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Randomness of Stock Market Movement: A Nonparametric Approach

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ABSTRAK

Dalam hipotesis pasaran cekap (HPK) bentuk lemah, adalah diandaikan yang harga saham bergerak secara rawak. Dalam kajian ini, penumpuan diberikan kepada indeks-indeks pasaran kebangsaan dan bukannya kepada harga saham, dan kita ingin menentukan sama ada indeks-indeks ini mempunyai gelagat yang serupa dengan perjalanan rawak. Disebabkan masalah ketidaknormalan dengan data-data yang digunakan, kajian ini menggunakan beberapa kaedah ujian bukan parametrik, berbeza dengan beberapa kajian dahulu yang menggunakan ujian-ujian parametrik. Data-data yang digunakan untuk kajian ini terdiri daripada indeks-indeks penutup harian bagi indeks industri KLSE (Malaysia), indeks Hang Seng (Hong Kong), indeks Nikkei Dow Jones (Tokyo), indeks purata industri Dow Jones (New York), indeks Australian All Ordinaries (Sydney), dan indeks Financial Times All Ordinaries (London). Keputusan kajian ini menunjukkan bahawa perubahan harian indeks berbeza daripada perjalanan rawak bagi pasaran kecil seperti Malaysia dan Australia. Tambahan pula, keputusan yang didapati tidak stabil mengikut masa bagi pasaran-pasaran yang kecil ini. Bagi data mingguan, hanya pasaran saham Malaysia yang menunjukkan keadaan tidak rawak bagi tempoh masa 1984-1988. Ujian arahaliran Cox-Stuart menggunakan data bulanan gagal mengesan arahaliran yang ketara dalam pergerakan pasaran-pasaran ini (kecuali bagi pasaran Malaysia). Secara keseluruhannya, kajian ini menunjukkan bahawa model perjalanan rawak masih lagi sah bagi indeks-indeks kebangsaan sebagaimana halnya dengan kes saham, terutamanya bagi pasaran-pasaran dunia yang lebih mantap dan aktif. Walau bagaimanapun, pasaran saham yang kecil dan tidak begitu aktif tidak begitu konsisten daripada segi menyokong model perjalanan rawak.

ABSTRACT

In the weak form of the efficient market hypothesis (EMH), it is assumed that stock prices move in a random fashion. In this study, the focus is on the national stock indices rather than on the stock prices, and to determine whether the stock indices behave in a manner consistent with the random walk. Due to the problem of nonnormality with the data under study, this

study employed various nonparametric tests as opposed to many previous studies which employed parametric tests. The data for this study consist of daily, weekly and monthly closing indices of the KLSE Industrial (Malaysia), Hang Seng (Hong Kong), Nikkei Dow Jones (Tokyo), Dow Jones Industrial Average (New York), Australian All Ordinaries (Sydney), and Financial Times Industrial Ordinaries (London). The results of this study indicate that daily changes do deviate from the random walk for smaller markets of Malaysia and Australia. In addition, the results are not quite consistent or stable over time for these smaller markets. For weekly data, only the market of Malaysia shows nonrandomness for the period 1984-1988. The Cox-Stuart test for trend using monthly data failed to detect a significant trend in the movements of these markets (except for the market of Malaysia). Overall, this study shows that the random walk model is still valid for the national stock indices just like in the case of stock, especially in the more established and active world's markets. However, smaller and "not-so-active" stock markets are not quite consistent in terms of their conformity to the random walk.

INTRODUCTION

In the weak form of the Efficient Market Hypothesis (EMH), it is assumed that the stock prices move in a random fashion, or stated differently, the future movement in stock prices is independent of their past movement. Studies in the past normally employed at least one popular parametric test called the serial correlation test (one popular one is that of Fama (1965) to test the independence nature of the stock price movement. This parametric test, however, requires that the data under study exhibit a normal distribution in order for the test to be valid. On the other hand, many past studies (examples are Fama (1965), Solnik (1974), Ang and Pohlman (1978) and Laurence (1986) reported nonnormality in the stock price changes. In fact, in order to use the parametric test, some studies employed a log transformation and thus surfaced the idea of stock prices having lognormal distribution. We should understand that "normally forced " data of stock prices (through transformation) do not exactly describe the actual behavior of the stock prices; rather, the data describe the behavior of the transformed data. In fact, the distribution of the stock prices is frequently described as leptokurtic (i.e., having more observations near the mean and in the extreme tails), sometimes as stable paretian, and at other time a mixture of normals distribution (see, for example, Hall, Brorsen, and Irwin 1989). In a nutshell, the distribution of the changes in stock prices is not normal.

