The Indonesian Capital Market Review

Volume 1
Number 1 *January*

Article 4

1-30-2009

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Recommended Citation
Bakara, Minarnita Yanti Verawati and Hermanto, Bambang (2009) "Are South East Asia Countries Capital Markets Characterized by Nonlinear Structures? An Investigation from Indonesia, Philippine and Singapore Capital Market Indices," *The Indonesian Capital Market Review*: Vol. 1 : No. 1 , Article 4.
DOI: 10.21002/icmr.v1i1.3918
Available at: https://scholarhub.ui.ac.id/icmr/vol1/iss1/4

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INDONESIAN
CAPITAL MARKET REVIEW

Are South East Asia Countries Capital Markets Characterized by Nonlinear Structures? An Investigation from Indonesia, Philippine and Singapore Capital Market Indices

Minarnita Yanti Verawati Bakara* and Bambang Hermanto

This research paper tries to detect the nonlinear structure in the South East Asia Countries Capital Markets. The capital markets of three South East Asia Countries are chosen: Indonesia, Philippine, and Singapore. Daily return data of Capital Markets composite indices are observed: Straits Times Index (STI) of Singapore Exchange from January 04, 1985 to December 31, 2007, Pilipino Stock Exchange Index (PSEi) of Philippines Stock Exchange from March 1, 1990 to December 31, 2007 and Jakarta Composite Index (JCI) of Indonesia Stock Exchange from January 05, 1988 to December 31, 2007.

Should nonlinearity be found, the outcomes of each observation are compared to analyze the implications of each country in global, regional and local position of their competition in the continuously changing world of interdependency environment. The implications of nonlinearity finding in the three ASEAN countries capital markets to the current issues of AFAS on Financial Services, Harmonization among ASEAN countries capital markets in the ASEAN region and ASEAN integration and liberalization on Financial Services are analyzed.

BDS statistic and R/S Analysis as our tools for nonlinearity testing are applied. Nonlinearity evidences in Jakarta Composite Index, Pilipino Stock Exchange Index and Straits Times Index are found.

Keywords: *Brock-Dechert-Scheinkman Statistic, Correlation Dimension, Deterministic Non Linear Dynamic System, Embedding Dimension, Fractal, Hurst Exponent, Rescaled Range (R/S) Analysis*

Introduction

In the global competition the role of South East Asia region should not be ignored especially in term of globalization of investment. Although majority of South

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Published by UI Scholars Hub, 2009

East Asia countries are developing countries but they have significant economic growth. To accelerate each country growth in this region a free trade area on Financial Services of this region is currently being created through the Association of South East Asian Nations (ASEAN). The ASEAN Free Trade Area on Financial Services agreement to accommodate and facilitate trading freely among ASEAN member countries will be a facility for liberalization and integration of Financial Services among ASEAN member countries. In designing this agreement cautions should be taken on the impact of the agreement by understanding how each country financial market systems had behave and will behave. Failing to understand the system will produce a false policy to be applied to the system. Policy as a system control tool applied inappropriately to the system affects undesired direction of outcome to be controlled. Deepen exploring South East Asia Nations Capital Markets will lead to better understanding of the behavior of the system which might be characterized by nonlinear structure.

Recently there is a trend of rapid growth in foreign investment in Financial Market particularly in stock market. The role of foreign buyers becomes crucial to succeeding securities trading. Liberalization in Financial Markets will facilitate foreign buyers to freely access foreign stock market. For diversification purpose, a continuing growth of internationally oriented financial products has taken place. In the international as well as regional arena, recent developments in many fields especially in information technology progress have increased cross listings of multinational companies in which have impacted stock market. As a result, stock markets have moved toward global integration as well as regional integration in their competition world both globally and regionally. Several empirical studies to assess degree of integration of international stock markets find strong statistical significant level of global integration leading to reduce benefits from international portfolio diversification. Other studies investigate the increased international interdependence by exploring national stock market crashes find the fall of national stock markets simultaneous and mutually reinforcing. Empirical evidence indicates a slowing down of current growth and possible reduction of international portfolio investment. This leads to questioning the efficiency concept of foreign financial market besides efficiency of national financial market.

Since capital market is an informational driven system the role of information technology progress in accelerating dissemination of information has affected financial market in general and stock market particularly. Nowadays people collect information easily by exploring internet. They gather true or untrue, correct or incorrect, right or wrong, valid or invalid information even without any knowledge and understanding of it. Some people have enough knowledge and time to verify any information acquired. Due to high speed of information changes and its high degree of dissemination most people don't make any verification of information and believe rumors as true material information. How people perceive the information they elaborate will define the decision they make. People's perception of information becomes crucial to determine the direction of finance and economic. Control of disseminated information through internet becomes uneasy due to limitation in legal, rule and policy across countries in term of internet information system.

In examining stock market efficiency most researches rely on linear techniques to find out a hidden structure that makes the movement of stock prices. This technique fails to detect multi dimensional and non

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DOI: 10.21002/icmr.v1i1.3918

linear patterns. Movements in stock prices are stochastic if not a random walk was taken for granted as a common believe for a long time to explain nonlinearity. Recent studies examine the possibility of nonlinearity in financial data. Some studies find the empirical evidence of nonlinear dependencies in financial time series.

Linear methods are related to all regularities of the structure in which small causes lead to small effects and one closed solution will be produced in the outcome. Linear equations lead to exponentially growing or periodically oscillating solution only. Therefore possible causes of irregular behavior in a system are nonlinear and chaos besides random external input. Uncertainty evolves due to irregularities in which there are many possible solutions. Nonlinear equations produce many possible solutions instead of one closed solution. No one closed solution shows non equilibrium. Irregularities are characteristic of most financial and economic data. Financial players behave irrationally due to uncertainty and irregularities. Behavioral finance studies irrational behavior of financial players.

The aim of this research is to answer our research question whether three South East Asia countries capital markets index return series are better described by linear models or composed by nonlinear specifications as evidence of more complex dependence. Investigation of nonlinear dependence in stock market index return is an integral part of informational efficiency investigation. The analysis of nonlinearity and non random walk finding by elaborating market efficiency and behavioral finance in the national stock market will be used for examining globalization of investments and international integration either regional integration or global integration.

The next section provides review related literatures. In section 3 the methodology is outlined. Section 4 presents preliminary descriptive statistics and describes datasets for each index including time frame. The results are presented and discussed in section 5. The paper concludes with a summary and describes the implications in the sixth section.

Literature Review

Some studies (Brock et al., (1987, 1991), Hsieh, (1989, 1991, 1993), Willey, (1992), and Scheinkman and LeBaron, (1989)) on nonlinear dynamics have found evidence that residuals of whitened stock index returns are not IID (independently and identically distributed). Barnett and Chen (1986, 1988), Brock and Sayers (1988), Barnett and Hinich (1992, 1993), Chen (1988), and DeCoster and Mitchell (1991) provided evidence of nonlinear structures. Philippatos et al., (1993) use the Brock's Residual test theorem to uncover the presence of similar nonlinear behavior in ten international indexes. Sewell et al., (1993) document nonlinear dependencies in the stock markets of Hong Kong, Korea, Japan, Singapore and Taiwan. Errunza et al., (1994) identify nonlinear dependencies in the market of Germany, Japan, and the emerging markets of Argentina, Brazil, Chile, India and Mexico. Pandey et al., (1998) study deterministic nonlinearity of major European equity markets and the United States. Abhyankar et al., (1997) test for nonlinear dependence and chaos on the world's four most important stock-market indexes. Empirical evidences on nonlinear dependencies suggest that stock prices may be more predictable than formerly thought (Hinich and Patterson, (1985), Scheinkman and LeBaron, (1989), Peters, (1991, 1994), Hsieh, (1991)).

Previous studies have provided useful information of informational efficiency of financial markets (Atkins and Dyl, 1990 and Ball and Kothari, 1989) but there are very little evidences on the nonlinear dynamics of the major global markets.

Efficient Market Hypothesis (EMH) followers argue that the market price movements are rational and efficient. The concept of the rational investor was crucial to the EMH. The EMH believes that stock prices reflect all information known. EMH claims that the stock market is driven by purely random unanticipated news. EMH holds that there is no systematic structure exists on stock market. EMH has an independence assumption which says that past information does not affect market activity, once the information is known. The EMH justifies the use of probability calculus in analyzing capital markets. However, if the markets are nonlinear dynamic systems, then the use of standard statistical analysis can give misleading results, particularly if a random walk model is used.

