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THE RANDOM WALK BEHAVIOUR OF MALAYSIAN STOCK MARKET: EVIDENCE FROM INDIVIDUAL STOCKS

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ABSTRACT

This study re-examines the price behaviour of 77 individual stocks listed on Bursa Malaysia in light of the random walk hypothesis. With a new statistical tool, namely the Brock-Dechert-Scheinkman (BDS) test, it is possible to detect a more complex form of dependencies in series of financial returns that often appear completely random to standard statistical tests, such as serial correlation tests, runs test, variance ratio test and unit root tests. Our econometric results reveal that the market in general as proxied by the KLCI and all the 77 individual stocks do not follow a random walk process. This conclusion holds even when the sample period is broken down into two sub-periods with the exception of five stocks- IOICorp, KLK, MUIInd, Pos Hldgs and Tchong. The price behaviour of these five stocks in the sub-periods before and during the crisis provides empirical support to our conjecture that the Asian financial crisis in 1997 adversely affected the market's ability to price stocks efficiently, thus preventing stock prices from following a random walk process.

Keywords: *Random walk; weak-form efficiency; BDS test; Malaysian stock market.*

ABSTRAK

Kajian ini meneliti semula kelakuan harga dalam konteks hipotesis pergerakan rawak bagi 77 saham individu yang disenaraikan di Bursa Malaysia. Dengan menggunakan alat statistik baru iaitu ujian Brock-Dechert-Scheinkman (BDS), penyelidik dapat mengesan bentuk perkaitan yang lebih kompleks di antara siri pulangan kewangan yang selalunya dianggap rawak hasil daripada ujian statistik yang standard, seperti ujian korelasi bersiri, 'runs test', ujian *nisbah varians dan ujian punca satu. Keputusan ekonometrik kajian ini menunjukkan pasaran secara amnya tidak mengikut proses pergerakan rawak seperti yang diwakili oleh KLCI dan semua 77 saham individu. Kesimpulan ini masih sah walaupun sampel dibahagikan kepada dua tempoh yang kecil, kecuali lima saham- IOICorp, KLK, MUIInd, Pos Hldgs dan Tchong. Kelakuan harga bagi kelima-lima saham tersebut dalam tempoh sebelum dan semasa krisis memberi sokongan empirikal kepada tekaan kajian ini bahawa krisis kewangan di Asia pada tahun 1997 akan menjejaskan keupayaan pasaran untuk menetapkan harga secara cekap, seterusnya menghalang harga saham daripada mengikut proses pergerakan rawak.*

Kata Kunci: *Pergerakan rawak; kecekapan bentuk lemah; ujian BDS; pasaran saham Malaysia.*

INTRODUCTION

In the early treatments of the efficient market hypothesis (EMH), the statement that the current price of a security reflects all available information is assumed to imply that successive price changes are independent. Furthermore, it is usually assumed that successive price changes are identically distributed. Together, these two hypotheses constitute the cornerstone of the random walk model (Fama, 1965).

Formally, the random walk model can be stated as:

$$p_t = p_{t-1} + \mu_t$$

where p_t is the price at time t, p_{t-1} is the price in the immediate preceding period and m_t is a random error term. A purely random process is what statisticians call 'independent and identical distribution' (i.i.d.), such as a Gaussian with zero mean and constant variance. The price change, $\Delta p_t = p_t - p_{t-1}$, is simply μ_t which being white noise, is unpredictable from previous price changes. Looking from a different perspective, Equation (1) states that the best forecast of the price of a security at time t+1 is the price at time t, which in turn implies that the expected gain or loss for any holding period is zero. Therefore, analysis of past prices is meaningless because patterns observed in the past occurred purely by chance. Annuar and Shamsher (1993), Yong (1993a), Campbell *et al.* (1997), Lo and MacKinlay (1999), Malkiel (2003) and Singal (2004) provide an excellent account on the subject of random walk.

The literature on the random walk behaviour of stock prices can be considered as one of the most voluminous. The factors that contributed to the phenomenal growth of this body of empirical literature can be attributed to its profound implications on the weak form EMH and time series forecasting. First, most of the empirical studies hypothesize the random walk behaviour of stock prices to test for the informational efficiency of stock markets. In particular, a random walk price series implies that the market is weak-form efficient.[1] Since new information is deemed to come in a random fashion in an efficient market, changes in prices that occur as a consequence of that information will seem random. Thus, investors in weak-form efficient market cannot expect to find any patterns in the historical sequence of stock prices that will provide insight into future price movements and allow them to earn abnormal rates of returns.

However, if the hypothesis of random walk is rejected, it will be a strong statement to conclude that the market is inefficient. As noted by Ko and Lee (1991: 224),

> "If the random walk hypothesis holds, the weak form of the efficient market hypothesis must hold, but not vice versa. Thus, evidence supporting the random walk model is the evidence of market efficiency. But violation of the random walk model need not be evidence of market inefficiency in the weak form".

In this case, it is necessary to first uncover the structure of dependencies in this non-random series. If investors could have profitably operated a trading rule (net of all transactions costs) that exploits those detected dependencies, then it would be at odds with the weak-form efficient market hypothesis. Second, the most enduring question in financial economics literature concerns the predictability of stock prices and much research endeavour has been devoted to forecast stock prices in order to "beat the market". In this regard, technical analysts argue that past price changes can provide rich insights into the behaviour of stock prices, and hence can be used to forecast future price changes. However, if stock prices are found to behave randomly, then this poses a major challenge to technical analysts who believe that history tends to repeat itself, even to the extent of implying that their work is of no real value to the stock market investors.

In this vast body of literature, the emerging Malaysian stock market, Bursa Malaysia (formerly known as Kuala Lumpur Stock Exchange)[2], has also received considerable attention from researchers as the testing ground in those earlier years of 1980s, especially in the framework of random walk to examine the weak-form efficiency of the market. Barnes (1986) examined 30 companies and six sector indices for the six years ended 30 June 1980. Using monthly data, the serial correlation and runs tests results exhibit a high degree of efficiency in the weak form, with little departure from the random walk hypothesis. Further spectral analysis confirms the earlier findings that the Malaysian stock market is fairly efficient. Laurence (1986) used daily closing prices adjusted for cash and stock dividends, splits and rights issues, of 16 individual stocks traded on Bursa Malaysia over the sample period of 1 June 1973 through 31 December 1978. Results from serial correlation and runs tests suggest only slightly deviation from perfect weak-form efficiency. Using data for six sector indices and the all-share index from 1975 to 1982, Saw and Tan (1989) found that the Malaysian stock market is inefficient in the weak form when weekly data were used, but pockets of market efficiency existed when monthly data were used.

Entering the 1990s, the random walk behaviour of stock prices traded on Bursa Malaysia continued to grow at a phenomenal rate, and it is impossible for us to review all of those published works in one single paper. Annuar *et al.* (1991) conducted the weak-form test on 82 individual stocks that were continuously traded on the Malaysian stock exchange from 1975 to 1989, using the unit root methodology to account for cyclicality in price series and controlling thin trading effect. Overall, about 87% of the total sample of 82 stocks possess unit root, implying that there is a 13% chance that a security price is inefficient over the fifteen-year period. Though the findings suggest that the market is generally weak-form efficient, pockets of inefficiency are observed for shares that suffer liquidity problem. Annuar *et al.* (1993) addressed similar issue but using indices data in place of individual stocks, covering sample period from January 1977 through May 1989, with weekly and monthly intervals. The results from unit root analysis, serial correlation test and Q statistics strongly suggest that the Malaysian stock market is weak form efficient, though, once again, pockets of inefficiency are reported for some indices. Kok and Lee (1994) analyzed the stock prices behaviour of 32 companies listed on the Second Board of Bursa Malaysia over the period 2 January 1992 to 30 December 1994.

The results from various statistical tests- runs test, serial correlation test, Ljung-Box-Pierce Q test and Von Neumann's ratio test, suggest that information based on historical prices is fully reflected in current price within a week but may not be fully impounded in current price within a day. Thus, the Second Board is weak-form efficient with respect to weekly data. Though daily price series are serially correlated, the magnitude of their correlations is not large enough to devise any mechanical trading rules for profitable investment timing. Kok and Goh (1995) utilized daily, weekly and monthly closing prices of 7 stock indices over a period of nine years from 1984 to 1992. Using similar methodologies as Kok and Lee (1994), the authors found serial dependencies in successive price changes for all daily stock indices of Bursa Malaysia. However, the significant correlations found are very small that it is unlikely to have any economic value, and this led the authors to conclude the market is weak-form efficient. When weekly data were used, the efficiency of the Malaysian stock market had improved from a weak-form inefficient market in the mid 1980s to a weak-form efficient market by the late 1980s and early 1990s. Finally, the results from monthly data provide conclusive evidence of weak-form efficiency, suggesting that market efficiency improves with longer temporal aggregation of sample data. Unlike other studies, Kok and Goh (1995) proceeded to address the issue of mean reversion using long-horizon returns. Though the variance ratio test provides evidence of mean reversion, it is not statistically significant to reject the long run random walk hypothesis.

