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INVESTIGATING RANDOM WALK HYPOTHESIS IN INDIAN STOCK MARKET DURING POST-GFC PERIOD

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Abstract
In this paper, a fresh attempt is made to examine the existence of Random Walk Hypothesis in the Indian Stock Market. The objective is pursued with the help of data on adjusted daily returns, weekly returns and monthly returns of six stock indices of BSE and NSE during the post GFC (global financial crisis) period i.e., from 1st April 2008 to 31st March 2013 (over a period of 5 years). The study has used two non-parametric techniques namely Runs test and spearman's Rank correlation. Both the methods give almost consistent results and show that stock indices in BSE and NSE evidence weak form efficiency, and the random walk hypothesis. While rank correlation analysis tests the significance of rank correlation between stock indices returns of BSE and NSE, the runs test examines whether the events occur in a random order or not. The empirical results support the information efficiency and random walk hypothesis more in the case of daily stock return and weekly stock returns as compared to the case of stock indices returns on monthly basis. This might have occurred because of high degree of aggregation and relatively lesser observations of monthly stock returns. The paper concludes by discussing the implications of findings and suggestions for future research.

Keywords: Random walk Hypothesis, National Stock Exchange, Runs test, Spearman's Rank correlation, India,JEL Classification.

1.Introduction

According to Samuelson (1965) and Fama (1965), EMH supposes that share price adjust rapidly to appearance of new information, and thus, current stock prices fully reflect all available information. Hence it should follow a random walk process, which means successive stock price changes (returns) are independently and identically distributed. Fama (1965) had broken-down the market efficiency into three levels. First, the weak form of EMH reveals that current stock prices fully reflect all historical market information such as prices, trading volumes and any market-oriented information. Second, the semi-strong-form EMH states that stock prices adjust rapidly to all publicly available information such as earnings and dividend announcements, stock splits, bonus issues, economic and political news. Third, the strong-form EMH contends that stock prices reflects all information from historical, public and private sources, so that no one investor can realise abnormal rate of return. Fama (1970) defined an efficient market as a market that 'fully reflects' all available information in the price instantly and hence no scope should be left to earn abnormal profits. However, Levich (1979) has usefully demonstrated and counter the view that market efficiency necessarily implies that the prices should follow a random walk.

One of the most important issues is current research on Indian Capital Market is whether the stock market is efficient or not. When we talk about Indian capital market then we can say that it has witnessed a paradigm shift as par with the advanced markets of the world in the last ten years. India is one of the emerging market economies (EMEs) which is characterised as transitional which means that it is in the process of moving from a closed to an open market economy. It means that investors should not be able to consistently earn abnormal gains by analysing the historical prices. Hence one should not be able to make a profit from using something that everybody else knows. Where past studies have examined the weak-form of efficiency of various markets and the effect of globalisation and global financial crisis on the various sectors of developing and emerging economies, this paper attempts to study the weak form of efficiency of the Indian capital market in the period after the Global Financial Crisis (after year 2008) in the form of random walk.

2. Random Walk Model

Market efficiency implies that all 'possible to know' information is immediately discounted by the investors and reflected in the current price of the asset being traded in the market. If all the assets are fairly valued, the investors

will earn a return on their investment which is appropriate for the level of risk assumed. Thus, by knowing the degree of efficiency of the markets, the future prices and returns in the market can be estimated. A popular definition (Fama, 1970) is as follows : Weak form Market efficiency refers that the current prices fully reflect the information implied by the past prices (historical sequence of prices). This form has been designated as the random walk hypothesis (RWH). Random Walk theory is a special and restricted case of efficient market theory, which assumes that successive returns are independent and that returns are identically distributed over time. Evidence supporting the random walk model is evidence –suporting efficiency with respect to past returns.