Methodology

In this paper two robust enough tests are implemented for nonlinear testing. BDS Statistic is applied to test nonlinear dependence. R/S Analysis test is used to test persistence or strong dependence as an indicator of the presence of Long-Term memory.

BDS Statistic (Brock et al. (1987, 1996)) tests for nonlinearity based on the null hypothesis that a data series is Independent and Identically Distributed (IID). The BDS test statistic attempts to overcome shortcomings of the correlation dimension. The BDS statistic is distributed asymptotically normal and avoids the biases of the correlation dimension. BDS statistic test rely on the limiting value of the correlation integral and transforms it into a formal test statistic which is asymptotically distributed as a standard normal variable under the null hypothesis of IID against an unspecified alternative. Brock et al. (1987) derived the estimator variance providing a basis for tests of the IID hypothesis.

Rejecting the null hypothesis of IID is not enough to claim a data series is chaotic

The BDS test statistic is defined by:

$$W(m,\varepsilon,T)=\sqrt{T}\,\frac{C(m,\varepsilon,T)-C(1,\varepsilon,T)^m}{\hat{\sigma}(m,\varepsilon,T)} \tag{3.1}$$

$$\sigma_m(\varepsilon)=2\left\{K^m+2\left[\sum_{j=1}^{m-1}K^{m-j}C(\varepsilon)^{2j}\right]+(m-1)^2C_{1,T}(\varepsilon)^{2m}-m^2KC_{1,T}(\varepsilon)^{2m-2}\right\}^{1/2} \tag{3.2}$$

where the correlation integral is defined by:

$$C_m(\varepsilon)=\frac{1}{(T-m+1)(T-m)}\sum_{\forall t,s}I_\varepsilon\left(X_t^m X_s^m\right) \tag{3.3}$$

and K(ε) is estimated by:

$$K(\varepsilon)=\frac{6\sum_{t<s<r}h_\varepsilon\left(x_t^m,x_s^m,x_r^m\right)}{(T-m+1)(T-m)(T-m-1)} \tag{3.4}$$

$$h_\varepsilon(i,j,k)=\frac{[I_\varepsilon(i,j)I_\varepsilon(j,k)+I_\varepsilon(i,k)I_\varepsilon(k,j)+I_\varepsilon(j,i)I_\varepsilon(i,k)]}{3} \tag{3.5}$$

DOI: 10.21002/icmr.v1i1.3918

where: T = the number of observations
ε = a distance measure as chosen proximity parameter
m = the number of embedding dimensions
C = the Grassberger and Procaccia Correlation integral
σ^2 = a variance estimated of C (C(m,ε,T)-C(1,ε,T)^m)
σ(m,ε,T) = Statistic deviation standard of correlation integral varied by dimension m

$$\left(R/S\right) = \frac{\underset{1\le t\le N}{Max}\left[\sum_{t=1}^{N}\left(r_t - \bar{r}_t\right)\right] - \underset{1\le t\le N}{Min}\left[\sum_{t=1}^{N}\left(r_t - \bar{r}_t\right)\right]}{S} \qquad (3.6)$$

where: R/S = a standardized range of cumulative deviations for all N-length sub periods
t = an integer time increment contained within N
r_t = the tth observation in the series being analyzed
S = the standard deviation of the original series

$$Q_n \equiv \frac{1}{\hat{\sigma}_n(q)}\left[\underset{1\le k\le n}{Max}\sum_{j=1}^{k}\left(X_j - \overline{X}_n\right) - \underset{1\le k\le n}{Min}\sum_{j=1}^{k}\left(X_j - \overline{X}_n\right)\right] \qquad (3.7)$$

$$\hat{\sigma}_n^2(q) \equiv \frac{1}{n}\sum_{j=1}^{n}\left(X_j - \overline{X}_n\right)^2 + \frac{2}{n}\sum_{j=1}^{q}\omega_j(q)\left\{\sum_{i=j+1}^{n}\left(X_i - \overline{X}_n\right)\left(X_{i-j} - \overline{X}_n\right)\right\} \qquad (3.8)$$

and as an evidence of the presence of nonlinear dynamics. The BDS test rejects IID for linear as well as nonlinear processes. The Rescaled Range (R/S) analysis is an indicator of the persistence of a series where the influence of a set of past returns on a set of future returns is effectively captured. The Rescaled Range (R/S) analysis was developed by Hurst (1951). The application of Hurst's technique is explained by Peters (1991). Mandelbrot (1972) suggests using R/S Statistics or the range over standard deviation which is the range of partial sums of deviations of a time series from its mean rescaled by its standard deviation to detect long-range or "strong" dependence. R/S analysis can detect nonperiodic cycles that are cycles with periods equal to or greater than the sample period. Long-range dependence can be detected by the "classical" Rescaled Range (R/S) statistic which is given by Eq.3.6.

However the most important shortcoming of the rescaled range is its sensitivity to short-range dependence, implying that any incompatibility between the data and the predicted behavior of the R/S statistic under the null hypothesis need not come from long-term memory, but may merely by a symptom of shor-term memory (Lo and MacKinlay, 1999). Lo and MacKinlay (1999) suggests using modified rescaled range to distinguish between long-range and short-range dependence by modifying classical R/S statistic so that its statistical behavior is invariant over a general class of short memory processes but deviates for long memory processes Eq.3.7 and Eq.3.8

Since the test has power against many forms of deviation from IID, BDS test is usually carried out on the residuals of a linear and/or GARCH-type filter. This step is known as pre-whitening or bleaching and makes it possible to see if further determinism beyond that described by linear or GARCH process is present in the data. After data has been pre-whitened and nonstationarity is ruled out, the rejection of the null of IID by the BDS statistic points towards the existence of some forms of nonlinear dynamics.

Besides taking the raw data as comparison, methodology for R/S analysis used by Peters (1991) by taking residual of AR(1) for correcting short-range dependence in R/S analysis is applied in this study rather than using modified R/S analysis suggested by Lo and MacKinlay due to its simplicity in data processing.

Hurst (1951) found that R/S could be estimated by the following empirical relationship referred to as Hurst's Empirical Law:

$$(R/S) = a^*(N)H \quad (3.9)$$

The logs of above equation:

$$\log(R/S) = H \times \log(N) + \log(a) \quad (3.10)$$

where: a = a constant
H = Hurst Exponent

H can be estimated by performing an OLS regression between observing log (R/S) and log (N) for the linear portion of the plot. For short natural memory cycles, R/S estimates would display persistence or anti persistence only for a short length period. H = 0.5 implies a non deterministic process or random process in which the past history does not influence the future of the series. H below 0.5 implies anti-persistent behavior in which a positive trend in a period will be followed by a negative trend in the next period. H above 0.5 implies persistent behavior in which a positive trend will be followed by another positive trend.

This study examines three capital markets of the following countries in the South East Asia Region: Indonesia, Philippine, and Singapore. The data consist of daily closing price indices for the following equity markets: Jakarta, Singapore and Philippine. The Straits Times Index (STI) data from December 06, 1985 to March 15, 2000 were collected from Singapore Exchange – Archived Press Releases of Singapore Press Holding. The Pilipino Stock Exchange Index (PSEi) data from March 1, 1990 to December 31, 2007 were collected from Philippines Stock Exchange. The Jakarta Composite Index (JCI) data from January 05, 1988 to December 31, 2007 were

Table 1. Summary of Descriptive Statistics

	JCI		*PSEI*		*STI*	
	Index	*Return*	*Index*	*Return*	*Index*	*Return*
SAMPLES	01/04/1988 - 12/31/2007	01/05/1988 - 12/31/2007	02/28/1990 - 12/31/2007	03/01/1990 - 12/31/2007	01/04/1985 - 12/31/2007	01/07/1985 - 12/31/2007
NUMBER OF OBSERVATIONS	5216	5215	4654	4653	5997	5996
MEAN	625.4506	0.000672	1942.007	0.000272	1587.406	0.000286
STANDARD DEVIATION	463.3537	0.016917	767.1365	0.015234	655.8818	0.013446
SKEWNESS	2.337672	3.039809	0.432037	0.475608	0.748393	-1.868788
KURTOSIS	8.839385	86.7847	2.177641	11.88103	3.888675	54.27394
MAXIMUM	2810.962	0.403102	3873.5	0.161776	3875.77	0.154812
MINIMUM	82.6	-0.225811	516.205	-0.097442	456.35	-0.291862
NORMALITY	12161.38	1533392	275.9238	15466.86	757.1494	660306.2

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DOI: 10.21002/icmr.v1i1.3918

