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Episodic Transient Behaviour of Dependencies in the Malaysian Stock Market

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ABSTRAK

Kajian ini menggunakan prosedur ujian tingkap Hinich dan Patterson (1995) untuk memeriksa proses penjanaan data bagi siri pulangan KLCI. Keputusan ekonometrik menunjukkan bahawa pergantungan berbentuk linear dan tak linear memainkan peranan penting dalam dinamik asas. Ini seterusnya mengimplikasikan kebolehramalan siri pulangan tersebut. Namun demikian, struktur pergantungan yang dikesan didapati tidak stabil dan berterusan melalui masa kerana keputusan menunjukkan gelagat pergantungan bersifat sekali-sekala dan juga sementara. Ini tidak mendatangkan faedah kepada para pelabur. Tambahan pula, siri pulangan didapati menghampiri pergerakan rawak bagi kebanyakan tempoh masa. Secara keseluruhan, penemuan kajian ini tidak menunjukkan bukti yang kuat untuk menolak hipotesis kecekapan pasaran bentuk lemah di Bursa Malaysia. Yang lebih penting ialah ketakstabilan proses penjanaan data menyukarkan usaha pembentukan model berdasarkan gelagat siri pulangan, menyebabkan ramalan jangka panjang sukar dilakukan walaupun mungkin.

ABSTRACT

This study utilizes the windowed-test procedure of Hinich and Patterson (1995) to examine the data generating process of KLCI returns series. Our econometrics results indicate that linear and non-linear dependencies play a significant role in the underlying dynamics of the returns series, implying the potential of returns predictability. However, these dependency structures are not stable and persistent across time as the results reveal their episodic and transient behaviour, and hence do not bring much benefit to investors. Moreover, for most of the time periods, the returns series move along at a close approximation to random walk. As a whole, the results do not constitute strong evidence against the weak-form EMH in *Bursa Malaysia.* More importantly, the instability of the underlying data generating process makes it difficult to model the behaviour of the returns series over long time histories, rendering long-horizons prediction difficult if not impossible.

INTRODUCTION

The efficient market hypothesis (EMH) introduced three decades ago was a major intellectual advance and much research endeavour has been devoted over the years to examine the efficiency of stock market price formation, both in developed and emerging stock markets. The phenomenal growth in this body of literature is partly due to the concern and 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 historical sequence of stock prices, has been widely employed to test the efficiency of stock market, particularly in the context of weak-form efficiency. 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. Therefore, price movements in a weak-form efficient market occur randomly and successive price changes are independent of one another.

Over the past two decades, the efficiency of the Malaysian stock market, *Bursa Malaysia* (formerly known as Kuala Lumpur Stock Exchange), has received considerable attention from researchers. Generally, the empirical evidence reported suggests the market is weak-form efficient, for instance, Barnes (1986), Laurence (1986), Saw and Tan (1989), Annuar *et al.* (1991, 1993), Kok and Lee (1994) and Kok and Goh (1995), just to name a few. However, empirical evidence of inefficiency cannot be suppressed, which is documented in Yong (1989, 1993). Another 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.

Though the empirical results on *Bursa Malaysia* are mixed, one notable similarity of all the aforementioned studies is the application of standard statistical tests- serial correlation test, runs test, variance ratio test and unit root tests, 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 dependencies which cannot be detected by these standard methodologies.[1] 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, the author strongly believed that if a different approach, using more powerful techniques, it may 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

[1] 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 explained 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 shared 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".

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 postulates that even non-linear combinations of previous prices are not useful predictors of future prices (Brooks 1996; Brooks and Hinich 1999; McMillan and Speight 2001). However, Hsieh (1989) argued that the standard statistical tests such as serial correlation test, runs test, variance ratio test and unit root tests may fail to detect non-linear departure from the random walk hypothesis. In this regard, those earlier Malaysian studies in favour of EMH might have drawn incorrect inferences or even policy recommendations since they have implicitly disregarded the presence of non-linearity.[2] This concern is well directed as Lim *et al.* (2003a) and Lim and Tan (2003) provided convincing evidence that non-linearity plays a significant role in the underlying dynamics of the Malaysian stock market.