To test the randomness of price movements in stock market, Rao and Mukherjee (1971) applied random walk model in the context of Indian capital market.
The random walk model says – that the price changes are independently and identically distributed i.e. the current price 'fully reflects' all the available information and the future prices are independent of past price behaviour.
Formally $f(r_{j,\,t+1}/\phi_t) = f(r_{j,\,t+1})$.,
where $r_{j,\,t+1}$ is the return expected to accrue at the time period t+1 and ϕ_t is the information set available at the time period t.
The empirical evidence in support of the random-walk hypothesis rests formerly on statistical tests, such as runs test, correlation analysis and filter test.
In this paper, an attempt is made to examine the random-walk behaviour of stock indices in the Indian capital market. For this purpose, the paper is divided into five sections including the present section. Section 2 reviews the existing literature and discuss the findings of major empirical researches conducted in India. Section 3 outlines the data sources, research design and the methodology. Section 4 discuss the results of the empirical tests for randomness of stock indices and its implications. Section 5 is devoted to summary and conclusion.

3. Literature Review

The applicability of the random walk hypothesis to the Indian capital market has not been investigated as much as in the USA or the UK stock markets. However, a number of studies have been reported during the last three decades. Most of these studies have employed runs test and serial correlation tests to test the randomness of the stock prices. Some have used spectral analysis and filter rule tests. Most of these studies have found that Indian stock prices follow a random walk. Simultaneously, some of them have rejected the null hypothesis that stock price changes are random. Several studies have been conducted on the weak form of market efficiency. Sharma and Kennedy (1977), Sharma (1983), Gupta (1985), Rao (1988) studied the applicability of the random walk hypothesis in Indian capital market and found the evidences supporting the weak form of EMH.

Sharma and Kennedy [1977] compared the behavior of stock indices of the Bombay, London and New York Stock Exchanges during 1963-1973 using runs tests and spectral analysis. Both runs tests and spectral analysis confirmed the random movement of stock indices for all the three stock exchanges. Kulkarni (1978) investigated the weekly RBI stock price indices for Bombay, Calcutta, Delhi, Madras and Ahmedabad stock exchanges and monthly indices of six different industries by using spectral method. He concluded that there is a repeated cycle of four weeks for weekly prices and seasonality in monthly prices. This study has thus rejected the hypothesis that stock price changes were random. Yalawar (1988) studied the month end closing prices of 122 stocks listed on the Bombay Stock Exchange during the period 1963-82. He used only the non-parametric tests- Spearman's rank correlation test and runs test. 21 out of 122 lag 1 correlation coefficients were significant at 5% level and 17 correlation coefficients were significant for lag 10. Runs tests also showed significant difference for 9 out of 122 stocks. These results appeared to contradict the random walk hypothesis. He concluded that the BSE was efficient at least in the weak form. Obaidullah (1990) conducted a study using the price series of 36 actively traded scripts, over the period January 1985 through December 1988. He found that out of the 720 serial correlation coefficients of lags 1 to 20, only 56 were more than twice standard errors and thus no significant serial dependence was observed. In the case of runs tests, only in one case the number of runs was found to be significantly different from the expected number of runs obtained from a series of random numbers. Thus the studies of Obaidullah supported the random walk hypothesis.

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Chowdhary (1991) disputed the contention of random behavior of stock prices. He studied 93 shares during the period January 1988 to April 1990 using runs tests and serial correlation tests. 70 first order serial correlation coefficients were observed to be significantly different from zero at 1% level. Sunil Poshakwale [1996] provided empirical evidence on weak form of efficiency and the day of the week effect in Bombay Stock Exchange over a period of 1987-1994. The results provide evidence of day of the week effect and that the stock market is not weak form efficient. Subrata Kumar Mitra [2000] conducted an empirical study with BSE-Sensex and found profitable trading opportunity in Indian Stock Market. He observed that returns exhibit positive serial correlation in short-term and when the effect of any information is not quickly absorbed in price, the possibility of slow adjustment causes serial correlation. Pradhan and Narasimhan (2002) investigated the behaviour of Indian stock price indices for 12 years from 1990 to 2001. Various tests of market efficiency suggested that the Indian stock market was growing informationally efficient and efficiency had increased over the time. The estimated results show that these markets are weak-form.

Verma and Rao (2007) examined the weak-form efficiency of BSE100 Index companies for three years. The serial correlation and run test exhibited that for the first two years market was not weak-form efficient, but the results of third year indicated that the market was weak-form efficient. Chander et al. (2008) studied empirical evidences on weak-form stock market efficiency for Indian scenario. Both parametric and non-parametric tests concluded the weak-form stock market efficiency and their results signalled that trading strategies which were based on historic prices could not be relied for abnormal gains consistently, except when these coincided with underlying drifts in the stock price movements. Siddiqui (2009) study focused on the current financial crisis and its impact on the growth, trade and employment in EMEs namely China and India. He concluded that the recession is bound to affect demand, capacity utilisation and employment in manufacturing industries catering for domestic markets. In India widespread banking crisis will create a serious credit crunch for traders.

