DOI: 10.20472/IAC.2016.024.045

**HASAN AĞAN KARADUMAN**
**Yildiz Technical University, Turkey**

# STYLIZED FACTS AND WEAK-FORM EFFICIENCY IN TURKISH STOCK MARKET

## Abstract:

The question of whether the price and return series of a stock market exhibit a predictable and tractable pattern is always of interest in both theory and practice. After a brief overview of the literature on market efficiency, the stylized facts about the pre-global crisis, crisis and post-global crisis daily returns of Turkish stock market are explored at the statistical level as an example of the behavioural change in stock market of an emerging country. The weak-form market efficiency is also addressed using a range of statistical and econometric methods, namely unit root tests, variance-ratio tests, testing some anomalies which may falsify the stock market efficiency. The findings indicate there exists some form of deviations from the efficient market hypothesis during the global crisis period.

## Keywords:

Stylized facts; Stock Market Efficiency; Global Crisis; Turkish Economy

**JEL Classification:** G00, G01, C58

## Introduction and Literature Review

Two main questions are addressed in relation with the recent global crisis in this study. The first question is whether there is any change in the stylized facts of Turkish stock market. And the second one is whether there is any difference in the behavior of the Turkish stock market in terms of weak form market efficiency.

Firstly the Fama's breakthrough idea about the efficient market hypothesis is briefly reviewed. In an efficient market, there are a lot of rational profit-maximizers and they compete with each other to predict future values of stock prices, and in this type of market, the relevant past information is considered almost freely available to all stock market participants In a nutshell the security prices fully reflect all available information set if a stock market is efficient (Fama, 1965 and 1970). There are also different forms of market efficiency. The first is the weak-form efficiency. In the weak form, the information set covers only the historical security prices. The testing procedure tries to exploit how genuine past returns predict the future returns. The second one is semi-strong form efficiency. The information set is about the publicly available information. In this form of market efficiency, the testing strategy is based on the idea that how quickly stock prices will respond to public announcements. The final form of the efficient markets the strong-form efficiency. The information set covers also private information. Testing this kind of efficiency inquiries whether one has private information which is not fully reflected in stock prices (Fama, 1970 and 1991).

In the literature, the efficiency market hypothesis is usually tested in weak-form because of the availability of data. But it is hardly to find a consensus about the stock market efficiency even for a single stock market index at the empirical level. For this point to clarify, it is fairly enough to check some survey-type studies on the stock market efficiency, namely Beechey et al. (2000), Shleifer (2000), Yen and Lee (2008). This two-faced dispute is also valid for Turkish stock market. While the findings of some authors such as Buguk and Brorsen (2003), Ozdemir (2008), Karan and Kapusuzoglu (2010), Gozbasi et al. (2014) support the weak-form efficiency for the Turkish stock market, a number of authors like Balaban and Kunter (2007), Ozer and Ertokatli (2010) reach the counter findings against the efficient market.

There is also a growing literature on the relation between the stock market efficiency and the 2008 global crisis. Anagnostidis et al. (2016) and Vieito et al. (2016) examine the effects of the recent global crisis on the stock market efficiency. The former finds the evidence against the efficient market hypothesis while the latter's findings is in line with the stock market efficiency.

The first form efficiency, the weak-form efficiency is tested in this study. The historical prices will be used to detect whether the future values can be forecasted by just using past values taken as all available information to any stock market participant. In the first place, the sub-periods like pre-crisis, crisis and post-crisis are determined using the fluctuations in the industrial production index (IPI) of Turkey. Then the degrees of the resemblance of the sample properties of the returns of BIST100 Index with the stylized facts of the asset returns are investigated. To check the validity of the weak-

form market efficiency, the variance-ratio test, autocorrelation test, unit root test are also conducted. Finally it is also questioned whether there is any significant seasonal dummy at monthly level using return series in different sub-periods.

## Data and Identifying the Sub-periods of Interest

Firstly the sub-periods namely pre-crisis, crisis and post-crisis should be based on the real fluctuations in the industrial production index (IPI) of Turkey. Then the daily closing prices and returns of BIST100[1] Index corresponding with these sub-periods are analyzed. The period of interest is between February 2007 and April 2011.

