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The Behavior of Indonesian Stock Market:
Structural Breaks and Nonlinearity

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Abstract: This study empirically examines the behaviour of Indonesian stock market under the efficient market hypothesis framework by emphasizing on the random walk behaviour and nonlinearity over the period of April 1983 - December 2010. In the first step, the standard linear unit root test, namely the augmented Dickey-Fuller (ADF) test, Phillip-Perron (PP) test and Kwiatkowski-Philllips-Schmidt-Shin (KPSS) test identify the random walk behaviour in the indices. In order to take account the possible breaks in the index series Zivot and Adrews (1992) one break and Lumsdaine and Papell (1997) two breaks unit root test are employed to observe whether the presence of breaks in the data series will prevent the stocks from randomly pricing or vice versa. In the third step, we employ Harvey et al. (2008) test to examine the presence of nonlinear behaviour in Indonesian stock indices. The evidence of nonlinear behaviour in the indices, motivate us to use nonlinear unit root test procedure recently developed by Kapetanios et al. (2003) and Kruse (2010). In general, the results from standard linear unit root test, Zivot and Adrews (ZA) test and Lumsdaine and Papell (LP) test provide evidence that Jakarta Composite Index characterized by a unit root. In addition, structural breaks identified by ZA and LP test are corresponded to the events of financial market liberalization and financial crisis. The nonlinear unit root test procedure fail to rejects the null hypothesis of unit root for all indices, suggesting that Jakarta Composite Index characterized by random walk process supporting the theory of efficient market hypothesis.

Abstrak: Penelitian ini secara empiris mengamati perilaku pasar saham Indonesia dalam kerangka hipotesis pasar yang efisien dengan menekankan pada perilaku pergerakan harga acak (*random walk*) dan nonlinier selama periode April 1983 - Desember 2010. Pada langkah pertama digunakan uji unit root yang standar dan linier, yaitu uji *augmented* Dickey-Fuller (ADF), Phillip-Perron (PP) dan Kwiatkowski-Philllips-Schmidt-Shin (KPSS), yang mengidentifikasi perilaku *random walk* pada indeks. Untuk memperhitungkan kemungkinan adanya patahan (*breaks*) dalam indeks, digunakan uji Zivot dan Adrews (1992) satu *breaks* dan Lumsdaine dan Papell (1997) dua *breaks* unit root, untuk mengamati apakah kehadiran patahan dalam seri data akan mempengaruhi perilaku harga saham dari perilaku *random* atau sebaliknya. Pada langkah ketiga, kami menggunakan model Harvey et al. (2008) untuk memeriksa adanya perilaku nonlinier dalam indeks saham Indonesia. Adanya temuan perilaku nonlinier dalam indeks, memotivasi peneliti untuk menggunakan

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prosedur tes nonlinear unit root yang dikembangkan oleh Kapetanios et al. (2003) dan Kruse (2010). Secara umum, hasil dari uji unit root yang standar dan linier, Zivot dan Adrews (ZA) dan Lumsdaine dan Papell (LP) menunjukkan bahwa IHSG memiliki perilaku pergerakan harga yang acak. Selain itu, adanya patahan struktural diidentifikasi oleh uji ZA dan LP yang berhubungan dengan peristiwa liberalisasi pasar keuangan dan krisis keuangan. Prosedur uji unit root nonlinier gagal untuk menolak nul hipotesis unit root untuk semua indeks, menunjukkan bahwa IHSG ditandai oleh proses *random walk* mendukung teori hipotesis pasar efisien.

Keywords: linearity and non-linearity; smooth transition autoregressive (STAR) models; stock markets; structural breaks

Introduction

Financial markets such as bond and stock markets plays important role in promoting economic efficiency and economic growth by channeling funds from people who do not have a productive use to those who need funds for productive investment. Equally important is the information efficiency of the financial market. Market efficiency is essential because it helps to explain why asset prices change in financial markets and how these changes take place. More precisely, efficient market implies that 1) one investment is as good as any other because the securities' prices are correct; 2) a security's price reflects all available information about the intrinsic value of the security; 3) security prices can be used by managers of both financial and nonfinancial firms to assess their cost of capital (cost of financing their investments) accurately and hence that security prices can be used to help them make the correct decisions about whether a specific investment is worth making or not (Mishkin 2004). Thus market efficiency is indisputably desirable for market development and economic growth as a whole.

