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Examining the Islamic stock market efficiency: Evidence from nonlinear ESTAR unit root tests

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This paper empirically examines the efficient market hypothesis (EMH) in the Islamic stock market namely Jakarta Islamic Index by emphasizing on the random walk behavior and nonlinearity. In the first step, we employ Brock et al. (1996) test to examine the presence of nonlinear behavior in Jakarta Islamic Index. The evidence of nonlinear behavior in the indices, motivate us to use nonlinear ESTAR unit root test procedure recently developed by Kapetanios et al. (2003) and Kruse (2011). The nonlinear unit root test procedure fail to rejects the null hypothesis of unit root for the indices, suggesting that Jakarta Islamic Index characterized by random walk process supporting the theory of efficient market hypothesis. In addition, Lumsdaine and Papel (LP) test identified significant structural breaks in the index series.

Keywords: *Islamic stock market, Efficient market hypothesis, Nonlinearity*

Introduction

The efficient market hypothesis is among the most popular research topic in the economic literature. Since stock trading is essential for both individual and institutional investors, understanding the behavior of stock price play important role in economic policy, corporate investments and financing strategies. Fama (1970) stated that the main function of the stock market is to distribute ownership to capital resources in the economy. This mechanism is accomplished through price setting on the secondary market, that provide accurate signals for resource allocation, which means that firm can make investment and production decisions. On the other hand, investors can choose among the securities that represent ownership of firms' activities based on the assumption that security prices fully reflect all available information that is called efficient.

Fama (1970) divides the efficient market hypothesis (EMH) into three forms; the weak form, the semi-strong form, and the strong form, depend on the underlying information set that is available for market participants. The weak form of EMH is popularly known as the random walk theory, which means that stock market return cannot be predicted from previous price change. According to Fama (1970), markets are supposed to be efficient if the current stock prices fully reflect information contained in the past realizations of the price. In an efficient market, stock prices only response to the unexpected information, information are random, thus stock price changes should be also unpredictable and

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random and one cannot earn abnormal returns on the basis of historical information on prices and trading volume. Therefore, testing for mean reversion in stock prices is one avenue for examining stock market efficiency.

There is a large body of the literatures that investigate the efficient market hypothesis using variety methodology and produced mixed results. For instance, Fama and French (1988), Lo and MacKinlay (1988), Poterba and Summers (1988), Urrutia (1995), Grieb and Reyes (1999), Chaudhuri and Wu (2003), Shively (2003), Narayan (2008), Huang (1995), Poshakwale (1996), Mobarek and Keasey (2002), and Khaled and Islam (2005) have found a lack of evidence to support the efficient market hypothesis (EMH) in the stock indexes. In contrast, others studies conclude that stock prices are characterized by a unit root process supporting the EMH. For instance, Ojah and Karemera (1999); Hubber (1997); Lee (1992); Abrosimova et al. (2005); Mustofa (2004); Narayan (2005); Narayan and Smyth (2005); Ozdemir (2008); Qiant et al. (2008).

Considering the theoretical and practical implication as well as conflicting evidence resulted from empirical studies on efficient market hypothesis motivate us to have a fresh look at the context of Islamic stock market. This study is potentially interesting case study for Jakarta Islamic Index (JII), which shares the characteristics of stocks of corporations whose business and activities are compatible with Islamic law. Hence, there are some criteria that need to be fulfilled by companies if they want to be included in this index. These requirements may be make the JII different in term of behavior and tend to be segmented as compare to the composite index. Secondly, the deregulation in financial markets and advance on technology in Indonesian stock market will attract more international investors in the hope to get benefit from portfolio diversification. Thirdly, the majority of previous studies apply the traditional unit root test in testing the null hypothesis of unit root in stock prices. It is well known that the traditional test may be bias in not rejecting the null hypothesis in the presence of structural breaks (Perron, 1989).

Moreover, economic theory give an indications that the behavior of stock prices may follow nonlinear pattern in the series due to transaction costs and market frictions, heterogeneity of agent's investment objectives, and diversity in agent beliefs (Hasanov 2009). Therefore, the reliability of the finding from prevailing studies assuming linearity in the time series is questionable. Hence, some researchers then adapt to Narayan (2005); Munir and Mansur (2009) investigate the random walk hypothesis in the stock market by adopting nonlinear threshold autoregressive (TAR) model of Caner and Hansen (2001). Furthermore, Hasanove and Omay (2007) and Hasanov (2009) are among the studies that examine the random walk hypothesis by adopting nonlinear unit root test procedure proposed by Kapetanios et al. (2003).