The literature reported thus far is in favour of weak-form efficiency, with little departure from random walk for those sampled market indices or individual stocks. However, empirical evidence of inefficiency cannot be suppressed. One of those is documented in Yong (1989) who conducted serial correlation and runs tests on weekly closing prices of 30 stocks of random selection over the period January 1977 to June 1988. Another significant contribution to the literature is made by Yong (1993b), who used weekly closing prices of all 170 stocks traded on Bursa Malaysia from January 1977 to May 1985 inclusive. Results from various statistical tests, especially those from the runs test reinforce earlier findings of departure from weak form market efficiency. As postulated by the author, the low trading volumes in most stocks and the possible price manipulations by those investors who own majority of the stocks might help to explain the findings of the runs test. A recent study by Lai *et al.* (2003) using the variance ratio test also reveals the non-randomness of successive price changes in the Malaysian stock market. The potential of predictability is further verified by the significantly positive returns generated by the fixed length moving average (FMA) and variable length moving average (VMA) trading rules even in the presence of trading costs, thus invalidating the weak-from EMH for the Malaysian stock market.

There are some common shortcomings associated with the above-cited literature. In particular, the application of standard statistical tests-serial correlation test, runs test, variance ratio test and unit root tests to examine the random walk behaviour of stock prices in those earlier studies has been challenged in recent times by the development of new statistical tests. On one hand, most of those cited studies focused only on testing the first hypothesis of successive price changes that are independent of one another, partly due to the limitations of methodologies employed. In this regard, they are not testing the strongest version of the random walk model.[3] On the other hand, in testing for independence, the standard statistical tests-serial correlation test, runs test, variance ratio test and unit root tests[4] employed are designed to uncover linear dependencies in the data. However, the lack of linear dependencies does not imply that the series are random as there might be other more complex forms of dependencies that cannot be detected by these standard methodologies. Even Fama (1965: 80) admitted that linear modelling techniques have limitations, as they are not sophisticated enough to capture complicated 'patterns' that the chartist sees in stock prices. Steurer (1995: 202) expressed similar opinion, in which he argued that there is an order to the apparent randomness of the market. This order is so complex that the random walk concept is proven by the standard linear statistical tests. Another researcher, Brooks (1996: 307) agreed that series of financial returns often appear completely random to standard linear and spectral tests. However, he strongly believed that if a different approach, using more powerful techniques, it might be possible to uncover a more complex form of dependencies in these series.

One of the possibilities that might contribute to the departure from random walk is the presence of non-linear serial dependencies in the underlying data generating process (DGP). Even the influential paper of Fama (1970: 394) acknowledged this possibility, *"Moreover, zero covariances are consistent with a fair game model, but as noted earlier, there are other types of nonlinear dependence that imply the existence of profitable trading systems, and yet do not imply nonzero serial covariances"*. In this regard, Hinich and Patterson (1985) is the first published paper reporting evidence of non-linearity in common stock returns. As recalled by Patterson and Ashley (2000), the original manuscript of Hinich and Patterson (1985) met with resistance from the finance journals because finance academics were reluctant at that time to recognize the importance of distinguishing serial correlation from non-linear serial dependencies. Subsequent evidence documented in Scheinkman and LeBaron (1989), Hsieh (1991), Abhyankar *et al.* (1995, 1997), Barkoulas and Travlos (1998), Opong *et al.* (1999) and Ammermann and Patterson (2003) strongly suggest that non-linearity is a cross-sectionally universal phenomenon. This also explains the phenomenal growth of non-linear modelling in the literature as non-linearity is now widely accepted as a salient feature of financial returns in general, and stock returns series in particular.

The evidence of non-linearity has strong implication on the weak-form EMH for it implies the potential of predictability in financial returns.

Specifically, if investors could have profitably operated a trading rule (net of all transactions costs) that exploits this detected non-linearity, it would be at odds with the weak-form EMH, which postulate that even non-linear combinations of previous prices are not useful predictors of future prices (Brooks, 1996; Brooks & Hinich, 1999; McMillan & Speight, 2001). However, Hsieh (1989) argued that those earlier standard statistical tests might fail to detect non-linear departure from the random walk hypothesis. Motivated by the concern that non-linearity might be present in the DGP, coupled with the recent breakthroughs pertaining to non-linear dynamics, Lim *et al.* (2003) re-examined the random walk hypothesis as all those earlier Malaysian studies in favour of EMH have implicitly disregarded the presence of non-linearity, which will have serious consequences of making incorrect inferences and policy recommendations, as highlighted by Liew *et al.* (2003). Using the Brock-Dechert-Scheinkman (BDS) test developed in Brock *et al.* (1987, 1996), which has been proven to be quite powerful in detecting departures from i.i.d. behaviour in some Monte Carlo simulations (see, for example, Brock *et al.*, 1991; Hsieh, 1991)[5], Lim *et al.* (2003) found the inadequacy of random walk model to describe the price behaviour of Malaysian stock market since some cycles or patterns show up more frequently than would be expected in a true random series. However, as highlighted by the authors, it would be premature to reject the weak-form EMH based on their findings unless the causes of rejection by the BDS test can be identified and those detected dependencies can be profitably exploited.

Though the paper of Lim *et al.* (2003) provided robust empirical evidence on the non-random behaviour of the Malaysian stock market, the study is not without limitation. One particular concern is the use of market index in their empirical testing, in particular the Kuala Lumpur Composite Index (KLCI) as a proxy of market. According to Fama (1965), the use of market index data in random walk tests may lead to a false perception of price change dependence even when price changes of individual stocks represented by the index are independent. This spurious dependence comes from the persistence of the effect of the market factor on stocks not trading coincidentally. Other critical comments can also be found in Campbell *et al.* (1997: 72):

> "Individual returns contain much company-specific or idiosyncratic noise that makes it difficult to detect the presence of predictable components. Since the idiosyncratic noise is large attenuated by forming portfolios, we would expect to uncover the predictable systematic component more readily when securities are combined."

From the above statements, it would seem to suggest that the findings of non-random structures in market index by Lim *et al.* (2003) are not surprising and it warrants further investigation whether these structures would still persist in individual stocks represented by the market index. Though it was claimed by Campbell *et al.* (1997) that such dependencies are difficult to detect in individual stocks, it remains a conjecture that require further empirical verification, as Granger (1975: 11) pointed out that the random walk hypothesis is "... *only an 'average' kind of law, and may not hold true for all securities at all times*". Nevertheless, this study is also motivated by the concern of some technical analysts who claimed that earlier efficiency studies on Bursa Malaysia are irrelevant because they use market indices rather than individual stocks (Dawson, 1990; Annuar *et al.*, 1991). In this regard, it would be fair to this group of analysts that a revisit of the random walk behaviour of stock prices be conducted, applying a more robust test on individual stocks.

Thus, the main objective of this paper is to re-examine the random walk behaviour of individual stocks traded on the Malaysian stock market, using the BDS test as employed in Lim *et al.* (2003). In most of the recent empirical testing of random walk hypothesis, the BDS test has been widely employed due to its high power in detecting departures from the i.i.d null, and hence provides a robust test of the strongest version of random walk model (see, for example, Hsieh, 1989, 1991; Scheinkman & LeBaron, 1989; De Grauwe *et al.*, 1993; Steurer, 1995; Brooks, 1996; Al-Loughani & Chappell, 1997; Mahajan & Wagner, 1999; Opong *et al.*, 1999; Serletis & Shintani, 2003).

BROCK-DECHERT-SCHEINKMAN (BDS) TEST

Brock, Dechert and Scheinkman (Brock *et al.*, 1987) developed a statistical test and the BDS statistic. The original BDS paper took the concept of the correlation integral[6] and transformed it into a formal test statistic which is asymptotically distributed as a normal variable under the null hypothesis of independent and identically distributed (i.i.d.) against an unspecified alternative. In principle, no distributional assumption on the underlying data generating process is needed in using the BDS test as a test statistic for i.i.d. random variables. Though the estimation is non-parametric, the test statistic is asymptotically distributed as a standard normal variable, with zero mean and unit variance. Hence, the significance of the test statistic is readily determined from standard normal tables. A revision of this original paper has been done in Brock *et al.* (1996).

