Sains Malaysiana 38(5)(2009): 699–705

Structural Break Unit-root Tests: An Empirical Study of Malaysian Equity Markets

(Ujian Perubahan Struktur Punca Unit: Satu Kajian Empirik di Pasaran Ekuiti Malaysia)

CHIN WEN CHEONG* & ZAIDI ISA

ABSTRACT

This research investigated the unit-root tests using nonparametric sequences-reversals (S-R), Phillip-Perron (PP) tests and parametric Augmented Dickey-Fuller (ADF) test for the Malaysian equity indices. Under the considerations of drift and structural break, it was found that during the restructuring period after the Asian financial crisis, most of the indices provided evidences against the unit-root tests. These results are somewhat contrasted with the conventional unit-root tests that ignored the impact of structural changes. In addition, the S-R tests were found to have little power to identify the deviations from the unit-root even after the inclusion of structural break.

Keywords: Random walk hypothesis; sequences-reversals test; structural change

ABSTRAK

Kajian ini menyelidik ujian punca unit dengan menggunakan ujian rentetan pembalikan (S-R) tak berparameter, ujian Phillip-Perron (PP) dan ujian Dickey-Fuller (ADF) terimbuh terhadap ekuiti indek Malaysia. Di bawah pertimbangan hanyutan dan perubahan struktur, adalah didapati semasa tempoh penstrukturan selepas krisis kewangan Asia, majoriti indeks didapati bercanggah terhadap ujian punca unit. Keputusan ini adalah bertentangan dengan ujian punca unit konvensional dengan impak perubahan struktur adalah diabaikan. Tambahan pula, ujian S-R mempunyai kuasa yang kecil untuk mengenal pasti persisihan daripada punca unit setelah perangkuman perubahan struktur.

Kata kunci: Hipotesis gerakan rawak; perubahan struktur; ujian rentetan pembalikan

INTRODUCTION

The unit-root (random walk) test received considerable attentions in the market efficiency testing. The early study by Bachelier (1964) and Samuelson (1965) suggested that the presence of random walk theory in the commodity markets where the random nature of the stock prices is unforecastable. The RW model of financial asset prices has long considered being a necessary condition for an efficient asset market. Roberts (1967) defined the martingale hypothesis as weak-form market efficiency. However, the early study of this model does not account for risk in the expected return. Due to the relaxations of risk and higher statistical properties, Leroy (1973) and Lucas (1978) claimed that martingale property is neither a necessary nor a sufficient condition for rationally determined asset prices.

Although the implications from random walk (RW) may not fully portray the actual behaviour of the financial stock exchange, nevertheless the result allowed us to gain the insight understanding in the perspective of market efficiency as well as econometrics modelling.

The early martingale framework (Fama 1970) was replaced by the RW hypothesis in the empirical analysis of financial markets. The most restrictive RW model (Lo & Mackinlay 1997) required independent and identically distributed (IID) of the price changes:

$$P_t = \omega + P_{t-1} + \varepsilon_t, \qquad \varepsilon_t \sim \text{IID}(0, \sigma^2) \tag{1}$$

where ω is the drift. The recursive substitution of RW1 produced the conditional mean and variance conditional on arbitrary initial value P_0:

$$E[\,P_t \mid P_0\,] = P_0 + \omega t, \tag{2}$$

$$V[\,P_t \mid P_0\,] = \sigma^2 t, \tag{3}$$

Under the IID assumption, the RW is a nonstationary time-linear (in term of conditional mean and variance) process. Based on this framework, we concentrated on the IID assumptions of RW hypothesis under the drift and structural break. It is worth noting that the unit-root test relied heavily on the specification assumption with unbroken linear trend. Recent studies by Bai and Perron (1998), Chaudhuri and Wu (2003) and Henry (2000) indicated that the structural changes could cause spurious inferences in market efficiency analysis across international stock market and foreign exchange. In addition, the unawareness of structural change in the asset prices may bring severe impacts to investment performance as well as risk control to the volatile financial markets. The common sources of structural changes including drastic changes of foreign exchange scheme, economic policy (fiscal or monetary), political stability, terrorism issues, nature disasters, etc.