Table 2. BDS Statistics test for the Jakarta Composite Index

m	ε/σ	Index	Shuffle Index	Return	Shuffle Return	Linear Filter Return ARMA (1,165)	Nonlinear Filter Return GARCH (4,2)	Linear and nonlinear filter Return ARMA(1,13) & GARCH(7,3)
2	0.25	242.53	**-1.2015**	24.831	**1.8702**	26.727	24.833	27.167
3	0.25	446.29	**-0.65467**	37.305	**0.65011**	39.689	37.308	39.365
4	0.25	895.92	**-0.43188**	52.005	**0.30683**	56.547	52.008	55.677
5	0.25	1953.4	**-0.0030853**	74.639	**0.22372**	81.887	74.646	80.635
6	0.25	4532.7	**0.15102**	111.44	**0.10899**	126.86	111.45	125.4
7	0.25	11009	**-0.016235**	181.65	**-0.13979**	209.62	181.66	205.55
8	0.25	27654	**-0.070945**	312.67	**-0.59553**	365.44	312.7	355.09
9	0.25	71239	**0.15387**	551.08	**0.042495**	658.04	551.13	620.34
10	0.25	187080	**-0.20441**	1053.5	**0.93958**	1260.7	1053.6	1149.8
2	0.5	142.95	**-0.78674**	24.133	**1.2814**	24.269	24.133	25.228
3	0.5	182.04	**-0.23557**	32.425	**0.51078**	32.881	32.425	33.583
4	0.5	239.08	**-0.1651**	39.913	**0.48131**	41.219	39.912	41.778
5	0.5	327.95	**0.076833**	48.921	**0.41049**	51.303	48.92	51.892
6	0.5	467.29	**0.18461**	60.429	**0.27979**	64.89	60.427	65.725
7	0.5	687.34	**0.02201**	77.91	**0.064044**	84.594	77.907	85.8
8	0.5	1037.8	**-0.23737**	103.05	**-0.077925**	113.71	103.05	114.92
9	0.5	1601	**-0.34842**	139.18	**0.00078243**	156.69	139.18	157.86
10	0.5	2513.9	**-0.41946**	193.56	**0.091872**	222.03	193.55	223.21
2	0.75	118.85	**0.017022**	23.558	**0.97316**	24.468	23.558	25
3	0.75	132.89	**0.10552**	29.626	**0.73478**	30.694	29.626	31.095
4	0.75	150.77	**-0.10767**	34.022	**0.84849**	35.425	34.022	35.736
5	0.75	176.1	**0.018419**	38.317	**0.79134**	40.296	38.317	40.458
6	0.75	211.13	**0.16825**	42.918	**0.60793**	45.912	42.918	45.992
7	0.75	258.85	**0.0037489**	49.209	**0.32339**	53.385	49.21	53.4
8	0.75	323.49	**-0.33698**	57.194	**0.19678**	63.009	57.194	62.945
9	0.75	410.96	**-0.50113**	67.243	**0.25339**	75.439	67.243	75.232
10	0.75	529.51	**-0.54483**	80.495	**0.24574**	91.732	80.495	91.44
2	1	110.32	**0.56845**	23.655	**0.7752**	25.379	23.655	25.508
3	1	116.71	**0.17564**	28.612	**0.72988**	30.279	28.612	30.394
4	1	124.61	**-0.14395**	31.588	**0.83798**	33.312	31.588	33.457
5	1	136.25	**-0.17776**	33.915	**0.74308**	35.869	33.915	35.968
6	1	152.2	**-0.055569**	36.031	**0.50949**	38.571	36.03	38.606
7	1	173.12	**-0.19768**	38.789	**0.2655**	41.922	38.789	41.897
8	1	199.99	**-0.52295**	42.071	**0.18693**	45.963	42.071	45.884
9	1	234.14	**-0.75047**	45.867	**0.24102**	50.89	45.867	50.665
10	1	277.35	**-0.81771**	50.455	**0.23565**	56.798	50.455	56.471

BDS Statistic tabulated value (Brock et al, 1987):				
	Significance Level 5%		Significance Level 1%	
250 observations:	E/SD=0,5	E/SD=1	E/SD=0,5	E/SD=1
m:				
2	2.35	1.86	3.71	2.79
3	2.59	1.91	4.04	2.92
4	3.02	1.98	4.85	2.96
5	3.88	2.1	6.44	3.06

Table 3. BDS Statistics test for The Pilipino Stock Exchange Index

m	ε/σ	Index	Shuffle Index	Return	Shuffle Return	Linear Filter ARMA (119,1)	Nonlinear Filter GARCH (1,8)	Linear and nonlinear filter ARMA(119,1) & GARCH(6,7)
2	0.25	1365.4	**0.65277**	11.919	**0.37653**	10.59	11.919	10.59
3	0.25	4851	**1.1037**	15.015	**0.48061**	13.951	15.013	13.952
4	0.25	20573	**1.2441**	17.966	**0.36046**	17.3	17.968	17.301
5	0.25	98546	3.4449	19.91	**0.49485**	20.033	19.912	20.034
6	0.25	510350	**2.303**	23.194	**1.4617**	23.755	23.196	23.755
7	0.25	2785700	**-0.23141**	30.055	**0.98529**	30.842	30.058	30.843
8	0.25	15789000	**-11.902**	35.693	**2.4936**	43.759	35.696	43.76
9	0.25	92031000	**-14.76**	39.265	**-6.3098**	55.881	39.268	55.883
10	0.25	548320000	**-12.228**	30.655	**-5.1008**	68.76	30.658	68.762
2	0.5	815.91	**-0.025424**	13.691	**0.17343**	11.68	13.691	11.68
3	0.5	1772.5	**-0.039784**	17.317	**0.64612**	15.386	17.317	15.386
4	0.5	4312	**-0.46183**	20.699	**0.55885**	18.857	20.699	18.857
5	0.5	11557	**0.12025**	23.85	**0.19192**	22.043	23.85	22.043
6	0.5	33206	**0.53569**	28.232	**0.26128**	26.425	28.232	26.425
7	0.5	100280	**0.89805**	33.618	**0.26984**	31.625	33.619	31.624
8	0.5	314090	**0.93919**	39.912	**0.314**	37.375	39.913	37.375
9	0.5	1011200	**1.9961**	48.601	**0.50089**	44.843	48.602	44.842
10	0.5	3326400	**2.5667**	60.225	**0.4354**	55.12	60.226	55.119
2	0.75	616	**0.16755**	14.395	**0.039572**	12.496	14.396	12.496
3	0.75	1017.1	**0.38888**	18.275	**0.80648**	16.257	18.276	16.257
4	0.75	1802.7	**-0.14654**	21.527	**0.86633**	19.618	21.527	19.618
5	0.75	3436.2	**-0.25281**	24.442	**0.55377**	22.7	24.442	22.7
6	0.75	6938.9	**-0.2703**	28.052	**0.57363**	26.526	28.052	26.526
7	0.75	14649	**-0.24326**	32.208	**0.52948**	30.842	32.208	30.842
8	0.75	32000	**-0.32732**	37.019	**0.37663**	35.572	37.02	35.572
9	0.75	71781	**-0.16152**	42.66	**0.25894**	41.233	42.661	41.233
10	0.75	164420	**0.083945**	49.496	**0.21561**	48.002	49.496	48.002
2	1	491.02	**-0.29963**	15.067	**0.10756**	13.133	15.067	13.134
3	1	688.22	**-0.0096641**	18.886	**0.93546**	16.597	18.886	16.597
4	1	1009.3	**-0.44778**	21.864	**1.0646**	19.608	21.865	19.608
5	1	1563.3	**-0.61617**	24.451	**0.76288**	22.386	24.451	22.386
6	1	2535.6	**-0.68879**	27.346	**0.69811**	25.416	27.347	25.417
7	1	4270.8	**-0.84812**	30.569	**0.59376**	28.736	30.57	28.737
8	1	7415.4	**-1.0531**	34.117	**0.41756**	32.268	34.118	32.268
9	1	13195	**-1.0615**	38.096	**0.20799**	36.2	38.096	36.2
10	1	23953	**-1.085**	42.655	**0.087179**	40.508	42.656	40.508

BDS Statistic tabulated value (Brock et al, 1987):				
	Significance Level 5%		Significance Level 1%	
250 observations:	E/SD=0,5	E/SD=1	E/SD=0,5	E/SD=1
m:				
2	2.35	1.86	3.71	2.79
3	2.59	1.91	4.04	2.92
4	3.02	1.98	4.85	2.96
5	3.88	2.1	6.44	3.06