Although Islamic finance has experienced rapid growth during the last decade, there are still limited studies investigating the behavior of Islamic stock market in the international literature. To the best of our knowledge, there is no study which applies nonlinear unit root methods for testing the EMH in the case of Jakarta Islamic Indices. Thus, this paper attempts to contribute to the existing literature on the Islamic stock market efficiency by taking both structural breaks and nonlinearity into consideration. We employ the Lumsdaine and Papell (1997) unit root test with breaks and linearity test proposed by Brock *et al.* (1996). Furthermore, we use nonlinear STAR unit root test developed by Kapetanios *et al.* (2003) and Kruse (2011) which allows for testing unit root behavior in a more general nonlinear framework where the transition between regimes occurs in a smooth manner, rather than instantaneously. Finally, we also estimate the speed of transition parameter. The estimated ESTAR model indicates that Jakarta Islamic index is not mean reversion process.

The remaining of the article is organized as follows. In the next section, we provide a review of relevant literature. Section 3 briefly describes the empirical approach and section 4 presents data and estimation results. Finally, section 5 contains some concluding remarks.

Literature Review

Most of earlier studies on efficient market hypothesis apply the covariance ratio test. The study of Fama (1970), Fama and French (1988),

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Lo and McKinlay (1988), Poterba and Summers (1988), Lee (1992), and Hubber (1997) are among the few that have been conducted to evaluate the random walk hypothesis. In the context of emerging market, even though the efficient capital market is supposedly to be in process, due to financial market imperfections, however, in most studies conducted in emerging markets, the empirical evidence in support of an efficient market hypothesis is still mixed. Firstly, by using correlation analysis, Olowe (1999), Abeysekera (2001), and Aga and Kocaman (2008) examined the random walk hypothesis in some developing countries namely Sri Lankan and Turkey stock exchange. Furthermore, investigations on random walk hypothesis in developing countries also try to adopt different methodology to get more comprehensive result. As done by Ayadi and Pyun (1994), Malliaropulos and Priestley (1999), Abraham, Seyyed, and Alsakran (2002), and Kim and Shamsuddin (2008) which employed variance ratio test in examining random walk hypothesis in Asian region. While, Urrutia (1995), Ojahand Karemera (1999), and Grieb and Reyes (1999) used the same approach for Latin American stock markets. The mixed result from the studies using variance ratio test, led to another investigation using standard linear unit root test. Asiri (2008), Ozdemir (2008), Sundeand Zivanomoyo (2008), Uddin and Khoda (2009), and Oskooe et *al*. (2010) are some studies which employ standard linear unit root test, namely; ADF, PP, and KPSS test, in their studies on emerging stock markets. This test is based on univariate unit root test assuming data generating process are linear.

On the other hand, according to Perron (1989), the conventional unit root test will lacks of power if the true data generating process of a series exhibits structural breaks. Structural breaks manifest themselves in time series data for a number of reasons, for instance, due to economic crisis, policy changes, and regime shifts. Thus, to account for impact of structural breaks on the results, several studies employ Zivot and Andrews (1992) one break and the Lumsdaine and Papell (1997) two breaks unit root test. Using this approach, Chauduri and Wu (2003) and Narayan and Smyth (2004) investigated random walk hypothesis for emerging market and Korean market respectively. Even though, they use the same approach but the result is still mixed.

Furthermore, to account the presence of nonlinearities in the financial data, Munir and Mansur (2009) employ two regime threshold autoregressive (TAR) model to investigate whether the Malaysia's Kula Lumpur stock market is efficient. Utilizing monthly stock price data for the period January 1980 to August 2008, their finding indicate that the Kuala Lumpur stock market exhibits nonlinear behaviors with unit root. This implies that returns on the Kuala Lumpur stock market cannot be predicted using past price behavior.

Recently, Kapetanios et al. (2003) have developed a unit root test procedure in an exponential smooth transition autoregressive (ESTAR) framework, which has better power than previous approach. Unlike the conventional linear ADF test, this test allows smooth transition between the stationary regime and the nonstationary regime which can be justified by nonlinear adjustments of financial market variables. Hasanov and Omay (2007) apply this approach to investigate eight transition stockmarkets, while, Hasanov (2009) also apply this method in investigating Korean stock market.

