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Are the Eastern European Markets Efficient? Evidence from Nonlinear Unit Root Tests

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Abstract

The efficient market hypothesis, a topic discussed for over a half century, has been tested with different econometric models in the literature.Linear and non-linear series have to be tested with different unit root tests.In this study, ADF and PP unit root tests are applied to linear series and Kapetanios et al. (2003) and Kruse (2011) unit root tests were applied to nonlinear series.In our study, Poland and Russia showed linear characteristics and Turkey, Czech Republic and Hungary showed nonlinear characteristics. Linear and nonlinear unit root tests have been used in this regard. According to the analysis results, other Eastern European countries included in the sample outside Turkey exhibit a weak-form efficiency characteristic

Keywords: Efficient Market Hypothesis, Eastern European Markets, Unit Root Test, Nonlinearity

Introduction

Efficient market hypothesis (EMH) is one of the topics discussed frequently in the finance literature and not yet on consensus. According to this hypothesis put forward by Fama (1970), there are 3 types of information in the market; Past price information, publicly disclosed information and insider trading. The hypothesis deals with the fact that whether the investor with this knowledge is making a return above the normal. According to information types, markets are classified in 3 types of activity level. If an investor with past price information can not obtain a return above normal using this information, then the market is considered weak-form efficiency. If there is no return above normal with the help of past price and information made publicly available, it is considered to be semi-strong form of efficiency. Lastly, it is considered as strong form efficiency if an investor with past price, publicly disclosed and insider information cannot obtain a return above normal.

The effectiveness of the markets is especially important for policy makers, investors and academicians.. When financial depth and the impact of financial development on economic

growth is considered,especially in developing countries, market activity becomes even more important. In this context, it will be examined whether the markets of Turkey, Czech Republic, Hungary, Poland and Russia of emerging Eastern European countries are weak-form efficiency.

Literature

In the literature, frequently the efficiency of a market is investigated by testing the random walk hypothesis. The type of efficient mentioned here is weak-form efficiency. According to this, if a series follows the random walk, then that series is called weak-form efficiency. The random walk hypothesis is tested with the runs test (Balaban, 1995; Tas and Dursunoglu, 2005) and often with the unit root tests (Muradoglu and Metin, 1996; Kasman and Kırkulak, 2007; Özdemir, 2008; Ergül, 2009; Duman Atan et al., 2009; Gozbasi et. al., 2014; Kılıç and Buğan, 2016).

When studies of EMH are examined, it seems that there is not yet a consensus on this issue. While some studies have found evidence of EMH (Kan and O'Callaghan, 2007;Ergül, 2009; Aga and Kocaman, 2011; Gozbasi et al., 2014), others have reached findings against EMH (Lo and MacKinlay, 1988; Çevik and Erdoğan, 2009; Çevik, 2012; Kılıç and Buğan, 2016). The differences in findings related to EMH can be caused by different reasons such as different methods applied, different frequency of data and different date ranges. Table 1 contains detailed information on some of the works.

Table 1
Literature summary of EMH in Turkish Stock Market

Study	Data	Tests used	Series	Validity of EMH
Balaban (1995)	January 4, 1988-August 5,1994 (daily)	Runs test	ISE composite index	Reject
Muradoglu and Metin (1996)	January, 1986-December, 1993 (monthly)	ADF unit root test Engle-Granger and Johansen tests	ISE composite index	Reject
Antoniou et al. (1997)	1988-1993 (daily)	Logistic map	ISE composite index	Reject 1988-1990 period Accept for the 1991-1993 period
Balaban and Kunter (1999)	January, 1989-July, 1995 (daily)	Granger causality tests	ISE composite index, Foreign exchange market and interbank money market	Reject
Müslümov et al. (2003)	1990-2002 (monthly)	GARCH	ISE100 index	Reject