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Table 4. BDS Statistics test for the Straits Times Index

STI								
m	ε/σ	Index	Shuffle Index	Return	Shuffle Return	Linear Filter Return ARMA (1,165)	Nonlinear Filter Return GARCH (4,2)	Linear and nonlinear filter Return ARMA(1,13) & GARCH(7,3)
2	0.25	1235.8	**-0.48362**	15.993	**0.06586**	17.997	15.993	17.997
3	0.25	4120.6	**-0.41997**	19.21	**-0.14706**	22.357	19.21	22.357
4	0.25	16280	**0.14199**	23.211	**-0.38644**	26.558	23.211	26.558
5	0.25	72431	**0.36058**	27.973	**-0.50063**	31.906	27.973	31.906
6	0.25	348030	**2.1735**	32.976	**-0.7366**	38.124	32.976	38.124
7	0.25	1761000	7.5589	39.934	**-0.24227**	47.135	39.934	47.135
8	0.25	9248900	12.691	47.258	**0.25019**	54.824	47.258	54.824
9	0.25	49954000	13.907	61.776	**0.4457**	71.962	61.776	71.962
10	0.25	275650000	**-11.107**	84.709	**1.1456**	124.62	84.709	124.62
2	0.5	839.85	**0.1051**	18.139	**0.1601**	18.983	18.139	18.983
3	0.5	1721.9	**-0.19672**	22.143	**0.025697**	23.737	22.143	23.737
4	0.5	3918.7	**-0.63068**	26.299	**-0.25466**	28.177	26.299	28.177
5	0.5	9779.2	**-0.39392**	30.664	**-0.21711**	32.948	30.664	32.948
6	0.5	26110	**-0.10603**	35.418	**-0.20709**	38.215	35.418	38.215
7	0.5	73193	**-0.21739**	41.945	**0.1055**	45.253	41.945	45.253
8	0.5	212710	**-1.0135**	49.908	**0.3209**	53.86	49.908	53.86
9	0.5	635250	**0.71513**	60.314	**0.67551**	64.933	60.314	64.933
10	0.5	1937800	**1.616**	72.888	**1.1711**	78.196	72.888	78.196
2	0.75	598.55	**0.34141**	19.484	**0.17615**	19.835	19.484	19.835
3	0.75	954.02	**0.17613**	23.608	**0.21979**	24.536	23.608	24.536
4	0.75	1622.8	**-0.16208**	27.365	**-0.043139**	28.355	27.365	28.355
5	0.75	2956.9	**0.085111**	30.922	**-0.12577**	32.165	30.922	32.165
6	0.75	5694.9	**0.080174**	34.687	**-0.26353**	36.142	34.687	36.142
7	0.75	11451	**-0.14804**	39.391	**-0.13131**	41.002	39.391	41.002
8	0.75	23807	**-0.16055**	44.975	**0.066343**	46.928	44.975	46.928
9	0.75	50808	**-0.35426**	51.66	**0.31984**	54.156	51.66	54.156
10	0.75	110700	**-0.57523**	59.573	**0.47045**	62.779	59.573	62.779
2	1	416.36	**0.79755**	20.449	**0.25583**	20.754	20.449	20.754
3	1	561.23	**0.32582**	24.575	**0.42179**	25.42	24.575	25.42
4	1	786.73	**0.010056**	27.769	**0.13853**	28.697	27.769	28.697
5	1	1159.2	**0.10149**	30.44	**-0.026829**	31.597	30.44	31.597
6	1	1783	**0.13053**	33.11	**-0.18896**	34.452	33.11	34.452
7	1	2841.2	**-0.22777**	36.214	**-0.12905**	37.697	36.214	37.697
8	1	4660.5	**-0.46625**	39.811	**0.0062399**	41.527	39.811	41.527
9	1	7827.4	**-0.81304**	43.903	**0.19331**	45.943	43.903	45.943
10	1	13404	**-1.1425**	48.609	**0.25115**	51.027	48.609	51.027

BDS Statistic tabulated value (Brock et al, 1987):				
	Significance Level 5%		Significance Level 1%	
250 observations:	E/SD=0,5	E/SD=1	E/SD=0,5	E/SD=1
m:				
2	2.35	1.86	3.71	2.79
3	2.59	1.91	4.04	2.92
4	3.02	1.98	4.85	2.96
5	3.88	2.1	6.44	3.06

compiled from Indonesia Stock Exchange and Thomson Reuters.

To avoid problem showed by Hinich and Patterson (1985) that non-stationarity in time series data may cause a spurious rejection of linearity, the raw data of three time series data Indices: STI, PSEi, and JCI is transformed into return data. The return on each of the series is calculated by:

$$R_i = \ln (P_i / P_{i-1}) \quad (4.1)$$

where R_i is the log return of the ith time observation.

The summary of descriptive statistics for indexes and their returns is presented in Table 1. All return series are approximately zero mean. Due to non-stationarity all index series are far from zero mean. All series are positively skewed but STI return series is negatively skewed. There is evidence of leptokurtosis in all series but PSEI raw index is platikurtosis. The coefficients of kurtosis for all indices are different from normal distribution. Eventhough different from normal distribution PSEI raw index and STI raw index approach normal distribution. All of the series show strong signs of non normality due to leptokurtosis and skewness. This is a feature of most financial data (Hsieh. 1988). These finding leads to an expectation that the indexes return possess some dependence structure.

Result and Discussion

The results of the BDS tests are given in Table 2, 3 and 4 for each data series for dimensions m=2, …, 10 and the distance measure ε = 0.25σ, 0.5σ, 0.75σ and 1.00σ. A high positive BDS statistic indicates that the probability of any two m histories, (xt, xt-1, …, xt-m+1) and (xs, xs-1, …, xs-m+1), being close together is higher in the non random data than in truly random data. This means some clustering occur too frequently in an m-dimensional space and some patterns of stock return movements take place more frequently with non random data than with truly random data. A lower ε value is a more stringent criterion while a higher ε value is the most relaxed one.

We test the return series, the shuffled return series, the filtered return series, the raw index series and the shuffled index series. Since this research concerns with nonlinearity which is the detection of nonlinear dynamics, autocorrelations are filtered out using autoregressive moving average models. The appropriate lag length is determined by the Akaike Information Criterion (AIC) to expect the best fitted model of return series. The return series are filtered to eliminate linear dependence by taking residual of ARMA process, to eliminate nonlinear dependence by taking residual of GARCH process, and to eliminate linear and nonlinear dependence. The return series are scrambled three times to destroy any linear and non linier dependence.

The results in Table 2, 3 and 4 show a summary rejection of the null hypothesis of IID for all series at all dimensions except for shuffled series. For each embedding dimension, BDS test statistic is insignificant for the shuffled series but significant for all raw index series, filtered return series and return series. Rejection of the null hypothesis of IID for raw index series and return series indicates existence of non random processes in the raw index data that might be caused by linear process, stochastic nonlinear process, combine of linear and nonlinear process or chaotic process.

Filtering through a GARCH model which is residual of GARCH model does not reduce the BDS value or change the rejection of the null hypothesis of IID. This indicates that dependence on return series cannot be explained by stochastic non linear model. Filtering through ARMA model for JCI and STI return indexes does not reduce BDS value. For PSEi return, filtering through an

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DOI: 10.21002/icmr.v1i1.3918

ARMA model will reduce the BDS value a little bit but it does not change the rejection of the null hypothesis of IID. Residual of a true stochastic process (linear or non linear) should be random. This means that PSEi return might be created by linear process but since the null hypothesis of IID for the residual of the linear process is rejected thus there remains further dependence in the data that cannot be explained by reference to linear models.

The results of the R/S Analysis can be found in Table 5. Figure 2, 8 and 14 displays the rescaled ranges and V-Statistic for return of JCI, PSEi and STI respectively. V-statistic is used to find the non periodic cycle. In this test, pre-whitening or bleaching will not be applied. Only return series is applied without filtering them since the results of BDS statistic show data series are not affected by linear process. BDS statistic results show stochastic process is not robust enough in the return series and high nonlinearity found in the return series is not generated by stochastic processes.

However Peter's technique by taking residual of AR(1) is applied to correct for short-range dependence. The result of R/S Analysis and V-Statistic of AR(1) residual is shown in Figure 6, 12 and 18 for return series of JCI, PSEi and STI respectively.