In an efficient market, changes of stock prices are influenced by different types of information. Fama (1970) distinguishes three versions of market efficiency depending on the underlying information set that is available to market participants: weak form, semi-strong form and strong form. Markets are said to be weak form 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 unpredictable news, news are random, thus stock price changes should be also unpredictable and random and one cannot earn abnormal returns on the basis of historical information on prices and trading volumes. Stock prices are characterized by a unit root if stock prices follow a random walk. Thus, testing for a unit root in stock prices is one way to validate the weak form efficiency hypothesis.

Over the years, there has been a large body of empirical research concerning the validity of the efficient market hypothesis with respect to stock markets in both developed and developing countries. Empirical research on testing the random walk hypothesis has 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) have found that stock indexes are not characterized by a unit root. In contrast, others studies have found stock prices are characterized by a unit root process. For instance, Hubber (1997); Lee (1992); Ozdemir (2008); Narayan (2005); Narayan and Smyth (2005); Qiant et al. (2008).

As far as the emerging markets are concerned, it is widely believed that the majority of emerging markets are less efficient than developed markets due to certain market imperfections such as transaction costs, poor quality of information disclosures, thin trading, and inadequate financial and accounting regulations. For this reason, recent studies on emerging markets have mainly stressed the weak form efficiency whereas the literature on developed markets is concerned by all three forms of efficiency. The empirical evidence is also inclusive for the developing countries. These studies on emerging stock markets can be divided into two groups depending on findings. Researches who finds the evidence to support the weak-form efficiency [e.g., (Urrutia 1995); (Ojah and Karemera 1999); (Abrosimova et al. 2005); (Moustafa 2004)], and others shows the evidence of predictability or rejection of the random walk hypothesis in stock returns [e.g., (Huang 1995); (Poshakwale 1996); (Mobarek and Keasey 2002); (Khaled and Islam 2005)].

Considering the theoretical and practical significance, the testable implications and conflicting empirical evidence of the random walk hypothesis motivates us to have a fresh look at this issue of weak-form efficiency in the context of an emerging market, namely Indonesian stock market. This study is potentially interesting case study for a developing capital market, which shares most of the characteristics of a typical emerging market. Secondly, the liberation of financial market and advance on technology, these markets become more integrated with global equity markets, which attracting more international investors in the hope to benefit from higher abnormal returns and portfolio diversification, where market efficiency has important implications for those investors. Thirdly, the majority of previous studies apply the traditional unit root test in testing the null hypothesis of a unit root in stock prices. It is well known that the tradition test may bias in not rejecting the null hypothesis in the presence of structure breaks (Perron 1989). Chauduri and Wu (2003), Narayan and Smyth, (2004), Narayan (2005), Lean and Smyth (2007), Narayan (2008); Lee et al. (2010) investigate the stationarity properties using the new unit test with structure breaks for other markets.

Furthermore, economic theory suggests that the behavior of stock prices may exhibit nonlinear pattern in the series due to transaction costs and market frictions, heterogeneity of agent's investment objectives, and diversity in agent beliefs (Hasavov 2009).[1] Therefore the reliability of the finding from existing studies assuming linearity in the time series is questionable. To this end, some researcher then adopt 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).

As far as Indonesian stock is concerned, limited empirical studies are available yet the results are mixed. While Huang (1995), Huang and Yang (1995), Groenwold and Ariff (1998) Karemera et al. (1999) find the Indonesian stock weak-form efficient, Magnusson and Higgs (2005), Fuss (2005), Kim and Shamsuddin (2006), Hoque et al. (2006) and Zulfadin (2008) find that the market is weak-form inefficiency. Given Indonesian has gone through financial liberation, and financial crisis that may cause structural breaks. Previous studies did not take structure breaks into consideration. Furthermore, previous studies are based on the assumption of linear data generating process. Therefore the reliability of the finding from existing studies is questionable.

Thus, this paper attempts to overcome the above mentioned problems and contributes to the existing literature on the Indonesian stock market efficiency by taking both structural breaks and the nonlinearity into consideration. More specifically, this paper contributes to exiting literature on random walk hypothesis for Indonesian stock market

[1] See, Brock and Lebaron (1996), Brock and Hommes (1998), Peters (1994), Guillaume et al. (1995), Dumas (1992); Shleifer (2000), Hong and Stein (1999), among others

in four novel ways. *Firstly*, in addition to the conventional unit root test, the Zivot and Andrew (1992) one break and the Lumsdaine and Papell (1997) two-break unit root tests are used. *Secondly*, we employ the powerful linearity test proposed by Harvey et al. (2008) which is applicable when the order of integration of the time series under investigation is uncertain. It reveals that the Indonesian Stock index is nonlinear process in which allow us to question the validity of linear unit root test. *Thirdly*, we use nonlinear STAR unit root test developed by Kapetanios et al. (2003) and Kruse (2010) 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 the Indonesian stock market is not mean reversion process.

