TESTING THE RANDOM WALK HYPOTHESIS FOR EMERGING MARKETS: EVIDENCE FROM LINEAR AND NON-LINEAR UNIT ROOT TESTS

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Abstract

In this study, the random walk hypothesis for emerging markets has been tested. First of all, Harvey et. al. (2008) linearity test was made in this study where different time intervals were handled. ADF (1979) unit root test was made to the linear series in order to test the efficiency of the market based on the results of the linearity test and in stock exchanges in India and Russia where Brazil and China stock markets are not efficient, it was concluded that the efficient market hypothesis is valid. In addition, these results were supported by Kapetanios (2005) unit root test that allowed more than two breaks and structural breaks were endogenously. For non-linear series, Kapetanios, Shin and Snell (2003) (KSS) unit root tests were made and the efficient market hypothesis in Argentina, Indonesia, Mexico and Turkey is valid. In addition, it was found with the help of a time varying KSS unit root test which also takes the seasonal changes into account that activity at different periods for all markets was concerned but this efficiency was not valid at all periods for any market. This result supports the idea which was about the findings on the validity of the random walk hypothesis for many developing countries in previous studies that were not clear.

Keywords: Market Efficiency, Unit Root, Time Varying, Random Walk, Linearity

Jel Codes: G14, G15

1. Introduction

According to the efficient markets hypothesis, markets reflect all the information available to investors and their price fluctuations are not predictable (Markowitz, 1959, 1970; Samuelson, 1965). The price and returns of financial assests formed a basis in the formation of the concept of efficient markets. According to the efficient markets hypothesis, there are a large number of buyers and sellers in the stock market yet none of them can not affect share prices. All the information can be reached by every investor at the same costs (Alagidede and Panagiotidis, 2009) and the asymmetric information is not concerned in these markets. In addition, the operating costs are very low or zero (Saraç, 2013).

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However, some criticism in recent years has been made for the efficient market hypothesis. As it is known, many processes of trading in the markets have been made. The people that make these processes are not trained or experienced finance professionals (Peterson, 2012). This situation also brought the question about efficient market hypothesis with the new findings that detected the presence of anomalies and extreme volatility in the market (Dima and Miloş, 2009). According to the theory of behavioral finance, rational theories will not be sufficient in explaining investor behaviours and psychological and sociological factors should be taken into account that may affect the behaviours of individuals (Karan, 2011). These discussions about efficient markets require examination of the development of the markets.

A feature owned by a series in a long term may emerge with the determination of the affect of the previous variable. Although various methods have been developed in this regard, the most commonly used is unit root tests (Tarı, 2012: 386). If a serie has a unit root, a random walk hypothesis is meant to be valid for that series (Gujarati, 2011: 718).

2. Literature Review

In literature, market efficiency theory is tested by variance ratio test, run test, autocorrelation test, linear and non-linear unit root test.

The first study on behalf of the efficient markets hypothesis that was a fundamental and building block of finance was made by Fama (1970). It was concluded from the study where an American stock market was examined that the random walk hypothesis is valid.

Borges (2008) examined the six European country with the help of ADF unit root test in his study and found that the random walk hypothesis was valid in all stock exhanges according to the monthly data but according to the daily data, only France, Germany and Spain showed random walk behaviour. Hamid et al (2010) examined 14 Asia Pacific country in the study where ADF test was used and concluded that this hypothesis was invalid. Lucey and Segot (2005) used KPSS unit root test in their study where they handled MENA countries and concluded that efficient market hypothesis was valid for Turkey and Israel that gave directions to the region. Khan and Vieito (2012) that used that test again examined the efficiency of stock unification process and while the stocks were not efficient in Portugal before unification and they became efficient after unification. Cooray and Wickremasinghe (2007) examind the South Asian countries in their studies and found that all countries except for Bangladesh were efficient in a weak form.

