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RETURNS PREDICTABILITY OF MALAYSIAN BANK STOCKS: EVIDENCE AND IMPLICATIONS

KIAN-PING LIM
Labuan School of International Business and Finance
Universiti Malaysia Sabah

HUI-BOON TAN
SIONG-HOOK LAW
Faculty of Economics and Management
Universiti Putra Malaysia

ABSTRACT

The main objective of this study is to address the question of whether stock prices follow random walk all the time. Using the samples of four Malaysian bank stocks- Hong Leong Bank, Malayan Banking, Public Bank and Southern Bank, coupled with the Hinich and Patterson (1995) windowed-testing procedure, the results show that the series under study follow a random walk for long periods of time, only to be interspersed with brief periods of strong linear and non-linear dependency structures. Unlike previous studies, this paper provides a different perspective on the subject of random walk. In addition to that, several important implications drawn from the findings are also provided in the paper.

Keywords: *Returns predictability; Random walk; Weak-form efficient market hypothesis; Stock market; Malaysian bank.*

ABSTRAK

Objektif utama kajian ini adalah untuk menjawab soalan sama ada harga-harga saham mengikut pergerakan rawak setiap masa. Dengan menggunakan sampel empat saham bank Malaysia iaitu Hong Leong Bank, Malayan Banking, Public Bank, Southern Bank, dan prosedur ujian tingkap Hinich dan Patterson (1995), keputusan menunjukkan siri yang dikaji mengikut pergerakan rawak untuk satu tempoh yang panjang, hanya diselangi oleh struktur pergantungan linear dan tak linear yang kuat dalam beberapa tempoh singkat. Berlainan daripada kajian lepas, artikel ini memberi satu perspektif *yang berbeza dalam subjek pergerakan rawak. Tambahan pula, beberapa implikasi penting yang diperoleh daripada keputusan kajian juga dibekalkan dalam artikel ini.*

Kata Kunci: *Kebolehramalan pulangan; Pergerakan rawak; Hipotesis kecekapan pasaran bentuk lemah; Pasaran saham; Bank Malaysia.*

INTRODUCTION

The efficient market hypothesis (EMH) introduced three decades ago was a major intellectual advance and reached its height of dominance in academic circles around the 1970s. Much research endeavour has been devoted over the years to empirically examine the efficiency of stock market price formation, both in developed and emerging stockmarkets. The phenomenal growth in this body of literature is partly due to the interest of financial economists and investment communities on the predictability of stock prices. Within this framework, the random walk theory of stock prices, which postulates that future price movements cannot be predicted from the historical sequence of stock prices, has been widely employed to test the efficiency of the stock market, particularly in the context of weak-form efficiency (for a review of the literature, refer to Lim, Habibullah & Lee, 2004). As McInish and Puglisi (1982) pointed out, a sufficient condition for weak-form efficiency is that stock prices fluctuate randomly [1]. The justification is that in an efficient market new information is deemed to come in a random fashion; thus changes in prices that occur as a consequence of that information will seem random. However, empirical evidence on the random walk theory of stock prices is inconclusive even in Wall Street. For instance, Malkiel (2003) documented the random walk down Wall Street, while the opposite was reported in Lo and MacKinlay (1999) and Singal (2004). The present study, in an attempt to reconcile these contradicting findings, conjectures that stock price movements down the historical time path are typically characterized by random and non-random walks. To stock market investors, our conjecture suggests that the predictable non-random patterns evolve over time, that is, there are times stock prices move randomly, and times they follow non-random and predictable patterns.

Formally, the random walk model can be stated as:

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

where p_t is the price at time t, p_{t-1} is the price in the immediate preceding period and μ_t is a random error term. A purely random process is what statisticians called '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 m_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), Campbell, Lo and MacKinlay (1997), Lo and MacKinlay (1999), Malkiel (2003) and Singal (2004) provided an excellent account of the subject of random walk.

Over the past two decades, the efficiency of the Malaysian stock market, *Bursa Malaysia* (formerly known as the Kuala Lumpur Stock Exchange)[2], has received considerable attention from researchers. Generally, the empirical evidence reported suggests the market is weak-form efficient with prices moving in a random fashion (see, Barnes, 1986; Laurence, 1986; Annuar & Shamsher, 1991, 1993a,b, 1994; Kok & Lee, 1994; Kok & Goh, 1995). However, empirical evidence of inefficiency as documented in Yong (1993) cannot be suppressed. Another recent study by Lai, Balachandher & Fauzias (2003) using the variance ratio test also reveals the non-randomness of successive price changes in the Malaysian stock market.

The inconclusive empirical evidence in *Bursa Malaysia* sent mixed signals to stock market investors, making their investment decisions difficult. On the one hand, the random walk movements of stock prices suggest that analysis of past prices to forecast future price movements is meaningless because patterns observed in the past occurred purely by chance. This implies that technical analysis is of no real value to the stock market investors. However, this hardly makes sense given the wide usage of technical analysis in the investment world, as reported by Taylor and Allen (1992), Lui and Mole (1998) and Oberlechner (2001). On the other hand, the favourable findings in Yong (1993) and Lai *et al.* (2003) revealed the potential of profitability from technical trading rules.