Singh (2010) examined the impact of globalisation and capital market reforms on efficiency of the Indian stock market. She concluded the improved market efficiency. The study found that the stock market efficiency and volatility remain vulnerable to manipulation and major political and economic events in India and rest of the world. Easton and Kerin (2010) in their article focuses on market efficiency and the evidence provided by the GFC to refuse the efficient markets hypothesis. They noted that the GFC reinforces the idea that private information is not completely integrated into prices immediately. Mishra et al. (2010) studied the performance of Indian capital market with the recent GFC that originated from the US sub-prime mortgage market and spread over to the entire world as a contagion. They attempt to analyse the key market parameters such as market size, market liquidity, market turnover ratio, market volatility and market efficiency of Indian capital market over a period from 2002 to 2009 so as to assess its performance. The application of time series econometrics provides the evidence of greater volatility and weak form inefficiency of the market. However, the market shows strong potential for greater market size, more liquidity and reasonable market turnover ratio.

Thus in the Indian context, except for some of the studies, the available evidence in general indicates that the successive price changes are independent and the random walk model is appropriate to describe the stock price behavior.

4. Data and Research Methodology

The data for the purpose of this study is taken for three stock indices of BSE (namely, BSE Sensex, BSE-100, BSE-200) and three indices of NSE (namely NSE Nifty, NSE Junior and NSE Defty). The data pertains to the daily closing prices, weekly closing prices and monthly closing prices for each of the six stock indices. The data is collected during the post GFC (global financial crisis) period i.e., from 1st April 2008 to 31st March 2013 (over a period of 5 years), so that the sample size is large enough to obtain in greater degree of freedom for making inferences. This period is taken so as to study the impact of Global Financial Crisis (GFC) of year 2008 and its implication towards market efficiency in Indian stock market. The required data has been obtained from secondary sources like Bombay Stock Exchange Directory, NSE Newsletters and from the website facility of

Bombay Stock Exchange and National Stock Exchange, namely www.bseindia.com and www.nse-india.com respectively.

The paper tries to formulate a simple analytic framework regarding testing the null hypothesis which states that Indian stock market (characterized by stock indices of BSE and NSE) is random and efficient in the weak form. The daily weekly and monthly return in each stock indices is completed by using the following formula :

$$R_{d,t} \text{ (or } R_{w,t} \text{ or } R_{m,t}) = \frac{P_t - P_{t-1}}{P_{t-1}}$$

Where $R_{d,t}$, $R_{w,t}$, $R_{m,t}$ represent daily return, weekly return and monthly return respectively in the period t .P_t = Closing price of each stock indices for the current day, week or month (period t)
P_{t-1}= Closing price of each stock indices for the immediate previous time period (t-1)
This way, the paper analyses data on 60 monthly returns, 160 weekly return and above 740 daily return for each of the six stock indices.

In this paper, the random walk hypothesis is tested by Runs test and Spearman's Rank Correlation Analysis. Since both these tests are non-parametric, two tests are utilized in order to take care of statistical inefficiency of non-parametric tests.

Runs Test : One sample runs test is widely used to find out whether the process is random. Ray (1988) used run test for testing market efficiency. A run is a sequence of identical occurrences preceded and followed by different occurrences or by none at all. In this case, the statistic is :

$$Z = \frac{R - M}{\sqrt{V(R)}}$$

Where R stands for observed number of run, M is the expected number of runs and V(R) is the variance of Runs. The null hypothesis "***H_0 : Stock indices are Random***" is tested by the two-tailed distribution test. If the observed values of Z fall between the critical values like –2.58 and +2.58 at 1 percent level of significance, H_0 is accepted; otherwise H_0 is rejected.