The BDS test is based on the correlation integral as the test statistic. Given a sample of i.i.d. observations, $\{x_t: t = 1, 2, \ldots\ldots, n\}$, Brock *et al.* (1987; 1996) showed that:

$$Wm,n\,(\varepsilon) = \sqrt{n}\,\frac{T_{m,n}(\varepsilon)}{V_{m,n}(\varepsilon)}$$

has a limiting standard normal distribution, where $W_{m,n}\,(\varepsilon)$ is the BDS statistic. n is the sample size, m is the embedding dimension, and the metric bound, ε, is the maximum difference between pairs of observations counted in computing the correlation integral. $T_{m,n}(\varepsilon)$ measures the difference between the dispersion of the observed data series in a number of spaces with the dispersion that an i.i.d. process would generate in these same spaces, that is $C_{m,n}(\varepsilon)$ $-C_{1,n}\,(\varepsilon)^m$, $T_{m,n}(\varepsilon)$ has an asymptotic normal distribution with zero mean and variance $V^2_m(\varepsilon)$.[7]

This BDS test has an intuitive explanation. The correlation integral $C_{m',n}(\varepsilon)$ is an estimate of the probability that the distance between any two m-histories, $x^m_t = (x_t, x_{t+1}, \ldots, x_{t+m-1})$ and $x^m_s = (x_s, x_{s+1}, \ldots, x_{s+m-1})$ of the series $\{x_t\}$ is less than ε that is, $C_{m,n}(\varepsilon) \rightarrow$ prob $\{\,|x_{1+i} — x_{s+i}| < \varepsilon$, for all $i = 0, 1, \ldots\ldots\ldots\, m\text{-}1\}$, as $n \rightarrow \infty$.

If the series $\{x_t\}$ are independent, then, for $|t\text{-}s| > m$, $C_{m,n}(\varepsilon) \rightarrow \prod_{i=0}^{m-1}$ prob $\{\,|x_{t+i} - x_{s+i}| < \varepsilon\}$, as $n \rightarrow \infty$. Furthermore, if the series $\{x_i\}$ are also identically distributed, then $C_{m,n}(\varepsilon) \rightarrow C_1(\varepsilon)^m$, as $n \rightarrow \infty$. The BDS statistic therefore tests the null hypothesis that $C_{m,n}(\varepsilon) = C_{1,n}(\varepsilon)^m$, which is the null hypothesis of i.i.d. [8]

The need to choose the values of ε and m can be a complication in using the BDS test. For a given m, ε cannot be too small because $C_{m,n}(\varepsilon)$ will capture too few points. On the other hands, ε cannot be too large because $C_{m,n}(\varepsilon)$ will capture too many points. For this reason, we adopt the approach used by advocates of this test. In particular, we set ε as a proportion of standard deviation of the data, σ. Hsieh and LeBaron (1988a, b) have performed a number of Monte Carlo simulation tests regarding the size of the BDS statistics under the null of i.i.d. and the alternative hypotheses. The Monte Carlo evidence showed that the 'best' choice of ε is between 0.50 and 1.50 times the standard deviation.

On the other hand, at our chosen setting of ε, we produce the BDS test statistics, $W_{m,n}(\varepsilon)$ for all settings of embedding dimension from 2 to 5. Though most researchers computed the BDS statistics for embedding dimension varying from 2 to 10 (see, for example, Hsieh, 1989; De

Grauwe *et al.*, 1993; Brooks, 1996; Mahajan & Wagner, 1999; Opong *et al.*, 1999), it is important to take note that the small samples properties of BDS test degrade as one increases the embedding dimension. Specifically the Monte Carlo simulations in Brock *et al.* (1991) demonstrated that as the dimension goes beyond 5, the small samples properties of BDS degrade, mainly due to the reduction of non-overlapping observations as m grows. Thus, this study only computes the BDS test statistics for embedding dimensions of 2 to 5.

THE DATA

The data in this study consist of daily closing prices for individual stocks traded on the Malaysian stock market, Bursa Malaysia. In the study by Lim *et al.* (2003), the authors utilized the Kuala Lumpur Composite Index (KLCI) to test for the random walk behaviour of Malaysian stock market. It would be interesting to further investigate whether the non-random structures in market index detected by Lim *et al.* (2003) would still persist in individual stocks represented by the market index. Within this framework of objective, the sampled individual stocks would be limited to all the 100 component stocks that compose the KLCI. However, due to data availability for the sub-periods analysis to be discussed later, only 77 component stocks as listed in Appendix are included in this sample study. All the data are collected from the Malaysian stock exchange.

The prices covering the sample period from 1 July 1995 to 30 June 1999 are transformed into a series of continuously compounded percentage returns, using the relationship:

$$r_t = 100^* \text{In} (p_t/p_{t-1}) \tag{3}$$

where p_t is the closing price of the stock on day t, and p_{t-1} the price on the previous trading day.

The above transformation, though is a common practice in most empirical work, deserves our mentioning. A common explanation is that an investor is more concerned with the returns given by a stock rather than its actual price. Further justification can be found, for instance, in Campbell *et al.* (1997: 9), in which the authors provided two reasons. First, for the average investor, financial markets may be considered close to perfectly competitive, so that the size of the investment does not affect price changes. Second, returns have more attractive statistical properties than prices, such as stationarity and ergodicity.

In this study, we first test the random walk hypothesis over the whole sample period. To observe the consistency of the results, the study period is then broken down into two sub-periods with equal length for separate BDS test. The first sub-period is from 1 July 1995 through 30 June 1997 while the second period runs from 1 July 1997 through 30 June 1999, with the Asian financial crisis as the break point. The main consideration in determining the length of each sub-period is to ensure enough observations for the BDS statistic to have limiting normal distribution under the null of i.i.d. Specifically, the Monte Carlo simulations in Brock *et al.* (1991) suggested that the asymptotic distribution can approximate the finite sample distribution of the BDS statistic for 500 or more observations.

The motivation for this sub-periods analysis is at least twofold. One, it is possible to determine whether the rejection of the random walk in the full sample is driven by the behaviour of stock prices in any particular sub-period. Similarly, the inability to reject random walk for the full sample could have masked significant result in any sub-period. Second, it would be interesting to compare the behaviour of stock prices before and during a financial crisis, an area which has not been well-researched in the literature. It is well acknowledged that the economic and financial turmoil that struck Asia in July 1997 was representative of both crisis and panic. What appeared to be a local financial crisis in Thailand quickly escalated into an Asian financial crisis, spreading to other Asian countries like Indonesia, Korea, Malaysia and the Philippines. We conjecture that the crisis might contribute to the non-random behaviour of stock prices as these panic investors will not be able to make a rational assessment of the market and adjust rapidly and unbiasedly to the arrival of new information. As explained by Schachter *et al.* (1985: 324),

> "The investor is something more than the creature the economist hypothesizes. As well as the rational, utility maximizer of the economist's creation, the investor is also a social creature influenced by the opinions and actions of others as well as by his own assessment of hard, economic facts".

Empirically, Schachter *et al.* (1985) found that the South Sea Bubble during 1720 was a time of hysteria when all common sense, let alone rationality, abandoned the aggregate of investors. Thus, it would be interesting to know whether the investors in Bursa Malaysia behave similarly during the crisis period.

EMPIRICAL RESULTS

This study first computes the BDS statistics for all the 77 selected individual stocks covering the whole sample period. For the purpose of comparison, this study also reports the BDS statistics for the KLCI. All the BDS statistics, $W_{m,n}(\varepsilon)$, are computed in *EViews* version 4.1, for all combinations of m and ε where $m = 2, 3, \ldots\ldots 5$ and $\varepsilon = 0.50\sigma, 0.75\sigma, 1.00\sigma, 1.25\sigma$ and 1.50σ. As mentioned earlier, the Monte Carlo simulations in Brock *et al.* (1991) demonstrated that as the dimension goes beyond 5, the small samples properties of BDS degrade, mainly due to the reduction of non-overlapping observations as m grows. On the other hand, though our sample sizes have sufficient observations for the asymptotic normal distribution, including those in the sub-periods analysis, we have computed the bootstrapped p-values for the BDS statistics with 10000 repetitions, an option given in *EViews* 4.1, to ensure the robustness of the results.

The BDS test results on the random walk hypothesis over the full sample period are reported in Table 1. To conserve space, we only report the results for $\varepsilon = 1.00\sigma$.[9] It is obvious from Table 1 that all the BDS statistics are in the extreme positive tail of the standard normal distribution, both for the KLCI and all the 77 individual stocks. The positive values show that more clustering of points in m-dimensional space than would be expected in a true random series. On the other hand, negative BDS statistics indicate that certain patterns are too infrequent. However, only significant BDS statistics, both positive and negative, are indication of non-i.i.d. behaviour. The bootstrapped p-values given in parentheses show that all the BDS statistics are significant even at the 1% level, suggesting that all the returns series behave non-randomly. Though not reported, the p-values for the BDS statistics at other choices of ε are extremely small, hence strongly reject the random walk hypothesis. According to Brock *et al.* (1991), the large BDS statistics can arise in two ways. It can either be that the finite sample distribution under the null of i.i.d. is poorly approximated by the asymptotic normal distribution, or the BDS statistics are large when the null hypothesis of i.i.d. is violated. From the various Monte Carlo simulations, Brock *et al.* (1991) ruled out the first possibility, thus suggesting that our large BDS statistics in Table 1 provide strong evidence of departure from the i.i.d. null. To put these results into perspective, the finding of non-random structures in the market index corroborates those of Lim *et al.* (2003), though the sample size in this present study is shorter. Further investigation reveals that similar non-random structures still persist in all the 77 individual stocks, providing empirical evidence against, at least in the context of Malaysian stock market, the conjecture of Campbell *et al.* (1997) that it is difficult to detect the presence of predictable components in individual returns.

