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The Efficient Market Hypothesis: Evidence from Turkey

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Abstract
This paper investigates the Efficient Market Hypothesis (EMH) for ISE30, ISE50, ISE100 and ISE Composite indices with unit root tests which were adapted for the non-linear ESTAR process. Firstly, Harvey et al. (2008) linearity test is employed. The test results indicate that all indices have non-linear behavior. Afterwards, non-linear unit root tests developed by Kapetanios et al. (2003) and Kruse (2011) were conducted. While the Kapetanios et al. (2003) test accepts the existence of EMH for all indices, the Kruse (2011) test which is relatively more recent rejects the hypothesis.

Keywords: Efficient Market Hypothesis, Turkish Stock Market, Nonlinearity, Non-linear Unit Root Tests

Introduction
Efficient Market Hypothesis (EMH) assumes that new information entering a market reaches all investors simultaneously and that no investor can gain above-average profit. In a study on market efficiency conducted by Fama (1970), efficient markets are classified into three groups, namely weak form efficiency, semi-strong form efficiency and strong form efficiency markets. However, it is really difficult to talk about market efficiency in which there is no information undisclosed to the public and all types of information are reflected in prices. Therefore, the relevant literature mostly involves studies testing weak market efficiency.
EMH is generally tested in one of the two ways: by determining the anomalies in the market and by observing whether prices follow random walk (Shiller and Perron, 1985; Schwert, 2003). In the scope of the current research, we tried to test whether prices of securities follow random walk. If the price of the security follows random walk, the market is considered to have weak form of efficiency. However, if the opposite is the case, it means that the market is not weak-form efficient.
In this study, EMH was tested for ISE30, ISE50, ISE100 and ISE Composite indices, which are indices of Borsa Istanbul. To test the existence of EMH, unit root tests were utilized. In most studies in the literature, unit root tests were used without testing the linearity of financial

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series. In our research, first Harvey et al. (2008) linearity test was used to test the linearity of the series. According to the findings of this test, EMH was tested for the relevant indices using Kapetanios et al. (2003) and Kruse (2011) tests, which are among non-linear unit root tests.

1. Literature Review

Testing of EMH has commonly been dealt with by scholars, investors and regulators for years, yet a consensus has not been reached about market efficiency which is an important issue concerning the finance theory and investment strategies (Borges, 2010: 711). Among studies testing the existence of EMH, there are those which prove the existence of weak form market efficiency (Çelik and Taş, 2007; Aga and Kocaman, 2011; Ergül, 2009; Gozbasi et al., 2014; Kan and O'Callaghan, 2007) along with those which verify no market efficiency (Çevik, 2012; Çevik and Erdoğan, 2009; Lo and MacKinlay, 1988). A similar situation is observed in the earliest studies inquiring into market efficiency. In their studies, Roberts (1959), Granger and Morgenstern (1962), Fama (1965, 1970) and Lumsdaine and Papell (1997) have demonstrated that markets are efficient. Conversely, Lo and MacKinlay (1988, 1989) and Kim et al. (1991) refuted the validity of EMH.

We can find both studies that test the market efficiency of a single country and those that evaluate more than one country in the literature. Çelik and Taş (2007) tested EMH in the stock markets of Argentina, Brazil, Czech Republic, Egypt, Indonesia, Hungary, India, Israel, South Korea, Mexico, Russian and Turkey. As a result of the runs test, randomness could not be rejected for all the stock markets excluding the Czech stock market for the period between 1998 and 2007. In other words, weak form efficiency was validated for all the other countries. Based on the ADF, PP and KPSS unit root tests, EMH was validated for all countries but Russia. There was not country stock market for which weak form efficiency was rejected in all conducted tests, yet for Turkey and South Korea, it was not rejected in any of the tests. Hoque et al. (2007) tested the random walk hypothesis using variance ratio tests in Hong Kong, Indonesia, Korea, Malaysia, the Philippines, Singapore, Taiwan and Thailand stock markets. For Taiwan and Korea stock markets, random walk hypothesis was validated, whereas the other countries did not follow random walk. Smith and Ryoo (2003), analysing five European emerging markets, namely Greece, Hungary, Poland, Portugal and Turkey, used multiple variance ratio tests for their analyses. The researchers, using weekly data covering the period between April 1991 and August 1998, could not reach findings that validate EMH in any of the countries expect Turkey, where the market follows a random walk.