In the weak-form test of EMH, one has to be cautious when interpreting the results of linear and non-linear serial dependencies. There is no doubt that the conclusion of weak-form market efficiency can be made when the random walk hypothesis cannot be rejected by a robust test such as the Brock-Dechert-Scheinkman (BDS) test.[3] However, when the hypothesis is instead rejected due to the presence of certain dependency structures, it will be a strong statement to conclude that the market is inefficient. This was highlighted 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". The deciding factor here is whether those detected patterns in the historical sequence of stock prices can be exploited by investors to earn abnormal rates of returns. To reiterate, though the evidence of linear and non-linear dependencies implies the potential of returns predictability, it has to be further demonstrated, in order to reject the weak-form EMH, that investors are able to profitably exploit those detected underlying patterns. For instance, Kok and Lee (1994) and Kok and Goh (1995) argued that though daily price series are found to be serially correlated in their respective studies, the magnitude of the correlations is not large enough for any mechanical trading rules to be devised for profitable investment timing. Hence, the presence of linear dependencies in their studies cannot be taken as evidence against the weak-form EMH. In contrast, the potential of predictability as suggested by the variance ratio test results in Lai *et al.* (2003) is 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. Another excellent piece of work is provided by Ammermann and Patterson (2003), in which the authors found that the detected non-linear dependency structures are not persistence enough to allow improvements over the random walk for predicting stock returns. Rather, these dependencies show up at random intervals for a brief period of time but then disappear again before they can be exploited by investors.

The above discussion clearly shows that it is not sufficient to only uncover 'patterns' in the underlying DGP, but requires further verification on its predictability. One alternative approach[4]

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[2] Liew *et al.* (2003) demonstrated that the conventional diagnostic tests are unable to identify the inadequacy of linear model for most of the Asian real exchange rates under study. In this case, using a mis-specified linear model will result in incorrect inferences and wrong clues in policy matters.

[3] The BDS test developed in Brock *et al.* (1987, 1996) 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). In particular, 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. Lim *et al.* (2003b) provided a literature review and brief discussion on the BDS test. The authors also applied the test to re-examine the random walk hypothesis in the Malaysian stock market.

[4] The conventional approach is to examine whether trading rules can generate abnormal rates of returns, net of all transactions costs, as adopted by Lai *et al.* (2003). However, Neely (1997: 29) cautioned that: "The rule should be commonly used to reduce the problem of drawing false conclusions from data mining- a practice in which many different rules are tested until, purely by chance, some are found to be profitable on the data set. Negative test results are ignored, while positive results are published and taken to indicate that trading rule strategies can yield profits".

is to ensure that the detected patterns are persistent across time in order for them to have much benefit to investors (Ammermann and Patterson 2003). The issue of persistency or stability[5] of the DGP is even more pertinent in the context of time series modelling to ensure accurate forecasts. The intuition is that if the DGP were found to be unstable, it would then be difficult to model the process accurately over a long period of time, thus rendering longer horizons prediction impossible. To address the issue of stability of the underlying DGP, this study utilizes the windowed-test procedure of Hinich and Patterson (1995). The test is designed to detect episodes of transient serial dependencies within a data series, by breaking the full sample into smaller sub-samples or windows of data. In other words, this procedure examines whether the dependencies found in the full sample are in fact due to strong but episodic occurrences that appear only infrequently and fleetingly. Hinich and Patterson (1995), Brooks and Hinich (1998), Brooks *et al.* (2000) and Ammermann and Patterson (2003) have utilized this procedure to investigate the time series properties and stability of the underlying dynamics of financial data. In addition to its good performance even with smaller sample sizes (Hinich and Patterson 1995), the windowed-test can detect both the linear and non-linear dependencies concurrently via the C and H statistics respectively[6], which are discussed in Section III of this paper. The possibility that linear and non-linear dependencies might co-exist in the time domain cannot be ruled out and has to be incorporated if their existence is detected. This is important because any statistical model constructed should adequately captures all important time series features of the data in order to provide accurate forecasts.