Table 1
BDS Test Results for Full Sample

Stock	*m* 2	3	4	5
KLCI	10.7444	13.9976	16.2752	18.6038
	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Affin	9.0000	13.2333	10.8762	11.8530
	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Alcom	10.9207	13.1209	14.6807	15.9954
	(0.0000)	(0.0000)	(0.0000)	(0.0000)
AMDB	11.8550	14.0412	15.5625	17.2790
	(0.0000)	(0.0000)	(0.0000)	(0.0000)
AMMB	11.7670	13.9233	16.0100	18.2085
	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Braya	6.8137	8.7575	10.8095	12.5158
	(0.0000)	(0.0000)	(0.0000)	(0.0000)
BJToto	9.4510	10.6703	11.9125	12.9529
	(0.0000)	(0.0000)	(0.0000)	(0.0000)
BAT	8.0898	8.1966	7.9821	8.2951
	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Carlsbg	7.8994	8.1245	8.4041	9.1022
	(0.0000)	(0.0000)	(0.0000)	(0.0000)
CCM	8.4313	8.6989	8.2951	9.7567
	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Commerz	13.0327	15.4189	17.4010	19.1834
	(0.0000)	(0.0000)	(0.0000)	(0.0000)
CHHB	8.9186	9.8688	10.4263	11.1809
	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Gamuda	12.4387	13.5643	14.2264	15.0341
	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Genting	8.0234	10.0139	11.3344	12.3534
	(0.0000)	(0.0000)	(0.0000)	(0.0000)

(continued Table 1)

Stock	m			
	2	3	4	5
Ghope	8.1065 (0.0000)	9.4267 (0.0000)	10.1711 (0.0000)	10.7605 (0.0000)
Guiness	9.8732 (0.0000)	11.1001 (0.0000)	11.6595 (0.0000)	12.3960 (0.0000)
HapSeng	10.0637 (0.0000)	10.8244 (0.0000)	11.3029 (0.0000)	11.7178 (0.0000)
HLBank	10.2554 (0.0000)	12.9423 (0.0000)	14.7974 (0.0000)	17.1489 (0.0000)
HLProp	9.6922 (0.0000)	12.0549 (0.0000)	13.4887 (0.0000)	15.4935 (0.0000)
HumeInd	8.8022 (0.0000)	10.4782 (0.0000)	11.8417 (0.0000)	13.4454 (0.0000)
IGB	10.2744 (0.0000)	12.3934 (0.0000)	14.1652 (0.0000)	15.5975 (0.0000)
IJM	8.8040 (0.0000)	9.8732 (0.0000)	11.1315 (0.0000)	12.0750 (0.0000)
IOICorp	9.4907 (0.0000)	10.9547 (0.0000)	11.5519 (0.0000)	12.4168 (0.0000)
Jtiasa	7.6982 (0.0000)	9.8197 (0.0000)	10.9161 (0.0000)	12.2426 (0.0000)
Hancock	9.8552 (0.0000)	12.6334 (0.0000)	14.6868 (0.0000)	16.0998 (0.0000)
JTInter	7.7863 (0.0000)	8.3982 (0.0000)	9.1075 (0.0000)	9.8983 (0.0000)
KianJoo	7.9538 (0.0000)	9.0256 (0.0000)	10.2645 (0.0000)	11.3539 (0.0000)
KimHin	12.4897 (0.0000)	13.3449 (0.0000)	13.6965 (0.0000)	14.2629 (0.0000)

(continued Table 1)

Stock	m 2	3	4	5
KLK	6.3190	8.1488	9.2417	10.0920
	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Kulim	11.2938	12.8612	13.4890	13.9399
	(0.0000)	(0.0000)	(0.0000)	(0.0000)
K Guthrie	12.2035	13.5078	15.1703	16.5757
	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Leader	10.4994	12.5916	13.7573	15.0314
	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Lingui	11.3572	11.8342	12.0985	12.0960
	(0.0000)	(0.0000)	(0.0000)	(0.0000)
MAA	12.4497	13.4410	13.7987	14.3979
	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Magnum	7.7740	9.5063	10.9120	12.7739
	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Malakof	10.3457	12.1454	13.4755	14.0612
	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Maybank	9.1929	11.5246	13.2105	14.9713
	(0.0000)	(0.0000)	(0.0000)	(0.0000)
LMCEMNT	12.1794	13.7946	14.1946	15.0209
	(0.0000)	(0.0000)	(0.0000)	(0.0000)
MUIInd	10.0516	12.6458	15.2990	18.0864
	(0.0000)	(0.0000)	(0.0000)	(0.0000)
MISC	12.3712	14.7093	16.0890	17.0468
	(0.0000)	(0.0000)	(0.0000)	(0.0000)
MMC	10.3968	11.2523	13.1166	14.6432
	(0.0000)	(0.0000)	(0.0000)	(0.0000)
MAS	10.5432	12.9649	14.3747	16.3163
	(0.0000)	(0.0000)	(0.0000)	(0.0000)
MIDF	10.9331	12.0878	12.8850	13.9051
	(0.0000)	(0.0000)	(0.0000)	(0.0000)

(continued Table 1)

Stock	m			
	2	3	4	5
MOX	7.3130 (0.0000)	8.2374 (0.0000)	8.2413 (0.0000)	8.9087 (0.0000)
MPI	9.4621 (0.0000)	11.0277 (0.0000)	11.9345 (0.0000)	13.4581 (0.0000)
Measat	9.5016 (0.0000)	10.4009 (0.0000)	10.8391 (0.0000)	11.6592 (0.0000)
MBMR	9.3062 (0.0000)	10.9290 (0.0000)	11.6262 (0.0000)	12.4844 (0.0000)
MNI	9.3240 (0.0000)	9.9124 (0.0000)	9.9324 (0.0000)	10.0430 (0.0000)
Mulpha	11.6331 (0.0000)	13.9448 (0.0000)	15.0345 (0.0000)	16.1230 (0.0000)
NCB	9.2578 (0.0000)	11.5961 (0.0000)	13.0864 (0.0000)	14.1438 (0.0000)
Nestle	10.1594 (0.0000)	10.7790 (0.0000)	10.8046 (0.0000)	10.8290 (0.0000)
NSTP	13.0280 (0.0000)	15.0679 (0.0000)	16.4721 (0.0000)	17.3040 (0.0000)
Nylex	11.2784 (0.0000)	12.3473 (0.0000)	13.2697 (0.0000)	14.9205 (0.0000)
Orient	8.4917 (0.0000)	9.2574 (0.0000)	10.2437 (0.0000)	11.0470 (0.0000)
Proton	11.6083 (0.0000)	13.2634 (0.0000)	14.7564 (0.0000)	16.0522 (0.0000)
PetDag	7.8387 (0.0000)	8.9733 (0.0000)	9.2508 (0.0000)	9.4376 (0.0000)
Pos Hldgs	7.6551 (0.0000)	10.6280 (0.0000)	11.9243 (0.0000)	13.4968 (0.0000)
PPB	7.7830 (0.0000)	9.2142 (0.0000)	9.7908 (0.0000)	9.6843 (0.0000)

(continued Table 1)

Stock	m			
	2	3	4	5
PBBank	9.1163	11.2832	12.8536	14.6519
	(0.0000)	(0.0000)	(0.0000)	(0.0000)
RHBCap	10.9556	14.1788	16.5348	18.7325
	(0.0000)	(0.0000)	(0.0000)	(0.0000)
RoadBld	9.8839	12.1658	12.8751	13.5092
	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Sarawak	8.0364	9.8943	11.6411	13.4056
	(0.0000)	(0.0000)	(0.0000)	(0.0000)
SDred	10.7951	12.9512	14.2227	15.8654
	(0.0000)	(0.0000)	(0.0000)	(0.0000)
SPB	8.2728	9.5191	10.2462	10.9513
	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Shang	11.5477	13.8914	15.2415	16.5029
	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Shell	8.0210	8.7432	9.1081	9.4781
	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Sime	10.6204	13.6910	15.2587	16.8734
	(0.0000)	(0.0000)	(0.0000)	(0.0000)
SPSetia	10.1687	11.1679	11.7909	12.4319
	(0.0000)	(0.0000)	(0.0000)	(0.0000)
TA	11.6168	14.0735	15.6845	16.8617
	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Tchong	7.8573	10.0431	10.7215	11.3793
	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Tanjong	7.8919	9.4003	10.5084	11.4472
	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Telekom	11.8199	15.5422	18.6593	21.5753
	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Tenaga	9.6925	12.0860	14.4439	16.4586
	(0.0000)	(0.0000)	(0.0000)	(0.0000)

(continued Table 1)

Stock	m			
	2	3	4	5
Time	11.7822 (0.0000)	13.5392 (0.0000)	14.6553 (0.0000)	16.4334 (0.0000)
TWS	7.5835 (0.0000)	9.8186 (0.0000)	11.5853 (0.0000)	13.9808 (0.0000)
UMW	8.8985 (0.0000)	10.4351 (0.0000)	11.8386 (0.0000)	12.7241 (0.0000)
UtdPlt	8.5306 (0.0000)	6.4409 (0.0000)	7.0735 (0.0000)	7.9671 (0.0000)
YTL	8.3139 (0.0000)	9.8149 (0.0000)	11.4378 (0.0000)	12.6052 (0.0000)

Notes: All the BDS test statistics are computed using *EViews* version 4.1. Asymptotically, the computed BDS test statistics, $W_{m,n}(\varepsilon) \sim N(0,1)$ under the null of i.i.d. To compensate for smaller sample sizes, this table provides the bootstrapped *p*-values in parentheses, with 10000 repetitions, generated by *EViews*. The table shows that all the BDS test statistics are significant even at 1% level.