Spearman's Rank Correlation Test : Yalawar (1986) conducted the Spearman's rank correlation test for testing the randomness in respect of Indian capital market. Spearman's rank correlation test is a test of correlation using the ranked data. It is a non-parametric test because this test uses the rank order and not the actual values for determining the association between two sets of values.
Under this test, the stock index value for two successive periods are used to estimate the stock returns as follows:

$$R_{j\,t} = (e_{j\,t} - e_{j\,t-1})/e_{jt-1}$$

Where, $R_{j\,t}$ is the stock (j) returns at time 't', $e_{j\,t}$ is the index value of 'j' stock index at the time period 't' (t=1,2,3,….n).

The ranks are given on the basis of return figures and ranked in descending order.

For each of the n values of variables, Stock returns (R_X)and the one-period lagged value of the stock returns (R_Y) are calculated and a "set of rank difference scores"(d) is obtained, that is

$$\mathbf{d} = R_X - R_Y = R_{j,t} - R_{j,t-1}$$

and then, the Spearman's Rank Correlation Coefficient is calculated as follows:

$$r_S = \frac{1 - 6\Sigma d^2}{n(n^2 - 1)}$$

where, r_S is the rank correlation for the stock indices returns, and 'd' is difference in the ranks for each pair of observations and 'n' is the number of period observations. In an ideal case, the correlation (r_s) between the ranks

should be zero. Statistical significance of the estimated rank correlation coefficient is tested with the help of F-statistic.

5. Empirical Result and Discussion

Run Test

The test is applied on the rates of stock indices returns on daily, weekly and monthly data to determines whether the stock indices movements are Random.

Case – I: Randomness of stock returns on the three BSE stock indices.
The null hypothesis tested in this case is as follows:
H_0 : ***"Daily, weekly and monthly returns on BSE Sensex, BSE 100 and BSE 200, each move Randomly" .***
The randomness results on the stock returns of the three stock indices of BSE, performed by runs test, are shown in Table 1. For BSE 100, while the hypothesis (H_0) is accepted for daily and weekly returns, it is rejected on basis of monthly stock returns (Z value of – 2.705 fails to i.e. between $\pm$ 2.58, for 1 percent significance level) In the case of both BSE Sensex and BSE 200, the null hypothesis assuming random behaviour of indices is accepted for daily, weekly and monthly stock returns, which reflects the efficiency of BSE stock indices.

Table 1, Summary Results of Runs Test in Case of Stock Indices Returns in BSE

Variables \ Particulars		Total Observations (n)	Actual Number of Runs (R)	Expected Number of Runs (M)	'Z' Value	Asymp. Significance (Two-Tailed)	Accept / Reject Ho (at 1% level of significance)
BSE Sen-sex	Monthly Stock Return	60	19	29	-2.251**	0.0120	Accept Ho *
	Weekly Stock Return	160	48	62	-2.117	0.000	Accept Ho *
	Daily Stock Return	739	212	227	-1.519	0.00112	Accept Ho *
BSE - 100	Monthly Stock Return	60	20	31	-2.705**	0.0115	Reject Ho *
	Weekly Stock Return	160	66	49	-1.973	0.000	Accept Ho *
	Daily Stock Return	740	218	235	-1.854	0.005	Accept Ho *
BSE - 200	Monthly Stock Return	60	21	28	-2.215	0.0041	Accept Ho *
	Weekly Stock Return	160	69	52	-2.100	0.0032	Accept Ho *
	Daily Stock Return	740	221	242	-1.872	0.0021	Accept Ho *

* Critical value of Z at 1% level of significance is $\pm$ 2.58 ; ** Significant at 5 percent level ; H_O : Stock Returns move Randomly

Case – II : Randomness of stock returns on NSE stock indices.
The null hypothesis tested is as follows :

H_0 : ***"Daily, weekly and monthly stock returns on each of NSE indices (namely, NSE Nifty, NSE Junior and NSE Defty) move Randomly".***
The result of the runs test on stock returns (daily, weekly and monthly) of the three NSE indices are presented in Table 2. It is found that the null hypothesis (H_0) has been accepted in the case of all the variables i.e. daily, weekly and monthly stock returns, for NSE Nifty, NSE Junior and NSE Defty. This indicates that at the returns level, National Stock Exchange (NSE) stock indices is efficient in all three cases of daily, weekly and monthly returns as per the Runs test.