This study is further motivated by the recent empirical findings of episodic transient behaviour of dependencies in financial time series of developed markets. Brooks and Hinich (1998) found that the Sterling exchange rates are characterized by transient epochs of dependencies surrounded by long periods of white noise, suggesting that the serial dependency structures detected are not stable, but rather vary over time. Similar application to stock indices by the authors reveals the prevalence of these statistical features. In Ammermann and Patterson (2003), a closer examination via the windowed-testing procedure of Hinich and Patterson (1995) shows that the detected non-linear dependencies do not appear to be cross-temporally universal in that there are few brief periods in which the dependencies are very noticeable while other periods, in fact most of the time, the returns rather closely approximating a random walk. This means that the significant full sample results for non-linearity are actually triggered by the activity within a few relatively short "pockets" of highly non-linear data. It was suggested by the above two studies that these episodic transient behaviour are likely to be prevalent in many financial markets. Thus, it would be interesting to investigate whether the financial data of developing countries exhibit similar instability in the DGP. With this motivation, along with its profound implications on the weak-form EMH and model construction as discussed earlier, this study attempts to make a modest contribution to the current literature by broadening the existing evidence to include the emerging Malaysian stock market.

In the following section, this paper reviews some of the important developments in the Malaysian stock market. Section III gives a brief description of the data and the methodology used in this study. Section IV presents the empirical results as well as the analysis of the findings. Finally, concluding remarks are given at the end of the paper.

MAJOR DEVELOPMENTS IN THE MALAYSIAN STOCK MARKET

In Malaysia, the Kuala Lumpur Stock Exchange (KLSE) is the only body approved by the Minister of Finance, under the provisions of the Securities

[5] A stable process implies that there is one correct model that describes the underlying data generating process and the parameters of this correct model remains constant throughout the time period from which the data are drawn. For example, the model parameters of a linear autoregressive process will remain constant throughout the entire sample period. Even for non-linear processes like ARCH and GARCH, the evolution can be described by equations whose parameters are constant over time.

[6] Those popular non-linearity tests as outlined in Barnett and Serletis (2000) and Patterson and Ashley (2000) are designed for the sole purpose of detecting the presence of non-linearity in the DGP of time series data.

Industry Act, 1983, as the stock exchange in the country. The KLSE is a self-regulatory organization with its own memorandum and articles of association, as well as rules which govern the conduct of its members in securities dealings. The KLSE is also responsible for the surveillance of the market place, and for the enforcement of its listing requirements which spell out the criteria for listing, disclosure requirements and standards to be maintained by listed companies.

Although the history of KLSE can be traced to the 1930s, the public trading of shares in Malaysia only really began in 1960 when the Malayan Stock Exchange (MSE) was formed. When the Federation of Malaysia was formed in 1963, with Singapore as a component state, the MSE was renamed the Stock Exchange of Malaysia (SEM). With the secession of Singapore from the Federation of Malaysia in 1965, the common stock exchange continued to function but as the Stock Exchange of Malaysia and Singapore (SEMS).

The year 1973 was a major turning point in the development of the local securities industry, for it saw the split of SEMS into the Kuala Lumpur Stock Exchange Berhad (KLSEB) and the Stock Exchange of Singapore (SES). The split was opportune in view of the termination of the currency interchangeability arrangements between Malaysia and Singapore. Although the KLSEB and SES were deemed to be separate exchanges, all the companies previously listed on the SEMS continued to be listed on both exchanges.

When the Securities Industry Act 1973 was brought into force in 1976, a new company called the Kuala Lumpur Stock Exchange (KLSE) took over the operations of KLSEB as the stock exchange in Malaysia. Its function was to provide a central market place for buyers and sellers to transact business in shares, bonds and various other securities of Malaysian listed companies. On 1 January 1990, following the decision on the "final split" of the KLSE and SES, all Singaporean incorporated companies were de-listed from the KLSE and vice-versa for Malaysian companies listed on the SES.