This paper aimed to examine the presence of non-stationary with a unit-root in the Malaysian equity market under the possible structural breaks. During the long spanning of empirical data from year 1996 until 2006, the Malaysian stock markets have experienced numerous important economic events such as the Asian economic crisis, drastic USD pegged with RM, financial market restructuring and market liberalisation. The volatile market conditions provided a test ground for researchers and investors for empirical studies and possible investments alternatives. For this specify study, we concentrated on the test for non-stationary of the five indices including the main composite index and four sectoral indices. Three methodologies have been implemented to reach the consensus of unit-root test results.

METHODOLOGY

UNKNOWN TWO BREAK-POINTS IDENTIFICATION

There are voluminous alternatives of unknown break location tests (Perron del 1989; Vogelsang & Perron 1998) that based on the ordinary least squares (OLS) approaches. We have selected the Andrews and Quant methodology (1993) in our empirical study. Two breakpoints have been detected in each of the indices in our empirical data. This test derived the asymptotic distribution of the Wald test for one shift based on a first order autoregressive model:

$$\begin{aligned} p_t &= r_1 p_{t-1} + \varepsilon_{1t}, \qquad & t &= 1,\ldots,T_1 \\ p_t &= r_2 p_{t-1} + \varepsilon_{2t}, \qquad & t &= T_1+1,\ldots,T_2 \\ p_t &= r_3 p_{t-1} + \varepsilon_{3t}, \qquad & t &= T_2+1,\ldots,T \end{aligned} \tag{4}$$

where $\varepsilon_t \sim N(0,\sigma^2_t)$ and $T_1<T_2<T$. The maximum of Chow's F-statistics are selected as the most possible location of structural change according to the following derivations

$$\textit{Sup}\text{ Wald F-statistic } \max_{1\le t\le T_i} \frac{\left(\hat{\varepsilon}'\hat{\varepsilon} - \left(\hat{\varepsilon}_I'\hat{\varepsilon}_I + \hat{\varepsilon}_{II}'\hat{\varepsilon}_{II}\right)\right)/r}{\left(\hat{\varepsilon}_I'\hat{\varepsilon}_I + \hat{\varepsilon}_{II}'\hat{\varepsilon}_{II}\right)/\left(T_{i+1}-2r\right)}; \tag{5}$$

Sup Exponential Wald F-statistic

$$= \log_e\left(\frac{1}{r}\sum_{t=1}^{T_{i+1}} e^{\max_{1\le t\le T_i} 0.5\frac{\left(\hat{\varepsilon}'\hat{\varepsilon} - \left(\hat{\varepsilon}_I'\hat{\varepsilon}_I + \hat{\varepsilon}_{II}'\hat{\varepsilon}_{II}\right)\right)/r}{\left(\hat{\varepsilon}_I'\hat{\varepsilon}_I + \hat{\varepsilon}_{II}'\hat{\varepsilon}_{II}\right)/\left(T_{i+1}-2r\right)}}\right). \tag{6}$$

where $\hat{\varepsilon}$ is the residual in a certain regime, r is the number of parameters and T_i denoted the break location until sub-sample T_{i+1}. The maximum F-statistic has an asymptotic chi-square distribution with $(T_{i+1}\text{-}1)r$ degrees of freedom. Repeated the similar procedures to identify the next break-point. In practice, we customary trimmed out the overall observations to avoid the statistic distribution degeneration. According to Hansen (1995), p-values are more preferable than the predefined significance tests. As indicated in Table 1, three regimes are detected and in the coming discussions, we denoted the data as Regime I (crisis period), Regime II (restructuring period) and Regime III (recovering period), respectively.