Econometric Methods

The Lumsdaine and Papell (1997) unit root test with two structural breaks

Lumsdaine and Papell (1997) proposed the extension of Zivot and Andrews (1992) model to allow for two structural breaks. There are two types of model that proposed by Lumsdaine and Papell (1997), namely, model AA allows for two breaks in the intercept of the trend, and model CC allows for two breaks in the intercept and slope of the trend. Model AA is based on the following equation;

$$\Delta Y_t = \alpha_0 + \alpha Y_{t-1} + \beta t + \theta DU_t + \omega DU_t + \sum_{j=1}^{k} d_j \Delta Y_{t-j} + \varepsilon_t \quad 1)$$

Model CC is defined as follows:

$$\Delta Y_t = \alpha_0 + \alpha Y_{t-1} \beta t + \theta DU_t + \gamma DT_t + \omega DU2_t + \psi DT2_t \sum_{j=1}^{k} d_j \Delta Y_{t-j} + \varepsilon_t \quad 2)$$

The null hypothesis for model 1 and 2 is that α = 0, which implies there is a unit root in Yt, against the alternative hypothesis α < 0, which implies that Yt is breakpoint stationary. DU1t and DU2t are indicator dummy variables for a mean shift occurring at TB1 and TB2 respectively, where TB2 > TB1 + 2 and DT1t and DT22 are the corresponding trend shift variables.

$$DU1_t \begin{cases} 1 & if\ t > TB1 \\ 0 & otherwise \end{cases}$$

$$DU2_t \begin{cases} 1 & if\ t > TB2 \\ 0 & otherwise \end{cases}$$

and

$$DU1_t \begin{cases} t = TB1 & if\ t > TB1 \\ 0 & overwise \end{cases}$$

$$DU2_t \begin{cases} t - TB2 & if\ t > TB2 \\ 0 & otherwise \end{cases}$$

Linearity test

Brock *et al*. (1996) developed the BDS test based on the concept of correlation integral, which is a measure of the frequency with which temporal patterns are repeated in the data. The test statistic is asymptotically distributed as a normal variable under the null hypothesis of i.i.d. against an unspecified alternative using a nonparametric technique.

Consider a time series x_t for $t = 1,2,\ldots,n$ and define its *m*-history as $x_t^m = (x_t, x_{t-1}, \ldots, x_{t-m+1})$ Brock, Dechert, Scheinkman and LeBaron (1996) define BDS statistic as follows:

$$W_{m,n}(\varepsilon) = \sqrt{n}\frac{T_{m.m(\varepsilon)}}{V_{m,\in(\varepsilon)}} \qquad 3)$$

Where *n* is the sample size, *m* is the embedding dimension, and the metric bound (ε) is the maximum difference between pairs of observation counted in computing the correlation integral. $T_{m,n}(\varepsilon)$, which has an asymptotic normal distribution with zero mean and variance $V_m^2(\varepsilon)$, measures the difference between the dispersion of the observed data series in a number of spaces with the dispersion that and i.i.d. process would generate in these same spaces, that is $C_{m,n}(\varepsilon) - C_{1,n},(\varepsilon)^m$. So the null hypothesis of i.i.d. is rejected at the 5% significance level whenever $|W_{m,n}|>1.96$.

Nonlinear unit root test

Considering a univariate smooth transition autoregressive (ESTAR) model of order one:

$$\Delta y_t = \Phi y_{t-1}(1 - \exp\{-\gamma(y_{t-d} - c)^2\}) + \varepsilon_t \qquad 4)$$

Kapetanios *et al*. (2003) test assumes that the location parameter *c* in the smooth transition function is equal to zero. On the contrary, a lot of empirical studies on financial data report significant estimate of *c*. According to Kruse (2011) when relaxing this assumption, we are faced with a nonstandard testing problem.