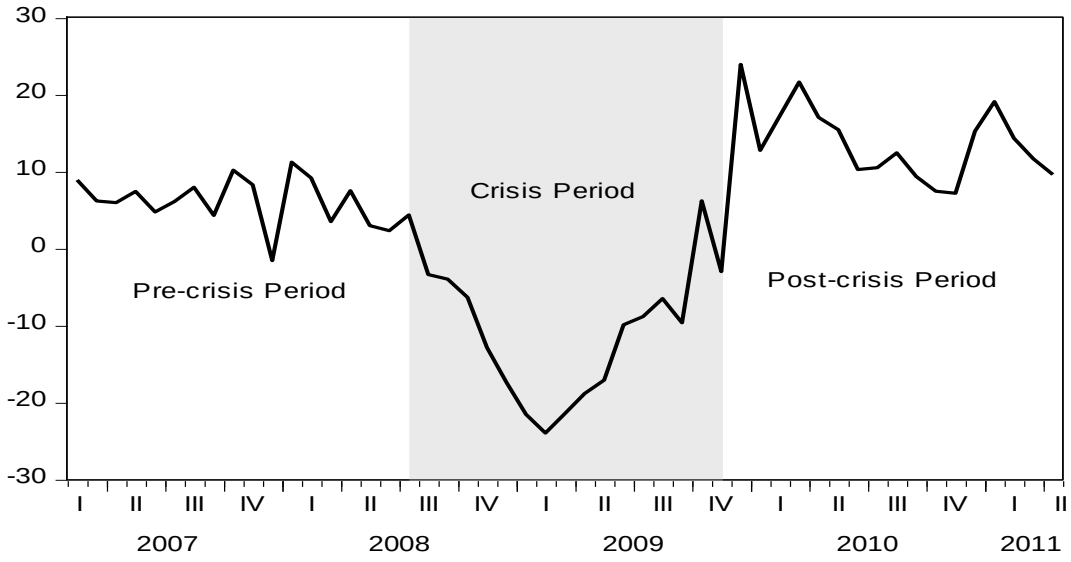
The periodization with respect to the global crisis is done through using the annual growth rates of the monthly industrial production index (IPI) of Turkey running from February, 2007 to April, 2011. Because the main objective of this study is to observe, if any, the changing behavior in the Turkish Stock Market in terms of market efficiency.

The source of the monthly industrial production index series is the electronic data delivery system (EDDS) of the Central Bank of Turkey. The annual growth rates are calculated by using the following formula. The annually differenced data (12th difference) is used for the periodization. Therefore there is no need to make any seasonal adjustment.

$$\text{Annual Growth Rate of IPI} = \frac{IPI_t - IPI_{t-12}}{IPI_{t-12}} x100 \quad (1)$$

where $\boldsymbol{IPI_t}$ : Monthly Industrial Production Index at month *t* and $\boldsymbol{IPI_{t-12}}$ : Monthly Industrial Production Index at month (*t-12*)

**Figure 1: Annual growth rates of Turkey's IPI (February 2007- April 2011)**




***Source: Electronic data delivery system (EDDS) of the Central Bank of Turkey, http://evds.tcmb.gov.tr***

[1] BIST100 Index is used as the main composite index for Borsa Istanbul Equity Market consisting of 100 selected stocks among the stocks traded on the Turkish stock market.