The rest of the study is organized as follows: Section two briefly describe about the methodology employed in the study. Data on which analysis is based is then presented in Section 3. Section 4 in turns discusses the empirical results and some implications of the study. Finally, Section 5 concludes the study.

Methodology

Unit Root Test With One Structural Break

According to Perron (1989), if structural break exist, the power to reject a unit root decreases when the stationary alternative is true and the structural break is ignored. Therefore, Perron (1989) then developed three alternative models, which accommodate a break in the trend function, namely: a) The crash model, which allows for a one time structural break in the intercept of the trend function; b) The changing growth model, which allows for a structural break in the slope; c) The crash-cum-growth model, which allows for a structural break in the intercept and slope.

However, Zivot and Andrews (1992) have argued that selecting the break point a priori based on ex post examination or knowledge of the data, as developed by Perron (1989) could lead to an over rejection of the unit root hypothesis. Hence, to avoid spurious results the break date is also treated as being endogenous. To this end, Zivot and Andrews (1992) developed two versions of the sequential trend break model to investigate the unit root hypothesis, as follows:

Model A:

$$\Delta Y_t = \alpha_0 + \alpha Y_{t-1} + \beta_t + \theta DU_t + \sum_{j=1}^{k} d_j \Delta Y_{t-j} + \varepsilon_t \text{................}(1)$$

Model C:

$$\Delta Y_t = \alpha_0 + \alpha Y_{t-1} + \beta_t + \theta DU_t + \gamma DT_t + \sum_{j=1}^{k} d_j \Delta Y_{t-j} + \varepsilon_t \text{........................}(2)$$

The null hypothesis for model 1 and 2 is that $\alpha = 0$, which implies there is a unit root in Y_t, against the alternative hypothesis $\alpha < 0$, which implies that Y_t is breakpoint stationary. Where DU_t is an indicator dummy variable for a mean shifting occurring at time TB, while DT is the corresponding trend shift variable, where:

$$DU_t = \begin{cases} 1 & \textit{if } t > TB \\ 0 & \textit{otherwise} \end{cases}$$

and

$$DU_t = \begin{cases} t - TB & \textit{if } t > TB \\ 0 & \textit{otherwise} \end{cases}$$

Furthermore, to implement the sequential trend break model, some region must be chosen such that the end points of the sample are not included. This is because in the presence of the end points the asymptotic distribution of the statistics diverges to infinity. Zivot and Andrews (1992) suggest the trimming region be specified as (0.15T, 0.85T), which is followed here. Thus, the break points are selected by choosing the value of TB for which the ADF t-statistic is maximized.

Unit Root Test with Two Structural Breaks

A possible problem with the Zivot and Andrews (1992) test is the loss of power if there are two structural breaks in the series. In response to this condition, Lumsdaine and Papell (1997) proposed the extension of Zivot and Andrews (1992) model A and C to allow for two structural breaks. Lumsdaine and Papell (1997) then call these models AA and CC respectively. 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 can be represented as follows:

$$\Delta Y_t = \alpha_0 + \alpha Y_{t-1} + \beta_t + \theta DU_t + \omega DU_t + \sum_{j=1}^{k} d_j \Delta Y_{t-j} + \varepsilon_t \text{.................(3)}$$

Model CC takes the following form:

$$\Delta Y_t = \alpha_0 + \alpha Y_{t-1} + \beta_t + \theta DU_t + \gamma DT_t + \omega DU2_t + \Psi DT2_t \sum_{j=1}^{k} d_j \Delta Y_{t-j} + \varepsilon_t \text{ ....(4)}$$

The null and alternative hypotheses are the same as in the one break case. $DU1_t$ and $DU2_t$ are indicator dummy variables for a mean shift occurring at TB1 and TB2 respectively, where TB2 > TB1 + 2 and $DT1_t$ and $DT2_2$ are the corresponding trend shift variables:

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

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

and

$$DU1_t = \begin{cases} t - TB1 & \textit{if } t > TB1 \\ 0 & \textit{otherwise} \end{cases}$$

$$DU2_t = \begin{cases} t - TB1 & \textit{if } t > TB1 \\ 0 & \textit{otherwise} \end{cases}$$

The same trimming region is used as in the case of model A and C. The critical values are calculated using the same methodology as in the case of model A and C.