Nonparametric Sequences-reversals (S-R) test:

The nonparametric approach is very suitable for financial time series analysis because most of financial asset prices displayed non-normal heavy-tail distribution (Rama 2001) with excess kurtosis. The S-R test has been used by Cowles and Jones (1937) in IID RW test in the stock returns. The sequences referred to the pairs of consecutive returns with

TABLE 1. Regimes and important economic events

Index	Regime	Period	Break point	Max-W	Exp-W	Possible related events
	I	1-519	1st Sep 98	23.978** (0.0002)	4.5147** (0.0134)	*Economic crisis (96-98)*
KLCI	II	520-821	17 Dec 99	10.222* (0.0962)	3.2893** (0.0465)	The Asian Financial crisis:
	III	822-2447				-Thai Baht currency crisis (Jul 97);
	I	1-519	1st Sep 98	20.116** (0.0014)	2.9213* (0.0688)	-Malaysian economics:
INP	II	520-713	17 Jun 99	16.097** (0.0089)	4.6477** (0.0118)	-Negative (7.5%) GDP growth (98);
	III	714-2447				-RM depreciated 35% to USD (Dec 97);
	I	1-519	1st Sep 98	22.4495** (0.0005)	3.9587** (0.0233)	-Poverty rate 7%(98);
IND	II	520-751	10 Aug 99	16.3187** (0.0081)	6.1102** (0.0031)	-1 USD pegged with 3.8 RM (Sep 98);
	III	752-2447				*Restructuring period (98-99)*
	I	1-519	1st Sep 98	20.7852** (0.0011)	3.4771** (0.0382)	-Restructures banking system by Central bank (Jun 99);
CON	II	520-714	16 Jun 99	17.3558** (0.0051)	5.0637** (0.0079)	-Corporate Debt Restructuring
	III	715-2447				-Committee(CDRC) solved corporate debt (Sep 99);
	I	1-519	1st Sep 98	14.3629** (0.0190)	1.4840** (0.0301)	-Flat exit levy to encourage longer foreign investments (Sep 99);
PLA	II	520-770	7 Sep 99	17.3124** (0.0052)	6.3239** (0.0026)	-GDP increased 5.8% (99);
	III	771-2447				

Note: 1. Structural break test -Null hypothesis: No structural break;
2. * and ** indicated significant at 5% and 10% levels.

same signs whereas the reversals indicated the opposite signs. For continuously compounded returns

$$p_t = \omega + p_{t-1} + \varepsilon_t, \tag{7}$$

where $\varepsilon_t \sim IID(0,\sigma^2)$, p_t is the logarithm of P_t.

Considered a realisation of i+1 returns $r_1, r_2, \ldots, r_{i+1}$, the values of sequences V_s and reversals V_r can be expressed as follows:

$$V_s \equiv \sum_{t=1}^{i} A_t \text{ and } V_r = i - V_s, \tag{8}$$

where $A_t = D_t D_{t+1} + (1-D_t)(1-D_{t+1})$. The IID assumption with drift (either positive or negative) has the tendency to create more sequences than reversals. For the dummy variable that followed the direction of drift:

$$D_t^d = \begin{cases} 1, & \pi \\ 0, & 1-\pi \end{cases}, \tag{9}$$

where $\pi = \begin{cases} > \frac{1}{2} & \omega > 0 \\ < \frac{1}{2} & \omega < 0 \end{cases}$ with the probability $P(r_t > 0)$ which is equivalent to a standardized normal cumulative distribution $\Phi\left(\frac{\omega}{\sigma}\right)$. The nonzero drift of $\hat{C}_d$ statistics is defined as:

$$\hat{C}_d = \frac{\hat{\pi}_s}{1-\hat{\pi}_s}, \tag{10}$$

where $\hat{\pi}_s = \hat{\pi}^2 + (1-\hat{\pi})^2$. The statistical comparison between the $\hat{C}$ and $\hat{C}_d$ can be obtained from the normal asymptotic approximation for the distribution of V_s:

$$\hat{C} \sim N\left(\frac{\pi_s}{1-\pi_s}, \left(\frac{\pi_s(1-\pi_s) + 2\left(\pi^3 + (1-\pi)^3 - \pi_s^2\right)}{i(1-\pi_s)^4}\right)^2\right). \tag{11}$$

The variance of the V_s does not follow a binomial distribution $i\pi_s(1-\pi_o)$ because the dependent existed at the pairs of A_t.