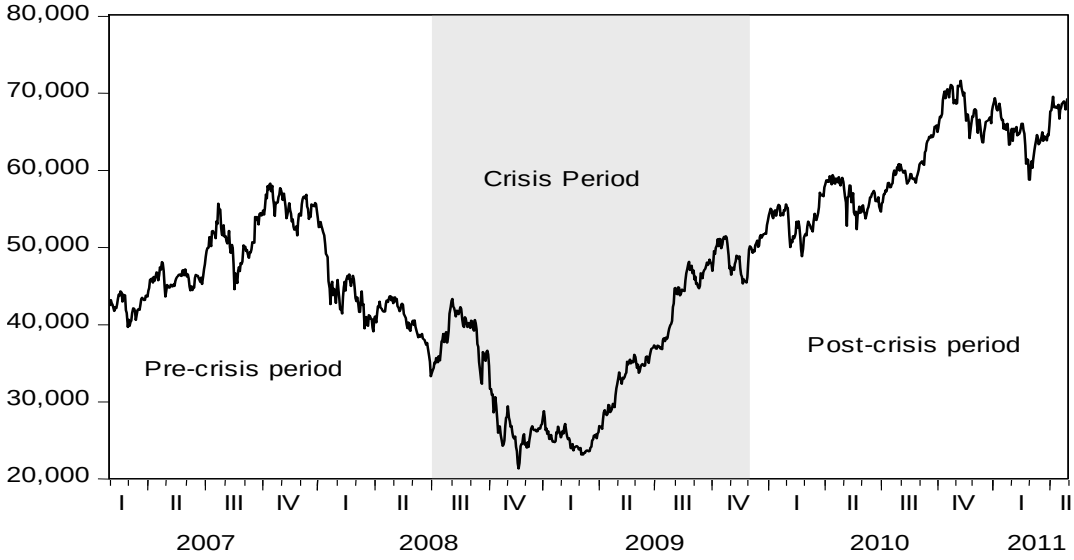
The industrial production index is a good proxy for the general economic condition in a country on monthly base. Eventually three sub-periods (pre-crisis, crisis and post-crisis) are identified by the dynamics of the real economy as seen in Figure 1:

- **Pre-crisis period: February 2007 - June 2008**
- **Crisis period: July 2008 - November 2009**
- **Post-crisis period: December 2009 - April 2011**

The average annual growth rates of IPI in the sub-periods are 6.18%, -9.55%, and 13.83% respectively. It is obvious that there was a dramatic decrease in average annual growth rate of IPI in the crisis period and the global crisis seriously affected the real side of Turkish economy.

The identified sub-periods are directly applied to Turkish Stock Market. The daily closing prices of BIST100 Index are used in this study running from February 2007 to April 2011. The data is also downloaded from the EDDS of the Central Bank of Turkey.

**Figure 2: Daily closing prices of BIST100 Index (February 2007-April 2011)**




***Source: Electronic data delivery system (EDDS) of the Central Bank of Turkey. http://evds.tcmb.gov.tr***

The behavior of the daily price series of BIST100 is clearly observable within the identified sub-periods. The fall in BIST100 Index is also very apparent in the crisis period as expected seen in Figure 2. The daily returns are calculated as follows:

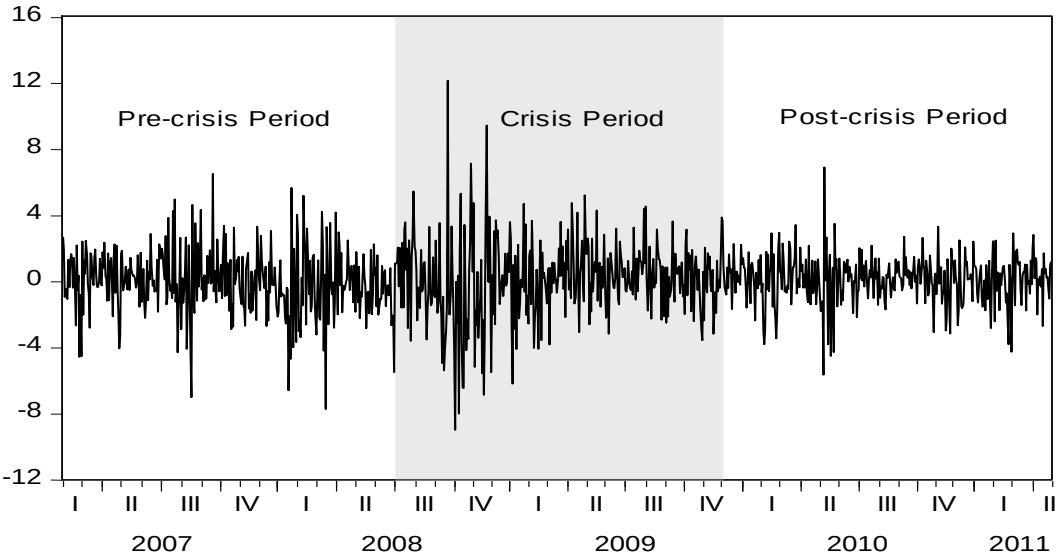
$$\mathbf{return} = \log\left(\frac{price_t}{price_{t-1}}\right) x100 \qquad (2)$$

$\boldsymbol{log}$ : the natural logarithm

$\boldsymbol{price_t}$ : the daily closing price at day t

$\boldsymbol{price_{t-1}}$ : the daily closing price at day (t-1)

**Figure 3: Daily closing prices of BIST100 Index (February 2007-April 2011)**




***Source: Electronic data delivery system (EDDS) of the Central Bank of Turkey and author's own calculations.***

The remarkable issue about the return series in Figure 3 is that the volatility increased in the period of the crisis. The return series is analyzed in detail under the heading of stylized facts of the daily returns of BIST100 Index.