Nonlinear Unit Root Test of Kapetanios et al. (2003)

Consider a univariate smooth transition autoregressive (STAR) model of order one:

$$y_t = \beta y_{t-1} + \gamma y_{t-1} F(\theta; y_{t-d}) + \varepsilon_t$$
$$t = 1, \ldots T \quad \text{........................(5)}$$

where y_t is a mean zero stochastic process and $e_t \sim i.i.d.\ (0, \sigma^2)$, and β *and* γ are unknown parameters. The transition function is assumed to be of the exponential form:

$$F(\theta; y_{t-d}) = 1 - \exp(-\theta y^2_{t-d}) \text{.................}(6)$$

Where it is assumed that $\theta > 0$ and $d \geq 1$ is the delay parameter. The exponential function is bounded between zero and one, i.e. $F: R \rightarrow [0,1]$ has the properties $F(0) = 0$; $\lim_{x \rightarrow \pm\infty} F(x) = 1$ and is symmetrically U-shaped around zero. The parameter θ is slope coefficient and determines the speed of transaction between to regimes that correspond to extreme values of the transition function. Substituting (6) into (5) one obtains the following exponential STAR (ESTAR) model:

$$y_t = \beta y_{t-1} + \theta y_{t-1} [1 - \exp(-\theta y^2_{t-d})] + \varepsilon_t \text{......}(7)$$

Subtract y_{t-1} from both side of (3), we have:

$$y_t = \phi y_{t-1} + \gamma y_{t-1} [1 - \exp(-\theta y^2_{t-d})] + \varepsilon_t \text{......}(8)$$

where $\phi = \beta - 1$. The ESTAR model has a nice property that it allows modeling different dynamics of series depending on the size of the deviations from the fundamental equilibrium (Teräsvirta 1994; Michael et al. 1997).

The theory suggests that arbitrageurs shall not engage in reversion strategies if deviations from the equilibrium are small in size (arbitrage is not profitable). If the deviations from equilibrium are large enough, however, arbitrageurs shall engage in profitable reversion trading strategies, and thus bring the prices to their equilibrium levels. In the context of ESTAR model, this would imply that while $\phi \geq 0$ is possible, one must have $\gamma < 0$ and $\phi + \gamma < 0$ for the process to be globally stationary. Under these conditions, the process might display unit root for small values of y^2_{t-d}, but for larger values of, it has stable dynamics, and as a result, is geometrically ergodic. Furthermore, the speed of mean reversion increases with the size of deviation from the fundamental equilibrium.

Following the practice in the literature (Balke and Fomby 1997 in the context of TAR models and Michael et al 1997 in the context of ESTAR models), Kapetanios et al. (2003) further impose, implying that follows a unit root in the middle regime. The reason is that, in some economic contexts it is reasonable to assume that the variable displays a mean reverting behavior towards an attractor when it is sufficiently far away from it, but a random walk representation in the neighborhood of the attractor. In this case, the ESTAR model can be written as:

$$\Delta y_t = \gamma y_{t-1} [1 - \exp(-\theta y^2_{t-d})] + \varepsilon_t \text{.............}(9)$$

The global stationarity of the process can be established by testing the null hypothesis $H_0 : \theta = 0$ against the alternative $H_0 : \theta > 1$. However, testing the null hypothesis directly is not feasible since the parameter is not identified under the null. To overcome this problem, Kapetanios et al. (2003) follow suggestion of Luukkonen et al. (1988) to replace the transition function by its appropriate Taylor approximation to derive a *t*-type test statistic. Replacing the transition function with its first order Taylor approximation yields the following auxiliary regression:

$$\Delta y_t = \delta y^3_{t-1} + \varepsilon_t \text{.....................}(10)$$

where e_t comprises original shocks ε_t as well as the error term resulting from Taylor approximation. The test statistic for $\delta = 0$ against $\delta < 0$ is obtained as follows:

$$t_{NL} = \hat{\delta}/s.e.(\hat{\delta}) \text{..........................} (11)$$

where,

$\hat{\delta}$ = the OLS estimate, and

$s.e.(\hat{\delta})$ = the standard error of $\hat{\delta}$.

The asymptotic distribution of this test t_{NL} is non-standard and KSS (2003) derive it and provide asymptotic critical values.