Tas and Dursunoglu (2005)	January, 1995-January, 2004 (daily)	ADF unit root test Runs test	ISE30 index	Reject
Kasman and Kırkulak (2007)	1988-2007 (weekly)	ADF and KPSS unit root tests ZA and LP unit root tests GPH fractional integration test	ISE100, ISE30, service, industrial, financial and other sub-sector indexes	Accept
Özdemir (2008)	January 2, 1990-June 14, 2005 (weekly)	LP two structural breaks unit root test ADF unit root, Runs test Variance ratio test	ISE100 index	Accept
Çevik and Erdoğan (2009)	2003-2007 (weekly)	Bai and Perron Multiple Structural Break Test; Geweke and Porter-Hudak Fractional Integration Test;MLP	ISE, banking sector	Reject
Ergül (2009)	1988-2007 (daily)	ADF and PP unit root tests	ISE100, ISE50, ISE30 indexes, ISE service incex, ISE financial index, ISE industrial index	Accept
Duman Atan et al. (2009)	January 3, 2003-December 30, 2005 (15 minutes/daily)	ADF and KPSS unit root tests ELW	ISE100 index	Accept
Karacaer et al. (2010)	May 30, 2005-May 30,2008 (daily)	OLS regression	ISE100 index	Reject
Aga and Kocaman (2011)	January, 1996-November, 2005 (monthly)	OLS regression	ISE-20 index developed by Aga and Kocaman (2006)	Accept
Çevik (2012)	January 3, 1997-May 27, 2011 (daily)	FIGARCH, Modified Log-Periodogram (MLP), Exact Local Whittle ADF, PP and KPSS unit root tests	ISE, 10 sub-sectors	Reject
Gozbasi et. al. (2014)	July 1, 2002-July 7, 2012 (daily)	Kruse unit root test	ISE composite index, ISE industrial and financial indexes	Accept
Kılıç and Buğan (2016)	January 2, 2003-	Nonlinear unit root tests	SE30, ISE50, ISE100 and ISE Composite indices	Reject

	September 30, 2015 (daily)

Source: Kılıç and Buğan (2016;269).

Data

In this study, it is aimed to examine the effectiveness of the markets of Eastern Europe, Turkey, Czech Republic, Hungary, Poland and Russia in weak effective form. Country indexes of Morgan Stanley Capital Investment (MSCI) are used to represent the country's stock markets. The analysis period was selected between 03/06/2002-31/05/2016 and the daily closing prices of the indexes were obtained from MSCI-Barra web address. Analyzes were made by taking the natural logarithm of the series. Graphs of price indices are given in Figure 1.