Hasanov and Omay (2007) used the KSS unit root test in their study that was non-linear. It was concluded from the study where 8 of developing European countries were examined that Bulgaria, Czech Republic, Slovakia and Hungary stock markets were efficient in a weak form. In addition, Karadağlı and Omay (2012) supported the analysis made for the same countries with non-linear panel unit root

test of Uçar-Omay (2009). Tan et. al. (2010) implemented the non-linear threshold unit root test to India, Pakistan and Sri Lanka. As a result of the study, it was concluded that this stock market was efficient not at all times but in certain periods. Özcan and Yılancı (2009) used BDS and KSS unit root tests in their studies where ISE was examined and reached a finding that random walk hypothesis was not valid for Turkey market. Lim et. al. (2008) used non-linear Hinich bi-correlation test (1996) in the study where they examined 10 Asian countries and concluded that the price mobility can be estimated. In another study on the Romaian stock market that is one of the developing countries. Dima et. al. (2007) concluded that the random walk hypothesis is valid.

Kim and Shamsuddin (2008) examined Asian countries and used the variance ratio test and concluded that market efficiency is related to the stage of development. In another study that examined the market efficiency with variance ratio test, Charles and Darne (2009) examined the Chinese stock markets and concluded that the markets with A type shares were more effective compared with the markets with B type shares. Hague et. al. (2011) examined the Pakistan stock markets and concluded that the random walk hypothesis showed no compliance. Hassan and Chowdhury (2008) examined Bangladesh markets in their studies and concluded that efficient market hypothesis is valid. Onour (2007) examined Sudan markets, Prinpong and Abayie (2007) examined Ghana markets and concluded that random walk hypothesis is not valid in both markets. Joshi and Bahadur (2005) examined Nepal markets and concluded that the markets in African countries are not efficient to support these findings.

In the study, Sasdharan examined (2009) the India stock market and seperated the 1991-2008 period to 4 depending on the political developments and analyzed them seperately. As a result of the run test, only the markets between 2003-2006 were efficient. Similarly, Emenike (2008) seperated 1985-2007 period for Nigerian market to 3 depending on political regimes but identified that markets were not efficient in any period.

As can be seen, so many studies were made about financial markets but there never occurred a judgment about the validity of random walk hypothesis. This study, unlike other studies never classified the series as they are linear or not linear. The linearity of the series were determined according to Harvey et. al. (2008) linerarity test. Following this conclusion, ADF (1979) for the series of linear countries and Kapetanios (2005) unit root tests for taking into account the structural breaks and KSS (2003) unit root test for non-linear series were used. In addition, in order to obtain more detailed results and to take structural breaks into account for the series that are non-linear, time-varying KSS unit root test was used.

3. Model

Kapetanios (2005), Zivot Andrews (1992) and Lumsdaine-Papell (1997) tests were developed and despite the unit root basic hypothesis, a new test that tests the hypothesis of stability of m refraction was developed. Thanks to this test,

determining a priori constraint of a break was eliminated. The researcher will determine the maximum breaking number with this test and the appropriate number of fracture will be determined endogenously. The model used in this test is as the following:

$$y_t = \mu_0 + \mu_1 t + \alpha y_{t-1} + \sum_{i=1}^{k} \gamma_i \Delta y_{t-i} + \sum_{i=1}^{m} \phi_i \mathrm{DU}_{i,t} + \sum_{i=1}^{m} \psi_i \mathrm{DT}_{i,t} + \epsilon_t$$

$$\mathrm{DU}_{i,t} = 1(t > T_{b,i}), \quad \mathrm{DT}_{i,t} = 1(t > T_{b,i})(t - T_{b,i})$$

Here, the basic hypothesis states that serie is unit rooted and alternative hypothesis states that serie is stationary.