In this paper, we are interested in finding out whether or not national stock indices behave in a manner that can be described as random. Furthermore, the study period is divided into a few subperiods in order to determine the

stability of the test results. Daily, weekly and monthly data are used to find out whether the time intervals has any effect on the test results. In this study we assume that national stock indices reflect or represent the behavior of the stocks in the respective markets. Furthermore, since there is the problem of nonnormality as mentioned in the previous paragraph we employed only the nonparametric tests.

It should be stressed here that this study is not on the individual stock or a group of stocks which were normally assumed to be representative of the respective market chosen. Rather, this study looks at the national stock market index itself and to show whether or not the index moves or changes in a random fashion in line with the random walk model or the weak form of the EMH. Some people might object to the use of index in this kind of study because they argue that EMH deals with the stock return or changes in the stock price. To answer this objection, one has to look at various issues regarding the EMH and the index itself. First, EMH is a general concept, and therefore a general representation of the market, such as the index (which is supposed to represent the market in general) is quite appropriate in testing the validity of the concept. Secondly, when one talks about the market, one normally refers to the commonly quoted stock index. In fact, technical analysts look at the index to tell or explain the sentiment in the market. Thirdly, eventhough an index cannot be bought (not in the case of index futures, though) like in the case of the stock, it still has the characteristics of the group of stocks it represents because it is the average (either simple or weighted average) of the stocks it represents. Finally, this study focuses on the behavior of the index, and not on behavior of the stock.

DATA AND METHODOLOGY

The data for this study consist of daily, weekly and monthly closing indices of the KLSE Industrials (Malaysia), Hang Seng (Hong Kong), Nikkei Dow Jones (Tokyo), Dow Jones Industrial Average (New York), Australian All Ordinaries (Sydney), and Financial Times Industrial Ordinaries (London) as reported by Investors Digest (a publication of the KLSE) for a period from January 1984 to December 1988. For uniformity, only same date available closing indices are used. This means that if a market is closed because of holiday on any given date, then that date is dropped. In the case of the weekly data, the most recent available closing datum during the week is used if Friday is closed. The closing prices for the last trading day during the month are used for the monthly data. These indices were chosen because they are widely referred to and considered to be representative of the respective markets.

In this study a nonparametric test called the Kolmogorov - Smirnov test for normality was first performed on the data (the percentage changes in

index, to be exact). The results of this test are not reproduced here because it is not the purpose with this paper. It is suffice to say here that some index changes do exhibit normal distribution, but only within short time spans. Longer time spans result in nonnormality

The runs test employed are the runs test employed by many prior studies as introduced by Wallis and Roberts (1956), and the runs tests based on mean and median as mentioned by many text books on business statistics. Runs test based on mode is not used because of the problem of multiple modes.

With the Wallis and Roberts' (W-R) procedure, the formulas for the expected runs, E(R), and the standard error of runs, S(r), are as follows:

$$E(R) = \{N(N+1) - \sum_{i=1}^{3} n_i^2 \}/N \quad (1)$$

$$S(r) = \left\{ \frac{\sum_{i=1}^{3} n_i^2 \left(\sum_{i=1}^{3} n_i^2 + N(N+1) \right) - 2N \sum_{i=1}^{3} n_i^3}{n^2 (n-1)} \right\}^{1/2} \quad (2)$$

where n_i = number of changes for each sign of plus, minus and no change, and N = total number of changes.

The Z-observed in calculated as (3)

$$[R - E(R) \pm 1/2] / S(r)$$

where R = actual number of runs,

and 1/2 is the correction factor for continuity adjustment, in which the sign is plus if $R \leq E(R)$ and minus otherwise.

For the runs tests based on median and mean, the formulas for the expected runs, E(R), and the standard error of runs, S(r), are as follows:

$$E(R) = \frac{2n_1 n_2}{n_1 + n_2} + 1 \quad (4)$$

and

$$S(r) = \left\{ \frac{2n_1 n_2 (2n_1 n_2 - n_1 - n_2)}{(n_1 + n_2)^2 (n_1 + n_2 - 1)} \right\}^{1/2} \quad (5)$$

where n_1 =Number of observations less than median (or mean), and n_2 = Number of observations greater or equal to median (or mean).

The Z-observed is calculated as

$$\frac{R - E(R)}{S(r)} \quad (6)$$

The runs test are employed for daily, weekly and monthly observations. In the case of Cox-stuart test for trend, it is applied only for the monthly data because trend normally can be detected in a longer interval set of data (in fact, annual observations are more appropriate).