REGIME AUGMENTED DICKEY-FULLER(ADF) AND PHILLIP-PERRON(PP) TESTS

The well-known unit root test such as Dickey and Fuller (1981) and Phillips and Perron (1988) have low power and even spurious rejection of unit root caused by the presence of structural changes. To overcome this drawback, we separated the unit-root tests into three regimes namely the Regime I, II and III, respectively. The ADF can be used to test the null hypothesis of a unit root ($\alpha_2 = 1-\rho = 0$) based on the OLS estimation

$$\Delta p_t = \omega + \alpha_1 t + \alpha_2 p_{t-1} + \sum_{k=1}^{n} \beta_k \Delta p_{t-k} + \varepsilon_t, \tag{12}$$

where α_0 and α_1 represent the drift and deterministic trend, β denoted the possible lag of p_t. Whereas the PP test is based on the similar equation without the summation term.

$$t_{\alpha 1, ADF} = \frac{\hat{\alpha}_1}{SE(\hat{\alpha}_1)}; \tag{13}$$

$$t_{\alpha 1, PP} = t_{\alpha 1, ADF}\left(\frac{(\hat{\varepsilon}'\hat{\varepsilon}/T_i)}{f_0}\right)^{0.5} \frac{T_i\left(f_0 - (\hat{\varepsilon}'\hat{\varepsilon}/T_i)\right)SE(\hat{\alpha}_1)}{2\sqrt{f_0 \hat{\varepsilon}'\hat{\varepsilon}/(T_i - r)}}, \tag{14}$$

where the residual spectrum at frequency zero, f_0 is estimated by the OLS autoregressive spectral estimation. For appropriate number of lag difference terms to be included in the test regression, we used the modified Akaike Information Criteria (Ng & Perron 2001) with the maximum lag length, L_{max} = [12(T/100)]$^{1/4}$ (Schwert 1989) to avoid the spurious serial correlation. The L_{max} is implemented as the initial lag and obtained the AIC. Preserved the lag if the lag coefficient is significant at 5% level. Otherwise, decreased the maximum lag by one and repeated the procedures until the condition is fulfilled.

DATA SOURCES AND EMPIRICAL RESULTS

DATA SOURCES

The data sets of Kuala Lumpur Stock Exchange (KLSE) consisted of composite index (CI) and the four major sectoral indices namely the industrial(IND), industrial product(INP), construction(CON) and plantation(PLA) from year 1996 until year 2006. The long spanning data provided a good test ground for possible drastic events such as the Asian Financial and currency crises. In addition, a wide range of sectoral indices allowed us to investigate the possible similarities and divergences in their returns series.

THE R-S TEST

Table 2 shows that the driftless Cowles-Jones statistics, $\hat{C}$s, are all against the RW hypothesis at 5% significance level. Under the null hypothesis of randomness of S-R test, the probability π is ½ with the C equivalent to unity. The tests of RW with drift evidenced mostly negative drifts except for PLA. After taking into account the drift, the Cowles-Jones statistics indicated sharp contrast results where none of the indices rejected the RW hypothesis. This implied that the driftless RW tests have misinterpreted the drift as possible predictable components in all the returns series. Next, we tested whether the Cowles-Jones statistics under the drift and without drift are statistically distinguishable. Using the normal asymptotic approximation for N_s, we obtained the estimated standard error for the KLCI as 0.0404. From Table 2, the $\hat{C}$ is statistically different from $\hat{C}_d$ with the test statistic -39.7524. Similar conclusions are also evidenced from the other four indices.