One limitation of the aforementioned Malaysian studies that does not go well with technical analysts is the application of standard statistical tests- serial correlation test, runs test, variance ratio test and unit root tests - which are designed to uncover linear serial dependencies or autocorrelation 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 patterns that cannot be detected by these standard linear methodologies. For instance, Granger (2001) argued that the lack of autocorrelation in a time series does not imply that it cannot be predicted. The seminal paper of Fama (1965: 80) also acknowledged the limitations of linear modelling techniques as they are not sophisticated enough to capture the complicated patterns that the chartist sees in stock prices. One of the possible hidden patterns that went undetected in those earlier studies was the non-linear dependency structures in the underlying data-generating process of stock prices. Using advanced methodologies, most recent studies have detected the presence of non-linear serial dependencies[3], even in *Bursa Malaysia* (Lim & Liew, 2004a). These pieces of evidence have at least two important implications. First, those conventional linear statistical tests based on autocorrelation coefficients and runs tests are not capable of capturing non-linearity, as they are designed to uncover linear patterns in the data. Hence, the hypothesis of no predictability may be wrongly accepted and inferences drawn from such tests may be inappropriate (De Gooijer, 1989; Hsieh, 1989; Antoniou, Ergul & Holmes, 1997; Joe & Menyah, 2003; Liew, Chong & Lim, 2003). With regards to the Malaysian stock market, this implication strongly suggests that earlier conclusions of efficiency on *Bursa Malaysia*, in which non-linearity was recently detected by Lim and Liew (2004a), should be met with a healthy dose of scepticism. Second, the existence of non-linearity implies the potential of predictability in stock returns (Antoniou *et al*., 1997; Patterson & Ashley, 2000). In this regard, Lim and Liew (2004b) argued that non-linearity favours non-linear technical analysis techniques, and their view is further supported by the empirical work of Andrada-Félix, Fernadez-Rodrigues, Garcia and Sosvilla (2003) who demonstrated the profitability of non-linear trading rules. Furthermore, in testing the primary hypothesis that graphical technical analysis methods may be equivalent to non-linear forecasting methods, Clyde and Osler (1997) found that technical analysis works better on non-linear data than on random data, and the use of technical analysis can generate higher profits than a random trading strategy if the data-generating process is non-linear. Hence, the growing empirical evidence of non-linearity strongly suggests that the pendulum has swung in favour of the argument that stock markets are predictable to some degree (Campbell, Lo & MacKinlay, 1997; Cochrane, 1999; Lo & MacKinlay, 1999). Cochrane (1999) has even labelled stock market predictability as a 'new fact in finance'.

In addition to that, technical analysts have criticized earlier efficiency studies on *Bursa Malaysia* as irrelevant because they use market indices rather than individual stocks (Dawson, 1990; Annuar *et al*., 1991). According to these market analysts, the choice of individual stocks is more relevant to investors who are concerned with the predictability of stock prices. On the other hand, Fama (1965) argued that the use of market index data in random walk tests may lead to a false perception of return predictability in the general index even when price changes of individual stocks represented by the index are independent.

Another issue worth highlighting is the possibility that linear and non-linear dependency structures, in which both reveal the non-randomness of successive price changes, are present only in certain time periods. In other words, the rejection of the random walk hypothesis in the full sample is actually driven by strong dependency structures in some particular sub-periods. To accommodate this possibility, most researchers re-examine the data by breaking the full sample into smaller sub-periods. For instance, this sub-periods analysis has been performed by Kok and Goh (1995), Lai *et al.* (2003) and Lim *et al.* (2004). Two important pieces of work that supported our earlier conjecture, though not convincingly due to methodological drawback[4], are the papers by Schachter, Gerin, Hood & Andreassen (1985) and Hood, Andreassen, Schachter (1985) who demonstrated via sub-periods analysis that there are times when market movement is random, and times when the market moves in a significantly non-random and dependent pattern. This is not surprising 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".*

In the literature, a group of studies have found that the detected non-linear dependency structures that underlie financial time series are at best episodic transient in nature, that is, the series follow a random walk for long periods of time, only to be interspersed with brief periods of strong non-linear dependency structures. Among them are Brooks and Hinich (1998) on 10 major foreign exchange rates, Ammermann and Patterson (2003) on 6 major stock market indices and 247 individual stocks traded on the Taiwan Stock Exchange, Lim *et al.* (2003) on 4 Southeast Asian foreign exchange rates, Lim and Hinich (2005a) on 13 Asian stock market indices and Romero-Meza *et al.* (2006) on 7 Latin American stock market indices. This is in parallel with another strand of studies that have documented the evolving property of linear predictable patterns in emerging stock markets (see, Emerson, Hall & Zalewska-Mitura, 1997; Zalewska-Mitura & Hall, 1999, 2000; Rockinger & Urga, 2000, 2001; Li, 2003a, b). Hence, our conjecture receives empirical support from extant literature though not fully, as both strands of studies addressed only one particular type of dependency structure in their respective empirical analysis, while neglecting the possible existence of alternative patterns in those random periods identified by the statistical tests[5]. In terms of theoretical underpinning, the work of Lo (2004) seems to fill this gap. In an attempt to reconcile the contradictions between EMH and the emerging fields of behavioural economics and finance, Lo (2004) proposed an alternative to the classical EMH; the new paradigm of "Adaptive Markets Hypothesis" (AMH) that examines market efficiency from an evolutionary perspective. Contrary to the EMH; one major implication of AMH to the practice of portfolio management is that profit opportunities do exist from time to time. Specifically, from the evolutionary perspective, predictable patterns should not persist over time because they will disappear after identification and exploitation by investors, but new opportunities are continually being created as groups of market participants, institutions and business conditions all change.