$$\mathrm{H0}: \alpha = 1$$
$$\mathrm{H1}: \alpha: < 1$$

First of all the single fraction is sought during the whole sample for a given number of first breaking in the operation of this test and t statistics of α=1 hypothesis are obtained. Then, the minimum residual sum of square's the date of structural break on the model selected and the model is estimated by adding the date of the first break, the remaining parts of the second structural break between the date is required. T statistics are obtained for α=1 and the date of structural break is found by obtaining the minimum residual sum of squares. Finally, m is continued until getting the number of break. The appropriate break number is the number that gives minimum t statistic.

$$\mathrm{SSR} = \sum_{t=k+2}^{T} \left(y_t - \hat{\mu}_0 - \hat{\mu}_1 t + \hat{\alpha} y_{t-1} + \sum_{i=1}^{k} \hat{\gamma}_i \Delta y_{t-i} + \hat{\phi}_1 \mathrm{DU}_{1,t} + \hat{\psi}_1 \mathrm{DT}_{1,t} \right)^2$$

Star (1) model used for non-linear series can be indicated as follows:

$$\Theta(\theta;\ \mathrm{yt} - \mathrm{d}) \ = \ 1 - \exp(-\theta \mathrm{y2t} - \mathrm{d})$$
$$\mathrm{Yt} \ = \ \beta \mathrm{y} - 1 \ + \ \Upsilon \mathrm{yt} - 1 \Theta(\theta;\ \mathrm{yt} - \mathrm{d}) \ + \ \xi \mathrm{\Epsilon t}$$

Subsituting the exponential function in the model

$$\Delta \mathrm{yt} = {}^{\Phi}\mathrm{yt} - 1 + \Upsilon \mathrm{yt} - 1[1 - \exp(-\theta \mathrm{y2t} - \mathrm{d}) \ + \ \mathrm{\Epsilon t}$$

this model with constraints; Φ = 0 ve d = 1

$$\Delta \mathrm{yt} = {}^{\Phi}\mathrm{yt} - 1\,\{1 - \exp((-\theta \mathrm{y2t} - 1) \ + \ \mathrm{\Epsilon t}$$

Here are the basic unit of the series long-established hypothesis, the alternative hypothesis states that the series is stationary. This is an exponential transition autoregressive process. It is consistent with a stationary ESTAR process.

$$\mathrm{H0}: \theta \ = \ 0$$
$$\mathrm{H1}: \theta < \ 0$$

Despite unit root basic hypothesis, Kapetanios, Shin and Snell (2003) (KSS) unit root test serves to testing a non-linear process. This test is carried out for the entire range of observation. But sometimes, some of the periods of the examined series are stationary and some of the periods may have showed unit rooted behaviour. In such cases, the current KSS test results may be wrong and in order to analyze this situation, there is a need to use techniques that vary over time.

In order to perform time-varying KSS unit root test, a sample size up to n is selected. KSS unit root test is applied from the 1st element to nth element. In the second phase, KSS test is applied from 2nd element to n+1st element and this process is continued until the last element. All samples obtained after the application of test statistic is made is divided to a critical value that is %10 (-2.66) normally distributed and the obtained information is indicated in the chart. The values above the "1" line show the periods that are stationary and the values below show the periods that are not stable (Yılancı, 2013).

4. Data

In this study, ten of the developing countries in 2012 were discussed by IMF. 8 of them were expressed as the newly industrialized countries in 2011 (IMF, 2011). We could not reach the data that are equal so the number of observations with their start date and daily data are listed in the table below.

These data were obtained from www.ukfinance.yahoo.com address. Logarithmic transformations were taken before data were being inserted into the analysis.

Table 1: Data

Market	Date	Observation	Market	Date	Observation
Argentina	October-1996	4139	**India**	July-1997	3973
Brazil	April-1993	5010	**Mexico**	November-1991	5430
China	December-1990	5800	**Malaysia**	December-1993	4848
Indonesia	July-1997	3907	**Turkey**	January-1988	10992
Philippines	January-2000	3188	**Russia**	September-1995	4547

Instead of the series are analyzed as linear or non-linear, determining the linearities with linearity test is more appropriate approach. In this context, the results of Harvey et. al. Linearity Test (2008) in Table 2 are seen.