To accommodate stochastic processes with nonzero means and/or linear deterministic trends, the following modifications are needed. In the case where the data has nonzero mean, i.e., $x_t = \mu + y_t$, one must replace the raw data with de-meaned data $y_t = x_t - \bar{x}$ where $\bar{x}$ is the sample mean. In the case where the data has a nonzero mean and a nonzero linear trend, i.e., $x_t = \mu + \alpha t + y_t$, one must instead use the de-meaned and de-trended data $y_t = x_t - \hat{\mu} - \hat{\alpha}t$ where $\hat{\mu}$ and α are ordinary least square (OLS) estimators of μ and α. If errors in (10) are serially correlated, one may augment (9) and (10) into following:

$$\Delta y_t = \sum_{j=1}^{p} \rho j \Delta y_{t-1} + \gamma y_{t-1}[1 - \exp(-\theta y^2_{t-d})] + \varepsilon_t \text{ ....} (12)$$

$$\Delta y_t = \sum_{j=1}^{p} \rho j \Delta y_{t-j} + \delta y^3_{t-d} + \varepsilon_t \text{ ....} (13)$$

In practice, the number of augmentations p and the delay parameter d must be selected prior to the test. Kapetanios et al. (2003) propose that standard model selection criteria or significance testing procedure be used for selecting the number of augmentations p. They also suggest that the delay parameter d be chosen to maximize goodness of fit over d - $\{1,2,...d_{max}\}$. However, in practice, d is set to be one, see for example, Kapetanios et al. (2003) and Daiki (2005, 2006).

However, Kapetanios et al. (2003) test assumes that the location parameter c in the smooth transition function is equal to zero. According to Kruse (2010) when relaxing this assumption, we are faced with a nonstandard testing problem. Since standard inference c techniques are not appropriate in this situation, Kruse (2010) then proposed new approach to allow for a non-zero location parameter c in the exponential transition function. Following Kapetanios et al. (2003), Kruse (2010) applies a first order Taylor approximation to $G[y_t;\gamma,c = (1-\exp\{-\gamma(y_{t-1} - c]^2\})$ around $\gamma = 0$ and proceed with the test regression:

$$\Delta y_t = \beta_1 y^3_{t-1} + \beta_2 y^2_{t-1} + \beta_3 y_{t-1} + u_t \text{ ...} (14)$$

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

$$Dy_t = b_1 y^3_{t-1} + b_2 y^2_{t-1} + u_t \text{ ....} (15)$$

where $\beta_1 = \gamma\phi$ and $\beta_2 = 2c\gamma\phi$. Kruse (2010) interested in the pair of hypotheses given by H_0: $\gamma = 0$ against H_1: $\gamma > 0$. In the regression (15), this pair of hypothesis is equivalent to H_0: $\beta_1 = \beta_1 = 0$ against H_1: $\beta_1 < 0$, $\beta_2 \neq 0$. Note that the two-sidedness of β_2 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 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. The modified Wald test builds upon the one-sided parameter (β_1) and the transformed two-sided parameter, say $\beta_{\frac{1}{2}}$, that are stochastically independent by definition.

Let the parameter vector of the regression model (15) be $\theta = [\beta_1\ \beta_2]'$. Following the notation of Abadir and Distaso (2007), the null hypothesis of a unit root is written as:

$$H_0: h(\theta) \equiv [h_1(\theta)\ h_2(\theta)]' - [b1\ \ b2]' - [0\ 0]' \quad \text{..................(16)}$$

The alternative hypothesis of a globally stationary ESTAR model is given by:

$H_1 : h_1\ (\theta) < 0 \text{ or } h_2\ (\theta) \neq 0$

which includes the subset hypothesis $H_1^{\cap}: h_1(\theta) < 0$ and $h_2\ (\theta) \neq 0.$ Theorem 6 in Abadir and Distaso (2007) states that the modified Wald test is consistent against H_1 as well as $H_1^{\cap}$.

Kruse (2010) 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:

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

The two summands appearing in the test statistic τ can be interpreted as follows: the first term is a squared t-statistic for the hypothesis $\beta_{\frac{1}{2}} \equiv \beta_1 - \beta_1 v_{21}/v_{11}$ 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 H_1 is achieved by the multiplied indicator function.

Data Description

This study employs monthly Jakarta Composite index (JCI) over the period April 1983 to December 2010. The index is taken from Bloomberg database through a subscription by the Kulliyyah of Economics and Management Sciences, International Islamic University Malaysia. Specifically we retrieve the closing prices of the last trading days of all months and transformed into natural logarithm.