## Stylized Facts of the Daily Returns of BIST100 Index

The stylized facts of the daily returns of Turkish stock market are also explored at the statistical level. There are many stylized facts about the asset returns. In this study stylized facts under investigations are gain/loss asymmetry, heavy tails and non-normal distributional properties, and no autocorrelation. In gain/loss asymmetry, large downward movements are more observable in return series than large upward ones. The distribution of returns has a heavy tail and the estimated kurtosis is usually higher than two in most studies. So the return distribution does not follow the normal distribution. Finally the sample autocorrelation coefficients of stock market returns are often statistically insignificant (Cont, 2001).

**Table 1: Summary statistics of the daily returns of BIST100 Index**

| | Mean | Max. | Min. | Std. Dev. | Skewness | Kurtosis | Jarque-Bera | # of obs. |
|---|---|---|---|---|---|---|---|---|
| **Pre-Crisis** | -0.045 | 6.484 | -7.752 | 1.938 | -0.145 | **4.349** | **28.4** | 358 |
| **Crisis** | 0.073 | 12.127 | -9.014 | 2.423 | 0.056 | **5.738** | **110.4** | 353 |
| **Post-Crisis** | 0.118 | 6.895 | -5.675 | 1.449 | -0.276 | **5.214** | **77.7** | 358 |

The summary statistics of the daily returns of BIST100 Index in Table 1 are interpreted in the light of the stylized facts. It is known that the standard normal distribution has a kurtosis of 3. And the sample kurtosis values in all periods are about 5 which indicate heavy-tailed distributions in all periods. Also the results of Jarque-Berra tests display the strong rejection of the null hypothesis of the normally distributed daily returns.

Therefore, the normal distribution in the return series for all periods is excluded. The result is in line with the stylized facts of the return series.

**Table 2: Loss/Gain asymmetry of the daily returns of BIST100 Index**

| | Pre-crisis Period | | Crisis Period | | Post-crisis Period | |
|---|---|---|---|---|---|---|
| **Return (%)** | **Count** | **Percent** | **Count** | **Percent** | **Count** | **Percent** |
| **[-10, -5)** | 3 | **0.84** | 11 | **3.12** | 1 | **0.28** |
| **[-5, 0)** | 188 | 52.51 | 156 | 44.19 | 150 | 41.9 |
| **[0, 5)** | 164 | 45.81 | 180 | 50.99 | 206 | 57.54 |
| **[5, 10)** | 3 | 0.84 | 5 | 1.42 | 1 | 0.28 |
| **[10, 15)** | 0 | 0 | 1 | 0.28 | 0 | 0 |

Table 2 indicates that the big negative returns (big losses) are more pronounced than the big positive returns (big gains) in the crisis period, the percent of the big losses is 3.12 as expected by the loss/gain asymmetry of the stock market return, which is clearly far beyond those in other two sub-periods respectively 0.84% and 0.28%. The percentage of the big loses for the crisis period is 2.7.

**Table 3: Sample autocorrelation coefficients and statistical significance: Daily returns of BIST100 Index**

| **Lags** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** |
|---|---|---|---|---|---|---|---|---|---|---|
| **Pre-crisis** | -0.04 | -0.02 | 0.00 | 0.03 | -0.05 | 0.05 | -0.01 | -0.08 | 0.06 | 0.04 |
| **Crisis** | **0.12**** | **0.01*** | -0.05 | 0.06 | 0.02 | **-0.13**** | **-0.04**** | **-0.01*** | **0.08*** | **0.09**** |
| **Post-crisis** | 0.04 | -0.05 | -0.02 | -0.02 | -0.06 | 0.00 | -0.07 | 0.00 | 0.00 | -0.01 |
| **Lags** | **11** | **12** | **13** | **14** | **15** | **16** | **17** | **18** | **19** | **20** |
| **Pre-crisis** | 0.06 | -0.01 | 0.09 | 0.03 | 0.01 | -0.02 | -0.07 | -0.02 | 0.03 | -0.13 |
| **Crisis** | **0.01*** | **-0.04**** | **0.06*** | **0.10*** | **-0.00*** | **-0.03*** | **0.04*** | **0.12**** | **0.00**** | **0.02*** |
| **Post-crisis** | 0.07 | 0.04 | 0.10 | -0.03 | -0.02 | 0.02 | -0.03 | 0.03 | 0.05 | -0.08 |