Kruse (2011) then proposed new approach to allow for a non-zero location parameter c in the exponential transition function. Considering the nonlinear time series model in equation (4), following Kapetanios *et al*. (2003), he applies a first order Taylor approximation to $G(y_t;\gamma,c=(1-\exp\{-\gamma(y_{t-1}-c)^2\})$ around γ = 0 the regression model for the testing procedure is written as follows:

$$\Delta y_t = \beta_1 y_{t-1}^3 + \beta_2 y_{t-1}^2 + \beta_3 y_{t-1} + u_t \qquad 5)$$

Following Kapetanios *et al*. (2003), he imposes $\beta_3=0$ to improve the power of the test, hence we proceed with

$$\Delta y_t = \beta_1 y_{t-1}^3 + \beta_2 y_{t-1}^2 + u_t \qquad 6)$$

where $\beta_1=\gamma\phi$ and $\beta_2=-2c\gamma\phi$. Kruse (2011) interested in the pair of hypotheses given by $H_0: \gamma = 0$ against the alternative hypothesis of the global stationary ESTAR process, $H_1: \gamma > 0.$ In the regression (6), this pair of hypothesis is equivalent to $H_0:\beta_1=\beta_2=0$ against $H_1:\beta_1<0,\beta_2\neq 0$. Note that the two-sidedness of β2 under H_1 stems from the fact that c is allowed to take real values. This testing problem is nonstandard in the sense that one parameter is one sided under H¬1, while the other is two-sided. A standard Wald test would be inappropriate and he therefore applies the methods

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Table 1. Unit Root Test with Two Structural Breaks

	Model AA	Model CC
TB1	03/1998	05/2002
TB2	03/2000	08/2008
A	**-0.1452**	**-0.4239****
	[-4.4490]	**[-7.0072]**
Θ	-0.1110*	-0.0474
	[-3.1457]	[-1.4952]
Ω	-0.1084**	-0.3318*
	[-2.9009]	[-5.5149]
Γ	-	0.0148*
		[6.6127]
Ψ	-	0.0014
		[0.5657]
K	6	6
Critical values for tα		
1%	-6.94	-7.34
5%	-6.24	-6.82
10%	-5.96	-6.49

Notes: The optimum lag length k is selected according to Schwarz Information Criteria (SIC). Model AA refers to structural break in the intercept only, and model CC refers to structural breaks both in the intercept and slope of the trend function. Numbers in parentheses are t-statistics. *, and ** denote significance at 1% and 5% level respectively.

of Abadir and Distaso (2007) to derive a suitable test. In a nutshell, the one-sided parameter is orthogonalized with respect to the two sided one.

Kruse (2011) then modified the standard Wald test statistic based on the Hessian matrix. Hence, now we have the new test statistic for the unit root hypothesis against globally stationary ESTAR. A simpler and more intuitive way to formulate the statistic is

$$\tau = t^2_{\beta_{\frac{1}{2}}=0} + 1\left(\hat{\beta}_1 < 0\right) t^2_{\beta_{1=0}} \quad 7)$$

The two summands in the test statistic τ can be interpreted as: the first term is a squared t-statistic for the hypothesis $\beta_{\frac{1}{2}} \equiv \beta_2 - \beta_1 v_{21} / v_{11} = 0$ with $\beta_{\frac{1}{2}}$ being orthogonal to β_1. Additionally, the second term is a squared t-statistic for the hypothesis $\beta_1=0$, the one-sidedness under H1 is achieved by the multiplied indicator function.

Result and Discussion

This study employs the logged values of the Jakarta Islamic Index (JII), which is the index for *shari'ah* compliance stocks. Monthly stock price over the period January 1995 to December 2013 are utilized for analysis. The data are taken from Bloomberg database. Specifically we retrieve the closing prices of the last trading days of all months and all series are transformed into natural logarithm.

In the first step, we consider the case in which the stock index is assumed to contain a structural break with the break point determined endogenously. Allowing for multiple breaks in the unit root test is important because Indonesia have been experienced several economic events over the period of the study, such as Asian financial crisis (1997-1998) and Global financial crisis (2006-2009). For this purposes, we estimate model AA and CC of Lumsdaine and Papell (1997) test with two structural breaks.

