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RE-VISITING THE TURKISH STOCK MARKET EFFICIENCY: EVIDENCE FROM ADAPTIVE WILD BOOTSTRAP TESTING PROCEDURES

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ABSTRACT

Purpose - This study aims to test the weak form efficient market hypothesis in Borsa Istanbul (BIST). We analyze weekly price indices, BIST-100, BIST-Financials, BIST-Industrials, BIST-Service, and BIST Technology over the period January 1988 – September 2018.
Methodology – In addition to well-known unit root tests, we apply adaptive wild bootstrap testing procedures proposed by Cavaliere et al. (2018) and Boswijk and Zu (2018), both considering the non-stationary volatility process.
Findings – The standard unit root tests provide mixed results. However, Carrion-i-Silvestre et al. (2009) and Maki (2015) unit root tests, and adaptive wild bootstrap testing procedures of both Boswijk and Zu's (2018) and Cavaliere et al. (2018) suggest that all price indices contain unit root at 5% level.
Conclusion- The Turkish stock market is informationally weak-form efficient. The price indices follow a random-walk process; thus, it is fruitless to conduct trading strategies based on past price information to reap excess returns.

Keywords: Market Efficiency, Borsa Istanbul, Unit Root, Long Memory, Adaptive Wild Bootstrap Testing
JEL Codes: G32, G40, C23

1. INTRODUCTION

The studies on market efficiency can be dated back to early 1900s (Bachelier, 1900; Cowles, 1933). Academics have conducted studies to examine the behavior of stock market prices and observed that the prices are fluctuating randomly (see Mandelbrot, 1963; Samuelson, 1965; Fama, 1965a, 1965b). Fama (1970) formalizes the early ideas, observations and develops efficient market hypothesis. Fama (1970) defines efficient market as "a market in which prices always `*fully reflect*` available information". Jensen (1978) states that it is impossible make economic profits using the information set in efficient markets.

Since we do not observe information set directly, Fama (1970) proposes three information subsets relevant to the adjustments of security prices in markets: (i) Weak-form efficiency, (ii) semi-strong form efficiency, (iii) strong-form efficiency. In weak-from efficient markets, information set contains only past prices of the securities, thus, it is fruitless to conduct technical analysis to reap positive risk-adjusted returns after accounting transaction costs. The information set in semi-strong form efficient markets contains public fundamental data (e.g. earnings and dividend prospects of corporations) in addition to the past prices, so that trading strategies based on fundamental and technical analyses cannot generate economic profits. Finally, for strong form of efficiency, the information set contains all public and private (insider) information available to any market participant, indicating that the changes in prices are random over time.

A myriad of studies has attempted to test the efficient market hypothesis. Essentially, the studies have checked whether the security prices exhibit random walk or predictable patterns. The studies employ serial correlation tests, runs tests, variance ratio tests, unit root tests, long-memory tests for testing weak-form efficiency (Keim and Stambaugh, 1986; Lo and MacKinlay, 1988, Fama and French, 1988, 1989; Campbell and Shiller, 1988), conduct event studies for testing semi-strong form efficiency (Banz, 1981; Basu, 1983; Blume and Stambaugh, 1983; Fama and French, 1992), and investigate the presence of private information in the security prices for testing strong-form of efficiency (Jaffe, 1974; Givoly and Palmon, 1985; Seyhun, 1986). Following the early studies, a number of empirical studies provide evidence in favor of efficient market hypothesis, while others have suggested rejecting the efficient market hypothesis. This leads academics to test the efficient market hypothesis constantly for different markets, using different methods overcoming the shortcomings of the conventional statistical procedures.

This study aims to test weak form efficient market hypothesis in Turkish stock market, Borsa Istanbul (BIST). There is no consensus on the issue for Borsa Istanbul: Smith and Ryoo (2003), Buguk and Brorsen (2003), Ozdemir (2008), Karan and Kapusuzoglu (2010) and Gozbasi et al. (2014) suggest that Turkish stock market is weak form efficient; Balaban (1995a, 1995b), Demirer and Karan (2002) and Ozer and Ertokatli (2010) provide evidence against the efficient market hypothesis. Our study differs from the previous literature since we employ battery of unit root tests, some of which consider integrated volatility process, structural breaks, and nonlinearity in the data. The remainder of the paper is organized as follows: Section 2 describes methodology, Section 3 presents the data and empirical findings, and Section 4 concludes the paper.

2. METHODOLOGY

We employ battery of unit root tests to check whether the time-series have a unit root (random walk) or stationary (predictable pattern) over time. The rejection of unit root implies market is not informationally efficient. First three unit root tests we employ are standard unit root tests, Augmented Dickey and Fuller (1979) (*ADF*), Phillips and Perron (1988) (*PP*), and Kwiatkowski, Philips, Shin and Schmidt (1992) (*KPSS*). The null hypothesis of *ADF* and *PP* is that the time series contains a unit root, while that of *KPSS* test is the stationarity.