With the Cox-Stuart test, we pair early observations with one of the later observations. When the later observation exceeds the earlier observation, we replace the pair with a minus sign, and a plus sign if otherwise. A preponderence of plus signs suggest a downward trend, and upward trend if otherwise. No trend is present if positive and negative signs occur in equal number. The Z-observed is calculated as:

$$\frac{(k \pm 0.5) - 0.5n}{0.5n^{1/2}} \quad (7)$$

where k = number of observation of less frequently observed sign (either negative or positive),
n = number of pairs constructed (in the case of odd observations, the middle observation is dropped in the construction of the pairs),
and 0.5 is the continuity adjustment factor, in which the sign is plus if k is less than n/2 , and minus if otherwise.

RESULTS AND DISCUSSION

Table 1 through 3 show the results of daily data of various runs test according to period. As we can see only the markets of Hong Kong and New York exhibit randomness is all the tests performed for all the time periods. The market of London shows nonrandomness in both mean and median runs tests

for the period 1986. It shows randomness, however, for the periods under the W-R runs test. The market of Tokyo show nonrandomness for the period 1984-1988 under both the median and W-R runs tests. It shows randomness, however, for all the periods under the mean runs test. The smaller markets of Malaysia and Australia show nonrandomness at the 5 percent and the 1 percent significance levels at various time periods.

Tables 4 through 6 show the results of weekly data of various runs tests according to period. Only the market of Malaysia shows nonrandomness for the period 1984-1988 under the median and the mean runs test at the 5 percent significance level. For shorter subperiods, however, the market of Malaysia shows randomness in its index changes. All other markets exhibit randomness in their movements.

Table 7 shows the results of various runs test for the monthly data for the entire 1984-1988 period. Only the market of London exhibits nonrandomness at the 1 percent significance level under the W-R runs test. However, it does exhibit randomness under the other two runs tests. All other markets do show randomness under all the runs tests performed.

Table 8 shows the results of the Cox-Stuart test for trend for the monthly data for the entire 1984-1988 period. As we can see, only the market of Malaysia exhibits a significant trend (upward) at the 5 percent level. All other markets do not exhibit significant trend.

CONCLUSIONS AND IMPLICATION

In this paper we have shown the results of various runs tests and also the Cox-Stuart test for trend. All these tests are classified as nonparametric which make no assumption regarding the distribution of the data under study. The W-R runs test is the most widely used runs test in the previous studies. The runs tests based on median and mean are added because they look at the movements or fluctuation above or below a stated point (namely the mean or the median) as apposed to the W-R runs test which looks at the movements as either up, down or no movement. Cox-Stuart test for trend is introduced to determine the existence of upward or downward trend in the monthly data.

Based on the runs tests on the daily data, the more established and actively traded markets of New York and Hong Kong and to a lesser extent the markets of Tokyo and London do exhibits randomness in terms of their movements (as shown by the changes in their indices). The markets of Australia and Malaysia, however, show nonrandomness in the period 1984-1988 and various shorter subperiods. The results of runs tests for weekly data do indicate randomness in the movements of these stock markets (except for the market of Malaysia for the longer period of 1984-1988, under the median and mean runs tests).

TABLE 1. Results (Z-observed) of W-R runs test for daily data according to period

Period	KLSE	Hang Seng	Aust. Ord.	DJIA	Fin. Times	Nikkei
1984	-2.387*	0.102	-2.342*	-1.375	0.400	-1.003
1985	-1.218	-0.439	-2.013*	0.983	1.320	-0.528
1986	-2.152*	-0.665	-2.030*	0.117	-1.847	-1.644
1987	-4.001**	-0.563	-1.941	-0.080	-0.452	-1.539
1988	-0.091	-1.165	-2.353*	-0.817	-1.250	-0.580
1984-1988	-4.873**	-1.378	-5.083**	-0.834	-0.750	-2.506*

*Notes:*1) * Reject null hypothesis at the 5 percent level
2) ** Reject null hypothesis at the 1 percent level

TABLE 2. Results (Z-observed) of runs test based on median for daily data according to period

Period	KLSE	Hang Seng	Aust. Ord.	DJIA	Fin. Times	Nikkei
1984	-2.953**	-0.618	-2.266*	-0.618	-0.343	-0.893
1985	-1.937	-0.138	-1.660	1.522	1.245	-0.968
1986	-2.678**	-1.167	-1.854	0.756	-2.678**	-1.030
1987	-3.289**	-0.411	-2.741**	0.548	-0.274	-1.096
1988	-0.551	0.169	-2.203*	-0.964	-1.652	0.000
1984-1988	-5.087**	-1.532	-4.229**	-0.245	-1.042	-2.390*

*Notes:*1) * Reject null hypothesis at the 5 percent level
2) ** Reject null hypothesis at the 1 percent level