***Notes on Table 3: The calculated test statistic and checking its statistical significance for each lag is based on Ljung and Box (1979). For further details, see Ljung and Box (1979). *** 1% level, **5% level, and *10% level. Adding more lags does not affect the results which is available upon request.***

Based on the results from Table 3, all of the sample autocorrelation coefficients are not statistically different from zero in pre-crisis period. But for the crisis period, most of the sample autocorrelations are statistically significant at the conventional levels. This finding offers the evidence against the null hypothesis of no autocorrelation. So, the violation of the efficient market hypothesis in weak form is obvious for the crisis period. In the post crisis period, the return series does not suffer from autocorrelation as the one in the pre-crisis period.

## Testing the Weak Form Efficiency in BIST100 Index

The question of whether the return series of a stock market exhibit a predictable and tractable pattern is always of interest in both theory and practice. One approach is to conduct the variance ratio test. Lo and MacKinlay (1988) studied the predictive power of any time series by comparing variances of differences calculated over different intervals. If the data follows a random walk, the variance of q-period difference would be equal to q times the variance of the one-period difference. For the detailed technical treatment, see Lo and MacKinlay (1988 and 1989). In this study, the Lo and MacKinlay variance ratio tests for heteroskedastic random walks, using the asymptotic normal distribution with differences and log differences are conducted. The null hypothesis in the variance-ratio tests is that the closing price of BIST100 Index or closing logprice of BIST100 Index follows random walk process. If the price series is not a random walk process, the weak form market efficiency hypothesis can be falsified.

**Table 4: Lo and MacKinlay's variance ratio individual test results for the closing prices of BIST100 Index**

| | Pre-crisis Period | | Crisis Period | | Post-crisis Period | |
|---|---|---|---|---|---|---|
| **Period** | **Variance ratio** | **z-statistic** | **Variance ratio** | **z-statistic** | **Variance ratio** | **z-statistic** |
| **q=2** | 0.96 | -0.59 | 1.13 | 2.36** | 1.04 | 0.57 |
| **q=4** | 0.93 | -0.59 | 1.22 | 2.04** | 0.99 | -0.08 |
| **q=8** | 0.94 | -0.34 | 1.26 | 1.48 | 0.90 | -0.51 |
| **q=16** | 1.06 | 0.22 | 1.37 | 1.35 | 0.85 | -0.57 |

***Note: *** 1% level, **5% level, and *10% level.***

**Table 5: Lo and MacKinlay's variance ratio individual test results for the logarithm of the closing prices of BIST100 Index**

| | Pre-crisis Period | | Crisis Period | | Post-crisis Period | |
|---|---|---|---|---|---|---|
| **Period** | **Variance ratio** | **z-statistic** | **Variance ratio** | **z-statistic** | **Variance ratio** | **z-statistic** |
| **q=2** | 0.96 | 0.96 | 1.13 | 2.29** | 1.04 | 0.57 |
| **q=4** | 0.93 | 0.92 | 1.20 | 1.77* | 1.00 | 0.98 |
| **q=8** | 0.94 | 0.90 | 1.22 | 1.15 | 0.89 | 0.59 |
| **q=16** | 1.06 | 1.02 | 1.31 | 1.06 | 0.84 | 0.57 |

***Note: *** 1% level, **5% level, and *10% level.***

For the pre-crisis period, we do not reject the null of random walk processes. All of the individual statistics do not reject the null hypothesis at any conventional significance level. But in the crisis period, we fail to reject the null of a random walk for 2 and 4 period differences in the individual tests. The findings are clearly against the efficient market hypothesis. The results of the post-crisis variance-ratio tests also

claim that the data follows random walk as in those of the pre-crisis variance-ratio tests. The above interpretation holds for Table 4 and Table 5.