Scrambling will destroy the structure of the system and also the long memory process which indicated by drop value of Hurst Exponent H. Figure 4, 10 and 16 displays the rescaled ranges and V-Statistic for shuffled return series of JCI, PSEi and STI respectively. E(H) which is expected R/S values under the random null hypothesis is used as significance test of H. For shuffled return series H will approach and close to E(H) and 0.5. For non scrambled series H will be higher enough than E(H). Non random walk series or non gaussian series will have H above 0.5. Due to insufficiency of scrambling procedure (applied only 3 times) H of index and return shuffle series might be above E(H).

The objective of forecasting the behavior of index (or prices) makes using return is inappropriate since return whitens data by eliminating serial dependence and makes the data appropriate for linear analysis and independence. Finance and economics have a long tradition of using returns but returns are not an appropriate transformation of prices for research of nonlinear dynamic systems. Using returns complicates the problem dramatically in the other side using prices involves a different problem of continually growing value of assets without bound because of economic growth and inflation (Peters, 1991). Very high H value of index series proves this phenomenon. Therefore raw index series and shuffle index series are also tested. Odd number figures (Figure 1, 3, 5, …, 17) present the rescaled ranges and V-statistics for index series, shuffle index series and residual AR(1) index series of JCI, PSEi and STI respectively. Due to nonstationarity, H of raw index series is very persistence with a high value of H. Non periodic cycles of Index series are less than return series.

All series show persistence with Hurst Exponent H is less than 0.6 for return series and more than 0.7 for raw index series. Closer values to 0.5 indicate bias caused by (1) the existence of noise and (2) insufficient data caused by insufficient length of data period or over sampling (Peter, 1991 & 1994). STI series has a longest non periodic memory cycle (999 days) and in the other hand PSEi series has a shortest non periodic memory cycle (775 days). JCI has a strongest evidence of temporal persistence dependency with a highest H value of 0.585 and a lowest fractal dimension of return time series (1/H = 1.709) but STI is in the opposite side. JCI return series will last for cycles of approximately 869 days. STI return series show weak persistence and weak nonlinear temporal dependency with Hurst exponent of 0.556 that last for a longest non periodic memory cycles. Removing short-dependence by taking out AR(1) will drop H to approacing E(H) and 0.5. By comparing the result of AR(1) residual series and shuffle series it can be concluded that there are still dependencies on the residual series although the results show very marginal persistence and very weak nonlinear temporal dependency with Hurst Exponents are below 0.55. Short memory cycle (less than 1000 days) suggest that only short term predictability is possible

Conclusion

The results of this study provide the evidences of nonlinearity in all examined daily raw indexes and returns. Hypothesis of independence for all raw indexes

Table 5. R/S Analysis

JCI											
Return		Return AR(1) Residual		Shuffle Return		Raw Index		Index AR(1) Residual		Shuffle Raw Index	
H	E(H)	H	E(H)	H	E(H)	H	E(H)	H	E(H)	H	E(H)
0.585	0.525	0.544	0.525	0.513	0.523	0.794	0.523	0.584	0.525	0.531	0.523
Non Periodic Cycle		Non Periodic Cycle				Non Periodic Cycle		Non Periodic Cycle			
869 days = antilog 2.93901977644867		869 days = antilog 2.93901977644867				237 days = antilog 2.3747483460101		869 days = antilog 2.93901977644867			
Fractional Dimension		Fractional Dimension		Fractional Dimension		Fractional Dimension		Fractional Dimension		Fractional Dimension	
of Time Series		of Time Series		of Time Series		of Time Series		of Time Series		of Time Series	
1.709 (=1/0.585)				1.949 (=1/0.513)		1.259 (=1/0.794)				1.883 (=1/0.531)	
PSEi											
Return		Return AR(1) Residual		Shuffle Return		Raw Index		Index AR(1) Residual		Shuffle Raw Index	
H	E(H)	H	E(H)	H	E(H)	H	E(H)	H	E(H)	H	E(H)
0.566	0.524	0.537	0.524	0.522	0.524	0.779	0.52	0.564	0.524	0.518	0.52
Non Periodic Cycle		Non Periodic Cycle				Non Periodic Cycle		Non Periodic Cycle			
775 days = antilog 2.88930170250631		775 days = antilog 2.88930170250631				186 days = antilog 2.26951294421792		775 days = antilog 2.88930170250631			
Fractional Dimension		Fractional Dimension		Fractional Dimension		Fractional Dimension		Fractional Dimension		Fractional Dimension	
of Time Series		of Time Series		of Time Series		of Time Series		of Time Series		of Time Series	
1.767 (=1/0.566)		1.862 (=1/0.537)		1.916 (=1/0.522)		1.284 (=1/0.779)		1.773 (=1/0.564)		1.93 (=1/0.518)	
STI											
Return		Return AR(1) Residual		Shuffle Return		Raw Index		Index AR(1) Residual		Shuffle Raw Index	
H	E(H)	H	E(H)	H	E(H)	H	E(H)	H	E(H)	H	E(H)
0.556	0.526	0.533	0.526	0.53	0.526	0.797	0.525	0.555	0.526	0.538	0.525
Non Periodic Cycle		Non Periodic Cycle				Non Periodic Cycle		Non Periodic Cycle			
999 days = antilog 2.99956548822598		999 days = antilog 2.99956548822598				333 days = antilog 2.52244423350632		999 days = antilog 2.99956548822598			
Fractional Dimension		Fractional Dimension		Fractional Dimension		Fractional Dimension		Fractional Dimension		Fractional Dimension	
of Time Series		of Time Series		of Time Series		of Time Series		of Time Series		of Time Series	
1.799 (=1/0.556)		1.876 (=1/0.533)		1.887 (=1/0.53)		1.255 (=1/0.797)		1.802 (=1/0.555)		1.859 (=1/0.538)	

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DOI: 10.21002/icmr.v1i1.3918

and returns are rejected which indicates nonlinearity. Even though Hurst exponents of return series have only small value above Hurst Exponent of random walk process R/S analysis shows the existence of persistence temporal dependency in all return series. A high H value shows less noise, more persistence and clearer trends than do lower values. Higher values of H mean less risk because there is less noise in the data (Peters (1991)). Predictability may be feasible in the short term because of short memory cycles are ranging from 775 days for PSEi return and 186 days for PSEi index to 999 days for STI return and 333 days for STI index. Peters (1990) suggests to testing R/S analysis in lower sampling period such as weekly data therefore it is better to rerun R/S analysis for weekly index return series.

Nonlinearity structure found in all return series suggests the stock market of Indonesia, Singapore and Philippine are not efficient or reject EMH model. EMH holds in the efficient capital market, prices reflect all public information.

All series have different degree of complexity which suggests different degree of risk due to their Hurst exponent value. Different degree of risk among international markets as well as among regional markets, in this case among ASEAN member countries markets, provides opportunity of diversification by applying foreign investment in lower risk market. Foreign investment for diversification purpose leads to integration of companies from different countries. Integration as a way to reduce risk by diversification will be more promising to gain competition. Liberalization to invest in less risk foreign countries will be supported by riskier countries. Since each stock market has different complexity, then one policy for all can not be applied. Regional policy to accommodate integration and liberalization will affect differently in each stock markets.