The year 2004 represents another major milestone in the development of the Malaysian securities industry with the demutualisation of KLSE. The demutualisation process took place with the passing of the Demutualisation Bill by the Dewan Rakyat on 11 September 2003, together with other related amendments to the securities law. This was followed by the passing of the Bill by the Dewan Negara on 5 November 2003. As a result of the exercise, KLSE ceases to be a non-profit entity limited by the guarantee of its members, and becomes a public company limited by shares. On 20 April 2004, 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.

METHODOLOGY

The Data

This study utilizes the daily closing values of Kuala Lumpur Composite Index (KLCI) for the sample period of 2 January 1990 to 30 June 2002. The price series obtained are used to compute a set of continuously compounded percentage returns for the KLCI, using the relationship:

$$r_t = 100^* \ln(P_t/P_{t-1}) \quad (1)$$

where P_t is the closing price on day t, and P_{t-1} the rate 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.

Hinich and Patterson's Windowed-Test Procedure

In the windowed-test procedure of Hinich and Patterson (1995), a correlation portmanteau test similar to the Box-Pierce *Q*-statistic is developed for the detection of correlation or linear serial dependencies within a window. For detecting non-linear serial dependencies within a window, the procedure uses a bicorrelation portmanteau test, which can be considered as a time-domain analog of the Hinich bispectrum test statistic (Hinich 1982). In applying these tests, the full sample is broken down into smaller sub-samples or windows of data. If the full data sample does exhibit significant linear or non-linear serial dependencies, but there are only a few smaller windows that are significant, then this suggests the data may instead be characterized by episodes of transient dependencies. In other words, it is the activity of these few windows that is actually driving the results of the overall sample. As demonstrated in the Monte Carlo simulations of Hinich and Patterson (1995), the test performed well even with small sample sizes.

In this section, we provide a brief description of the test statistics used in this windowed-test procedure.[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[8] 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.

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

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

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

The sample correlation is:

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

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

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

The (r, s) sample bicorrelation is:

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

for $0 \leq r \leq s$

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

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

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

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 0.01. In this case, the chance of obtaining a false rejection of the null is approximately one 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 fact, there is no unique value for the window length. According to Brooks and Hinich (1998), the window length should be sufficiently long to provide adequate statistical power and yet short enough for the test to be able to pinpoint the arrival and disappearance of transient

[7] Interested readers can refer Hinich and Patterson (1995) and Hinich (1996) for a full theoretical derivation of the test statistics and some Monte Carlo evidence regarding the size and power of the test statistics.

[8] A stationary time series is called pure-noise or pure white-noise if $y(n_1), \ldots, n_N$. A white noise time series, by contrast is one for which the autocovariance function is zero for all lags. Whiteness does not imply that $y(n)$ and $y(m)$ are independent for $m \neq n$ unless the series is Gaussian.

dependencies, which is the main purpose of using a windowed-test procedure. In this study, we followed the choice of Brooks and Hinich (1998) in which the data are split into a set of non-overlapping windows of 35 observations in length, approximately seven trading weeks. In fact, it was found that the choice of the window length does not alter much the results of both test statistics.

EMPIRICAL RESULTS

Table 1 provides summary statistics for the returns series in order to get a better view of some of the important statistical features. The means are quite small. The KLCI returns series exhibit some degree of positive or right-skewness. On the other hand, the distributions are highly leptokurtic, in which the tails of its distribution taper down to zero more gradually than do the tails of a normal distribution. Not surprisingly, given the non-zero skewness levels and excess kurtosis demonstrated within these series of returns, the Jarque-Bera (JB) test strongly rejects the null of normality.