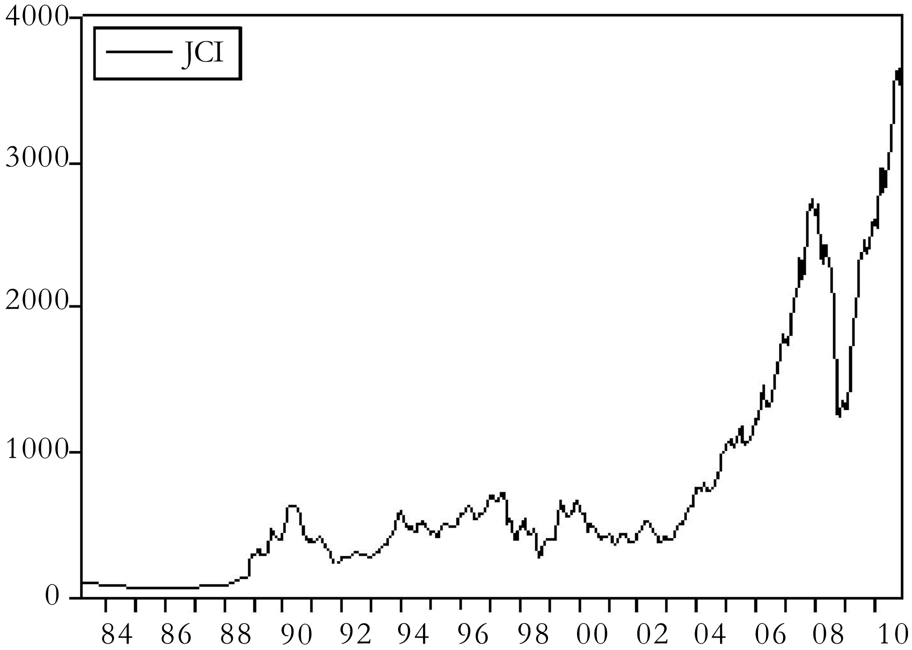
Empirical Results and Discussion

Standard Linear Unit Root Test Results

As preliminary step, the traditional unit root test such as ADF (Dickey and Fuller 1981), Phillip Perron and Kwiatkowski et al. (KPSS 1992) tests are employed, (see Table 1) indicates that the traditional unit-root tests provide no evidence of trend stationary, failing to reject the unit-root null at conventional significance levels. However, we find evidence that this variable is stationary when expressed in the first difference. Accordingly, JCI series seem to be integrated of order 1, or I (1). Hence, we can conclude that Jakarta Composite Index series behave according to random stochastic process.

Figure 1. **Plot of Monthly Closing Price of the Jakarta Composite Index and Its Transformation (April 1983-December 2010)**

(a)



(b)

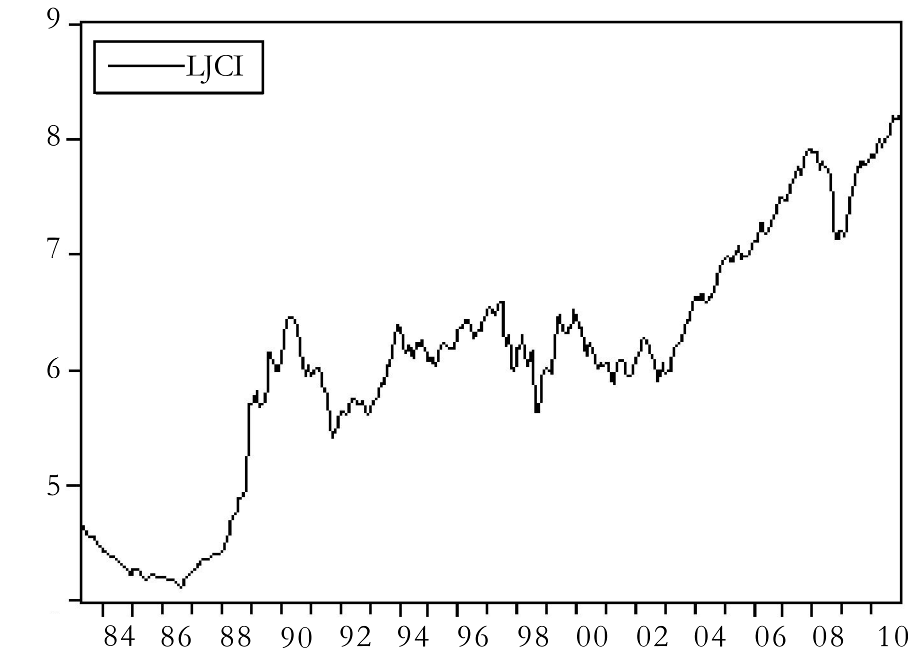


Table 1. **Linear Unit Root Test on Jakarta Composite Index**

Series	ADF		PP		KPSS	
	No Trend	Trend	No Trend	Trend	No Trend	Trend
lnJCI	-0.3485	-2.1430	-0.2529	-2.0568	1.7791*	0.1744**
ΔlnJCI	-14.8831*	-14.8809*	-14.8975*	-14.8809*	0.0929	0.0687