In an effort to provide full empirical support to our conjecture that stock price movements down the historical time path are typically characterized by random and non-random walks, the present paper carefully addresses the limitations of *prior* studies in our research framework. Using the Malaysian bank stocks data, coupled with the windowed-testing procedure of Hinich and Patterson (1995) in conjunction with the portmanteau correlation and bicorrelation test statistics, this paper is able to demonstrate statistically that these bank stocks are predictable to some extent, though not all the time. In particular, the detected return predictable patterns, both in the forms of linear and non-linear, do not persist over time as there are several time periods in which the returns series move along at a close approximation to random walk. The results from the present methodology are robust for at least three reasons: First, the portmanteau correlation (denoted as *C*) and bicorrelation (denoted as H) test statistics employed in the windowed-testing procedure are designed to detect linear and non-linear dependency structures in the data respectively; second, instead of selecting a period deliberately (see, Schachter *et al.*, 1985; Hood *et al.*, 1985), the methodology allows data analysis to determine the time periods when stock prices move randomly and those that do not; third, both the C and H test statistics have good sample properties over short horizons of data[6]. In the literature, this approach has been widely applied on financial time series data (see, Hinich & Patterson, 1995; Brooks & Hinich, 1998; Brooks, Hinich & Molyneux, 2000; Ammermann & Patterson, 2003; Lim *et al.*, 2003; Lim & Hinich, 2005a, b; Romero-Meza, Bonilla & Hinich, 2006).

METHODOLOGY

This section provides a brief description of the windowed-testing procedure and the test statistics employed[7]. Let the sequence $\{y(t)\}$ denote the sampled data process, where the time unit, t, is an integer. The test procedure employs non-overlapped data window, thus if n is the window length, then k-th window is $\{y(t_k), y(t_k+1),\ldots, y(t_k+n-1)\}$. The next non-overlapped window is $\{y(t_{k+1}), y(t_{k+1}+1),\ldots y(t_{k+1}+n-1)\}$, where $t_{k+1} = t_k+n$. The null hypothesis for each window is that $y\{t\}$ are realizations of a stationary pure noise process that has zero bicovariance. The alternative hypothesis is that the process in the window is random with some non-zero correlations $C_{yy}(r) = E[y(t)y(t+r)]$ or non-zero bicorrelations $C_{yyy}(r, s) = E[y(t)y(t+r)y(t+s)]$ in the set $0 < r < s < L$, where L is the number of lags. In this windowed-testing procedure, a correlation portmanteau test (denoted as C statistic) similar to the Box-Pierce Q-statistic is developed for the detection of linear dependencies within a window. For detecting non-linear dependencies, the procedure uses a bicorrelation portmanteau test (denoted as H statistic).

Define $Z(t)$ as the standardized observations obtained as follows:

$$Z(t) = \frac{y(t) - m_y}{S_y} \tag{2}$$

for each $t = 1, 2,\ldots\ldots, n$ where m_y and s_y are the sample mean and sample standard deviation of the window.

The sample correlation is:

$$C_{ZZ}(r) = (n-r)^{-1/2} \sum_{t=1}^{n-r} Z(t)Z(t+r) \tag{3}$$

The C statistic, which is developed for the detection of linear serial dependencies within a window, is defined as:

$$C = \sum_{r=1}^{L} [C_{ZZ}(r)]^2 \sim \chi^2_{(L)} \tag{4}$$

The (r, s) sample bicorrelation is:

$$C_{ZZZ}(r,s) = (n-s)^{-1} \sum_{t=1}^{n-s} Z(t)Z(t+r)Z(t+s) \quad \text{for} \quad 0 \le r \le s \tag{5}$$

The H statistic, which is developed for the detection of non-linear serial dependencies within a window, is defined as:

$$H = \sum_{s=2}^{L} \sum_{r=1}^{s-1} G^2(r,s) \quad \sim \chi^2_{(L-1)(L/2)} \tag{6}$$

where $G(r, s) = (n - s)^{1/2} C_{ZZZ}(r,s)$

In both the C and *H* statistics, the number of lags *(L)* is specified as $L = n^b$ with $0< b < 0.5$, where b is a parameter under the choice of the user. Based on the results of Monte Carlo simulations, Hinich and Patterson (1995) recommended the use of $b= 0.4$ in order to maximize the power of the test while ensuring a valid approximation to the asymptotic theory.

A window is significant if either the *C* or *H* statistic rejects the null of pure noise at the specified threshold level. This study uses a threshold of 0.05. In this case, the chance of obtaining a false rejection of the null is approximately five out of every 100 windows. With such a low-level threshold, it would minimize the chance of obtaining false rejections of the null hypothesis indicating the presence of dependencies where these actually do not exist. Another element that must be decided upon is the choice of the window length. In this study, the data are split into a set of non-overlapping windows of 30 trading days in length. In fact, it was found that the choice of the window length does not alter much the results of both test statistics.