5. Empirical Results

Table 2: Results of Harvey et. al. Linearity Test

Market		Critical Values			Results
	W-Lam	%1	% 5	% 10	
Argentina	22.83	15.95	16.49	17.49	Non-Linear
Brazil	28.25	33.50	33.91	34.64	Linear
China	25.53	40.08	40.34	40.80	Linear
Indonesia	10.00	9.85	9.89	9.98	Non-Linear
Philippines	178.73	144.62	146.71	150.51	Non-Linear
India	2.79	11.07	11.36	1.88	Linear
Mexico	29.58	18.52	19.01	19.92	Non-Linear
Malaysia	704.27	372.44	386.10	411.59	Non-Linear
Turkey	50.18	0.01	0.02	0.04	Non-Linear
Russia	1.43	6.96	7.03	7.15	Linear

According to the Harvey Linearity test results, According to the test results, Brazil, China, India and Russia are linear stock markets and Argentina, Indonesia, the Philippines, Mexico, Malaysia and Turkey stock markets are not linear.

Table 3: Results of ADF Unit Root Test

	T Statistics (Intercept)	T Statistics (Trend and Intercept)
Brazil	-6.10 (0.00)	-6.82(0.00)
China	-3.28(0.015)	-3.48(0.04)
India	-0.49(0.89)*	-2.40(0.37)*
Russia	-1.83(0.36)*	-2.38(0.38)*

Here, the structure of which is a stationary random walk hypothesis of stock markets in Brazil and China is not valid and random walk hypothesis is valid in India and Russia stock markets with its rooted united structure. Furthermore, these results and structural breaks are determined as internal and was supported by Kapetanios (2005) unit root test. These results are shown in Table 4. Brazil and China are seen stable in every break, but India is unit rooted in all break, Russia is unit rooted in 1-2 break. Where in the nature of the Kapetanios test, 1 break is selected that is the smallest value of t and therefore the random walk hypothesis is valid for India Stock Market.

Table 4: Results of Kapetanios Unit Root Test

Breaks	Brazil	China	India	Russia
5	-8.73	-8.64	-6.87*	-8.84
4	-7.97	-8.38	-6.41*	-8.33
3	-7.46	-7.54	-5.50*	-7.91
2	-7.30	-7.29	-4.87*	-5.75*
1	-6.64	-5.68	-3.15*	-3.74*

Note: Critical Values are -8.34 for 5 breaks, -7.73 for 4 breaks, -7.00 for 3 breaks, -6.11 for 2 breaks, -5.08 for 1 break in 5% meaningfulness and taken from study of Kapetanios (2005) named "Unit-Root Testing Against The Alternative Hypothesis Of Up To M Structural Breaks"

When the KSS unit root test results in Table 5 are examined; Argentina, Indonesia, Mexico and Turkey stock markets are efficient in both stable and trend, Philippines stock market is not efficient in stable form but efficient in trend form.