Table 2: Summary Results of Runs Test in Case of Stock Indices Return in NSE

Variables / Particulars		Total Observations (n)	Actual Number of Runs (R)	Expected Number of Runs (M)	'Z' Value	Asymp. Significance (Two-Tailed)	Accept / Reject Ho (at 1% level of significance)
NSE Nifty	Monthly Stock Return	60	17	25	-2.317**	.0512	Accept Ho *
	Weekly Stock Return	160	54	73	-2.301	.0001	Accept Ho *
	Daily Stock Return	741	242	257	-2.117	.0021	Accept Ho *
NSE Junior	Monthly Stock Return	60	18	32	-2.798**	.005	Reject Ho *
	Weekly Stock Return	160	52	69	-2.317	.003	Accept Ho *
	Daily Stock Return	740	232	247	-2.171	.0062	Accept Ho *
NSE Defty	Monthly Stock Return	60	19	29	-1.819	.0017	Accept Ho *
	Weekly Stock Return	160	58	71	-1.925	.002	Accept Ho *
	Daily Stock Return	740	217	235	-1.572	.0052	Accept Ho *

* Critical value of Z at 1% level of significance is ± 2.58 ; ** Significant at 5 percent level ; H_O : Stock Returns move Randomly

Spearman's Rank Correction Test

This test has been applied for first differences of stock returns on daily, weekly and monthly basis. F-statistic has been used to determine whether the value of the rank correlation (r_s) is significant or not. If the calculated value of F-statistic (F_c) is smaller than its critical value (F_x), if implies that the value of the rank correlation is insignificant which supports the randomness hypothesis.

Table : 3,Summary Results Of Rank Correlation in The Case Of Stock Indices RETURN IN BSE

Variables		r_s value (Rank Correlation)	Calculated F-Value (F_C)	Critical Values of F-Statistic (F_K)#	Accept / Reject Ho (at 5 Percent Significant Level)
BSE Sensex	Monthly Stock Return	0.2524	F(1,59)=11.15	4.00	Reject Ho *
	Weekly Stock Return	-0.00152	F(1,159)=2.92	3.89	Accept Ho *
	Daily Stock Return	0.00629	F(1,738)=0.831	3.89	Accept Ho *
BSE - 100	Monthly Stock Return	-0.1521	F(1,59)=1.52	4.00	Accept Ho *
	Weekly Stock Return	-0.0723	F(1,159)=0.052	3.89	Accept Ho *
	Daily Stock Return	0.00057	F(1,738)=2.15	3.86	Accept Ho *
BSE-200	Monthly Stock Return	0.3215	F(1,59)=1.717	4.00	Accept Ho *
	Weekly Stock Return	-0.1125	F(1,159)=2.723	3.89	Accept Ho *
	Daily Stock Return	-0.0032	F(1,739)=3.516	3.86	Accept Ho *

* Decision *Rule : if $F_c > F_k$, reject Ho; otherwise accept Ho where K-1 is the d.f.(degree of freedom) for numerator and n-k is the d.f. for denominator.*

 # Critical values for F-statistic are the approximate values, and for 95 percent confidence level.
Ho Rank Correlation = $r_s = 0$

Case – I : Randomness of daily, weekly and monthly stock returns of three BSE stock indices.
The hypothesis being tested is :
H_0 : ***r_s (rank correction coefficient) = 0***.
The estimated coefficient of rank correlation, the calculated values of F-statistic and critical F-statistic for daily, weekly and monthly data of the three BSE stock indices (namely BSE Sensex, BSE 100 and BSE 200) are given in Table 3. It is observed that the null hypothesis(H_0) assuming randomness of stock indices has been accepted in all cases, for BSE 100 and BSE 200. For BSE Sensex, the hypothesis is accepted for weekly and daily returns while the same is rejected for monthly stock returns (rank correlation = 0.2524, is significant at 95% confidence level). The non-randomness of the monthly data may be due to the averaging process which has smoothened the data.