For regime SR tests, all the indices indicated negative drifts in the Regime I (crisis). It is found that relative stronger positive drifts in the Regime II (restructuring period) than the Regime III (recovering period) except for the Regime III CON index in Table 3. The regimes comparison provided a better view regarding the possible

TABLE 2. S-R with drift and driftless tests for overall data

Index	N_s	Without drift $\hat{\pi}_s$	$\hat{C}$	$t(\hat{C})$	With drift $\hat{\pi} = \Phi(x)$	$\hat{\pi}_s$	$\hat{C}_d$	$t(\hat{C}_d)$	Comparison $\hat{C}$ and $\hat{C}_d$
KLCI	1334	0.5451	1.1985	4.9111*	0.4983	0.5000	1.0000	0.0005	-39.7524*
INP	1344	0.5492	1.2185	5.4041*	0.4923	0.5001	1.0005	0.0117	-43.7316*
IND	1284	0.5247	1.1040	2.5733*	0.4991	0.5000	1.0000	0.0002	-20.6693*
CON	1358	0.5549	1.2470	6.1095*	0.4922	0.5001	1.0005	0.0121	-49.6010*
PLA	1361	0.5562	1.2532	6.6263*	0.5016	0.5000	1.0000	0.0005	-50.9995*

* denoted significant at 5% level.

TABLE 3. S-R test under structural break

Index	Regime	$\hat{\pi} = \Phi(x)$	$\hat{\pi}_s$	$\hat{C}_d$	$se(\hat{C}_d)$	$t(\hat{C}_d)$
KLCI	I	0.4558	0.5039	1.0158	0.0081	0.1750
	II	0.5476	0.5045	1.0183	0.0140	0.1544
	III	0.5043	0.5000	1.0002	0.0025	0.0030
INP	I	0.4442	0.5062	1.0252	0.0083	0.2763
	II	0.5534	0.5057	1.0231	0.0221	0.1553
	III	0.4983	0.5000	1.0000	0.0023	0.0005
IND	I	0.4517	0.5047	1.0188	0.0082	0.2083
	II	0.5447	0.5040	1.0161	0.0182	0.1197
	III	0.5120	0.5003	1.0012	0.0024	0.0239
CON	I	0.4486	0.5053	1.0214	0.0082	0.2352
	II	0.5660	0.5087	1.0355	0.0228	0.2354
	III	0.4944	0.5001	1.0003	0.0023	0.0052
PLA	I	0.4587	0.5034	1.0137	0.0081	0.1529
	II	0.5301	0.5018	1.0073	0.0163	0.0571
	III	0.5182	0.5007	1.0027	0.0024	0.0543

Notes:
H_0: random walk ($\hat{C}_d = 1$)

drifts as compared to the previous (Table 2) overall analysis. In Table 3, all the indices in all the regimes shown little evidence against the random walks at 5% significance level under the null hypothesis test of random process. A much higher $\hat{\pi}$ (around 75% of the price changes exceeded/ less than zero) is required to detect the deviation from a random walk. As a conclusion, the power of RS test is not sufficient enough to identify deviations from the random walk given the studied historical information.

REGIME ADF AND PP TEST

First, the conventional ADF and PP tests are presented for all the overall data in Table 4 where the null hypothesis of a unit root with drift and trend for all the indices cannot be rejected at 5% significance level according to the MacKinnon critical values (Table 5). In other words, all the indices are non-stationary processes at 5% level in the overall data. The inclusion of overall observations may lead to biasness of non-rejection of null hypothesis if one awareness of possible structural changes which have been identified in Table 2.

Second, we investigated the impacts of structural breaks upon the inferences of unit root tests in all the indices. For Regime I and Regime III, similar conclusions are observed where all the indices contained unit roots. However in Regime II, most of the indices indicated rejection of unit root with drift as well as drift-trend especially for indices IND and CON. As a conclusion, the indices in Regime II (restructuring period) are tended to reject the presence of random walk or in other words, the data generating process is stationary. Under this test, it is worth noted that although the increment is IID, nevertheless the squared increments are not necessary independent to their lags[3].