TABLE 1
Summary statistics for KLCI returns series

	KLCI Returns Series
Sample Period	2/1/1990-30/6/2002
No. of observations	3259
Mean	0.007818
Median	0.000000
Maximum	20.81737
Minimum	-24.15339
Std deviation	1.679596
Skewness	0.457460
Kurtosis	38.02681
JB normality test statistic	166713.4
p-value	(0.000000)*

* Denotes very small value

Table 2 presents the correlation (*C*) and bicorrelation (*H*) test statistics for the full data sets. If the *C* and *H* statistics are highly significant, it will then prompt us to examine whether these serial dependency structures are stable or instead their occurrences are episodic and transient in nature. The results in Table 2 reveal that both the *C* and *H* statistics are highly significant, with extremely small *p*-values.[9] This indicates the non-randomness of successive price changes in *Bursa Malaysia*, with strong evidence of linear and non-linear serial dependencies within the KLCI returns series. The present results corroborate the findings of linear dependencies in Yong (1989, 1993) and Lai *et al.* (2003), and evidence of non-linearity reported by Lim *et al.* (2003a) and Lim and Tan (2003). This also provides some plausible explanation to the rejection of the random walk hypothesis by the BDS test in Lim *et al.* (2003b).

TABLE 2
C and *H* statistics for KLCI returns series

	KLCI Returns Series
Sample Period	2/1/1990-30/6/2002
No. of observations	3259
No. of lags	25
No. of bicorrelations	300
p-value	
- *C* Statistic	0.0000*
- *H* Statistic	0.0000*

* denotes extremely small *p*-value.

Subsequently, we examine whether the detected dependency structures in the full sample, both linear and non-linear, are in fact due to strong but episodic occurrences that appear only infrequently and fleetingly. Table 3 shows the results for the windowed testing, in which the data are split into a set of non-overlapping windows of 35 observations in length, approximately seven trading weeks. In this case, four lags are used in calculating both the *C* and *H* statistics. The fifth row in Table 3 shows the number of windows where the null of pure noise is rejected by the *C* statistic[10]. In parenthesis is the percentage of significant *C* windows. The results show that the null is rejected in six windows by the *C* statistic, which is equivalent to

[9] Instead of reporting the *C* and *H* statistics as chi-square variates, the T23 program written by the second author reports the statistics as *p*-values. Based on the appropriate chi square cumulative distribution value, the T23 program transforms the computed statistic to a *p*-value.

[10] In this study, the threshold level has been set at 0.01. The level of significance is the bootstrapped thresholds that correspond to 0.01.

6.45%. By using a threshold level of 0.01, we would expect the C statistic to reject 1% of the windows by random chance. However, the percentage of windows exhibiting significant linear serial dependencies is greater than the expected 1%. Similarly, the percentage of significant H windows is also larger than the 1% nominal threshold level, as displayed in the seventh row of the same table, suggesting that the rejection is not purely by chance.

Since both the C and H statistics are highly significant for the full data series as reported in Table 2, one would expect these serial dependencies to be persistent throughout the data or at least many more of the windows to exhibit strong serial dependencies. Instead, these significant test results in the full data series are reflected in only a relatively few windows. In other words, it is the activity of these few windows that is actually driving the results of the overall sample. Specifically, out of the total ninety three windows, only six (6.45%) exhibit significant linear serial dependencies and four (4.30%) exhibit non-linear serial dependencies. These results might be able to explain the mixed findings of those Malaysian studies using standard methodologies and the KLCI data. It is possible that the serial correlation test, runs test and unit root tests employed in Barnes (1986), Saw and Tan (1989), Annuar *et al.* (1993) and Kok and Goh (1995) are unable to detect linear dependencies in these few windows. In contrast, the results of Lai *et al.* (2003) show that variance ratio test has higher power in detecting departure from the random walk hypothesis.