Table : 4,Summary Results of Rank Correlation in the Case of Stock Indices Return in NSE

Variables		r_s value (Rank Correlation)	Calculated F-Value (F_C)	Critical Values of F-Statistic (F_K)#	Accept / Reject Ho (at 5 Percent Significant Level)
NSE Nifty	Monthly Stock Return	-2.0027	F(1,59)=1.316	4.00	Accept Ho *
	Weekly Stock Return	-0.00174	F(1,159)=2.412	3.89	Accept Ho *
	Daily Stock Return	0.00059	F(1,740)=0.075	3.89	Accept Ho *
NSE Junior	Monthly Stock Return	-0.2717	F(1,59)=8.719	4.00	Reject Ho *
	Weekly Stock Return	0.00252	F(1,159)=3.614	3.89	Accept Ho *
	Daily Stock Return	0.00019	F(1,739)=1.814	3.86	Accept Ho *
NSE Defty	Monthly Stock Return	-0.1924	F(1,59)=0.917	4.00	Accept Ho *
	Weekly Stock Return	-0.0047	F(1,159)=1.747	3.89	Accept Ho *
	Daily Stock Return	-0.00037	F(1,739)=2.25	3.86	Accept Ho *

** Decision Rule : if $F_c > F_k$, reject Ho; otherwise accept Ho where K-1 is the d.f. (degree of freedom) for numerator and n-k is the d.f. for denominator.*
 # Critical values for F-statistic are the approximate values, and for 95 percent confidence level.
Ho Rank Correlation = $r_s = 0$
Case – II : Randomness of stock return of the three NSE indices.
The Null hypothesis been tested is **:** H_0: ***$r_s = 0$***
(for daily, weekly and monthly stock return for each of NSE Nifty, NSE Junior and NSE Defty). Table 4 presents the estimated rank correction coefficients, critical values and calculated valves of F-statistic for NSE stock indices, in a manner to decide about the acceptance or rejection of H_0 (null hypothesis). Both NSE Nifty and NSE Defty stock returns evidence random behaviour on each parameters of daily, weekly and monthly returns, since the null hypothesis (H_0) is accepted. For NSE Junior, the null hypothesis (H_0) is rejected for monthly return (r_s = -0.2717) out accepted on basis of both daily and weekly stock returns.

6. Summary and Concluding Remarks

Table 5 shows the overall results of hypothesis testing of randomness of stock returns of BSE and NSE indices, based on runs test and rank correlation. The null hypothesis (of random behaviour of stock returns) is accepted for

all six stock indices based on daily return and weekly stock returns. In case of monthly stock returns, runs test showed that five stock indices (excluding BSE 100) evidence acceptance of null hypothesis implying random behaviour. Rank correlation analysis concluded that for four indices (namely BSE 100, BSE 200, NSE Nifty and NSE Defty). The monthly returns were random. The null hypothesis was rejected for the remaining two, i.e. BSE Sensex and NSE Junior. However, the runs test approves randomness of these stock indices of both BSE and NSE. Thus out of 36 cases of hypothesis testing (Table 5), the null hypothesis (randomness of stock return) was accepted in 33 cases (above 92 percent) which is a strong evidence of random walk hypothesis in the Indian Stock Market.

Table : 5summary Results Showing Stock Indices Efficiency in BSE & NSE by Both Runs Test and Rank Correlation Test

Variables		Runs Test			Rank Correlation Test		
		Monthly Stock Returns	Weekly Stock Returns	Daily Stock Returns	Monthly Stock Returns	Weekly Stock Returns	Daily Stock Returns
BSE	Sensex	Accept Ho	Accept Ho	Accept Ho	Reject Ho	Accept Ho	Accept Ho
	BSE-100	Reject Ho	Accept Ho	Accept Ho	Accept Ho	Accept Ho	Accept Ho
	BSE-200	Accept Ho	Accept Ho	Accept Ho	Accept Ho	Accept Ho	Accept Ho
NSE	NSE Nifty	Accept Ho	Accept Ho	Accept Ho	Accept Ho	Accept Ho	Accept Ho
	NSE Junior	Reject Ho	Accept Ho	Accept Ho	Reject Ho	Accept Ho	Accept Ho
	NSE Defty	Accept Ho	Accept Ho	Accept Ho	Accept Ho	Accept Ho	Accept Ho

Thus, on the whole, the study supports the informational efficiency more in the case of daily and weekly return of BSE and NSE stock indices as compared to monthly stock returns. It is suggested that the future research on random walk hypothesis in the Indian context may test 1) the randomness of individual scrips with respect to market index ii) the effect of number of securities in the various stock indices on the random behaviour of stock return and iii) the effect of market conditions and other information flow on randomness of stock indices returns.

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