Note: *, and ** denote significance at 1% and 5% level respectively

Table 2. **Unit Root Test with One Structural Break on Jakarta Composite Index**

	Model A	Model C
TB	10/1988	10/1988
A	-0.1083	-0.1064
	[-3.0265]	[-2.9393]
Γ	0.0567**	0.0482***
	[2.4670]	[1.5045]
Γ	-	-0.0003
		[-0.3779]
k	8	8
Critical values for t_α		
1%	-5.34	-5.57
5%	-4.80	-5.08
10%	-4.58	-4.82

Notes: The optimum lag length *k* is selected according to Schwarz Information Criteria (SIC). Model A refers to structural break in the intercept only $\Delta Y_t = k + \alpha Y_{t-1} + \beta t + \theta DU_t + \sum_j^k = 1 d_j \Delta Y_{t-1} + \varepsilon_t$, and model C refers to structural breaks both in the intercept and slope of the trend function $\Delta Y_t = k + \alpha Y_{t-1} + \beta_t + \gamma DT_t + \omega DU2_t + \omega DT2t + \psi DT2t \sum_j^k = 1 dj \Delta Y_{t-j} + \varepsilon_t$. Number in parentheses are *t*-statistics. *,** and *** denote significance at 1 percent, 5 percent and 10percent level respectively.

Zivot and Andrews (1992) One Structural Break Test

Table 2 reports the Zivot and Andrews (ZA) test results for Jakarta Composite Index. Table 2 clearly reveals that the null of unit root hypothesis still cannot be rejected for series of Jakarta Composite Index even after the structural breaks is allowed. It can be identified from the estimated test statistics of α (-3.0265) which is greater than ZA critical value for all significance level. While for model C also indicating the same results, where the test statistics of coefficient α (-2.9393) is greater than ZA critical value, fail to reject null hypothesis of non-stationary.

Furthermore, from the estimated coefficient of θ in model A the break in the intercept is found to be statistically significant at the 5 percent level (based on critical value from the standard normal distribution). While for model C it is found that estimated coefficient of θ is statistically significant at 10 percent level, implying the Jakarta Composite Index series exist at least one structural break in the intercept. The break date provided by model A and C is during October 1988. Period of 1987-1988 is corresponds to the issuance of PAKDES (December Package) 87 to give ways for companies to go public and foreign investors to invest their money in Indonesia. Furthermore, in December 1988, the government issued PAKDES 88 to encourage companies go public and some other regulations that brought positive impacts on the capital market growth.

Lumsdaine and Papell (1997) Two Structural Breaks Test

We now consider the case in which the series assumed to contain two structural breaks, with the break point determined endogenously. We estimate model AA and CC and compute the *t*-statistic for testing the level of significant for each parameter. Table 3 presents the test results, with *t*-ratios exhibited in parentheses. Several observations can be drawn from Table 3.

Model AA in the Table 3 provides strong evidence that by allowing for two structural breaks it is still not possible to reject the unit root null hypothesis, indicated from the statistical value of the estimated coefficient α (-4.0574) which is greater than LP critical value at all significant level. While, the results obtained from model CC indicate that Jakarta Composite Index is characterized by unit root process, it can be seen from the statistical value of α (-5.1812) which is greater than critical value of LP test for all significant level. These results support the existence of random walk process in the Jakarta Composite Index.

In addition, according to model AA the estimated coefficient of θ and ω are statistically significant at 1 percent level (based on critical value from the standard normal distribution), implying that in the stock price series there exist at least two structural breaks in trend. While according to model CC, we found that first break in the slope is statistically significant at 1 percent, this results indicated from the statistical value of θ (4.9237). For the second break, we have significant break in the slope at 5 percent significant level and break in the intercept at 1 percent level of significant, as indicated from the statistical value of ω (2.5550) for break in the slope and statistical value ψ (4.6856) for break in the intercept.

Table 3. **Unit Root Test with Two Structural Break on Jakarta Composite Index**

	Model A	Model C
TB1	10/1988	08/1988
TB2	08/2004	01/2000
A	-0.1908	-0.0958
	[-4.0574]	[-5.1812]
Θ	0.2814*	0.1524*
	[3.6508]	[4.9237]
Ω	0.1664**	-0.0602**
	[2.6690]	[-2.5550]
Γ	-	-0.0003
		[-1.2857]
Ψ	-	0.0017*
		[4.6856]
K	8	8
Critical values for t_α		
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 A refers to structural break in the intercept only $\Delta Y_t = k + \alpha Y_{t-1} + \beta t + \theta DU_t + \omega DU_t + \sum_j^k = 1 d_j \Delta Y_{t-1} + \varepsilon_t$ and model CC refers to structural breaks both in the intercept and slope of the trend function $\Delta Y_t = k + \alpha Y_{t-1} + \beta_t + \theta DU_t + \gamma DT_t + \omega DU2_t + \psi DT2t \sum_j^k = 1 dj \Delta Y_{t-j} + \varepsilon_t$. Number in parentheses are *t*-statistics. *,** and *** denote significance at 1 percent, 5 percent and 10 percent level respectively.