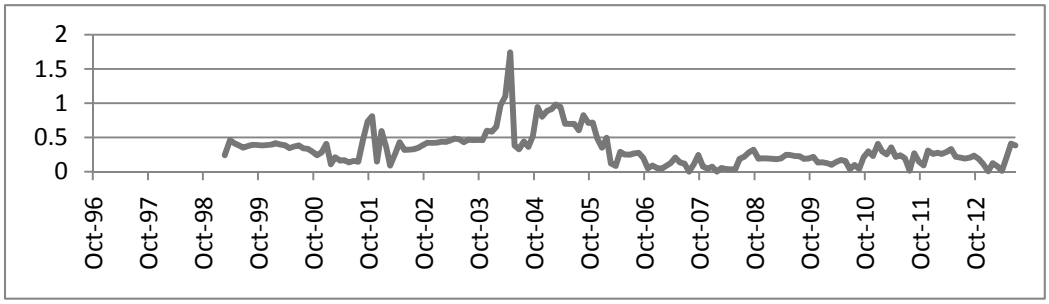
Table 5: Results of KSS Unit Root Test

	T Statistics (Intercept)	T Statistics (Trend and Intercept)
Argentina	-1.96*	-1.96*
Indonesia	-1.74*	2.09*
Philippines	2.73	2.74*
Mexico	2.11*	2.11*
Malaysia	3.62	3.67
Turkey	-1.71*	-1.76*

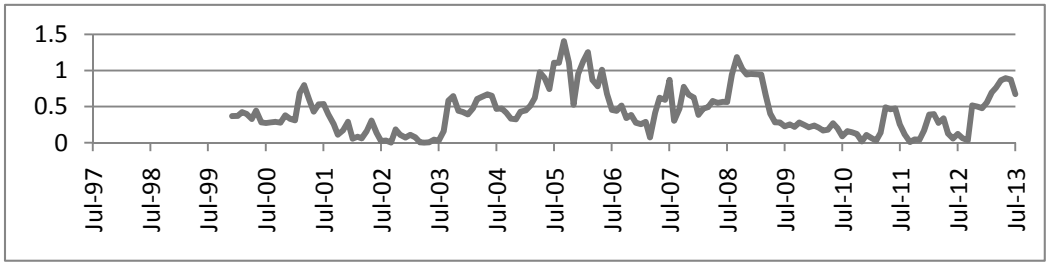
Note: Asymptotic critical values for the KSS test statistics at 1%, 5%, and 10% significance levels are 3.48, 2.93, and 2.66 for the test with intercept only, and 3.93, 3.40, and 3.13 for the test with intercept and trend, respectively. The critical values are taken from Table 1, Kapetanios et al. (2003, pp. 364).