To observe the consistency of the results, the study period is broken down into two sub-periods with equal length for separate BDS test. Only the results for $\varepsilon = 1.00s$ are reported in Table 2 (period before the crisis) and Table 3 (period during the crisis) respectively.[10] The comparison reveals that the rejection of the i.i.d. null is consistent in both sub-periods for the KLCI and all the individual stocks, with the exception of five component stocks- IOICorp (IOI CORPORATION BHD, stock code: 1961), KLK (KUALA LUMPUR KEPONG BHD, stock code: 2445), MUIInd (MALAYAN UNITED INDUSTRIES BHD, stock code: 3891), Pos Hldgs (POS MALAYSIA & SERVICES HOLDINGS BHD, stock code: 4634) and Tchong (TAN CHONG MOTOR HOLDINGS BHD, stock code: 4405). For most of the sampled stocks, the consistent BDS results across sub-periods confirm our earlier full sample findings and hence provide strong evidence that the price behaviour of individual stocks traded on Bursa Malaysia do not follow a random walk movement. The results provide some hope and motivation to technical analysis, which has been sidelined previously in the forecasting literature of Malaysian stock market, though it is difficult to explore those non-random structures and ascertain its economic values to investors. If technical analysts are able to profitably exploit (net of all transactions costs) those non-random structures via a trading rule, then it would be at odds with the weak-form EMH.

Table 2
BDS Test Results for Sample Period 1 (Before Crisis)

Stock	*m*			
	2	3	4	5
KLCI	2.3749 (0.0228)	3.1102 (0.0050)	3.7075 (0.0022)	4.7623 (0.0000)
Affin	2.5533 (0.0107)	3.1962 (0.0014)	3.6056 (0.0003)	3.9441 (0.0001)
Alcom	5.3103 (0.0000)	5.6781 (0.0000)	5.5690 (0.0000)	5.4212 (0.0000)
AMDB	5.1274 (0.0000)	5.9970 (0.0000)	7.1192 (0.0000)	7.9435 (0.0000)
AMMB	5.5408 (0.0000)	6.4507 (0.0000)	7.0621 (0.0000)	7.3205 (0.0000)
Braya	2.4007 (0.0164)	3.5921 (0.0003)	4.2690 (0.0000)	4.7789 (0.0000)
BJToto	3.8805 (0.0001)	4.0778 (0.0000)	3.9162 (0.0001)	3.9835 (0.0001)
BAT	3.7664 (0.0002)	3.5555 (0.0004)	2.9997 (0.0027)	2.5418 (0.0110)
Carlsbg	5.4680 (0.0000)	5.1933 (0.0000)	5.7176 (0.0000)	5.6719 (0.0000)
CCM	4.7066 (0.0000)	4.4266 (0.0000)	4.4516 (0.0000)	5.0826 (0.0000)
Commerz	3.3858 (0.0007)	3.7595 (0.0002)	4.1215 (0.0000)	4.1341 (0.0000)

(continued Table 2)

Stock	m			
	2	3	4	5
CHHB	4.9015 (0.0000)	5.6436 (0.0000)	6.1634 (0.0000)	6.8878 (0.0000)
Gamuda	4.6610 (0.0000)	4.4480 (0.0000)	3.8674 (0.0001)	3.3121 (0.0009)
Genting	4.9841 (0.0000)	6.9244 (0.0000)	7.3202 (0.0000)	7.3608 (0.0000)
Ghope	3.3156 (0.0009)	3.5540 (0.0004)	3.6994 (0.0002)	3.8259 (0.0001)
Guiness	5.4656 (0.0000)	5.5230 (0.0000)	5.6568 (0.0000)	5.7887 (0.0000)
HapSeng	6.0167 (0.0000)	6.8185 (0.0000)	7.6727 (0.0000)	7.9910 (0.0000)
HLBank	5.2852 (0.0000)	6.3971 (0.0000)	7.2349 (0.0000)	7.8981 (0.0000)
HLProp	2.3586 (0.0183)	3.5300 (0.0004)	3.7543 (0.0002)	4.2386 (0.0000)
HumeInd	5.4584 (0.0000)	6.5241 (0.0000)	6.3991 (0.0000)	6.2148 (0.0000)
IGB	4.4287 (0.0000)	5.1850 (0.0000)	5.7939 (0.0000)	6.1889 (0.0000)
IJM	3.9819 (0.0001)	4.0445 (0.0001)	4.5710 (0.0000)	4.5486 (0.0000)
IOICorp	**1.7620** **(0.0781)***	2.8035 (0.0051)	3.1426 (0.0017)	3.0893 (0.0020)
Jtiasa	4.8442 (0.0000)	5.1311 (0.0000)	6.2766 (0.0000)	7.5035 (0.0000)
Hancock	2.8876 0.0039)	4.4318 (0.0000)	4.8943 (0.0000)	5.0130 (0.0000)

(continued Table 2)

Stock	m			
	2	3	4	5
JTInter	5.6012 (0.0000)	5.6870 (0.0000)	5.5012 (0.0000)	5.2162 (0.0000)
KianJoo	3.6457 (0.0003)	4.6818 (0.0000)	5.3947 (0.0000)	6.1395 (0.0000)
KimHin	5.5873 (0.0000)	6.0678 (0.0000)	6.6744 (0.0000)	6.9854 (0.0000)
KLK	**1.4203** **(0.1555)***	2.0557 (0.0398)	2.7253 (0.0064)	2.6780 (0.0074)
Kulim	3.9459 (0.0001)	3.7063 (0.0002)	3.4674 (0.0005)	3.2335 (0.0012)
K Guthrie	3.8124 (0.0001)	5.8060 (0.0000)	7.0731 (0.0000)	7.5549 (0.0000)
Leader	2.5512 (0.0107)	3.0785 (0.0021)	4.3921 (0.0000)	4.9713 (0.0000)
Lingui	3.8050 (0.0001)	4.4740 (0.0000)	4.3951 (0.0000)	4.5664 (0.0000)
MAA	2.5141 (0.0119)	3.1366 (0.0017)	3.3240 (0.0009)	3.4377 (0.0006)
Magnum	2.8625 (0.0042)	3.5338 (0.0004)	4.5724 (0.0000)	5.4175 (0.0000)
Malakof	3.4910 (0.0005)	4.2746 (0.0000)	5.6547 (0.0000)	6.5877 (0.0000)
Maybank	4.0707 (0.0000)	4.8644 (0.0000)	4.9422 (0.0000)	5.1653 (0.0000)
LMCEMNT	4.3147 (0.0000)	3.9514 (0.0001)	4.3514 (0.0000)	4.9944 (0.0000)
MUIInd	**1.7993** **(0.0720)***	2.5398 (0.0111)	2.7771 (0.0055)	2.9203 (0.0035)
MISC	8.1515 (0.0000)	8.1927 (0.0000)	8.2860 (0.0000)	8.4137 (0.0000)

(continued Table 2)

Stock	m			
	2	3	4	5
MMC	4.8456 (0.0000)	5.5753 (0.0000)	5.8610 (0.0000)	6.5479 (0.0000)
MAS	4.6778 (0.0000)	5.7481 (0.0000)	5.7710 (0.0000)	6.2007 (0.0000)
MIDF	5.2146 (0.0000)	6.1801 (0.0000)	6.8624 (0.0000)	7.4885 (0.0000)
MOX	3.5769 (0.0003)	3.5491 (0.0004)	3.0185 (0.0025)	2.8311 (0.0046)
MPI	4.7285 (0.0000)	6.4094 (0.0000)	6.9027 (0.0000)	7.5266 (0.0000)
Measat	4.4618 (0.0000)	4.6820 (0.0000)	4.4747 (0.0000)	4.4579 (0.0000)
MBMR	2.7190 (0.0065)	4.3757 (0.0000)	5.0119 (0.0000)	5.4711 (0.0000)
MNI	5.1411 (0.0000)	5.7396 (0.0000)	5.7390 (0.0000)	5.8349 (0.0000)
Mulpha	4.8623 (0.0000)	4.9573 (0.0000)	5.6553 (0.0000)	5.9839 (0.0000)
NCB	3.5078 (0.0005)	4.7194 (0.0000)	5.2312 (0.0000)	5.5556 (0.0000)
Nestle	4.3005 (0.0000)	4.3221 (0.0000)	4.6869 (0.0000)	4.8869 (0.0000)
NSTP	5.6473 (0.0000)	6.2008 (0.0000)	6.3847 (0.0000)	6.2099 (0.0000)
Nylex	6.0475 (0.0000)	6.6617 (0.0000)	7.0390 (0.0000)	7.3802 (0.0000)
Orient	4.7841 (0.0000)	5.2059 (0.0000)	5.0547 (0.0000)	4.9003 (0.0000)
Proton	4.8938 (0.0000)	5.9941 (0.0000)	6.2774 (0.0000)	6.3150 (0.0000)