Furthermore, the statistically significant structural break in the model AA is happened during October 1988 and August 2004, while for model CC is happened during August 1988 and January 2000. As discussed in the Zivot and Andrews (1992) model, the first structural break for model AA and CC for JCI series is October 1988 and August 1988, corresponds to some important policies made by Indonesian stock market authorities. PAKTO (October Package) 88 designed for the banking sector, but having an impact on the development of capital markets. PAKTO 88 contains provisions on 3 L (Legal, Lending, Limit), and the imposition of tax on deposit interest. The imposition of this tax had a positive impact on the development of capital markets. Because with the release of this policy means the government gives equal treatment between the banking sector and capital market sectors. Followed by the issuance of PAKDES 88, this package basically gives further impetus to the capital market by opening opportunities for the private sector to hold the stock. Prior to these two policies, on June 1988 Indonesia Pararel Bourse started to operate and managed by the securities and money trading organization, it consisted of brokers and dealers. Because these three policies Indonesian stock market became active capital markets for the period 1988 to the present. On the other hands, during October 1987 stock market around the world crashed, shedding a huge value in a very short time. Major indexes of market valuation in the United States dropped 30 percent or more. This was the greatest loss Wall Street had ever suffered on a single day.[2]

The second break for model CC is January 2000, where during 2000 Indonesian stock market experienced a negative trend, due to the political and economic instability after general election on the late of 1999. The negative trend was ended after 2003-2004 period as indicated from the second break of model AA which is happened on August 2004. As we can see from the plot graph in the Appendix, starting from this period Jakarta composite index went up continued until the end of 2007 where the global financial crisis started to attack Indonesian capital market.

Linearity Test

Before we perform the nonlinear unit test, we investigate whether we can reject the linear autoregressive model in favor of nonlinear model. The existing tests of the null of linearity against a nonlinearity alternative in the literature such proposed by Luukkonen et al. (1998), Granger and Teräsvirta (1993) and Teräsvirta (1994), however, rely on an assumption of I(0) behavior in the underlying series. In this study, we employ linearity test newly developed by Harvey et al. (2008). This test, the W_λ test, does not require an *a priori* assumption as to the order of integration of the process. Using this test, we obtain W_λ= 0.7.24 which is significant at the 5 percent level suggesting that the linearity is rejected.

[2] http://hnn.us/articles/895.htmlλ

Table 4. **Nonlinear Unit Root Test on Jakarta Composite Index**

	Demeaned Series		De-trended Series	
	KSS	**T**	**KSS**	**τ**
t_{NL}/τ	-0.11020	1.269	-2.01698	4.172
θ	0.00658		0.00432	
SE of $\hat{\theta}$	0.00509		0.00323	
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, Kapetanios et al. (2003). Asymptotic critical values of the τ statistic are taken from Table 1, Kruse (2010).

Nonlinear unit root test of Kapetanios et al. (2003)

Having established the evidence of nonlinearity based on the Harvey et al. (2008) test, we use the test of Kapetanios et al. (2003) as well as Kruse (2010) where the null of a linear unit root process is tested against the alternative of a globally stationary non-linear ESTAR model. The estimated results of nonlinear unit root test base on equation (13) and (18) for Jakarta Composite Index are presented in Table 4. Table 4 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 (2010) 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 $\theta = 0$, the series follow a unit root.

Conclusions

This study investigates the behavior of Indonesian stock market using various statistical tools. The results from the conventional unit root test with and without structural breaks indicate that the stock market is characterized by a unit root process. Further nonlinear test revealed that the Indonesian stock market prices follow nonlinear dynamic process. An application of the recent nonlinear unit test of KSS (2003) and Kruse (2010) both indicate that Indonesian stock market prices are consistently characterized by random walk behavior in line with the efficient market hypothesis. Furthermore, we also find that Indonesian stock market exhibit significant structural breaks.

Our finding has important implications to both academician and investment practitioners. Given the evidence that Indonesian stock market are characterized by nonlinear dynamic process and experienced significant structural breaks, any results from previous or future without taking structure breaks or nonlinearity may lead to an inappropriate conclusions. For investors, our findings indicates that both foreign and domestic investors could, when making their investment decisions, consider an asset price to reflect its true fundamental value at all times.

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