The results from Lumsdaine and Papell (1997) test are presented in Table 1. Model AA clearly reveals that null of unit root hypothesis is cannot be rejected when two structural breaks is allowed. However, according to model CC, the null of unit root hypothesis is rejected at 5% level of significant. This implies that Jakarta Islamic Index series are characterized not by the presence of unit root process, but by stationary fluc-

Table 2. BDS Test Statistics

Length (Std. Dev. Terms) ε/σ	Embedding Dimension (m)	Raw series	Residual series
0.5	2	80.35754*	1.574570
0.5	3	135.1053*	2.141331**
0.5	4	244.6049*	3.522496*
0.5	5	477.9405*	3.820626*
1	2	65.93521*	2.240447**
1	3	81.93214*	2.929588*
1	4	104.9646*	3.520140*
1	5	140.2479*	3.637164*
1.5	2	51.36018*	3.466695*
1.5	3	55.98957*	4.428218*
1.5	4	61.87758*	4.979088*
1.5	5	70.51406*	5.104318*
2	2	37.28865*	3.426366*
2	3	36.85962*	4.611440*
2	4	36.61030*	5.129965*
2	5	37.12202*	5.322853*

Note: * and ** denote significance at 1% and 5% level respectively. Residual series obtained from ARMA (1,1) model and selected based on AIC

tuations around a breaking deterministic trend.

According to the break test results, for model AA, the estimated coefficients of θ and γ are significant at 1% and 5% level of significant respectively. Thus, at least there have been two structural changes in the means during the sample period as reported at TB1 and TB2. While from model CC, we found that estimated coefficient of ω and γ are statistically significant at 1% level, indicating that reported structural changes at TB1 and TB2 (Table 1) have impacted on both the intercept and trend. Furthermore, the reported structural break in model AA is happened on March 1998 and March 2000. The period of 1997 is considered as the era of Asian financial crisis, while year 2000 corresponds with the recovery period for the Indonesian economy after crisis. Furthermore, the statistically significant structural break for model CC is happened during period of August 2008, the year where global financial crisis happened. Since the results obtained from unit root test with structural breaks are mixed, in order to get more complete picture about Jakarta Islamic Index series, we precede with the nonlinearity test.

Before we perform the nonlinear unit root test, we investigate whether we can reject the linear autoregressive model in favor of nonlinear model. For that purposes, we apply the BDS test on the index series. Following Brock, Hsieh, and LeBaron (1991), Hsieh (1991), and Sewell *et al.* (1993), the value of ε used in the study equals 0.5σ, σ, 1.5σ, and 2σ, where σ is the standard deviation. As for the choice of the relevant embedding dimension *m*, we implement the range of *m*-values from 2 to an upper bound of 5.

Table 2 reports the BDS statistic for the raw series as well as residual series, in order to test the possible nonlinear hidden structure, for embedding dimension 2 to 5 and for epsilon values starting from 0.5 to 2 times the standard deviation of the series. It is obvious from Table 2 that all BDS statistics are strongly reject the null hypothesis of *i.i.d.* at 5 per cent and 1 per cent significance level, indicating that all series are nonlinearity dependent.

As argues by Antoniou et al. (1997) there are several reasons why nonlinearities may observe in financial markets. First, the characteristics of the market microstructure due to the difficulties in carrying out arbitrage transactions. For example, differing microstructures between stock markets and derivative markets may give rise to nonlinear dependence. Second, nonlinearities may come

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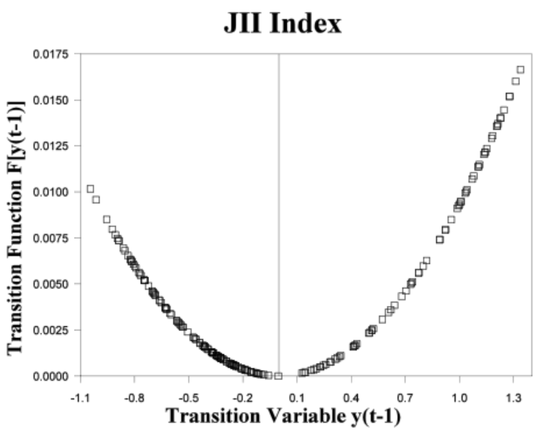
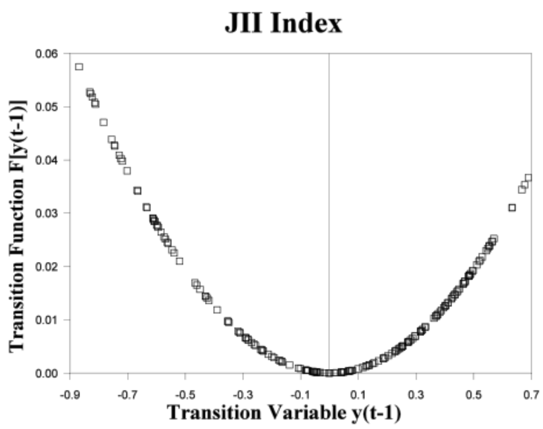
Table 3. Nonlinear Unit Root Test