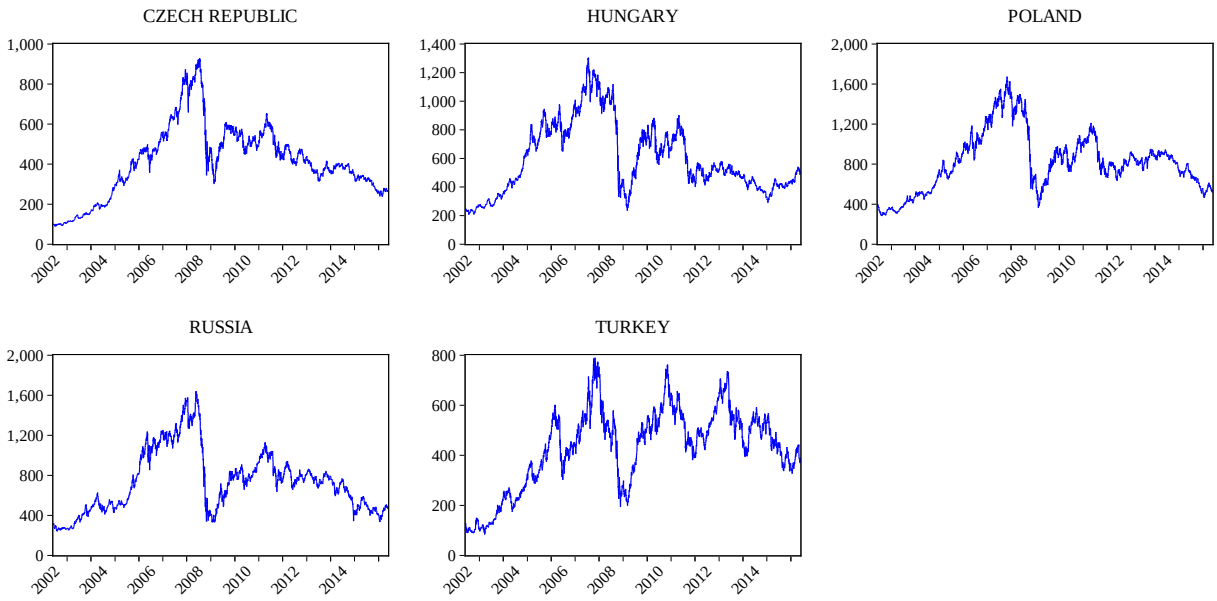

Figure 1. Price Series of Country Indices

Looking at Figure 1, the effects of the 2008 global financial crisis are seen in all countries involved in the analysis. Moreover, the effect of 2012 European debt crisis seems less when compared to 2008 crisis. It is also clear that other country markets analyzed in the scope of analysis outside Turkey can not keep up with the pre-crisis period. However, it is understood that the highest market for volatility is also Turkey's market. The daily returns of the indices are calculated by the formula $R_t = 100 \times \ln(P_t / P_{t-1})$ and the descriptive statistics are given in Table 2.

Table 2
Descriptive Statistics of Return Series

	Mean	Stand. Dev.	Max.	Min.
TURKEY	0.0305	2.4608	16.1584	-17.3429
CZECH REPUBLIC	0.0052	0.2953	3.3071	-2.6875
HUNGARY	0.0032	0.3580	3.3653	-3.2149
POLAND	0.0011	0.2979	2.2020	-2.0574
RUSSIA	0.0019	0.3733	3.5960	-3.9784

When Table 2 is examined, it is seen that the return is positive in all countries. It is seen that the market with the highest return is the Turkish market (3.05%). The lowest return belongs to Poland market (0.11%). Again, the highest volatility in terms of historical volatility is seen in the Turkish market and the lowest volatility in the Czech Republic markets. When the maximum and minimum returns are examined, it is understood that the highest variance belongs to the Turkish market.

Testing Methods[1]

Harvey et al (2008) Linearity Test

Linearity tests like Luukkonen et al (1988); Teräsvirta (1994) are based on the assumption that the series are stationary. However, when the series are nonlinear, the test loses power. Therefore, in non-stationary series, linearity tests are utilized to determine which unit root tests are to be made use of (Yavuz and Yilanci, 2012). In the current study, Harvey et al. (2008), which is a strong linearity test, was used.

Harvey et al (2008) developed the following model for when the stationary levels of the series is I(0):

$$y_t = \beta_0 + \beta_1 y_{t-1} + \beta_2 y_{t-1}^2 + \beta_3 y_{t-1}^3 + \sum_{j=1}^{p} \beta_{4,j} \Delta y_{t-j} + \varepsilon_t \qquad (1)$$

The null and alternative hypotheses for the Equation (1) are as follows:

$$H_{0,0}: \beta_2 = \beta_3 = 0$$

$$H_{1,0}: \beta_2 \neq 0 / \beta_3 \neq 0$$

In this case, the Wald statistic will be calculated in the following way:

$$W_0 = T(RSS_0^r / RSS_0^u - 1)$$

where RSS_0^r and RSS_0^u denote, respectively, the residual sums of squares from the unrestricted OLS regression (1).

When the series are I(1):

$$\Delta y_t = \lambda_1 \Delta y_{t-1} + \lambda_2 (\Delta y_{t-1})^2 + \lambda_3 (\Delta y_{t-1})^3 + \sum_{j=2}^{p} \lambda_{4,j} \Delta y_{t-j} + \varepsilon_t \qquad (2)$$

The null and alternative hypotheses for the Equation (2) are as follows:

$$H_{0,1}: \lambda_2 = \lambda_3 = 0$$

$$H_{1,1}: \lambda_2 \neq 0 / \lambda_3 \neq 0$$

[1] Information in this part is get from the Kılıç and Buğan (2016).

In this case, the Wald statistic will be calculated in the following way:

$$W_1 = T(RSS_1^r / RSS_1^u - 1)$$

Where RSS_0^r and RSS_0^u denote, respectively, the residual sums of squares from the unrestricted OLS regression (2).