THE DATA

The data in this study consist of the daily closing prices for Hong Leong Bank, Malayan Banking, Public Bank and Southern Bank, which are collected from *Datastream.* The sample period for each bank spans from 1 January 1990 to 30 June 2004, with the exception of Hong Leong Bank, in which the data starts from its listing date of 17 October 1994. The selection of these banks from the present 10 anchor banks in Malaysia is due to the availability and accessibility of their stock price data. In particular, the bank mergers exercise has led to the emergence of a new entity and this disrupted the continuity of certain bank stocks data during our sample period. However, the exclusion of certain banks from our sample does not defeat the objective of this paper to demonstrate that stock price movements are typically characterized by random and non-random walks, that is, the predictable patterns evolve over time. This is important as our conjecture holds profound implications to academics, professional analysts and stock market investors.

The closing prices are transformed into a series of continuously compounded percentage returns, using the relationship:

$$r_t = 100^* \ln(p_t / p_{t-1}) \tag{7}$$

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 a common practice in most empirical work, deserves 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 might be considered close to perfectly competitive, so that the size of the investment did not affect price changes. Second, returns had more attractive statistical properties than prices, such as stationarity and ergodicity.

In the windowed-testing procedure, the data were split into a set of non-overlapping windows of 30 trading days in length, which was an arbitrary choice. However, it was found that the choice of the window length did not alter much the results of both test statistics.

EMPIRICAL RESULTS

Table 1 provides summary statistics for all the selected bank stocks returns series. The mean values indicate that the daily returns for these stocks are on average very small. Consistent with the features of other financial time series, all the bank stocks returns series significantly deviate from normality. This is not surprising as all series exhibit right-skewness and are highly leptokurtic.

Table 1
Descriptive Statistics for Bank Stocks Returns Series

	HLB	MB	PB	SB
Sample Period	17/10/1974 30/6/2004	1/1/1990 30/6/2004	1/1/1990 30/6/2004	1/1/1990 30/6/2004
No. of observations	2532	3782	3782	3782
Mean	0.004489	0.045604	0.051278	0.026844
Median	0.000000	0.000000	0.000000	0.000000
Maximum	26.57032	28.19654	20.89012	15.86050
Minimum	-24.55005	-26.80229	-19.51697	-11.67631
Std deviation	2.523484	2.271141	2.262360	2.089956

(*continued*)

Skewness	0.442389	0.803780	0.849221	0.638912
Kurtosis	17.60925	23.40869	16.86540	9.955452
JB normality test statistic	22599.47	66042.97	30749.85	7880.922
p-value	0.000000*	0.000000*	0.000000*	0.000000*

Notes: HLB- Hong Leong Bank; MB- Malayan Banking; PB- Public Bank; SB- Southern Bank.
* denotes extremely small value.

Subsequently, this study proceeds with the windowed-testing procedure to examine the random walk movement over the sample period for all the four bank stocks under investigation. Both the *C* and *H* statistics are computed using the T23 program written by Melvin J. Hinich, with 5000 re-samples to ensure the robustness of the results in small samples. In this regard, the level of significance is the bootstrapped thresholds that correspond to 0.05.

The results of the windowed-testing are reported in Table 2. The fifth row shows the number of windows where the null of pure noise is rejected by the *C* statistic (indicate the presence of linear dependencies), with the corresponding percentage in parenthesis. The statistics for significant *H* windows (indicate the presence of non-linear dependencies) are also displayed in the same table. Since both significant *C* and *H* statistics indicate departure from random walk, the final row of Table 2 provides the total number of windows or sub-periods in which the returns series are non-random. A common finding is that all the bank stocks returns series are predictable to some extent but not all the time. In particular, the series under study follow a random walk for long periods of time, only to be interspersed with brief periods of strong linear and non-linear dependency structures. Since there are times that stocks move randomly and times they do not, the contradicting findings in the literature of random walk (Malkiel, 2003) versus non-random walk (Lo & MacKinlay, 1999; Singal, 2004) even in the same stock exchange might be due to the sample period selected for their empirical analysis. This possibility has been highlighted earlier by Schachter *et al.* (1985: 328) who wrote:

> *"Whenever, for example, over the course of time a market resembles that in fig. 1, whether or not one opts for randomness depends upon which portion of the curve one chooses to analyze. If, as we have done, one analyzes the curve for the 1720 period, chances are good that there will be long runs and that one will conclude non-randomness. If one analyses the curve for the 1715 period, chances* are

good but by no means certain that it will approach a random walk".

Table 2
Windowed-Test Results for Bank Stocks Returns Series

	HLB	**MB**	**PB**	**SB**
Total number of windows	84	126	126	126
Window length	30	30	30	30
Number of lags	4	4	4	4
Significant C windows	11	9	11	8
	(13.10%)	(7.14%)	(8.73%)	(6.35%)
Significant H windows	12	17	26	19
	(14.29%)	(13.49%)	(20.63%)	(15.08%)
Significant C and H windows	21	21	35	26
	(25%)	(16.67%)	(27.78%)	(20.63%)

Note: HLB- Hong Leong Bank; MB- Malayan Banking; PB- Public Bank; SB- Southern Bank.

To provide a better view of the evolution of the returns predictability over time, Figure 1 plots the time path of the predictable patterns for all the four bank stocks returns series. Since the windowed-testing procedure breaks the full sample into equal-length and non-overlapped windows, a graphical depiction of the results could provide a closer examination of the precise time periods during which the series deviate from random walk. The histograms in Figure 1 show the percentiles (i.e. one minus the *p*-value) into which the *C* and *H* statistics fall in each window. Thus, a very significant window is plotted as a value near 1.0. It is clear from the figure that these series follow a random walk for long periods of time, only to be interspersed with brief periods of strong linear and non-linear dependency structures. This suggests that predictability is a short-horizon phenomenon.