(continued Table 2)

Stock	m			
	2	3	4	5
PetDag	4.0372 (0.0001)	4.3784 (0.0000)	4.7439 (0.0000)	4.9655 (0.0000)
Pos Hldgs	**1.2485** **(0.2118)***	3.5970 (0.0000)	4.7743 (0.0000)	5.6033 (0.0000)
PPB	4.7320 (0.0000)	5.6593 (0.0000)	5.7553 (0.0000)	5.3865 (0.0000)
PBBank	3.7739 (0.0002)	4.5938 (0.0000)	5.0182 (0.0000)	4.8404 (0.0000)
RHBCap	2.6877 (0.0072)	3.7718 (0.0002)	5.1417 (0.0000)	5.9818 (0.0000)
RoadBld	3.1247 (0.0018)	3.9586 (0.0001)	4.0475 (0.0001)	4.1756 (0.0000)
Sarawak	3.9266 (0.0001)	5.0052 (0.0000)	6.0058 (0.0000)	6.8042 (0.0000)
SDred	4.8713 (0.0000)	6.0264 (0.0000)	6.5257 (0.0000)	6.9633 (0.0000)
SPB	4.1782 (0.0000)	4.8293 (0.0000)	5.5013 (0.0000)	6.2102 (0.0000)
Shang	7.8529 (0.0000)	10.4908 (0.0000)	12.0057 (0.0000)	13.1458 (0.0000)
Shell	3.5879 (0.0003)	3.7749 (0.0002)	3.0947 (0.0020)	2.8247 (0.0047)
Sime	3.4417 (0.0006)	4.9784 (0.0000)	5.9623 (0.0000)	6.5124 (0.0000)
SPSetia	7.0168 (0.0000)	7.9701 (0.0000)	8.0794 (0.0000)	8.6340 (0.0000)
TA	3.7687 (0.0002)	3.7485 (0.0002)	4.1983 (0.0000)	4.3325 (0.0000)
Tchong	**1.5029** **(0.1329)***	2.0223 (0.0431)	2.3878 (0.0170)	2.4388 (0.0147)

(continued Table 2)

Stock		m		
	2	3	4	5
Tanjong	3.1045	4.1285	5.1048	5.9884
	(0.0019)	(0.0000)	(0.0000)	(0.0000)
Telekom	3.7374	5.1172	5.9777	6.7348
	(0.0002)	(0.0000)	(0.0000)	(0.0000)
Tenaga	4.7040	4.8849	5.3454	5.7725
	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Time	3.9477	5.3177	5.9903	6.8038
	(0.0001)	(0.0000)	(0.0000)	(0.0000)
TWS	4.2457	5.3457	6.1257	7.0861
	(0.0000)	(0.0000)	(0.0000)	(0.0000)
UMW	4.5640	4.9884	5.0962	5.4700
	(0.0000)	(0.0000)	(0.0000)	(0.0000)
UtdPlt	3.9335	5.0584	5.5480	6.0003
	(0.0001)	(0.0000)	(0.0000)	(0.0000)
YTL	4.4357	4.1481	3.9358	4.1011
	(0.0000)	(0.0000)	(0.0001)	(0.0000)

Notes: All the BDS test statistics are computed using *EViews* version 4.1. Asymptotically, the computed BDS test statistics, $W_{m,n}(\varepsilon) \sim N(0,1)$ under the null of i.i.d. To compensate for smaller sample sizes, this table provides the bootstrapped *p*-values in parentheses, with 10000 repetitions, generated by *EViews*. The table shows that all the BDS test statistics are significant at the conventional level 5% except those with * and bold.

Table 3
BDS Test Results for Sample Period 1 (During Crisis)

Stock		m		
	2	3	4	5
KLCI	4.9651	6.3130	6.7301	7.0892
	(0.0000)	(0.0000)	(0.0000)	(0.0000)

(continued Table 3)

Stock	m			
	2	3	4	5
Affin	4.6171	5.2431	5.5421	5.9908
	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Alcom	5.9143	7.2880	8.3895	9.3841
	(0.0000)	(0.0000)	(0.0000)	(0.0000)
AMDB	4.9769	6.4794	6.6757	6.7424
	(0.0000)	(0.0000)	(0.0000)	(0.0000)
AMMB	6.3624	6.6477	6.9336	7.3342
	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Braya	2.4739	3.2963	3.7480	4.2081
	(0.0134)	(0.0010)	(0.0002)	(0.0000)
BJToto	5.0441	5.7597	6.6388	7.1381
	(0.0000)	(0.0000)	(0.0000)	(0.0000)
BAT	5.7489	5.8214	5.6738	6.2745
	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Carlsbg	5.4273	5.6097	5.7129	6.1954
	(0.0000)	(0.0000)	(0.0000)	(0.0000)
CCM	7.7817	8.3169	8.8125	9.2662
	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Commerz	7.6966	8.3945	8.9733	9.1251
	(0.0000)	(0.0000)	(0.0000)	(0.0000)
CHHB	7.4179	7.8387	7.8434	7.8579
	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Gamuda	7.2773	8.1473	8.6053	8.8430
	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Genting	4.6679	5.3584	5.6391	5.9520
	(0.0000)	(0.0000)	(0.0000)	(0.0000)

(continued Table 3)

Stock	m			
	2	3	4	5
Ghope	6.2623	7.2017	7.7023	8.3543
	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Guiness	5.8865	6.5310	6.8273	7.0832
	(0.0000)	(0.0000)	(0.0000)	(0.0000)
HapSeng	6.5232	7.1345	7.2669	7.4955
	(0.0000)	(0.0000)	(0.0000)	(0.0000)
HLBank	5.3189	6.6786	7.4423	8.1678
	(0.0000)	(0.0000)	(0.0000)	(0.0000)
HLProp	5.0403	5.6483	6.0238	6.6246
	(0.0000)	(0.0000)	(0.0000)	(0.0000)
HumeInd	4.8419	4.7466	4.9883	5.3336
	(0.0000)	(0.0000)	(0.0000)	(0.0000)
IGB	4.7809	5.2707	5.8970	5.8064
	(0.0000)	(0.0000)	(0.0000)	(0.0000)
IJM	6.4560	6.9397	7.4963	7.7628
	(0.0000)	(0.0000)	(0.0000)	(0.0000)
IOICorp	6.4868	6.8853	6.5892	6.5368
	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Jtiasa	4.0357	5.6715	5.9041	6.2264
	(0.0001)	(0.0000)	(0.0000)	(0.0000)
Hancock	5.7309	7.3386	8.3974	9.3867
	(0.0000)	(0.0000)	(0.0000)	(0.0000)
JTInter	4.4378	4.5592	4.7566	5.0114
	(0.0000)	(0.0000)	(0.0000)	(0.0000)
KianJoo	5.5391	6.2110	6.8713	7.5275
	(0.0000)	(0.0000)	(0.0000)	(0.0000)
KimHin	8.1783	8.3510	8.4589	8.7025
	(0.0000)	(0.0000)	(0.0000)	(0.0000)
KLK	5.3198	6.3900	6.8180	7.4755
	(0.0000)	(0.0000)	(0.0000)	(0.0000)

(continued Table 3)

Stock	m			
	2	3	4	5
Kulim	7.1699 (0.0000)	8.7129 (0.0000)	9.2384 (0.0000)	9.5235 (0.0000)
K Guthrie	7.7669 (0.0000)	8.3191 (0.0000)	9.1753 (0.0000)	10.2421 (0.0000)
Leader	6.0780 (0.0000)	7.2229 (0.0000)	7.1401 (0.0000)	7.0709 (0.0000)
Lingui	8.2290 (0.0000)	8.6538 (0.0000)	8.6622 (0.0000)	8.2146 (0.0000)
MAA	8.9949 (0.0000)	9.1046 (0.0000)	8.9826 (0.0000)	9.0524 (0.0000)
Magnum	4.2471 (0.0000)	4.3410 (0.0000)	4.1903 (0.0000)	3.9997 (0.0001)
Malakof	8.0771 (0.0000)	9.5208 (0.0000)	10.3332 (0.0000)	10.8048 (0.0000)
Maybank	4.4068 (0.0000)	5.6398 (0.0000)	6.1161 (0.0000)	6.6390 (0.0000)
LMCEMNT	8.2131 (0.0000)	9.2606 (0.0000)	9.2359 (0.0000)	9.3376 (0.0000)
MUIInd	4.8904 (0.0000)	5.2012 (0.0000)	6.0204 (0.0000)	6.9818 (0.0000)
MISC	6.6539 (0.0000)	8.2249 (0.0000)	9.1827 (0.0000)	9.4687 (0.0000)
MMC	6.4447 (0.0000)	6.4251 (0.0000)	7.3221 (0.0000)	8.1811 (0.0000)
MAS	5.2882 (0.0000)	5.6642 (0.0000)	5.9535 (0.0000)	6.5740 (0.0000)
MIDF	7.0277 (0.0000)	6.8906 (0.0000)	6.4575 (0.0000)	6.1887 (0.0000)
MOX	4.5100 (0.0000)	5.3068 (0.0000)	5.3968 (0.0000)	6.0358 (0.0000)