These episodic transient dependencies in the data indicate that the KLCI returns series are not stable, with the returns during most of the time periods move along at a close approximation to random walk, while during the remaining time periods (ten windows) they are characterized by highly significant linear and non-linear serial dependencies. The windowed-test procedure has an added advantage in that it permits a closer examination of the precise time periods during which these dependencies are occurring. Table 3 also reports these time periods, which are potentially useful for our future investigation into the causes of these detected episodic transient dependencies.

The episodic and transient behaviour of dependencies can be observed graphically. The histograms in *Fig. 1* and *Fig. 2* show the

TABLE 3
Windowed-test results for KLCI returns series

	KLCI Returns Series
Total number of windows	93
No. of lags	4
No. of bicorrelations	6
Significant C windows	6 (6.45%)
Dates of significant C windows	29/5/1990-16/7/1990
	7/5/1991-24/6/1991
	13/8/1991-30/9/1991
	7/1/1992-24/2/1992
	21/7/1992-7/9/1992
	29/5/2001-16/7/2001
Significant H windows	4 (4.30%)
Dates of significant H windows	17/7/1990-3/9/1990
	5/3/1996-22/4/1996
	4/8/1998-21/9/1998
	4/9/2001-22/10/2001

percentiles (i.e. one minus the p-value) into which the C and H statistics fall in each window for the KLCI returns series. Thus, a very significant window is plotted as a value near 1.0. It can be observed from these figures the episodic occurrence of these dependencies that appear within the data only infrequently. Another interesting feature is the transient nature of these dependencies, in which some windows appear highly significant, but then quickly disappear, or become too weak to be detected, in subsequent windows. As a whole, both figures show that the serial dependency structures are not stable and persistent.

CONCLUSIONS AND RECOMMENDATIONS

This study utilizes the windowed-test procedure of Hinich and Patterson (1995) to examine the data generating process of KLCI returns series. Our econometrics results indicate that linear and non-linear dependencies play a significant role in the underlying dynamics of the returns series examined. However, these dependencies are not stable and persistent as they are episodic and transient in nature. Given the prevalence of these episodic transient dependencies across financial markets in the world, it would certainly be important to the field of finance and deserve the attention of researchers.

At first glance, the evidence of linear and non-linear dependencies indicates departure from random walk and hence implies the