	Demeaned series		De-trended series	
	KSS	T	KSS	T
t_{NL} / τ	-0.70122	5.83300	-1.74831	3.62160
Θ	0.00423		0.01391	
SE of θ	0.00526		0.00857	
Critical values of the t_{NL} and τ statistic				
1%	-3.48	13.75	-3.93	17.10
5%	-2.93	10.17	-3.40	12.82
10%	-2.66	8.60	-3.13	11.10

Notes: Asymptotic critical values of the t_{NL} statistic are taken from Table 1, Kapetanioset *al*. (2003). Asymptotic critical values of the τ statistic are taken from Table 1, Kruse (2011).



(a) Demeaned series



(b) Demeaned and de-trended series

Figure 1. Plot of Estimated Transition Functions against Transition Variables y_{t-1}

from the nonlinear feedback mechanisms in price movements. When the price of an asset gets too high, self-regulating forces usually drive the price down. If the feedback mechanism is nonlinear then the correction will not always be proportional to the amount by which the price deviates from the asset's real value. Third, nonlinearities could arise because of the presence of market imperfections such as transaction costs. In other words, market participants will only take action whenever it is economically profitable, leading to clustering of price changes. The Fourth reason, related to the fact that capital market theory is based on the assumption of rational investors. However, in fact, investors may act as risk lovers when taking a gamble in order to recover their losses. Moreover, they may have too much faith in their own forecasts, hence introducing bias into their subjective probabilities. Therefore, linear model may not be adequate in explaining the market behavior.

Having established the evidence of nonlinearity based on the Brock *et al*. (1996) test, we use the test of Kapetanios et al.(2003) as well as Kruse (2011) where the null of a linear unit root process is tested against the alternative of a globally stationary nonlinear ESTAR model. The estimated results of nonlinear unit root test for Jakarta Islamic Index is presented in Table 3. Table 3 reveals, the null hypothesis of unit root could not be rejected for both demeaned and de-trended series, indicated from the value of t_{NL} which is greater than t_{NL} critical value for all significance level. In line with the results form KSS test, the Kruse (2011) test also cannot reject the null hypothesis of unit root giving the value of τ test which is less than their critical value. In addition, the estimates of transition parameters θ for both series are also insignificant, indicating that no mean reversion for the series under consideration. This is an expected result since under the null hypothesis that θ = 0, the series follow a unit root. The parameter θ indicates the speed of mean reversion process.

Figure 1 provides plots of the estimated transition functions against the corresponding transition variables. The insignificance of the estimated slope coefficients indicating that the speed of transition is very weak, suggesting that stock prices are characterized by slow and insignificant reversion to the long-run equilibrium level, as illustrated in Figure 1. This may explain why unit root tests fail to reject the null hypothesis of unit root.

Conclusion

This study investigates the behavior of Islamic stock market using Lumsdaine and Papell (1997) test and nonlinear unit root test. From the linearity test revealed that the Jakarta Islamic Index series follow nonlinear dynamic process. An application of the recent nonlinear unit test of KSS (2003) and Kruse (2011) both indicate that Jakarta Islamic Indices are consistently characterized by random walk behavior in line with the efficient market hypothesis. Moreover, the results from Lumsdaine and Papell (1997) test indicate that Jakarta Islamic index series experienced significant structural breaks.

The results of this study provide several implications in the area of financial research concentrating on capital market efficiency of Jakarta Islamic Index. Given the evidence that Islamic stock prices are characterized by nonlinear dynamic process, previous literatures, assuming that Islamic stock prices follows linear process, in examining the presence of mean reversion process are in applicable of tacking account of these features and as such may lead to an inappropriate conclusions being reached about the stock market efficiency. The evidence of stock indices series follow a random walk process implies that successive price changes are independent, i.e., the past prices cannot be used to predict the future prices, hence, market participants not be able to systematically earn abnormal profit from the market. Therefore, the theory of chartist which assume that there is dependence in series of successive price change, that is, the history of the series can be used to make meaningful predictions concerning the future, may not be relevant in Jakarta Islamic Index. In other words, our finding suggests that investors could, when making their investment decisions, consider an asset price to reflect its true fundamental value at all times. Where, fundamental value of the stock can be analyzed by considering macroeconomic and industry circumstances which might have influence on the firm's performance.

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