(continued Table 3)

Stock	m			
	2	3	4	5
MPI	5.7516 (0.0000)	6.2065 (0.0000)	6.0659 (0.0000)	6.6685 (0.0000)
Measat	5.9310 (0.0000)	5.7636 (0.0000)	5.4879 (0.0000)	5.7225 (0.0000)
MBMR	8.4870 (0.0000)	9.0808 (0.0000)	9.3186 (0.0000)	9.5798 (0.0000)
MNI	6.9649 (0.0000)	7.0101 (0.0000)	6.9112 (0.0000)	6.9818 (0.0000)
Mulpha	6.9333 (0.0000)	7.9065 (0.0000)	7.8104 (0.0000)	7.5559 (0.0000)
NCB	6.6905 (0.0000)	7.9146 (0.0000)	8.7389 (0.0000)	9.3763 (0.0000)
Nestle	7.9711 (0.0000)	8.6960 (0.0000)	8.5384 (0.0000)	8.6128 (0.0000)
NSTP	6.6447 (0.0000)	7.3170 (0.0000)	8.0401 (0.0000)	7.8807 (0.0000)
Nylex	7.3669 (0.0000)	7.6936 (0.0000)	7.5921 (0.0000)	7.9702 (0.0000)
Orient	5.2034 (0.0000)	5.2876 (0.0000)	5.5859 (0.0000)	5.7841 (0.0000)
Proton	6.5613 (0.0000)	7.5058 (0.0000)	8.4619 (0.0000)	9.2383 (0.0000)
PetDag	6.0918 (0.0000)	6.8231 (0.0000)	7.2613 (0.0000)	7.5548 (0.0000)

(continued Table 3)

Stock	m			
	2	3	4	5
Pos Hldgs	5.0200	6.0047	5.6985	5.9284
	(0.0000)	(0.0000)	(0.0000)	(0.0000)
PPB	5.1303	5.5295	5.7057	5.4672
	(0.0000)	(0.0000)	(0.0000)	(0.0000)
PBBank	3.8817	4.5188	4.6396	4.7106
	(0.0000)	(0.0000)	(0.0000)	(0.0000)
RHBCap	5.2452	6.0411	6.1402	6.2021
	(0.0000)	(0.0000)	(0.0000)	(0.0000)
RoadBld	6.8554	8.5093	8.8967	9.1085
	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Sarawak	3.9326	4.1455	4.2613	4.2803
	(0.0001)	(0.0000)	(0.0000)	(0.0000)
SDred	6.3751	7.2201	7.9399	8.9792
	(0.0000)	(0.0000)	(0.0000)	(0.0000)
SPB	6.0654	6.8910	7.3722	7.5967
	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Shang	6.8578	7.9079	7.9293	8.0447
	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Shell	5.3919	5.6780	6.0409	6.3634
	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Sime	5.8750	7.6334	7.7808	7.7952
	(0.0000)	(0.0000)	(0.0000)	(0.0000)
SPSetia	6.7084	7.3697	7.6829	7.7228
	(0.0000)	(0.0000)	(0.0000)	(0.0000)

(continued Table 3)

Stock	m 2	3	4	5
TA	6.5103 (0.0000)	7.8549 (0.0000)	8.2694 (0.0000)	8.0951 (0.0000)
Tchong	4.7512 (0.0000)	6.1419 (0.0000)	6.3561 (0.0000)	6.5036 (0.0000)
Tanjong	4.1108 (0.0000)	4.7284 (0.0000)	4.6938 (0.0000)	4.5098 (0.0000)
Telekom	5.2012 (0.0000)	6.8569 (0.0000)	8.8200 (0.0000)	10.3617 (0.0000)
Tenaga	5.5847 (0.0000)	7.4573 (0.0000)	8.7178 (0.0000)	9.5824 (0.0000)
Time	7.3176 (0.0000)	7.9777 (0.0000)	8.1260 (0.0000)	8.7938 (0.0000)
TWS	3.5520 (0.0004)	4.4178 (0.0000)	4.9911 (0.0000)	6.3207 (0.0000)
UMW	6.1762 (0.0000)	7.0123 (0.0000)	7.5859 (0.0000)	8.0450 (0.0000)
UtdPlt	3.3737 (0.0007)	3.2103 (0.0013)	3.1474 (0.0016)	3.5698 (0.0004)
YTL	5.5950 (0.0000)	5.8080 (0.0000)	6.4429 (0.0000)	6.5991 (0.0000)

Notes: All the BDS test statistics are computed using *EViews* version 4.1. Asymptotically, the computed BDS test statistics, $W_{m,n}(\varepsilon) \sim N(0,1)$ under the null of i.i.d. To compensate for smaller sample sizes, this table provides the bootstrapped *p*-values in parentheses, with 10000 repetitions, generated by *EViews*. The table shows that all the BDS test statistics are significant even at level 1% level.

The sub-periods analysis not only serves to determine the consistency of the BDS results, it does provide some meaningful comparisons. We have earlier justified the selection of July 1 1997 as the break point. This study postulates that the period during crisis might contribute to the non-random price behaviour since it is well acknowledged that the 1997 Asian financial crisis was representative of crisis and panic. In particular, it is widely believed that investors acted upon rumours rather than credible information and this adversely affected the market's ability to price stocks efficiently. The results in Table 3 clearly demonstrate that the market as a whole and all the individual stocks behave non-randomly during the crisis period, in which the null of i.i.d. is strongly rejected with extremely small p-values.

However, the empirical support for our conjecture that the Asian financial crisis does indeed prevent stock prices from following a random walk process comes from the five exceptional cases of IOICorp, KLK, MUIInd, Pos Hldgs and Tchong. The BDS test results in Table 2 show that there are pockets of efficiency in these five component stocks before the crisis, in which the null of i.i.d. cannot be rejected at certain dimension at the conventional 5% level of significance. However, as a result of the financial crisis, this evidence of efficiency disappears as all the BDS statistics become significant, suggesting that the crisis has contributed to the full divergence from random walk in these stocks.

CONCLUSION

This study re-examined the price behaviour of 77 component stocks listed on Bursa Malaysia in light of the random walk hypothesis. With a new and powerful statistical tool, namely the BDS test, it was possible to detect a more complex form of dependencies in series of financial returns that often appeared completely random to standard statistical tests, such as serial correlation tests, non-parametric runs test, variance ratio test and unit root tests. Our econometric investigation revealed that the market in general as proxied by the KLCI and all the 77 individual stocks did not follow a random walk process. This conclusion held even when the sample period was broken down into sub-periods, with the exception of five component stocks- IOICorp, KLK, MUIInd, Pos Hldgs and Tchong.

The results provide some hope and motivation to technical analysis, which has been sidelined previously in the forecasting literature of Malaysian stock market, though it is difficult to explore those non-random structures and ascertain its economic values to investors. As mentioned in the earlier section, the rejection of the i.i.d. null may be due to linear stochastic systems (AR, MA, ARMA, etc); non-stationarity (regime shift), non-linear stochastic structures (for example, ARCH or GARCH models) and non-linear deterministic structures (such as low dimensional chaos). If technical analysts are able to profitably exploit (net of all transactions costs) those non-random structures via a trading rule, then it would be at odds with the weak-form efficient market hypothesis.

Another interesting insight from this study is provided by the sub-periods analysis. Specifically, the occurrence of the Asian financial crisis on 1 July 1997 is selected as the break point as we conjecture that the crisis will adversely affect the market's ability to price stocks efficiently, thus preventing stock prices from following a random walk process. The results clearly demonstrate that the market as a whole and all the individual stocks behave non-randomly during the crisis period. The price behaviour of IOICorp, KLK, MUIInd, Pos Hldgs and Tchong deserves further mentioning as we observe contrasting behaviour in both sub-periods. The BDS test results show that there are pockets of efficiency in these five component stocks before the crisis. However, as a result of the financial crisis, this evidence of efficiency disappears, suggesting that the crisis has contributed to the full divergence from random walk in these stocks.