Given the fact that standard unit root tests lose their power in the presence of a structural break in the deterministic trend, we employ Carrion-i-Silvestre et al.'s (2009) unit root testing procedures which allow for an arbitrary number of changes up to five structural breaks in both the level and slope of the trend function. Following the procedures, we estimate three *M*-type unit root tests, *MZA*, *MSB*, and *MZT*. Each tests the null hypothesis of unit root against the alternative of stationarity.

We also estimate a unit root test in Exponential Smooth Transition Autoregressive (ESTAR) models proposed by Maki (2015) to account for nonlinearities in the data. Maki's (2015) unit root test (t) performs well in the presence of heteroskedastic variances, stochastic volatility by estimating p-value of the test through wild bootstrapping. The test tests the null hypothesis of unit root against the alternative of stationarity.

Finally, we employ adaptive wild bootstrap unit root tests of Boswijk and Zu (2018) and adaptive fractional time series models of Cavaliere et al. (2018). Both testing procedures account for integrated volatility process, and non-parametrically adapt to unconditional heteroskedasticity of unknown form. Boswijk and Zu (2018) modify Dickey-Fuller (*DF*) unit root test and estimate p-value of the *LR* test via wild bootstrapping. The null hypothesis of *LR* test is unit root against the alternative of stationarity. Cavaliere et al. (2018) estimate the memory parameter (d) in the fractional time series models, using both Quasi-Maximum Likelihood (*QML*) and Adaptive Conditional Sum-of-Squares (*ACSS*) estimators, recovering the efficiency losses. We consider testing the hypothesis on the memory parameter, d=1 for unit root.

3. DATA AND EMPIRICAL FINDINGS

We obtain price indices of BIST-100, BIST Financials (BIST-FIN), BIST Industrials (BIST-IND), BIST Services (BIST-SRV), and BIST Technology (BIST-TEC) from the Electronic Data Delivery System (EDDS) of the Central Bank of the Republic of Turkey (CBRT). We use weekly-frequency data, following the work of Lo and MacKinlay (1988), Buguk and Brorsen (2003). The sample period for all indices ends in September 2018, however the starting point of the sample period is different for price indices: January 1988 for BIST-100, January 1991 for BIST-FIN and BIST-IND, January 1997 for BIST-SRV, and June 2000 for BIST-TEC. We analyze the natural logarithm of the price indices.

Table 1 reports the results of the standard unit root tests, *ADF*, *PP*, and *KPSS*. The *ADF* test statistics suggest that all price indices except BIST-SRV contain unit root. According to *PP* unit root test statistics, BIST-100, BIST-IND, and BIST-SRV are found to be stationary at 10% significance level; however, BIST-FIN and BIST-TEC have unit root. The *KPSS* test statistics suggest rejecting the null hypothesis of stationary at 1% significance level, indicating that all price indices have unit root. Overall, standard unit root tests provide mixed results for the stationarity of the price indices.

Table 1: Standard Unit Root Tests

Index	ADF	PP	KPSS
BIST-100	-2.351	-2.617 [c]	4.368 [a]
BIST-FIN	-2.485	-2.481	3.850 [a]
BIST-IND	-2.475	-2.647 [c]	4.158 [a]
BIST-SRV	-2.572[c]	-2.815 [c]	4.100 [a]
BIST-TEC	-0.835	-0.773	3.561 [a]

Note: a and c denote rejection of null hypothesis at 1% and 10% statistical significance levels, respectively.

The estimation results for *M*-type unit root tests by Carrion-i-Silvestre et al. (2009) are reported in Table 2. We cannot reject the null hypothesis of unit root based on the *M*-type unit root tests, implying that all price indices contain a unit root in the presence of structural breaks which are accumulated around significant financial crises (e.g. economic crises in 1994, 2001 and 2007), socio-political events (e.g. Gezi Park protests in May-2013), and government changes (e.g. Justice and Development Party coming to power without the support of a coalition partner just before March-2003).

Table 2: Carrion-i-Silvestre (2009) Unit Root Tests

Test	BIST-100	BIST-FIN	BIST-IND	BIST-SRV	BIST-TEC
MZA	-37.612	-32.032	-35.065	-39.867	-29.756
MSB	0.115	0.124	0.119	0.112	0.129
MZT	-4.336	-3.986	-4.186	-4.462	-3.852
Break Points					
TB_1	Feb-91	Mar-94	Mar-94	Jan-00	Sep-02
TB_2	Mar-94	Jan-97	Oct-97	Jun-02	Feb-06
TB_3	Jan-00	Dec-99	Nov-00	Dec-07	Dec-07
TB_4	Mar-03	Mar-03	Feb-05	May-13	Apr-11
TB_5	Oct-07	Feb-06	Dec-07	Jul-16	Nov-16

Table 3 reports the results of the Maki (2015) unit root test which account for nonlinearities stemming from market frictions, noise traders, transaction costs, and so forth. The results suggest that all price indices except BIST-SRV have unit root in their level since their bootstrapped *p*-values are estimated higher than conventional statistical significance levels. BIST-SRV is found to be stationary at 10% statistical significance level.