If the stationary levels of series are I(0), W0 will be used; if series have a unit root I(1) then W1 will be used. But, when it is not known that series are stationary or not, W_λ, a weighted average statistic will be used;

$$W_\lambda = \{1-\lambda\}W_0 + \lambda W_1 \quad (3)$$

In this study, W_λ statistics regarding the indices were calculated. The findings are displayed in Table 3.

Table 3
Linearity Test Results

	W_λ	W 10%	W 5%	W 1%
TURKEY	42.37***	32.50	32.73	33.14
CZECH REPUBLIC	5.56***	5.42	5.45	5.50
HUNGARY	18.24**	18.10	18.20	18.40
POLAND	2.60	2.73	2.75	2.78
RUSSIA	0.28	0.58	0.59	0.59

*** and ** indicates 1% and 5% significance level.

As can be observed in Table 3, Turkey, Czech Republic and Hungary markets are nonlinear, Poland and Russia are linear. Therefore, the linear unit root tests will be applied for Poland and Russia indices and the nonlinear unit root tests will be applied for Turkey, Czech Republic and Hungary indices.

Kapetanios et al (2003) Non-linear Unit Root Test

Kapetanios et al. (2003) improved a unit root test which of the null of a unit root process against an alternative of a nonlinear exponential smooth transition autoregressive (ESTAR) process. Kapetanios et al (2003), proposed ESTAR model;

$$\Delta y_t = \alpha y_{t-1} + \phi y_{t-1}(1-\exp\{-\gamma(y_{t-1}-c)^2\}) + \varepsilon_t \quad (4)$$

where ε_t ~ iid(0,σ^2). Under restriction a=0;

$$\Delta y_t = \phi y_{t-1}(1-\exp\{-\gamma(y_{t-1}-c)^2\}) + \varepsilon_t \quad (5)$$

under restriction c=0;

$$\Delta y_t = \phi y_{t-1}(1-\exp\{-\gamma y_{t-1}^2\}) + \varepsilon_t \quad (6)$$

auxiliary regression;

$$\Delta y_t = \beta_1 y_{t-1}^3 + u_t \quad (7)$$

Kapetanios et al. (2003) developed their null ($H_0 : \beta_1 = 0$) and alternative ($H_1 : \beta_1 < 0$) hypotheses with Dickey-Fuller type t-test in the name KSS as follows;

$$KSS \Rightarrow \frac{1/4W(1)^4 - 3/2\int_0^1 W(r)^2 dr}{(\int_0^1 W(r)^6)^{1/2}} \quad (8)$$

Kruse (2011) Non-linear Unit Root Test

Kapetanios et al. (2003) assume the location parameter (c) in the smooth transition function is equal to zero. However, in the empirical studies conducted, it was found out that it is really difficult for the parameter (c) to be equal to zero in financial and economic series (Kruse, 2011; Michael et al., 1997; Rapach and Wohar, 2006; Sarantis, 1999; Taylor et al., 2001; Gozbasi et al., 2014).

In order to allow for a nonzero location parameter c in the exponential transition function, Kruse (2011) consider the nonlinear model;

$$\Delta y_t = \beta_1 y_{t-1}^3 + \beta_2 y_{t-1}^2 + \beta_3 y_{t-1} + u_t \quad (8)$$

to improve the power of the test, the author imposed β_3 =0;

$$\Delta y_t = \beta_1 y_{t-1}^3 + \beta_2 y_{t-1}^2 + u_t \quad (9)$$

where $\beta_1 = \gamma\phi$ and $\beta_2 = -2c\gamma\phi$. Pair of hypothesis given by $H_0 : \gamma = 0$ (in the test regression 9; $H_0 : \beta_1 = \beta_2 = 0$) against $H_1 : \gamma > 0$ (in the test regression 9; $H_1 : \beta_1 < 0, \beta_2 \neq 0$). After applying a standard Wald test by the method of Abadir and Distaso (2007), the test statistic which is the new test statistic for the unit root hypothesis against globally stationary ESTAR could be shown simply as;

$$\tau = t^2_{\beta_2 | \beta_1 = 0} + 1(\hat{\beta} < 0) t^2_{\beta_1 = 0} \quad (10)$$

Findings

According to the results of linearity test, Poland and Russia were found to be linear, Turkey, while Czech Republic and Hungary were nonlinear. For the test of the random walk hypothesis, ADF and PP unit root tests were applied to the linear series whereas the Kapetanios et al (2003); Kruse (2011) unit root tests were applied to nonlinear series. The applied unit root test results are given in Table 4 and Table 5.