The large departure from random walk for most of the individual stocks traded on Bursa Malaysia might have some implications for the regulatory authorities.[11] If further research found that those non-random structures can be profitably exploited, then it would be at odds with the weak-form EMH. If this is the case, then it calls for greater regulation of the stock market. For instance, restrictions on short sales, trading conditions, information disclosures by companies and listing requirements will have an impact on the efficiency of the market (Antoniou *et al.*, 1997). This point has been highlighted by (Fortune, 1991: 30),

> "... security market inefficiency provides an economic foundation for public policy interventions in security markets. Clearly, if markets are efficient, hence conforming to the paradigm of pure competition, there is little reason for a security market policy: the market works to correct imbalances and to efficiently disseminate information. However, if inefficiencies do abound, reflecting barriers to entry in transactions or inefficient collection, processing, and dissemination of information, there might be a role for public policy".

According to Mookerjee and Yu (1999), if this problem is not rectified by the authority, then it could seriously limit the ability of the stock market to allocate funds to the most productive sectors of the economy and potentially hamper long-term growth.

END NOTES

1. The weak-form EMH asserts that the only relevant information set to the determination of current security prices is the historical prices of that particular security.

2. On 20 April 2004, the Kuala Lumpur Stock Exchange (KLSE) was officially renamed as *Bursa Malaysia*, and there is no abbreviation or translation for its usage since it is a brand name for the exchange.

3. Campbell *et al.* (1997: 31-33) distinguished between three different versions of the random walk model. Random Walk 1 is the strongest version of the random walk hypothesis and requires independent and identically distributed price changes. Random Walk 2 model assumes independent but not identically distributed price changes. Finally, by relaxing the independence assumption of Random Walk 2 will provide the weakest version of the random walk hypothesis, which the authors refer to as the Random Walk 3.

4. Furthermore, Campbell *et al.* (1997: 65) argued that the detection of a unit root cannot be used as a basis to support the random walk hypothesis, hence the efficiency of the underlying market. Specifically, the authors explain that the focus of the unit root test is not on predictability, as it is under the random walk hypotheses. Since there are also other non-random walk alternatives in the unit root null hypothesis, tests of unit roots are clearly not designed to detect predictability. Lee et al. (2001: 200) also shares similar view on the subject matter: *"The null hypothesis in unit root tests only requires the error term to follow a zero-mean stationary process. As such, even under the unit root null hypothesis, price changes may be predictable".*

5. The BDS test uses the correlation integral to provide a direct test for the null hypothesis of independent and identical distribution (i.i.d.). The test has good power to detect at least four types of non-i.i.d. behaviour: non-stationarity, linear dependencies, non-linear stochastic process and non-linear deterministic process.

6. In Grassberger and Procaccia (1983), the correlation integral is introduced as a measure of the frequency with which temporal patterns are repeated in the data. For example, the correlation

integral $C(\varepsilon)$ measures the fraction of pairs of points of a time series $\{x_t\}$ that are within a distance of e from each other.

7. $V_m(\varepsilon)$ can be estimated consistently by $V_{m,n}(\varepsilon)$. For details, refer to Brock *et al.* (1987, 1996).

8. The null of i.i.d. implies that $C_{m,n}(\varepsilon) = C_{1,n}(\varepsilon)^m$ but the converse is not true.

9. Full results are available upon requests from the authors.

10. The *p*-values for the BDS statistics are quite similar for other choices of ε. Once again, the full results are available upon request from the authors.

11. The anonymous referee of the journal has rightly suggested for the inclusion of policy implications in the conclusion.

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APPENDIX
List of Sampled Stocks

NO.	STOCK	CODECOMPONENT STOCK	ABBREVIATION
1	5185	AFFIN HOLDINGS BHD	Affin
2	2674	ALUMINIUM COMPANY OF MALAYSIA BHD	Alcom
3	1007	AMDB BHD	AMDB
4	1015	AMMB HOLDINGS BHD	AMMB
5	1473	BANDAR RAYA DEVELOPMENTS BHD	Braya
6	1562	BERJAYA SPORTS TOTO BHD	BJToto
7	4162	BRITISH AMERICAN TOBACCO (MALAYSIA) BHD	BAT
8	2836	CARLSBERG BREWERY MALAYSIA BHD	Carlsbg
9	2879	CHEMICAL COMPANY OF MALAYSIA BHD	CCM
10	1023	COMMERCE ASSET-HOLDING BHD	Commerz
11	5738	COUNTRY HEIGHTS HOLDINGS BHD	CHHB
12	5398	GAMUDA BHD	Gamuda
13	3182	GENTING BHD	Genting
14	1953	GOLDEN HOPE PLANTATIONS BHD	Ghope
15	3255	GUINNESS ANCHOR BHD	Guiness
16	3034	HAP SENG CONSOLIDATED BHD	HapSeng
17	5819	HONG LEONG BANK BHD	HLBank
18	1503	HONG LEONG PROPERTIES BHD	HLProp
19	3328	HUME INDUSTRIES (M) BHD	Humelnd
20	1597	IGB CORPORATION BHD	IGB
21	3336	IJM CORPORATION BHD	IJM
22	1961	IOI CORPORATION BHD	IOICorp
23	4383	JAYA TIASA HOLDINGS BHD	Jtiasa
24	1058	JOHN HANCOCK LIFE INSURANCE (M) BHD	Hancock
25	2615	JT INTERNATIONAL BHD	JTInter
26	3522	KIAN JOO CAN FACTORY BHD	KianJoo
27	5371	KIM HIN INDUSTRY BHD	KimHin
28	2445	KUALA LUMPUR KEPONG BHD	KLK
29	2003	KULIM (M) BHD	Kulim
30	3131	KUMPULAN GUTHRIE BHD	K Guthrie
31	4529	LEADER UNIVERSAL HOLDINGS BHD	Leader
32	2011	LINGUI DEVELOPMENTS BHD	Lingui
33	1198	MAA HOLDINGS BHD	MAA
34	3735	MAGNUM CORPORATION BHD	Magnum

(*continued Table*)

NO.	STOCK	CODECOMPONENT STOCK	ABBREVIATION
35	2496	MALAKOFF BHD	Malakof
36	1155	MALAYAN BANKING BHD	Maybank
37	3794	MALAYAN CEMENT BHD	LMCEMNT
38	3891	MALAYAN UNITED INDUSTRIES BHD	MUIInd
39	3816	MALAYSIA INTERNATIONAL SHIPPING CORP BHD	MISC
40	2194	MALAYSIA MINING CORPORATION BHD	MMC
41	3786	MALAYSIAN AIRLINE SYSTEM BHD	MAS
42	5525	MALAYSIAN INDUSTRIAL DEVELOPMENT FINANCE BHD	MIDF
43	3832	MALAYSIAN OXYGEN BHD	MOX
44	3867	MALAYSIAN PACIFIC INDUSTRIES BHD	MPI
45	3875	MEASAT GLOBAL BHD	Measat
46	5983	MBM RESOURCES BHD	MBMR
47	2275	MNI HOLDINGS BHD	MNI
48	3905	MULPHA INTERNATIONAL BHD	Mulpha
49	5509	NCB HOLDINGS BHD	NCB
50	4707	NESTLE (M) BHD	Nestle
51	3999	NEW STRAITS TIMES PRESS (M) BHD, THE	NSTP
52	4944	NYLEX (M) BHD	Nylex
53	4006	ORIENTAL HOLDINGS BHD	Orient
54	5304 BHD	PERUSAHAAN OTOMOBIL NASIONAL Proton	
55	5681	PETRONAS DAGANGAN BHD	PetDag
56	4634	POS MALAYSIA & SERVICES HOLDINGS BHD	Pos Hldgs
57	4065	PPB GROUP BHD	PPB
58	1295	PUBLIC BANK BHD	PBBank
59	1066	RHB CAPITAL BHD	RHBCap
60	5541	ROAD BUILDER (M) HOLDINGS BHD	RoadBld
61	2356	SARAWAK ENTERPRISE CORPORATION BHD	Sarawak
62	2224	SELANGOR DREDGING BHD	SDred
63	1783	SELANGOR PROPERTIES BHD	SPB
64	5517	SHANGRI-LA HOTELS (M) BHD	Shang
65	4324	SHELL REFINING CO (FOM) BHD	Shell
66	4197	SIME DARBY BHD	Sime
67	8664	SP SETIA BHD	SPSetia
68	4898	TA ENTERPRISE BHD	TA
69	4405	TAN CHONG MOTOR HOLDINGS BHD	Tchong

(*continued Table*)

NO.	STOCK	CODECOMPONENT STOCK	ABBREVIATION
70	2267	TANJONG PLC	Tanjong
71	4863	TELEKOM MALAYSIA BHD	Telekom
72	5347	TENAGA NASIONAL BHD	Tenaga
73	4456	TIME ENGINEERING BHD	Time
74	4421	TRADEWINDS (M) BHD	TWS
75	4588	UMW HOLDINGS BHD	UMW
76	2089	UNITED PLANTATIONS BHD	UtdPlt
77	4677	YTL CORPORATION BHD	YTL