IMPLICATIONS, RECOMMENDATIONS AND CONCLUSION

In light of the controversy in the empirical literature of random walk, this paper offers an alternative perspective that stock price movements down the historical time path are typically characterized by random and non-random walks. Using the data of four Malaysian bank stocks, coupled with the powerful Hinich and Patterson (1995) windowed-testing procedure, the results provide further statistical evidence to support the argument that stocks are indeed predictable to some extent. More importantly, these predictable patterns do not persist over time,

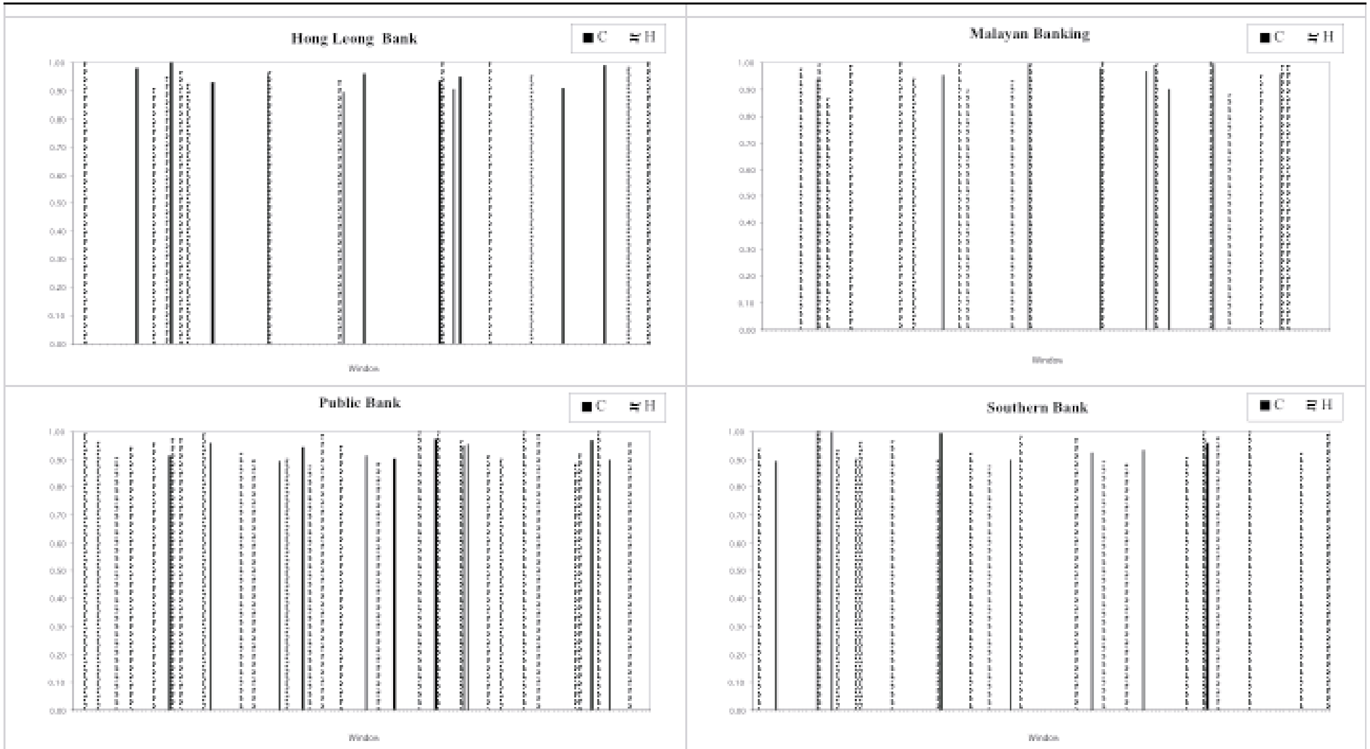

Figure 1
Significant C and H windows for bank stocks returns series

as clearly depicted in Figure 1 that there were times the returns series moved randomly, and times that they did not. Specifically, the series under study follow a random walk for long periods of time, only to be interspersed with brief periods of strong linear and non-linear dependency structures. With regard to the conflicting evidence documented in the literature, our results suggest that it might be due to different sample periods selected for empirical analysis.

To academics and researchers, the findings of predictable patterns in the present study further challenge the stronghold of EMH in finance. The existence of non-linear patterns strongly implies the inadequacy of conventional statistical tests in testing the hypothesis since they are all constructed in the linear framework. The evolving property of returns predictability further questioned the appropriateness of conventional efficiency tests that examine autocorrelation coefficients or variance ratios as these tests assumed a fixed level of market efficiency throughout the entire estimation period. However, the fundamental problem does not lie with the statistical tests but the hypothesis itself. The graphical depiction in Figure 1 strongly suggests that the evolution of market efficiency is rather complex than those predicted by the classical EMH. All these point to the search for an alternative hypothesis, and the statistical features of our data are very much in line with those postulated by the Adaptive Markets Hypothesis (AMH) of Lo (2004). For instance, contrary to classical EMH, profit opportunities do arise from time to time in AMH, which further argued that these predictable patterns should not persist over time because they would disappear after identification and exploitation by investors, but new opportunities are continually being created as groups of market participants, institutions and business conditions all change. Hence, the present paper provides an avenue for academicians to further explore this new paradigm that implies considerably more complex market dynamics, with cycles, trends, panics, manias, bubbles, crashes, and other phenomena that are routinely witnessed in natural market ecologies.