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Appendix

Figure 1. R/S Analysis & V-Statistic JCI Index

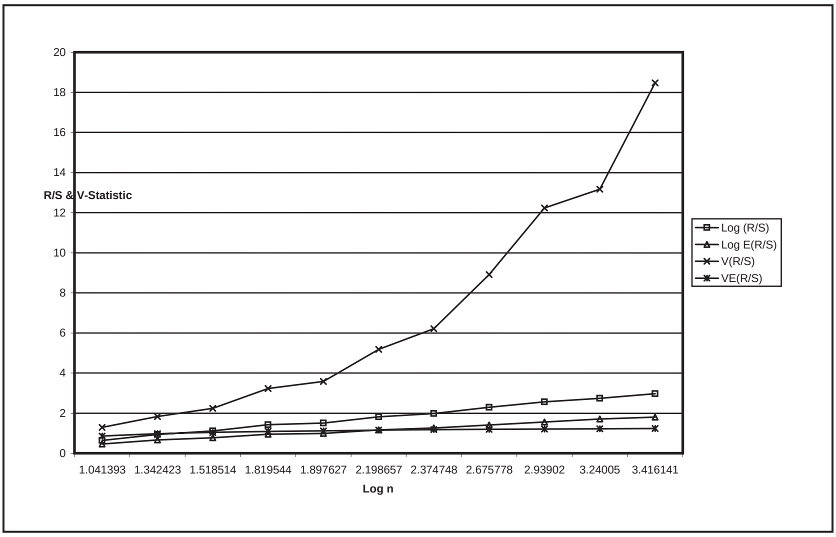

Figure 2. R/S Analysis & V-Statistic JCI Return

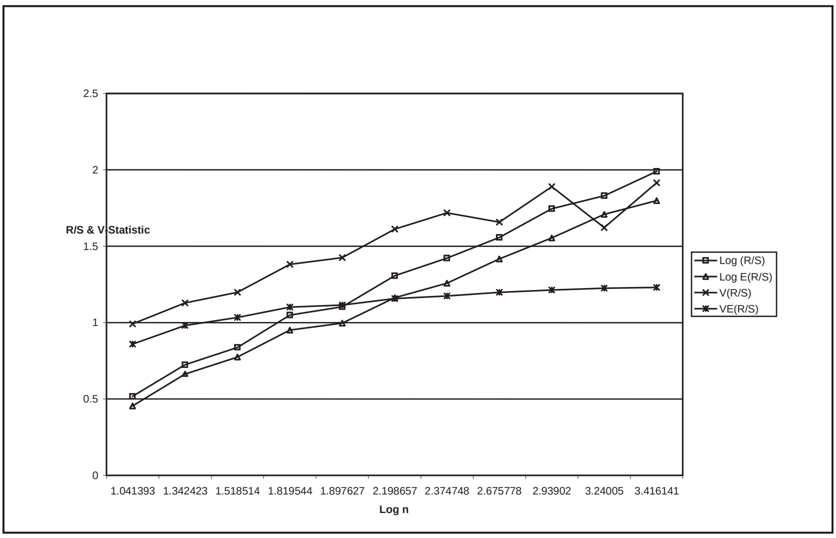

Figure 3. R/S Analysis & V-Statistics JCI Index Shuffle

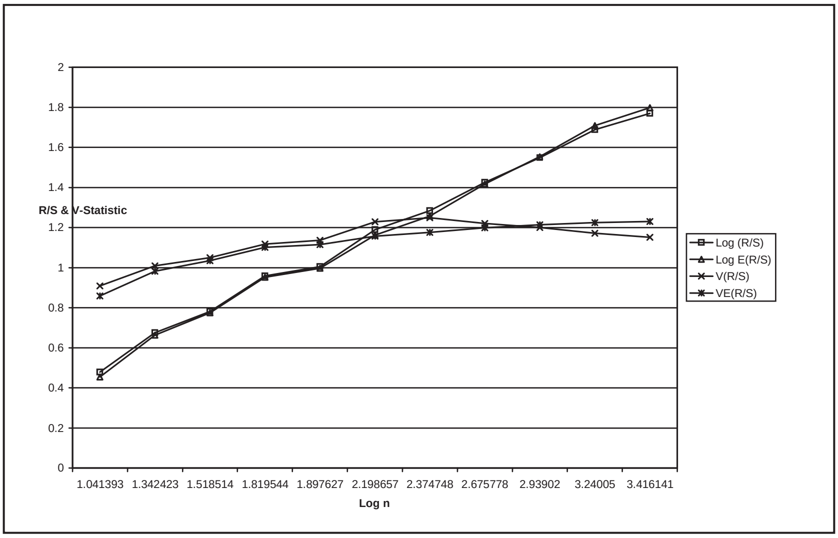

Figure 4. R/S Analysis & V-Statistic JCI Return Shuffle

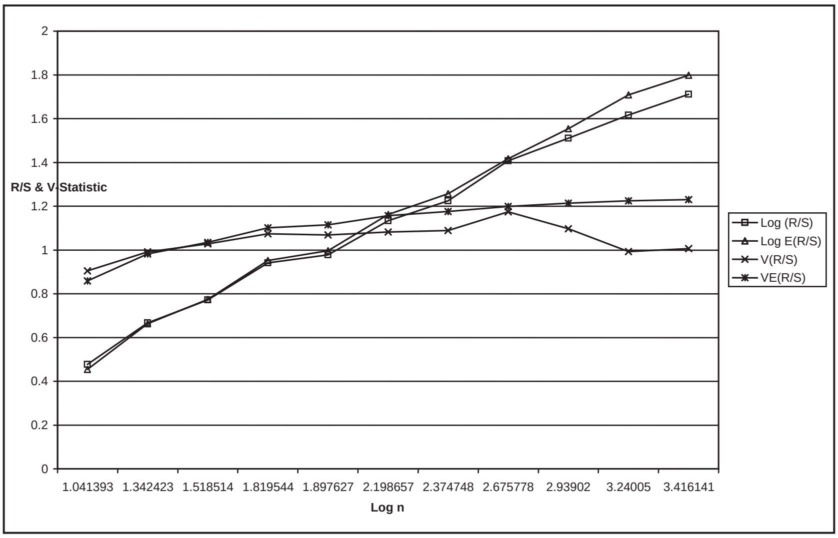

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Figure 5. R/S Analysis & V-Statistic JCI Index AR(1) Residual