From economic viewpoint, the drift directions and stationarity of the indices can be explained accordingly to the regimes. The Asian financial crisis and currency turmoil hit Malaysian stock markets severely in Regime I. Panic-stricken investors and traders radically pulled out

TABLE 4. Regime ADF and PP tests

Index	Regime	ADF_{drift}	lag	$ADF_{drift,trend}$	lag	PP_{drift}	lag	$PP_{drift,trend}$	lag
KLCI	overall	-2.1907	15	-2.3366	15	-2.1646	15	-2.2738	15
	I	1.1057	1	-1.1973	9	1.1862	1	-1.1482	9
	II	*-3.0519**	*15*	*-2.4645*	*15*	*-3.0296**	*15*	*-3.0125*	*15*
	III	-1.4173	1	-1.8036	1	-1.4194	1	-1.8015	1
INP	overall	-2.6564**	15	-2.3283	15	-2.5263	15	-2.2191	15
	I	1.4886	9	-1.5819	9	1.6896	9	-1.5633	9
	II	*-2.6982***	*4*	*-2.7691*	*4*	*-2.7770***	*4*	*-2.9774*	*4*
	III	-1.9449	14	-1.9497	14	-1.8891	14	-1.8898	14
IND	overall	-1.6221	14	-2.1883	14	-1.5800	14	-2.0714	14
	I	1.8032	1	-0.8843	7	1.8857	1	-0.7755	7
	II	*-3.0349**	*13*	*-2.2085*	*13*	*-3.0603**	*13*	*-3.5991**	*13*
	III	-1.1784	13	-1.5951	13	-1.1316	13	-1.7099	13
CON	overall	-2.4103	26	-2.309	26	-2.3410	26	-2.2960	26
	I	0.9904	1	-1.9943	8	1.0889	1	-1.9270	8
	II	*-2.6069***	*5*	*-3.3116***	*4*	*-2.8804**	*5*	*-3.5235**	*4*
	III	-1.8240	13	-2.2567	13	-1.7575	13	-2.1683	13
PLN	overall	-1.3281	5	-1.6721	6	-1.3395	5	-1.6592	6
	I	1.4613	1	-0.4809	7	1.5434	1	-0.3430	7
	II	*-2.7343***	*12*	*-2.1448*	*12*	*-3.0052**	*12*	*-2.5832*	*12*
	III	-0.1171	2	-1.9081	2	-0.1232	2	-1.9124	2

Notes:
1. Null hypothesis follows: H_0: The series has a unit root;
2. * and ** indicate 10% and 5% significance level;
3. Refers the critical values in the Table 5.

TABLE 5. Critical values for DF and PP tests based on MacKinnon one-tailed test

Critical values		τ drift			τ drift, trend		
Significant level		10%	5%	1%	10%	5%	1%
KLCI:	overall	-2.5673	-2.8625	-3.4328	-3.1277	-3.4116	-3.9618
	Regime I	-2.5696	-2.8669	-3.4427	-3.1318	-3.4187	-3.9762
	Regime II	-2.5718	-2.8708	-3.4518	-3.1354	-3.4248	-3.9887
	Regime III	-2.5676	-2.8631	-3.4342	-3.1282	-3.4125	-3.9637
02	overall	-2.5673	-2.8625	-3.4328	-3.1277	-3.4116	-3.9618
	Regime I	-2.5696	-2.8669	-3.4427	-3.1318	-3.4187	-3.9762
	Regime II	-2.5747	-2.8763	-3.4641	-3.1404	-3.4331	-4.0060
	Regime III	-2.5676	-2.8630	-3.4339	-3.1281	-3.4124	-3.9633
03	overall	-2.5673	-2.8625	-3.4328	-3.1277	-3.4116	-3.9618
	Regime I	-2.5696	-2.8669	-3.4427	-3.1318	-3.4187	-3.9762
	Regime II	-2.5734	-2.8738	-3.4584	-3.1381	-3.4293	-3.9981
	Regime III	-2.5676	-2.8630	-3.4340	-3.1281	-3.4124	-3.9634
05	overall	-2.5673	-2.8625	-3.4328	-3.1277	-3.4116	-3.9618
	Regime I	-2.5696	-2.8669	-3.4427	-3.1318	-3.4187	-3.9762
	Regime II	-2.5746	-2.8762	-3.4639	-3.1403	-3.4330	-4.0058
	Regime III	-2.5676	-2.8630	-3.4339	-3.1281	-3.4124	-3.9633
08	overall	-2.5673	-2.8625	-3.4328	-3.1277	-3.4116	-3.9618
	Regime I	-2.5696	-2.8669	-3.4427	-3.1318	-3.4187	-3.9762
	Regime II	-2.5729	-2.8728	-3.4563	-3.1373	-3.4278	-3.9950
	Regime III	-2.5676	-2.8630	-3.4340	-3.1281	-3.4125	-3.9635