The windowed-testing procedure of Hinich and Patterson (1995) employed in this study provides a useful tool for researchers to conduct a thorough investigation on the underlying factors that contribute to the occurrence of those predictable patterns. This is made possible since the procedure breaks the full sample into equal-length and non-overlapped windows, and hence provides a closer examination of the precise time periods during which the series deviate from random walk. For instance, Ammermann and Patterson (2003) found that the detected linear dependencies in their studies were driven, at least in part, by the price limits that were imposed on the market. Brooks *et al.* (2000) attributed the findings of non-linear dependencies to two important events that occurred during their sample period- widespread upsets in the currency markets and a change in the U.S. accounting procedures that affected the U.S. firms with business abroad. Lim and Hinich (2005b) identified those major political and economic events that contributed to the short bursts of non-linear behaviour in the Malaysian stock market. Hence, the present study not only invites further research to move beyond identifying the existence of predictable patterns, but also to investigate the underlying contributing factors.

This paper provides justification to the work of technical analysis, a practice dismissed by disciples of EMH who hold on to the belief that patterns observed in the past occurred by chance. First, the occurrence of predictable patterns suggests that it is possible for stock market investors to devise a trading rule to exploit those detected linear and non-linear dependencies to earn abnormal rates of returns. In this regard, the present study presents a challenge for researchers to explore the correlation and bicorrelation structures during those non-random periods so as to formulate specific types of profitable trading strategies. Second, since predictability is mainly a short-horizon phenomenon with predictable patterns appearing only sporadically, the results explain why there appears to be times when technical analysis works and times when it does not, thus highlighting the importance of market timing strategies (Lim, 2004). This is consistent with the implication of AMH that investment strategies will wax and wane, performing well in certain environments and performing poorly in others. Specifically, AMH implies that investment strategies undergo cycles of profitability and losses in response to changing business conditions, the number of competitors entering and exiting the industry, and the type and magnitude of profit opportunities available. As such, the results call for active management strategies and justify the application of technical techniques in stock market investment - the success of which depends on the ability to time the market. In fact, Lim (2005) argued that AMH could well be the theoretical foundation that technical analysis has been missing.

END NOTES

[1] 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 transaction costs) that exploits those detected dependencies, then it would be at odds with the weak-form efficient market hypothesis.

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

3 This rich literature includes stock markets of the U.S. (Scheinkman & LeBaron, 1989; Hsieh, 1991), U.K. (Abhyankar, Capeland & Wong, 1995; Opong, Mulholland, Fox & Farahmond, 1999), Germany (Kosfeld & Robé, 2001), G-7 countries (Sarantis, 2001), Turkey (Antoniou et al., 1997), Greece (Barkoulas & Travlos, 1998; Panas, 2001), eleven African markets (Joe & Menyah, 2003), five Southeast Asian markets (Lim & Liew, 2004a), and a random sample of world stock markets (De Gooijer, 1989; Ammermann & Patterson, 2003).

4 The studies of Schachter *et al.* (1985) and Hood *et al.* (1985) have implicitly disregarded the presence of non-linear dependencies as the authors employed serial correlation and runs tests in their empirical analysis. In this regard, the possibility that those random periods are in fact non-random cannot be ruled out, and this casts doubt on the robustness of the results drawn from the exercises conducted in the above two papers.

5 The argument against these two strands of studies is similar to those put forward in Note 4.

6 It is important to break the sample into smaller size in order to examine the randomness was stock prices. In the sub-periods analysis by Kok and Goh (1995), Lai *et al.* (2003) and Lim *et al.* (2004), the sample length selected for each sub-period was relatively long since the tests employed in these studies relied on asymptotic approximations,. For instance, the variance ratio test in Lai *et al.* (2003) required at least 256 observations (Chow & Denning, 1993), while 500 or more observations were required

for the BDS test in Lim *et al.* (2004) to have limiting normal distribution. With such a relatively large sample size, the possibility that any significant results have been masked could not be ruled out.

7 Interested readers can refer to Hinich and Patterson (1995) and Hinich (1996) for a full theoretical derivation of the test statistics and some Monte Carlo evidence on the good small sample properties of both the C and H statistics.

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REFERENCES

Abhyankar, A. H., Copeland, L. S. & Wong, W. (1995). Nonlinear dynamics in real-time equity market indices: Evidence from the United Kingdom. *Economic Journal, 105,* 864-880.

Ammermann, P. A. & Patterson, D. M. (2003). The cross-sectional and cross-temporal universality of nonlinear serial dependencies: Evidence from world stock indices and the Taiwan Stock Exchange. *Pacific-Basin Finance Journal, 11,* 175-195.

Andrada-Félix, J., Fernadez-Rodriguez, F., Garcia-Artiles, M. D. & Sosvilla-Rivero, S. (2003). An empirical evaluation of non-linear trading rules. *Studies in Nonlinear Dynamics and Econometrics, 7*(3), Article 4.

Annuar, M. N., Ariff, M. & Shamsher, M. (1991). Technical analysis, unit root and weak-form efficiency of the KLSE. *Banker's Journal Malaysia, 64,* 55-58.