The Dickey-Fuller (DF) tests are also conducted to detect whether the closing prices have a unit root/stochastic trend or follow a random walk process. The detailed treatment of the DF test can be found at Dickey and Fuller (1979).

**Table 6: DF Unit root test results for the daily closing prices of BIST100 Index**

| DF Test Equation | Constant | | | Constant + Trend | | |
|---|---|---|---|---|---|---|
| | Pre-crisis | Crisis | Post-crisis | Pre-crisis | Crisis | Post-crisis |
| DF Test Stat. | -1.00 | -0.44 | -2.09 | -1.30 | -1.26 | -2.93 |
| p-value | 0.75 | 0.90 | 0.28 | 0.89 | 0.90 | 0.15 |

***Note: There is no need to conduct Augmented DF test for there is no serial correlation in the residuals of all estimated test equations.***

The null hypothesis of non-stationary cannot be rejected for the pre-crisis period. So the results of the DF test are in favor of weak-form efficiency. For the crisis and post-crisis period, the results of ADF tests yield the same conclusion: the daily prices of BIST100 Index follow a random walk process as seen in Table 6. But in theory, ADF test has some drawbacks such as low power issues as summarized ay Maddala and Kim (1998). Hence it might be reasonable to rely on the findings of the variance-ratio tests while checking the market efficiency[2].

The return series are regressed on the seasonal dummies to test whether there is any anomaly at monthly level.

**Table 7: Estimated partial effects and their statistical significance by regressing return series on seasonal dummies for each identified period**

| | Pre-crisis | Crisis | Post-crisis |
|---|---|---|---|
| January | **-1.20*** ** | -0.17 | -0.02 |
| February | 0.13 | -0.38 | -0.32 |
| March | -0.20 | 0.32 | **0.39*** |
| April | 0.34 | **0.98*** | 0.27 |
| May | -0.09 | 0.53 | -0.40 |
| June | -0.31 | 0.25 | 0.04 |
| July | 0.52 | **0.71**** | 0.40 |
| August | -0.23 | 0.07 | 0.01 |
| September | 0.37 | -0.17 | 0.46 |
| October | 0.31 | **-0.67*** | 0.22 |
| November | -0.29 | -0.31 | -0.28 |
| December | 0.13 | 0.23 | 0.35 |

***Note: *** 1% level, **5% level, and *10% level***.

As seen in Table 7, several monthly dummies are statistically significant (namely April, July, and October) in the crisis period. It is a very interesting finding that the timing

[2] Other unit root tests such Philips and Perron (1988) and Kwiatkowski et al. (1992) are also conducted. The null of non-stationary is also rejected in these tests. To save space, the results are not reported here, but it is available upon request.

coincides with the public announcement of three-month balance sheet. The announcement of the balance sheet anomaly is obvious for the crisis period. Investors' expectations about the future balance sheets of the firms might be predictable with the global crisis. In pre-crisis period, we can also observe a classical anomaly, January Effect.

## Conclusion

The conducted analysis is generally in parallel with the stylized facts of the asset returns. The only exception is the existence of the autocorrelation in the returns during the global crisis. The results of the variance ratio tests indicate that the closing prices and the logarithm of the closing prices do not follow the random walk for the crisis period. So there might be a chance to predict the future values using the past values.

Month anomalies also invalidate the efficient market hypothesis especially for the crisis period. As a conclusion, the stylized facts and the validity of weak-form market efficiency have changed in Turkish stock market from the empirical point of view during the global crisis and then Turkish stock market has turned back to the main implication of the efficient market hypothesis in its weak form: the non-predictability of future stock prices and returns based on past values.

## References

ANAGNOSTIDIS, P.; VARSAKELIS, C.; EMMANOUILIDES, C.J. (2016) Has the 2008 Financial Crisis Affected Stock Market Efficiency? The Case of Eurozone. *Physica A: Statistical Mechanics and its Applications*. 2016, Vol.447, pp.116-128.

BALABAN, E. and KUNTER, K. (1997) A Note on the Efficiency of Financial Markets in a Developing Country. *Applied Economic Letters*. 1997, Vol.4, No.2, pp.109-112.