the short-term capital and created further currency crisis and hikes of interest rate. These are evidenced from the dropped of the KLCI from 1271 (25th Feb 1997) to 266 (1st Sep 1998), GDP contracts by 7.5% (1998), ringgit (RM) depreciated 35% to USD (Jul-Dec 1997) and etc. As a result, the uncertainties of volatile exchange rate and poor performance of stock market are the major contributors to the negative drift in the Malaysian stock markets. During the crisis, the Malaysian markets become relatively more efficient (drastic adjustments for the prices can be viewed during the Asian financial crisis period from 1997 to 1998) due to the homogenous reactions across the global and local investors where the market prices reflected all the information available in the markets. In other words, in an efficient market, the price adjustment is instantaneous to new information. This is because the studies of publicly available information and even private information become meaningless during this period where the market prices are the most reliable indicator to the actual economic condition.

On the other hand, positive drifts (Regime II and III) and inefficiency market are observed in the Regime II (restructuring period). After the implementation of selective capital control in 1st September 1998, the Securities Commission and the KLSE implemented recovery strategic such as strengthening the market intermediaries, improving the market transparency and improving the liquidity in corporate sectors. Most of the indices rebounded significantly immediately after the announcement, for example, the KLCI radically increased by 12%, Construction 13%, Finance, Plantation, Industrial product, 9% and the lowest is 3% by Property. In addition, Debt Restructuring Committee (CDRC) and Central bank have also solved significant corporate debts during this period. All the constructive actions taken by the government have trigged the positive drift which can be observed in all the indices. At the same time, the markets become less efficient because some well-informed investors start to make use of additional information to generate profits in the markets.

CONCLUSION

This paper investigated the random walk hypothesis for the Malaysian stock exchanges under the conditions of drift and structural break. Our results demonstrated that the currency control and restructuring period shown instantaneous impacts to the Malaysian stock market. Under the structural break, we observed the tendency of drift's direction changes from negative to positive before and after the currency control. The identification of breaks allowed us to have a better view of the Malaysia stock exchange.

Our empirical results evidenced trend stationary process especially in restructuring period whereas the other periods shown toward not rejecting the existence of unit-roots. Finally, it is worth to note that although the empirical results provided little evidence against the random walk hypothesis for Regime I and III, nevertheless we are not able to conclude that the Malaysian stock markets are informationally efficient since RW hypothesis can only be treated as equivalent to efficiency market hypothesis under the risk neutrality condition. In future work, we intended to relate the conditional heteroskedasticity volatility and risk premium to the returns series to further support the efficiency market hypothesis.

ACKNOWLEDGEMENT

The authors would like to thank the anonymous referees for their helpful comments on an earlier version of the paper. The authors would also like to gratefully acknowledge the financial support from the Fundamental Research Grant Scheme (FGRS0067-2006), MOSTI.