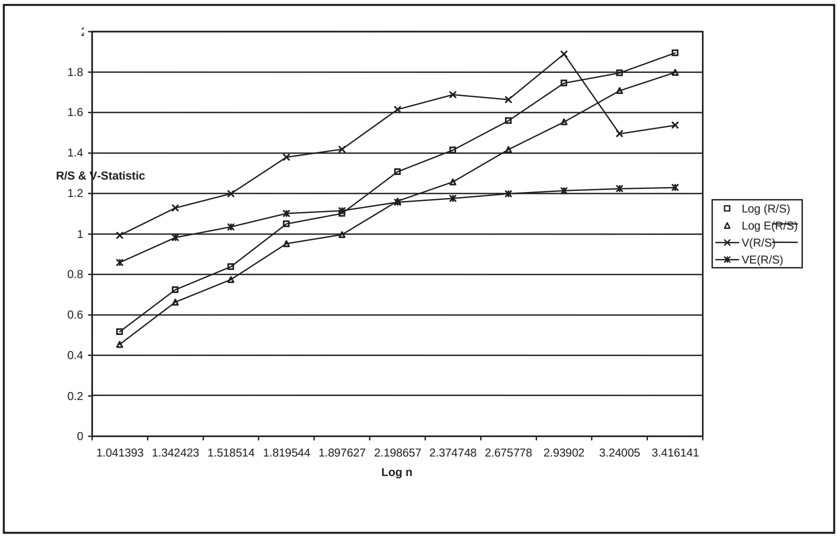

Figure 6. R/S Analysis & V-Statistic JCI Return AR(1) Residual

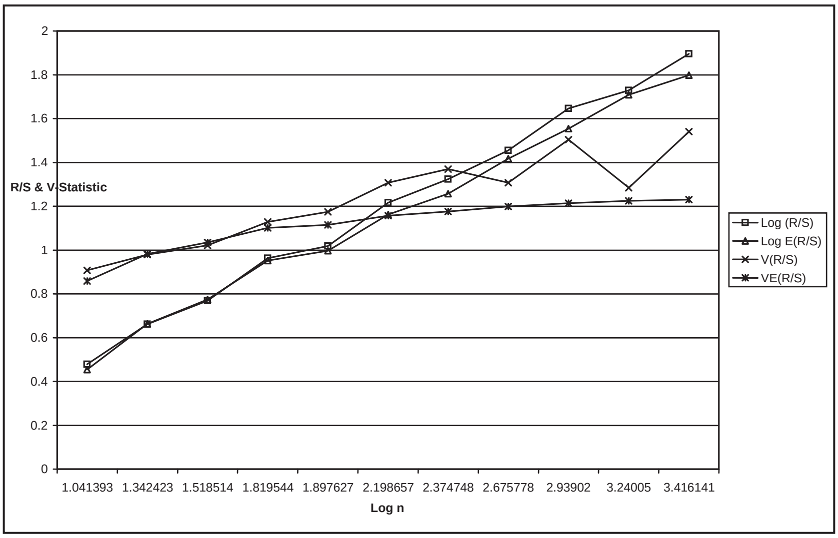

Figure 7. R/S Analysis & V-Statistic PSEI Index

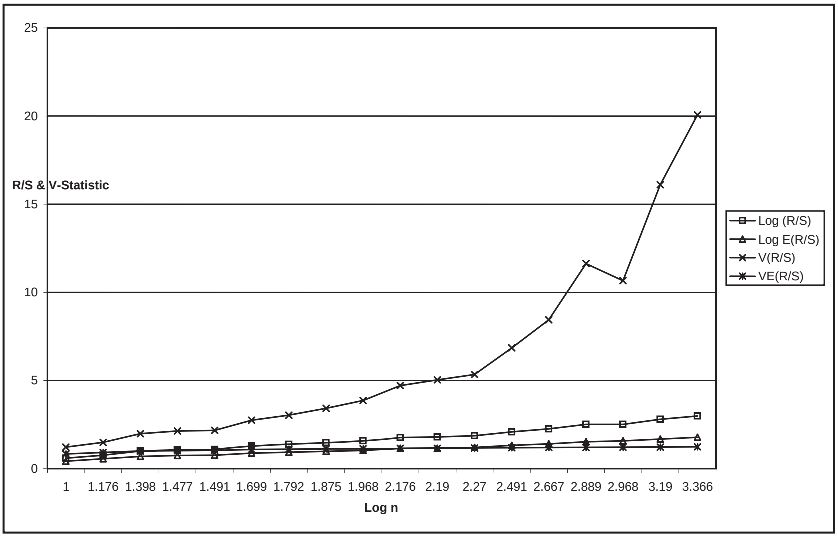

Figure 8. R/S Analysis & V-Statistic PSEi Return

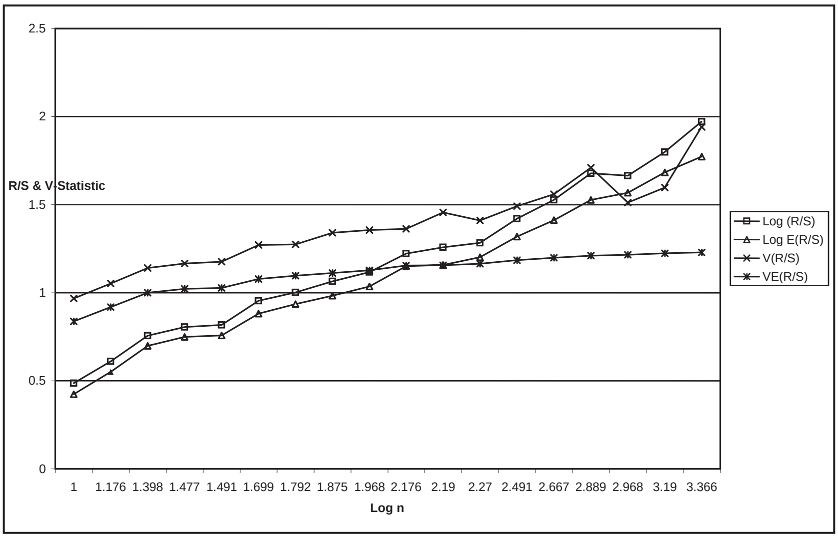

Figure 9. R/S Analysis & V-Statistic PSEi Index Shuffle

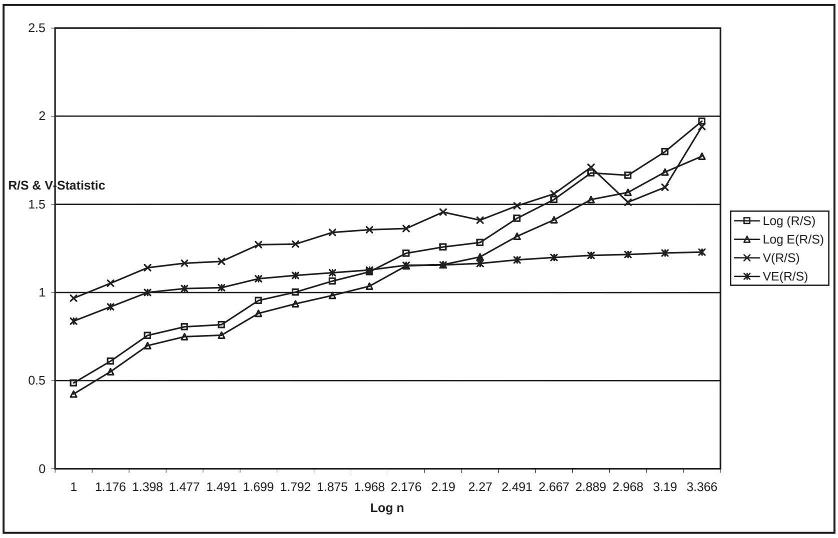

Figure 10. R/S Analysis & V-Statistic PSEi Return Shuffle

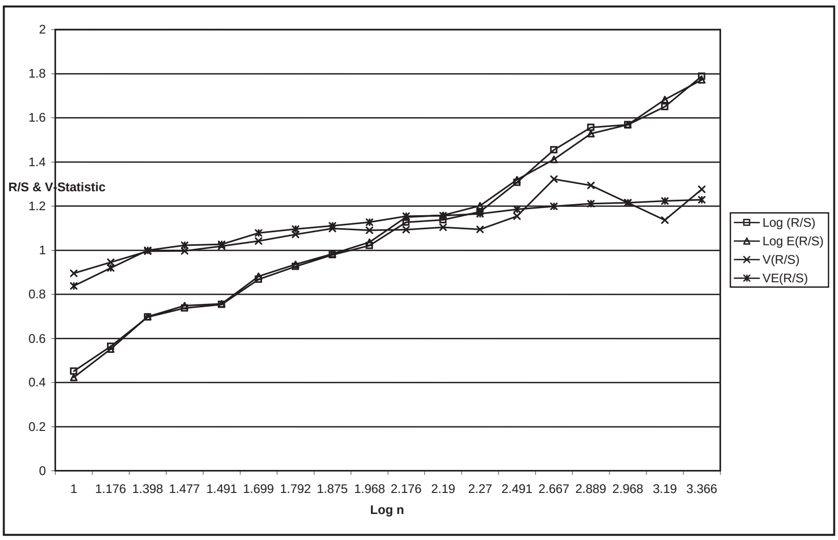

Figure 11. R/S Analysis & V-Statistic PSEI Index AR(1) Residual

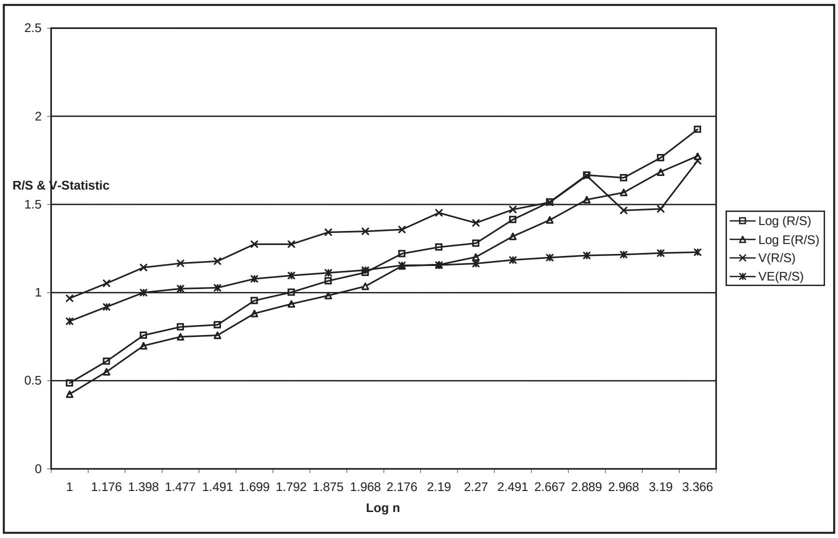

Figure 12. R/S Analysis & V-Statistic PSEI Return AR(1) Residual

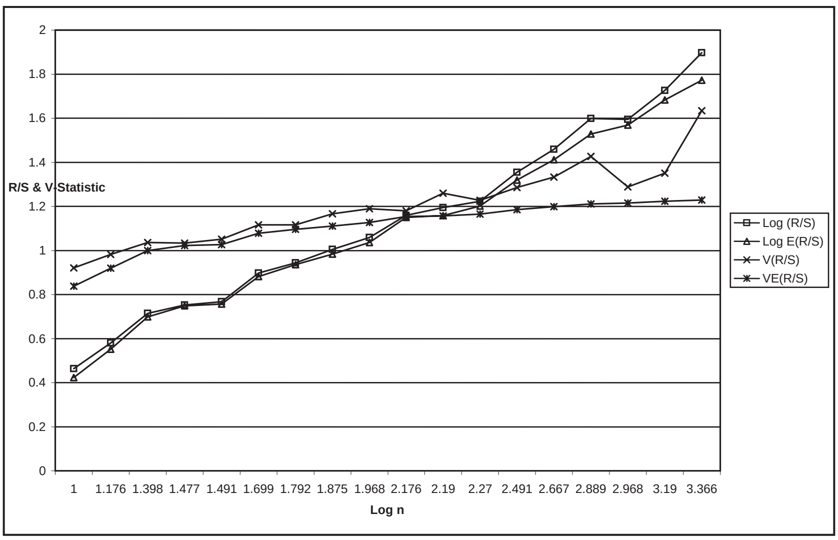

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Figure 13. R/S Analysis & V-Statistic STI Index