BEECHEY, M.; GRUEN, D.; VICKERY, J. (2000) The Efficient Market Hypothesis: A Survey. *Research Discussion Paper.* 2000, Reserve Bank of Australia.

BUGUK, C. and BRORSEN, B.W. (2003) Testing Weak-form Market Efficiency: Evidence from the Istanbul Stock Exchange. *International Review of Financial Analysis*. 2003, Vol.12, No:5, pp.579-590.

CONT, R. (2001) Empirical Properties of Asset Returns: Stylized Facts and Statistical Issues. *Quantitative Finance.* 2001, Vol.1, No.2, pp. 223-236

DICKEY, D.A. and FULLER, W.A. (1979) Distribution of the Estimators for Autoregressive Time Series with a Unit Root. *Journal of the American Statistical Association*. 1979, Vol.74, No.366, pp. 427-431.

FAMA, E. F. (1965) Random Walks in Stock Market Prices. *Financial Analysts Journal*. 1965, Vol. 21, No.5, pp.55-59.

FAMA, E. F. (1970) Efficient Capital markets: A Review of Theory and Empirical Work. *The Journal of Finance.* 1970, Vol.25, No.2, pp.383-417.

FAMA, E. F. (1991), Efficient Capital Markets: II. *The Journal of Finance*. 1991, Vol.46, No. 5, pp.1575-1617.

GOZBASI, O.; KUCUKKAPLAN, I.; NAZLIOGLU, S. (2014) Re-examining the Turkish Stock Market Efficiency: Evidence from Nonlinear Unit Root Tests. *Economic Modelling*. 2014, Vol.38, pp. 381-384.

KARAN, M.B. and KAPUSUZOGLU, A. (2010) An Analysis of the Random Walk and Overreaction Hypotheses through Optimum Portfolios Constructed by the Nonlinear Programming Model. *Australian Journal of Basic and Applied Sciences*. 2010, Vol.4, No.6, pp.1215-1220.

KWIATKOWSKI, D.; PHILLIPS, P.C.B.; SCHMIDT P.; SHIN, Y. (1992) Testing the Null Hypothesis of Stationary against the Alternative of a Unit Root. *Journal of Econometrics.* 1992, Vol.54, No.1-3, pp. 159-178.

LJUNG, G. and BOX, G. (1979) On a Measure of Lack of Fit in Time Series Model. *Biometrika*. 1979, Vol.66, No.2, pp. 265-270.

LO, A.W. and MACKINLAY, C.A. (1988) Stock Market Prices do not Follow Random Walks: Evidence from a Simple Specification Test. *The Review of Financial Studies*. 1998, Vol.1, No.1, pp.41-66.

LO, A.W. and MACKINLAY, C.A. (1989) The Size and Power of the Variance Ratio Test in Finite Samples. *Journal of Econometrics*. 1989, Vol.40, No.2, pp. 203-238.

MADDALA, G.S. and KIM, I.M. (1998). *Unit Roots, Cointegration and Structural Change*. Oxford: Oxford University Press.

OZDEMIR, Z.A. (2008) Efficient Market Hypothesis: Evidence from a Small Open-economy. *Applied Economics*. 2008, Vol.40, No.5, pp. 633-641.

OZER, G. and ERTOKATLI C. (2010) Chaotic Processes of Common Stock Index Returns: An Empirical Examination on Istanbul Stock Exchange (ISE) Market. *African Journal of Bussiness Management*. 2010, Vol.4, No.6, pp.1140-1148.

PHILLIPS, P.C.B. and PERRON, P. (1988) Testing for a Unit Root in Time Series Regression. *Biometrika*. 1998, Vol.75, No.2, pp.335-346.

SHLEIFER, A. (2000). *Inefficient Markets: An Introduction to Behavioral Finance*. Oxford: Oxford University Press.

VIEITO, J.P.; WONG, W.K.; & ZHU, Z.Z. (2016) Could the Global Financial Crisis Improve the Performance of the G7 Stocks Markets? *Applied Economics*. 2016, Vol.48, No.12, pp.1066-1080.

YEN, G. and LEE, C. (2008) Efficient market hypothesis (EMH): Past, present and future. *Review of Pacific Basin Financial Markets and Policies*. 2008, Vol.11, No.2, pp.305-329.