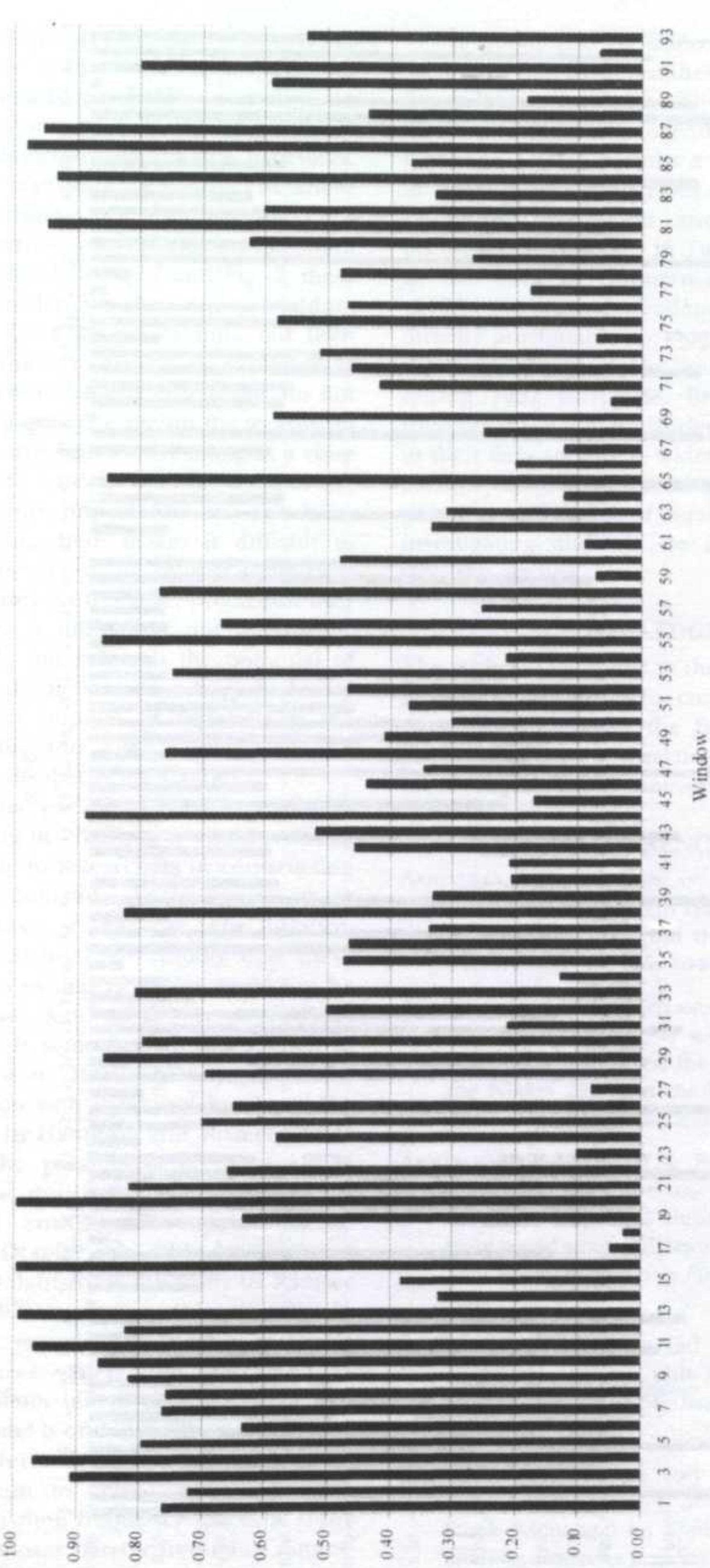

Fig. 1: C statistics for KLCI returns series

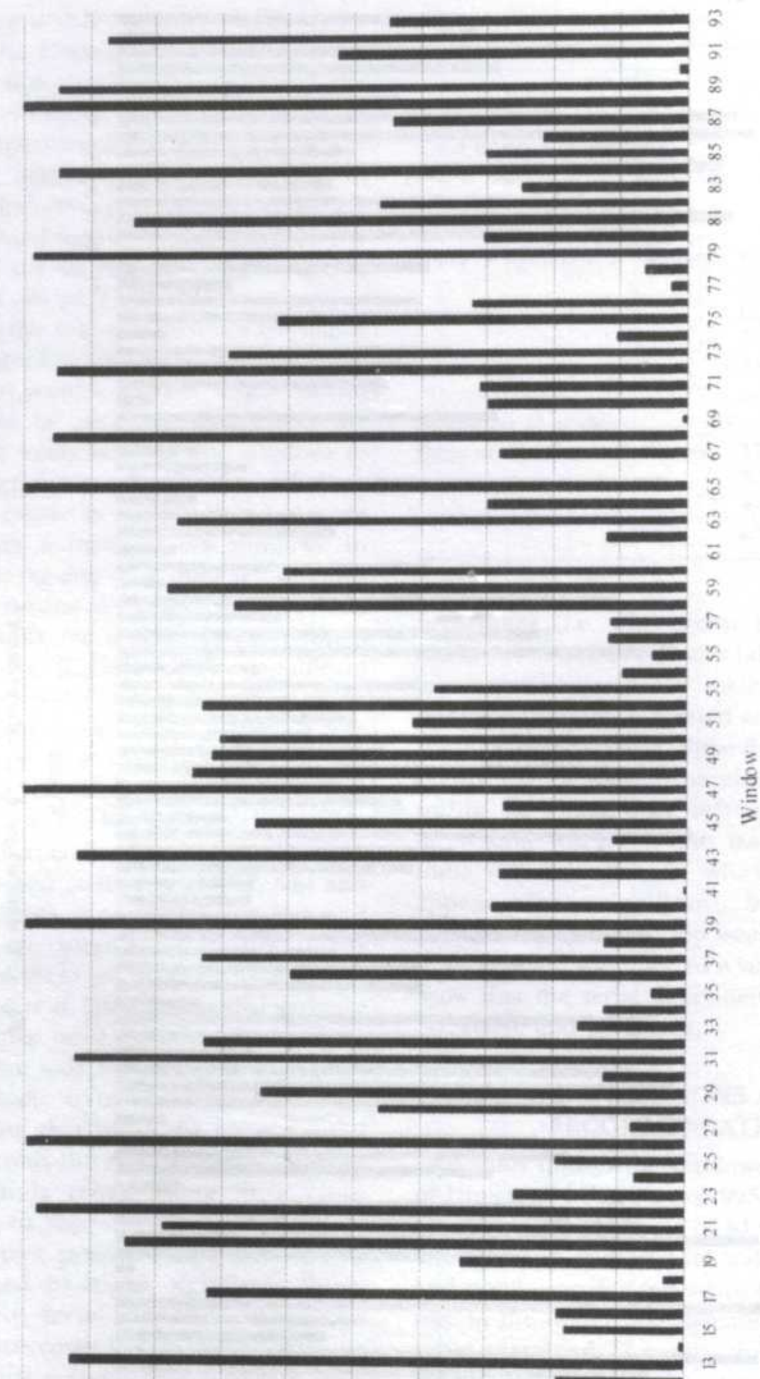

Fig. 2: H statistics for KLCI returns series

potential of returns predictability. However, as discussed in the earlier section, in order to reject the weak-form EMH, one has to demonstrate that investors are able to profitably exploit these detected dependency structures. The episodic transient behaviour of these dependencies suggests that they are not stable and persistent across time for investors to benefit from it. As depicted in *Fig. 1* and *Fig. 2*, these significant dependencies show up at random intervals for a brief period of time but then disappear again before they can be exploited by investors. The results, taken as a whole, do not constitute strong evidence against the weak-form EMH as the returns series move along at a close approximation to random walk for most of the time periods. More importantly, the instability of the underlying DGP makes it difficult to model the behaviour of the returns series over long time histories. In this case, prediction over longer horizons is difficult if not impossible. However, we do not rule out the potential of short-horizons prediction, in which technical analysis is highly popular as reported in the studies by Taylor and Allen (1992), Lui and Mole (1998) and Oberlechner (2001).

As mentioned earlier, given the complexity of the generating mechanism, it would certainly pose a challenge to researchers in constructing a model that could adequately capture these important features of the data. For instance, Brooks and Hinich (1998) found that these transient epochs of dependencies could not be generated by any kind of ARCH or GARCH model. Even with some modifications, such as those by Booth *et al.* (1994) which augments the GARCH equation with structural breaks in the mean, or those by Hamilton and Susmel (1994) which allows the parameters of the GARCH equation to be drawn from one of several regimes, still could not capture these dependencies. Despite this difficulty, one can draw some new light from the study by Ramsey and Zhang (1997) on the possible direction in this modelling exercise. The authors found similar structures which they described as 'localized frequency bursts' and suggested that the relevant model is one of oscillations induced by packets of information, leaving the median of changes invariant to zero. The packets are characterized in time frequency space by short bursts of activity over narrow frequency ranges. This will certainly be a promising line of research.

It would also be interesting to investigate the events that triggered these episodic transient dependencies in the data. This is possible because the windowed-test procedure of Hinich and Patterson (1995) permits a closer examination of the precise time periods during which these dependencies, linear and non-linear, are occurring, as reported in Table 3. For instance, in the work of Ammermann and Patterson (2003), the linear dependencies are found to be directly attributable to changes in the Taiwan Stock Exchange's price limits that were made during 1987 and 1988. Brooks *et al.* (2000) found that the non-linear dependency structures in their data are due to widespread upsets in the currency markets and a change in US accounting procedures. This line of inquiry is certainly worth investigating and will be included in future research agenda.

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