ENDNOTES

1. The term 'unit-root' represented the price index is a non-stationary process or a random walk (RW) process. In this paper, unit-root and random walk is used interchangeably.
2. The improved martingale model with risk adjustment (Lucas 1978; Merton 1990) has become more successful in capturing the behavior of asset pricing.
3. For instance, the KLCI shown Q(12) and LM ARCH F-statistics with the values of 1112.1(p-value=0.000) and 4.9878 (p-value=0.000) respectively. One might relate this property as the risk premia (Engle et al. 1978) to the returns series because the RW hypothesis can only be treated as equivalent to efficiency market hypothesis under the risk neutrality condition.

REFERENCES

Andrews, D.W.K. 1993. Tests for parameter instability and structural change with unknown change point. *Econometrica* 61: 821-856.

Bachelier, L. 1964. *Theory of speculation*, in Cootner, P.(ed), The random character of stock market prices, MIT Press, Cambridge, MA, 1964; Reprint.

Bai, J. & Perron, P. 1998. Estimating and testing linear models with multiple structural changes. *Econometrica* 66: 47-78.

Chaudhuri, K. & Wu, Y. 2003. Random walk versus breaking trend in stock prices: evidence from emerging markets. *Journal of Banking and Finance* 27: 575-592.

Cowles, A., & Jones, H. 1937. Some a posteriori probabilities in stock market action. *Econometrica* 5: 280-294.

Dickey, D.A. & Fuller, W. 1981. Likelihood ratio statistics for autoregressive time series with a unit root. *Econometrica* 49: 1057-1082.

Engle, R.F., Lilien, D.M. & Robins R.P. 1987. Estimating time varying risk premia in the term structure: the ARCH-M model. *Econometrica* 55: 391-407.

Fama, E. 1970. Efficient capital markets: a review of theory an empirical work. *Journal of Finance* 25: 269-282.

Hansen, B.E. 1995. Approximate asymptotic p-values for structural change test. *Boston College Working Papers in Economics 297*, Boston College.

Henry, P.B. 2000. Stock market liberalization, economic reform and emerging market equity price. *Journal of Finance* 55: 529-564.

LeRoy, S. 1973. Risk aversion and the martingale property of stock returns. *International Economic Review* 14: 436-446.

Lucas, R.,Jr. 1978. Asset prices in an exchange economy. *Econometrica* 46: 1429-1446.

Merton, R. 1990. Continuous-Time Finance. Cambridge, MA: Blackwell Publishers, Cambridge.

Ng, S. & Perron, P. 2001. Lag length selection and the construction of unit root tests with good size and power. *Econometrica* 69: 1519-1554.

Perron, P. 1989. The great crush, the oil price shock and the unit root hypothesis. *Econometrica* 55: 277-302.

Phillips P.C.B. & Perron, P. 1988. Testing for a unit root in time series regression. *Biometrika* 75: 335-346.

Rama Cont. 2001. Empirical properties of asset returns: stylized facts and statistical issues. *Quantitative Finance* 1: 223-236.

Roberts, H. 1967. *Statistical versus clinical prediction of the stock market,* unpublished manuscript. Center for Research in Security Prices, University of Chicago, May.

Samuelson, P. 1965. Proof that properly anticipated prices fluctuate randomly. *Industrial Management Review* 6: 41-49.

Schwert, W. 1989. Test for unit roots: a Monte Carlo investigation. *Journal of Business and Economic Statistics* 7: 147-159.

Vogelsang T.J. & Perron, P. 1998. Additional tests for a unit root allowing for a break in the trend function at an unknown time. *International Economic Review* 39: 1073-1100.

Chin Wen Cheong*
Research Centre of Mathematical Science
Multimedia University
63100 Cyberjaya
Selangor, Malaysia

Zaidi Isa
Faculty of Science and Technology
Universiti Kebangsaan Malaysia
43600 Bangi, Selangor, Malaysia

Corresponding author; email: wcchin@mmu.edu.my

Received: 17 October 2008
Accepted: 6 March 2009