Table 3: Maki (2015) Unit Root Test

	BIST-100	BIST-FIN	BIST-IND	BIST-SRV	BIST-TEC
Test statistics	-2.751	-2.507	-2.434	-3.613	-1.957
p-value	0.206	0.353	0.435	0.095	0.810

Table 4 reports the results of Boswijk and Zu's (2018) unit root tests, *DF*-statistics along with their asymptotic and wild bootstrapped *p*-values, and wild bootstrapped *p*-values of *LR* test statistics. The wild bootstrapped *p*-values of both *DF* and *LR* statistics are estimated higher than conventional significance levels, indicating that each price index contains a unit root.

Table 4: Asymptotic and wild bootstrap *p*-values of *DF* and adaptive *LR* statistics

	DF-stat	*DF* asymptotic *p*-value	*DF* WB *p*-value	*LR* WB *p*-value	*p*
BIST-100	2.056	0.991	0.999	0.996	3
BIST-FIN	1.548	0.971	0.987	0.968	3
BIST-IND	2.198	0.994	1.000	1.000	8
BIST-SRV	1.286	0.949	0.984	0.999	9
BIST-TEC	1.262	0.948	0.982	0.995	7

Note: *p* is the autoregressive order.

Using the fractionally integrated time series models of Cavaliere et al. (2018), we report the *d* parameter estimates along with their robust standard errors, and both 95% asymptotic and bootstrapped confidence intervals in Table 5. The *d* parameters are estimated close to 1. Based on the ACSS- and QML-based confidence intervals, the unit root null hypothesis (*d*=1) cannot be rejected at the 95% level for BIST-FIN and BIST-TEC. Moreover, the remaining price indices exhibit higher persistence than a unit root process, and they are also non-stationary and non-mean reverting.

Table 5: The QML and ACSS estimate of *d* parameter

			Asymptotic		WB1		WB2		WB3	
	d	**se(*d*)**	CI_L	CI_U	CI_L	CI_U	CI_L	CI_U	CI_L	CI_U
BIST-100 (*p* = 0)										
QML	1.060	0.018	1.024	1.096	1.027	1.093				
ACSS	1.041	0.020	1.002	1.081	1.002	1.081	1.000	1.083	1.003	1.080
BIST-FIN (*p* = 0)										
QML	1.045	0.013	1.019	1.071	1.023	1.066				
ACSS	1.035	0.021	0.994	1.075	0.993	1.076	0.996	1.073	0.993	1.077
BIST-IND (*p* = 0)										
QML	1.054	0.015	1.024	1.084	1.024	1.084				
ACSS	1.050	0.022	1.008	1.093	1.007	1.093	1.010	1.091	1.007	1.094
BIST-SRV (*p* = 1)										
QML	1.027	0.012	1.005	1.050	1.005	1.050				
ACSS	1.029	0.011	1.008	1.050	1.007	1.051	1.007	1.051	1.007	1.051
BIST-TEC (*p* = 0)										
QML	0.999	0.001	0.997	1.000	0.997	1.000				
ACSS	1.020	0.017	0.986	1.053	0.980	1.059	0.984	1.055	0.982	1.057

Note: *d* is the memory parameter. se(*d*) is the (robust) standard error. Wild-bootstrap-1 (WB1) does not re-estimate time-varying scale factor (σ_t) for each bootstrap replication; WB2 re-estimates σ_t for each bootstrap replication, estimating the bandwidth parameter in each bootstrap replication using cross-validation; WB3 re-estimates σ_t for each bootstrap replication using same bandwidth parameter as selected. *p* is selected based on forward search algorithm, increasing *p* by one until the additional lag is estimated statistically insignificant at 10% level. CI_L and CI_U stand for the lower and upper limits of the 95% confidence intervals.

4. CONCLUSION

The above econometric methods by Boswijk and Zu (2018) and Cavaliere et al. (2018) are employed for the first time to examine the weak form efficiency of the Turkish stock market. Overall results show that BIST-100 and sector price indices have a unit root. Particularly, some sector price indices exhibit higher persistence than a unit root process, they are non-stationary and non-mean reverting. The results may imply that the price indices follow a random-walk process; thus, it is fruitless to conduct trading strategies based on past price information to reap excess returns. We conclude that the Turkish stock market is informationally weak-form efficient in terms of Fama (1970), consistent with the findings of Smith and Ryoo (2003), Buguk and Brorsen (2003), Ozdemir (2008), Karan and Kapusuzoglu (2010), Gozbasi et al. (2014).

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