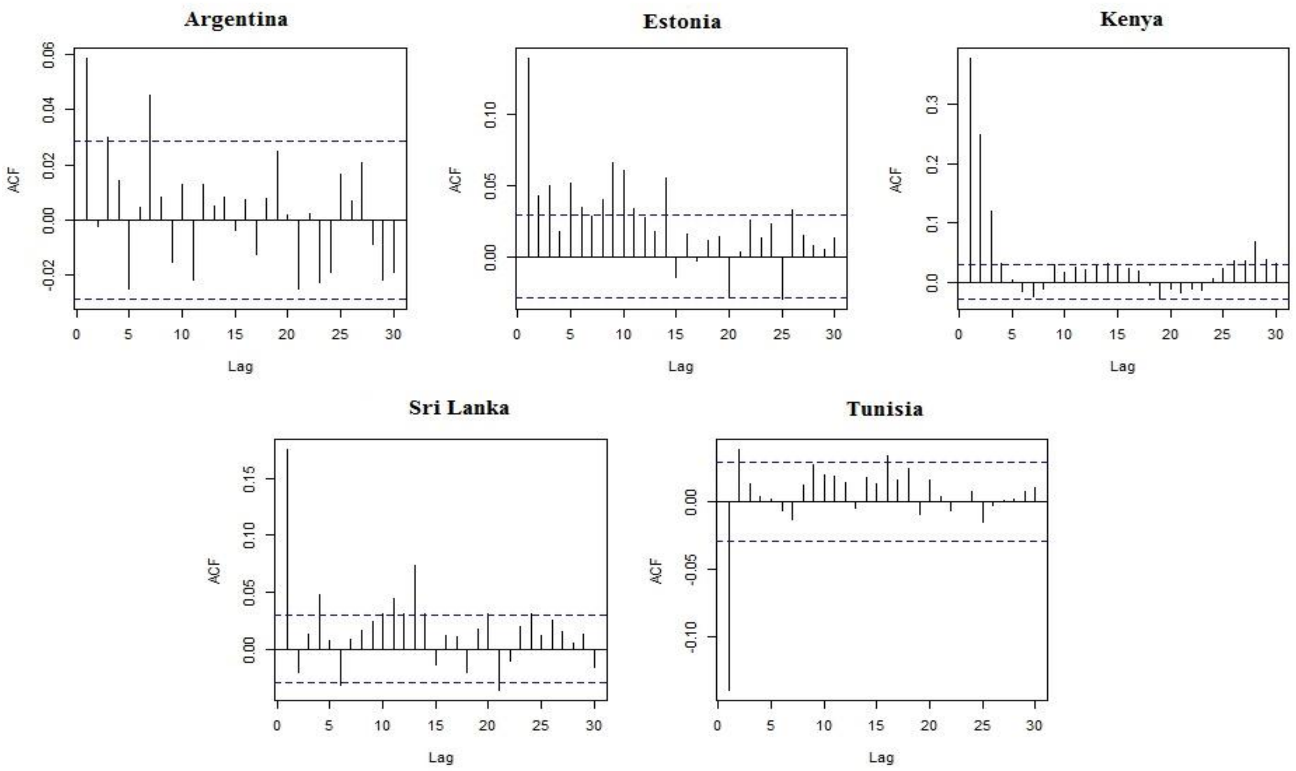

Table-5. Results of Runs Test and Hurst Exponent Tests:

	Country	Runs test	Hurst Exp
Developed Markets	Australia	1.5305 (0.1259)	0.5157518
	Canada	-0.28961 (0.7721)	0.5004794
	France	3.0139 (0.002579)	0.498682
	Germany	2.6026 (0.009251)	0.5312889
	Japan	1.9212 (0.05471)	0.4970536
	South Korea	0.29207 (0.7702)	0.525161
	Switzerland	0.57825 (0.5631)	0.5103696
	UK	1.3869 (0.1655)	0.4957245
	US	1.7073 (0.08777)	0.5387781
Emerging Markets	Brazil	0.79558 (0.4263)	0.538125
	China	-1.2679 (0.2048)	0.5577412
	Egypt	-8.0423 (8.815e-16)	0.5941458
	India	-3.788 (0.0001519)	0.5467232
	Indonesia	-1.9695 (0.04889)	0.5648068
	Mexico	-2.8063 (0.005011)	0.5447084
	Russia	-0.55142 (0.5813)	0.5256632
	South Africa	-1.7406 (0.08175)	0.5189259
	Thailand	-2.3178 (0.02046)	0.5324541
	Turkey	1.0143 (0.3104)	0.5160979
Frontier Markets	Argentina	-2.3496 (0.01879)	0.5209161
	Estonia	-5.0267 (4.99e-07)	0.6027237
	Kenya	-15.243 (2.2e-16)	0.632736
	Sri Lanka	-9.9703 (2.2e-16)	0.6012136
	Tunisia	-9.5994 (2.2e-16)	0.5975859

4. Summary and Conclusions:

Efficiency of stock markets is very important concept to be considered for investment strategies. Since Fama introduced the Efficient Market Hypothesis in 1970s, several studies have been conducted in testing market efficiency. From investors' point of view, this weak form inefficiency indicates that, one can forecast future movements of stock prices based on the historical data and different investment strategies can be developed to earn abnormal profits. In spite of extensive research, the debate on the efficiency of the stock markets has been continuing, because there are no uniform conclusions in all time periods of various stock markets. Here, we made an attempt to test the efficiency of developed, emerging and frontier stock markets around the world. We employed two parametric methods, viz. Autocorrelation functions and Ljung-Box tests and two non-parametric methods, namely Runs tests and Hurst Exponent tests by considering the daily returns from twenty-four stock indices from 01st January 2001 to 31st December 2018. This study reveals that all the markets, except three, namely, France, Japan and United Kingdom considered for the study are weak form inefficient and they do not follow random walk process.

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