In the testing of EMH, sector indices were commonly used (Çevik and Erdoğan, 2009; Çevik, 2012; Narayan et al., 2015) along with indices such as Top-100 and Top-30 (Karacaer et al., 2010; Muradoglu and Metin, 1996; Müslümov et al., 2003). When studies looking into whether Turkish Stock Market has weak form efficiency are overviewed, it can be observed that studies validating EMH exist along with those refuting it. Table 1 summarizes in a detailed way the studies testing EMH for Turkish Stock Market.

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	Accept

			index, ISE industrial index	
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 vd. (2014)	July 1, 2002-July 7, 2012 (daily)	Kruse unit root test	ISE composite index, ISE industrial and financial indexes	Accept

2. Data

In the current study, the daily closing market data of the ISE30, ISE50, ISE100 and ISE composite indices were used. The dataset formed covers 3199 observations for the period between January 2nd, 2003 and September 30th, 2015. In the sampling of the dataset, 2003 was considered as the starting date to eliminate the influence of the 2001 Turkish Economic Crisis. Four different time series were formed with data obtained from the FINNET database (www.finnet.com.tr) and the analyses were conducted on the logarithmic forms of the series (see Table 2).

Table 2. Descriptive statistics

	Mean	Std. Dev.	Maximum	Minimum
ISE30	10.89	0.55	11.66	9.31
ISE50	10.65	0.55	11.42	9.07
ISE100	10.67	0.56	11.44	9.09
ISECOMP	10.65	0.57	11.43	9.07

3. Testing Methods
Harvey et al. (2008) Linearity Test
Linearity tests like Luukkonen et al. (1988) and 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:

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

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

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;

$$W_\lambda = \{1-\lambda\}W_0 + \lambda W_1 \tag{3}$$

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

Table 3. Linearity Test Results

Indices	W_λ	W 10%	W 5%	W 1%
ISE30	37.08***	30.09	30.26	30.56
ISE50	42.25***	34.98	35.17	35.52
ISE100	45.95***	38.14	38.35	38.74
ISECOMP	50.45***	41.83	42.07	42.49

*** indicates 1% significance level

As can be observed in Table 3, all the indices included in the analyses are nonlinear.

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;

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

where $\varepsilon_t \sim$ iid(0,σ^2). Under restriction a=0;

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

under restriction c=0;

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

auxiliary regression;

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

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;

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

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;

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

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

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

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;

$$\tau = t_{\beta_2^\perp=0}^2 + 1(\hat{\beta} < 0) t_{\beta_1=0}^2 \qquad (10)$$

4. Findings

In this paper, both KSS and τ test statistics were calculated for comparison purposes. The findings of the unit root tests can be seen in Table 4.

Table 4. Unit Root Tests Results

Indices	Lags	KSS			τ		
		Log-level series	Demeaned series	Demeaned and detrended series	Log-level series	Demeaned series	Demeaned and detrended series
ISE30	1	1.39	-2.21	-2.76	8.71*	4.91	7.78
ISE50	1	1.43	-2.24	-2.72	9.01*	5.06	7.57
ISE100	1	1.50	-2.26	-2.75	8.90*	5.15	7.66
ISECOMP	1	1.60	-2.29	-2.75	9.24*	5.33	7.65
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

* indicate 10% significance level

Note; Critical values obtained from Kapetanios et al. (2003) and Kruse (2011)

According to Table 4, since KSS (2003) unit root test statistics are lower than critical values, the Ho hypothesis claiming that the series follow random walk is supported. Thus, all the indices included in the analyses have weak form efficiency in all the three models. Based on the findings of the Kruse (2011) unit root test, weak form was rejected for all the indices in the first model, while it was supported in the second and third models.

Conclusion

In this study, weak form market efficiency was tested using daily closing data of ISE national indices (ISE30, ISE50, ISE100 and ISE composite). In the testing of EMH, KSS (2003) and Kruse (2011), which are among non-linear unit root tests, were used based on a consideration of the linearity of the series. According to the KSS unit root test findings, EMH weak form was accepted for all the indices. That is, the series followed random walk. Therefore, it can be said that previous price information was reflected on market prices and prices move independent of each other. In this context, it is impossible for a person who conducts technical analyses on previous price information to gain more profit than one who does not possess that information and to earn above average. Based on the findings of the Kruse non-linear unit root test, a stronger measure, weak form was rejected for the first model, yet it was accepted for the other two models. The fact that the weak form was rejected means that it is possible to gain above-average income by using previous price information. In line with the previous studies in the literature, the validity of weak form market efficiency varied based on the analysis methods in the current study. Nonetheless, the study is of significance since the series were linear and two tests, which are newly developed and strong tests, were used together. In further studies, EMH tests can be conducted using Borsa Istanbul sub-sector indices with different unit root tests for different periods.

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