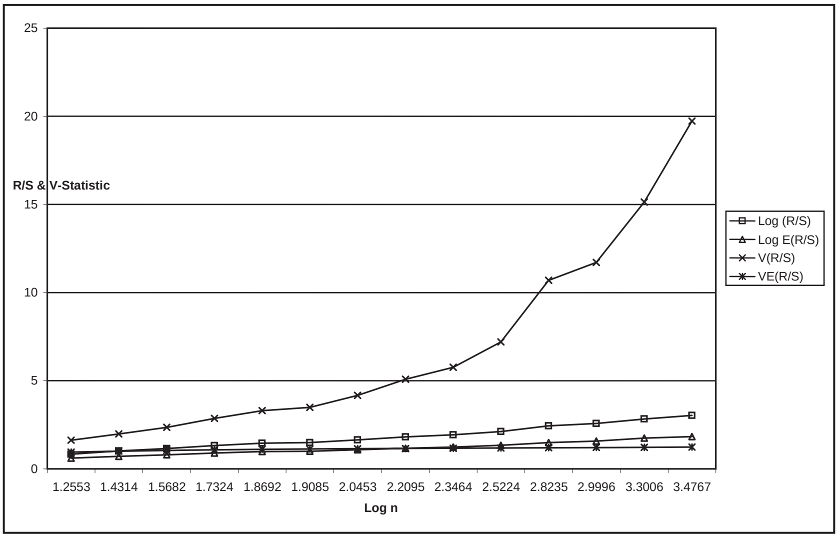


Figure 14. R/S Analysis & V-Statistic STI Return

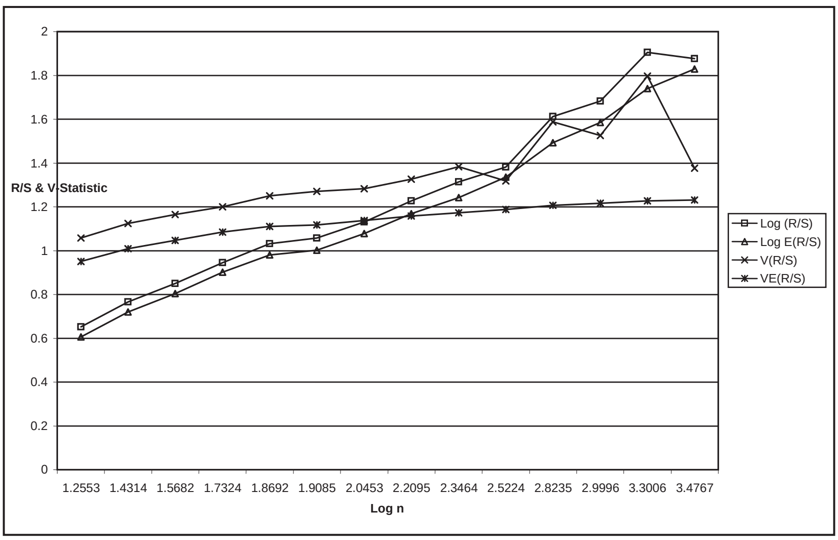


Figure 15. R/S Analysis & V-Statistic STI Index Shuffle

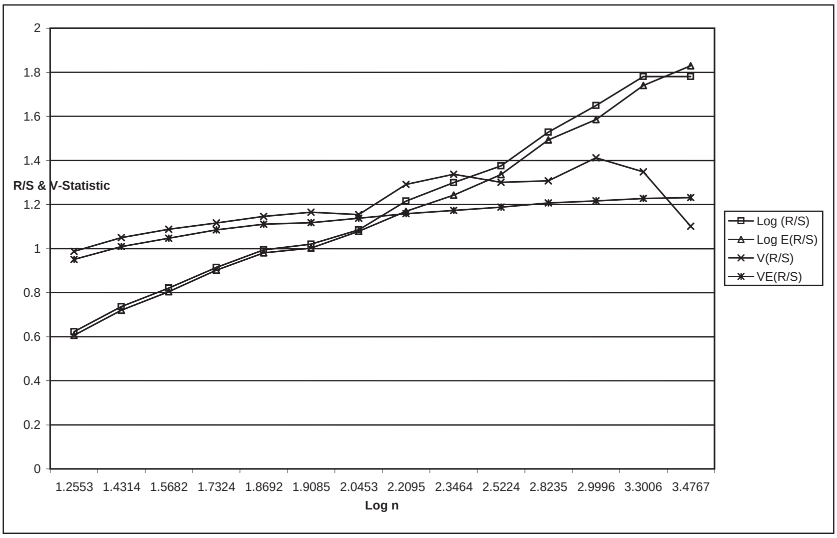
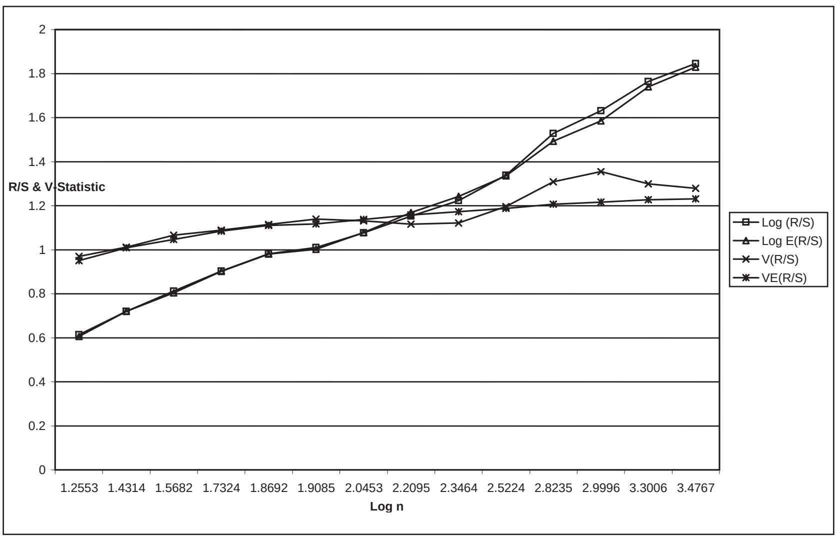


Figure 16. R/S Analysis & V-Statistic STI Return Shuffle



https://scholarhub.ui.ac.id/icmr/vol1/iss1/4
DOI: 10.21002/icmr.v1i1.3918

Figure 17. R/S Analysis & V-Statistic STI Index AR(1) Residual

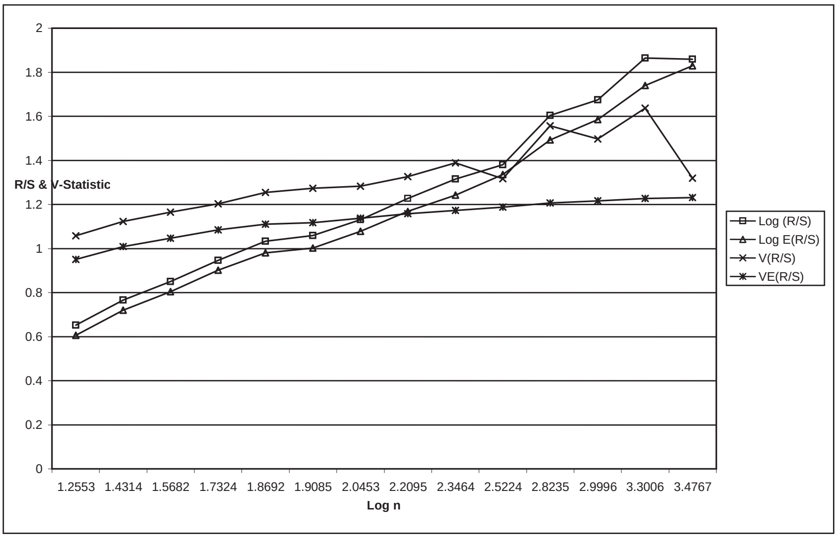


Figure 18. R/S Analysis & V-Statistic STI Return AR(1) Residual