Annuar, M. N., Ariff, M. & Shamsher, M. (1993a). Weak-form efficiency of the Kuala Lumpur Stock Exchange: An application of unit root analysis. *Pertanika Journal of Social Sciences and Humanities, 1,* 57-62.

Annuar, M. N., Ariff, M. & Shamsher, M. (1994). Is Kuala Lumpur's emerging share market efficient? *Journal of International Financial Markets, Institutions and Money, 4*(1/2), 89-100.

Annuar, M. N. & Shamsher, M. (1993b). *The efficiency of the Kuala Lumpur Stock Exchange: A collection of empirical findings. S*elangor, Malaysia: Universiti Putra Malaysia Press.

Antoniou, A., Ergul, N. & Holmes, P. (1997). Market efficiency, thin trading and non-linear behaviour: Evidence from an emerging market. *European Financial Management, 3*(2), 175-190.

Barkoulas, J. & Travlos, N. (1998). Chaos in an emerging capital market? The case of the Athens Stock Exchange. *Applied Financial Economics, 8,* 231-243.

Barnes, P. (1986). Thin trading and stock market efficiency: The case of the Kuala Lumpur Stock Exchange. *Journal of Banking Finance and Accounting, 13,* 609-617.

Brooks, C. & Hinich, M. J. (1998). Episodic non-stationarity in exchange rates. *Applied Economics Letters, 5,* 719-722.

Brooks, C., Hinich, M. J. & Molyneux, R. (2000). Episodic nonlinear event detection: Political epochs in exchange rates. In D. Richards (Ed.), *Political complexity: Political epochs in exchange rates* (83-98). Ann Arbor: Michigan University Press.

Campbell, J. Y., Lo, A. W. & MacKinlay, A. C. (1997). *The econometrics of financial markets.* Princeton: Princeton University Press.

Chow, K. V. & Denning, K. C. (1993). A simple multiple variance ratio test. *Journal of Econometrics, 58,* 385-401.

Clyde, W. C. & Osler, C. L. (1997). Charting: Chaos theory in disguise? *Journal of Futures Markets, 17,* 489-514.

Cochrane, J. H. (1999). New facts in finance. *Economic Perspectives, 23,* 36-58.

Dawson, S. M. (1990). Technical analysis: Mixed signals from recent research. *Banker's Journal Malaysia, 62* (*December*), 41-44.

De Gooijer, J. G. (1989). Testing non-linearities in world stock market prices. *Economics Letters, 31,* 31-35.

Emerson, R., Hall, S. G. & Zalewska-Mitura, A. (1997). Evolving market efficiency with an application to some Bulgarian shares. *Economics of Planning, 30,* 75-90.

Fama, E. F. (1965). The behavior of stock market prices. *Journal of Business, 38,* 34-105.

Granger, C. W. J. (1975). A survey of empirical studies on capital markets. In E. J. Elton & M. J. Gruber (Eds.), *International capital markets* (pp.3-36). Amsterdam: North-Holland.

Granger, C. W. J. (2001). Forecasting white noise. In E. Ghysels, N. R. Swanson & M. W. Watson (Eds.), *Essays in econometrics, collected papers of Clive W.J. Granger: spectral analysis, seasonality, non-linearity, methodology, and forecasting (23).* Cambridge University Press.

Hinich, M. J. (1996). Testing for dependence in the input to a linear

time series model. *Journal of Nonparametric Statistics, 6,* 205-221.
Hinich, M. J. & Patterson, D. M. (1995). Detecting epochs of transient dependence in white noise. Mimeo. University of Texas at Austin.
Hood, D. C., Andreassen, P. & Schachter, S. (1985). Random and non-random walks on the New York Stock Exchange. *Journal of Economic Behavior and Organization, 6,* 331-338.
Hsieh, D. A. (1989). Testing for non-linearity in daily foreign exchange rate changes. *Journal of Business, 62,* 339-368.
Hsieh, D. A. (1991). Chaos and non-linear dynamics: Application to financial markets. *Journal of Finance, 46,* 1839-1877.
Joe, A. K. & Menyah, K. (2003). Return predictability in African stock markets. *Review of Financial Economics, 12,* 247-270.
Ko, K. S. & Lee, S. B. (1991). A comparative analysis of the daily behavior of stock returns: Japan, the U.S and the Asian NICs. *Journal of Business Finance and Accounting, 18,* 219-234.
Kok, K. L. & Goh, K. L. (1995). *Malaysian securities market.* Petaling Jaya, Selangor: Pelanduk Publications.
Kok, K. L. & Lee, F. F. (1994). Malaysian second board stock market and the efficient market hypothesis. *Malaysian Journal of Economic Studies, 31*(2), 1-13.
Kosfeld, R. & Robé, S. (2001). Testing for non-linearities in German bank stock returns. *Empirical Economics, 26,* 581-597.
Lai, M. M., Balachandher, K. G. & Fauzias, M. N. (2003). An examination of the random walk model and technical trading rules in the Malaysian stock market. *Quarterly Journal of Business and Economics, 41*(1/2), 81-103.
Laurence, M. (1986). Weak-form efficiency in the Kuala Lumpur and Singapore stock markets. *Journal of Banking and Finance, 10,* 431-445.
Li, X. M. (2003a). China: Further evidence on the evolution of stock markets in transition economies. *The Scottish Journal of Political Economy, 50,* 341-358.
Li, X. M. (2003b). Time-varying informational efficiency in China's A-share and B-share markets. *Journal of Chinese Economic and Business Studies, 1*(1), 33-56.
Liew, V. K. S., Chong, T. T. L. & Lim, K. P. (2003). The inadequacy of linear autoregressive model for real exchange rates: Empirical evidence from Asian economies. *Applied Economics, 35,* 1387-1392.
Lim, K. P. (2004). When does technical analysis work …and when doesn't it? *The Technical Analyst, September/October issue,* 36-38.