Figure 1: Results of Time Varying KSS Unit Root Test

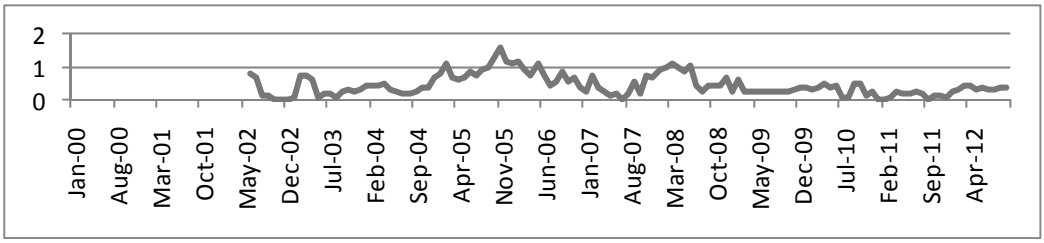
Argentina



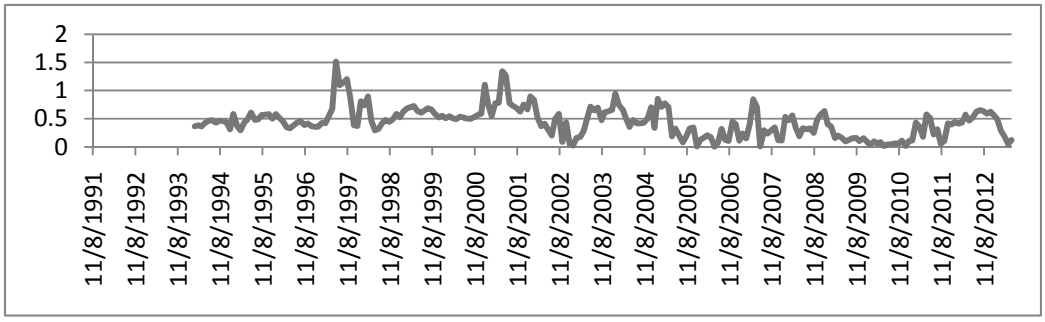
Indonesia



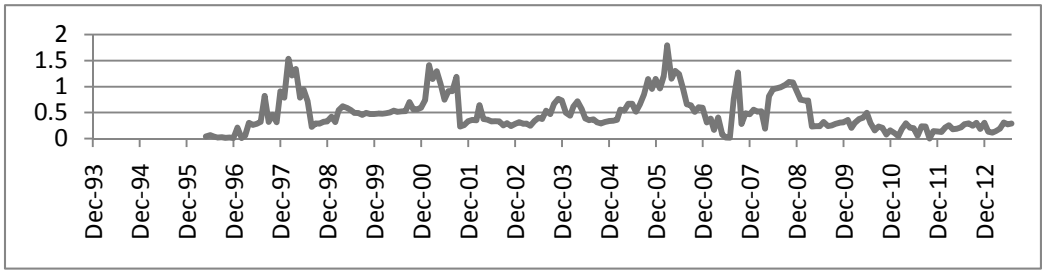
Philippines



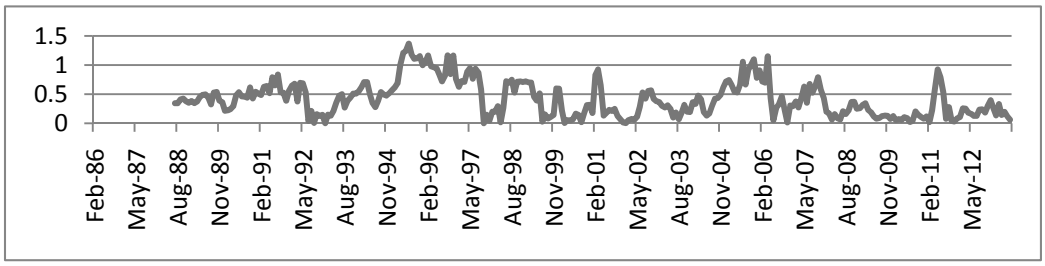
Mexico



Malaysia



Turkey



In terms of time-varying KSS unit root test results, the entire series are efficient in some quarters, but this situation is reflected in all periods. Also in support of KSS unit root test results, Malaysian stock exchange chart "1" on the line is greater than the observed periods of other exchanges.

6. Conclusion

In this study, developing countries, Argentina, Brazil, China, Indonesia, the Philippines, India, Mexico, Malaysia, Turkey, Russia and stationaryties exchanges through various unit root tests and the random walk hypothesis is examined and the current is detected by the stock exchanges. In order to achieve this goal, Harvey et al. (2008) developed by the help of the linearity test, determined whether series are linear. Then, the linear series ADF (1979), and as it determines endogenously structural breaks Kapetanios (2005) unit root tests, the non-linear series of KSS (2003) unit root and structural break-out, in a similar manner to take into account the effects of seasonal unit root tests are applied taking into account the time-varying KSS tests.

According to the ADF unit root test results, India and Russia stock markets are seen as efficient from linear series and Brazil and China stock markets are not efficient. These results were supported by Kapetanios (2005) unit test results. Argentina, Indonesia, Mexico and Turkey's stock markets are efficient and Philippines and Malaysia stock markets are not efficient as can be seen from non-linear series.

These results are supported by several studies in the literature but they are not supported by other studies. At this point, the different periods can give different results for the random walk hypothesis and the structural breaks have an importance. Compared to the studies in the literature for this purpose; the study allocated to the operation of the stock market examined by Khan and Vieto (2012) and the study of Tan et al (2010) and the study of Sasidharan (2009), examined four different periods according to the political events show that the efficient market hypothesis gives different results in different periods. These findings support the results of our time-varying KSS unit root test. In conclusion, technical analysis for the prediction of the future price of all stock exchanges will be useful not in all periods but only in some periods.

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