Table 4
Linear Unit Root Tests Results

	None		Intercept		Trend and Intercept	
	ADF	PP	ADF	PP	ADF	PP
POLAND	0.1079	0.1065	-1.9166	-1.8734	-1.5478	-1.4953
RUSSIA	0.1430	0.1650	-2.1441	-2.0096	-1.9381	-1.7796
Critical Values						
1%	-2.5656		-3.4320		-3.9606	
5%	-1.9409		-2.8621		-3.4110	
10%	-1.6166		-2.5671		-3.1273	

Note: Critical values are represent MacKinnon (1996) one-sided p-values.
When Table 4 is examined, it can be seen that each 3 models of both unit root tests of Poland and Russia are not stable at the level value. This can be regarded as proof of the random walking hypothesis in the series. Therefore, it can be said that Poland and Russia are active in weak effective form for the markets.

Table 5
Nonlinear Unit Root Tests Results

		KSS			τ		
	Lags	Log-level series	Demeaned series	Demeaned & detrended series	Log-level series	Demeaned series	Demeaned & detrended series
TURKEY	1	1.56	-2.56	-1.56	20.37***	8.12	2.81
	2	1.54	-2.52	-1.57	19.93***	7.86	2.86
	3	1.55	-2.55	-1.56	20.19***	8.01	2.83
CZECH REPUBLIC	1	0.26	-1.77	-1.52	7.22	3.29	2.31
	2	0.32	-1.84	-1.51	7.43	3.45	2.27
	3	0.36	-1.90	-1.51	7.68	3.66	2.28
HUNGARY	1	0.04	-1.99	-1.99	5.06	4.01	3.98
	2	0.08	-1.94	-1.94	4.82	3.80	3.77
	3	0.09	-1.93	-1.93	4.78	3.77	3.74
Critical Values							
1%		-2.82	-3.48	-3.93	13.15	13.75	17.10
5%		-2.22	-2.93	-3.40	9.53	10.17	12.82
10%		-1.92	-2.66	-3.13	7.85	8.60	11.10

*** indicates 1% significance level
Note; Critical values obtained from Kapetanios et al. (2003) and Kruse (2011).

According to Table 5, Turkey is not stationary with respect to each of the 3 unit root tests of Kapetanios et al. (2003), while having a unit root according to the first model of the unit root test of Kruse (2011). Therefore, the random walk hypothesis for Turkey is rejected according to Kruse (2011) test, which is a stronger test. These findings show that the Turkish market is not active in weak effective form. The Czech Republic and Hungary markets are also non-stationary with respect to each of the 3 unit root tests. Therefore, there is a weak effective form of activity for these markets.

Conclusion

According to Efficient market hypothesis, it is assumed that a new information on the market reaches all investors at the same time. In this way, new information coming to the market will be reflected in prices and investors will not be able to get a return above normal. The subject of EMH, which is one of the most frequently used topics in the literature, is still a mystery. In academic studies, the data set differs according to the frequency and scope of the data set, and the way in which these methods are applied leads to this situation.

In this study, the efficient market hypothesis was tested in developing eastern European market. In this context, MSCI's country stock market indices are used. When the stock index indices are examined, it is seen that the market with the highest returns and volatility is the Turkish market. It has been studied whether the series show linearity in terms of applying the correct method at the essence of the test of the random walk hypothesis. In line with this, the linearity of the series was tested by Harvey (2008) linearity test. As a result of the linearity test, Poland and Russia showed linear characteristics and Turkey, Czech Republic and Hungary showed nonlinearity. Linear and nonlinear unit root tests have been used accordingly. According to the analysis results, other Eastern European countries included in the sample outside Turkey exhibit a weak-form efficiency characteristic.

The scope and frequency of the data set used in this study have been kept as wide as possible and attention has been paid to the strength of the method used. As a sample, developing eastern european countries have been selected. In subsequent studies, the effectiveness of other developing country markets can be examined. In addition, the sample in this study can be applied with different methods and the results can be compared.

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