Lim, K. P. (2005). New theoretical light for technical analysis. *The Technical Analyst, March/April issue,* 38-39.

Lim, K. P., Habibullah, M. S. & Lee, H. A. (2004). Do Asian stock market prices follow random walk? A revisit. *International Journal of Management Studies* (formerly known as *Jurnal Analisis*), *11* (*special issue*), 101-126.

Lim, K. P. & Hinich, M. J. (2005a). Cross-temporal universality of non-linear dependencies in Asian stock markets. *Economics Bulletin, 7*(*1*), 1-6.

Lim, K. P. & Hinich, M. J. (2005b) Non-linear market behavior: Events detection in the Malaysian stock market. *Economics Bulletin, 7*(*6*), 1-5.

Lim, K. P., Hinich, M. J. & Liew, V. K. S. (2003). Episodic non-linearity and non-stationarity in ASEAN exchange rates returns series. *Labuan Bulletin of International Business and Finance, 1*(*2*), 79-93.

Lim, K. P. & Liew, V. K. S. (2004a). Non-linearity in financial markets: Evidence from ASEAN-5 exchange rates and stock markets. *ICFAI Journal of Applied Finance, 10*(*5*), 5-18.

Lim, K. P. & Liew, V. K. S. (2004b). Non-linearity favours non-linear TA techniques. *The Technical Analyst, May issue,* 38-40.

Lo, A. W. (2004). The Adaptive Markets Hypothesis: Market efficiency from an evolutionary perspective. *Journal of Portfolio Management, 30th anniversary issue,* 15-29.

Lo, A. W. & MacKinlay, A. C. (1999). *A non-random walk down Wall Street.* Princeton: Princeton University Press.

Lui, Y. H. & Mole, D. (1998). The use of fundamental and technical analyses by foreign exchange dealers: Hong Kong evidence. *Journal of International Money and Finance, 17,* 535-545.

Malkiel, B. G. (2003). *A random walk down Wall Street: The time-tested strategy for successful investing.* (8th Ed.). New York: W.W. Norton & Company.

McInish, H. & Puglisi, D. J. (1982). The efficiency of the international money market. *Journal of Business Finance and Accounting, 9*(*2*), 167-177.

Oberlechner, T. (2001). Importance of technical and fundamental analysis in the European foreign exchange market. *International Journal of Finance and Economics, 6,* 81-93.

Opong, K. K., Mulholland, G., Fox, A. F. & Farahmand, K. (1999). The behavior of some UK equity indices: An application of Hurst and BDS tests. *Journal of Empirical Finance, 6,* 267-282.

Panas, E. (2001). Estimating fractal dimension using stable distributions and exploring long memory through ARFIMA models in Athens Stock Exchange. *Applied Financial Economics, 11,* 395-402.

Patterson, D. M. & Ashley, R. A. (2000). *A non-linear time series workshop: A toolkit for detecting and identifying non-linear serial dependence.* Boston: Kluwer Academic Publishers.

Rockinger, M. & Urga, G. (2000). The evolution of stock markets in transition economies. *Journal of Comparative Economics, 28*(*3*), 456-472.

Rockinger, M. & Urga, G. (2001). A time varying parameter model to test for predictability and integration in stock markets of transition economies. *Journal of Business and Economic Statistics, 19*(*1*), 73-84.

Romero-Meza, R., Bonilla, C. A. & Hinich, M. J. (2006). Episodic non-linearity in Latin American stock market indices. *Applied Economics Letters,* forthcoming.

Sarantis, N. (2001). Nonlinearities, cyclical behaviour and predictability in stock markets: International evidence. *International Journal of Forecasting, 17*, 459-482.

Schachter, S., Gerin, W., Hood, D. C. & Andreassen, P. (1985). Was the South Sea Bubble a random walk? *Journal of Economic Behavior and Organization, 6*, 323-329.

Scheinkman, J. & LeBaron, B. (1989). Non-linear dynamics and stock returns. *Journal of Business*, *62*, 311-337.

Singal, V. (2004). *Beyond the random walk: A guide to stock market anomalies and low risk investing.* Oxford: Oxford University Press.

Taylor, M. P. & Allen, H. (1992). The use of technical analysis in the foreign exchange market. *Journal of International Money and Finance, 11,* 304-314.

Yong, O. (1993). Market efficiency (weak-form) of the Malaysian stock exchange. In I. Ibrahim & O. Yong (Eds.)*, Understanding the behavioural patterns of stock prices: A collection of readings on selected Far Eastern stock markets* (73-95). Kuala Lumpur: Leeds Publications.

Zalewska-Mitura, A. & Hall, S. G. (1999). Examining the first stages of market performance: A test for evolving market efficiency. *Economics Letters, 64,* 1-12.

Zalewska-Mitura, A. & Hall, S. G. (2000). Do market participants learn? The case of the Budapest Stock Exchange. *Economics of Planning, 33,* 3-18.