TABLE 3. Results (Z-observed) of runs test based on mean for daily data according to period

Period	KLSE	Hang Seng	Aust. Ord.	DJIA	Fin. Times	Nikkei
1984	-3.473**	0.048	-2.233*	-1.400	0.556	-1.153
1985	-1.926	-0.133	-1.585	1.390	1.268	-1.215
1986	-2.233*	-1.710	-2.260*	0.797	-2.602**	-0.686
1987	-3.776**	-0.536	-1.326	-0.147	-0.302	-1.341
1988	-0.546	-1.281	-2.202*	-0.963	-1.334	0.287
1984-1988	-4.680**	-1.401	-4.553**	0.009	-1.127	-1.709

Notes: 1)* Reject null hypothesis at the 5 percent level
2)** Reject null hypothesis at the 1 percent level.

TABLE 4. Results (Z-observed) of W-R runs test for weekly data according to period

Period	KLSE	Hang Seng	Aust. Ord.	DJIA	Fin. Times	Nikkei
1984	1.160	-0.220	0.000	0.000	1.030	0.680
1985	0.130	-0.030	-1.230	-1.190	0.000	-0.330
1986	-0.850	-0.100	-0.050	1.540	-0.060	-1.080
1987	-0.840	-1.450	-0.071	-1.030	-0.020	-1.500
1988	-0.690	0.030	-0.540	-0.220	-1.130	0.060
1984-1988	-1.480	-0.910	-1.220	-0.190	0.240	-0.600

Note: None shows significant nonrandomness at the 5 percent and 1 percent levels.

TABLE 5. Results (Z-observed) of runs test based on median for weekly data according to period

Period	KLSE	Hang Seng	Aust. Ord.	DJIA	Fin Times	Nikkei
1984	0.292	-0.263	0.003	0.581	2.025	0.291
1985	-0.280	0.280	-1.401	-0.560	2.280	0.840
1986	-1.271	1.276	-0.705	1.842	0.993	0.710
1987	0.869	-0.575	-0.575	0.292	0.292	-1.441
1988	-0.422	0.710	-0.705	-0.401	-1.271	0.710
1984-1988	-2.020*	0.000	-0.505	0.253	1.010	0.253

Note: Reject null hypothesis at the 5 percent level

TABLE 6. Results (Z-observed) of runs test based on mean for weekly data according to period

Period	KLSE	Hang Seng	Aust. Ord.	DJIA	Fin. Times	Nikkei
1984	0.317	-0.650	-1.248	0.581	1.476	0.546
1985	-0.239	0.889	-1.392	-0.560	0.280	0.840
1986	-0.930	1.303	-0.685	0.963	0.571	0.167
1987	0.000	-0.553	-0.708	-0.509	0.225	-1.917
1988	0.144	0.167	-0.422	0.167	-1.271	0.167
1984-1988	-2.494*	-0.723	-0.824	0.400	1.351	0.355

Note: *Reject null hypothesis at the 5 percent level.

TABLE 7 Results (Z-observed) of various runs test for monthly data 1984-1988 period

Runs test	KLSE	Hang Seng	Aust. Ord.	DJIA	Fin. Times	Nikkei
Mean	-1.664	0.134	0.188	0.396	1.205	-0.129
Median	-0.655	0.134	-0.917	0.396	1.185	0.396
W-R Test	-0.520	-1.320	-0.570	0.820	4.330**	1.730

*Note:*** Reject null hypothesis at the 1 percent level.

TABLE 8. Results of Cox-Stuart test for monthly data, 1984-1988

Market	k	Sign of k	Z-observed
KLSE	8	+ve	-2.228*
Hang Seng	14	-ve	0.000
Aust. Ord.	11	+ve	-1.114
DJIA	13	-ve	-0.371
Fin Times	11	-ve	-1.114
Nikkei	12	-ve	-0.743

Note: * Reject null hypothesis at the 5 percent level.

It is clear from these results that the daily movements are not as random as weekly movement. In addition, the more established and active markets behave in a manner consistent with a random walk model. Furthermore, the smaller markets do not always behave in a manner consistent with the random walk model; at times they do, and at other time periods they do not.

The Cox-Stuart test for trend failed to detect a significant trend in the monthly movements of these markets (except for the market of Malaysia). Perhaps a longer interval data(say, semi-annual data) might show some trend. It is obvious here that it is not easy to track a trend in the market movement.

Overall this study indicates that the idea of random walk is still applicable to the national stocks indices just like the case of individual stock or group of stocks, especially in the established and active world's markets. However, smaller and "not-so-active" stock markets are not very consistent in terms of their random movements or conformity to the random walk model.

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