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RANDOM WALK TESTS FOR ASSESSING SUSTAINABILITY IN INDIAN STOCK MARKET

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1. Introduction

The complexity of the integrated techno-socioeconomic systems and their interactions with the natural environment are driving attention in several areas like stock market. These areas include means for understanding the emergent dynamics of these interactions and supporting better decision making through predictive simulation and system adaptation. At the heart of this is the notion of a model, an abstraction created for a specific purpose like maximization of return from investment.

Stock market is one and only platform for the buyers and sellers for trading their stocks and bonds. During the past three decades, many companies have been listed regularly in the stock markets and invested huge funds from their capital. When the companies obtain their capital need, the shareholders will benefit through dividends paid by companies.

Appetite of risk is among one of the factors that influence the investor decision. On the risk appetite investors are classified as- Risk tolerant investor and risk averse investors. Risk tolerant invertors have a large appetite of risk as compared to risk averse. The main objective of risk tolerant is to earn more profit and of averse is capital prevention. Apart from these, the other factors that affect the investor decision are economic growth of the nation, market stability, market risks, interest rate, availability of choices, etc.

The random walk models for stock market index consider the following model:

$$I_t = I_{t-1} + e_t$$

where I_t is the index series and the error term,e_t, is random.

2. Literature review and research gap

Sharma (1983) indicated in his study that a minimum of weak form of random walk was compliant for the BSE (Bombay Stock Exchange whose index was subsequently labeled Sensex), considering 23 stocks listed in BSE between the time span of 1973 and 1978. Fama (1970) found that stock prices moved in line with fundamentals. But empirical researches since then have raised doubts about this observation. Shiller (1981) found stock prices to be more volatile than what would be warranted by economic events.

Fama and French (1988) found negative serial correlation which is in contrary with positive autocorrelation observed by Lo and MacKinlay (1991).

Parameswaran (2000) executed variance ratio tests to demonstrate that 80% size sorted portfolios don't follow a random walk and also observed that non-trading is not a reason for serial correlation within big sized companies.

Kim, Nelson and Startz (1991) examined the random walk process of stock prices by using weekly and monthly returns in five Pacific-Basin stock markets. The results provided evidence that the mean reversion was only a characteristic of the pre-World War II period, and not a feature of the post-war era. They found that the variance ratio tests created positive serial correlation.

Pan et al. (1991) examined the forecastability of stock returns based on daily and weekly return data for a five-year sample period in five Asian stock markets, namely, Hong Kong, Japan, Singapore, South Korea, and Taiwan. They inferred that every return based on the market indices of said five countries were positively auto-correlated except Japan.

Barman and Madhusoodanan (1993) used variance ratio test to conclude that in general, Indian market is mean reverting. Ayadi and Pyun (1994) showed that South Korean market does not follow random walk, indicating its forecastability, when tested under homoscedastic error term assumption and follows random walk when the test statistic is corrected for heteroscedasticity.

Ming, Nor and Guru (2000) showed that trading rules like variable length moving average (VMA) and fixed length moving average (FMA) have predictive ability of earning profits over and above the transaction costs. They rejected random walk for Kuala-Lampur stock exchange.

Darrat & Zhong (2000) advised artificial neural network (ANN) based models as strong tools for forecasting prices in the stock exchanges of China and developing countries.

Grieb & Reyes (1999) indicated non-random behavior in the Mexican market while the Brazilian market showed evidence in favor of the random walk using variance ratio on weekly stock returns.

Koh & Goh (1994) showed that the Malaysian stock market followed random walk in the long term by extending the framework of Cochrane (1988).

In the present study, the performances of sector-wise sensitivity indices have been compared with the help of random walk hypotheses testing for comparing their performances in order to assess the market efficiency and hence sustainability of Indian stock market, for which there was a long-felt need of such work.

3. Objective of the study and methodology

The objective of this paper is to investigate whether Indian stock markets' sector wise indices follow a random-walk hypothesis as mandated by market efficiency

within the sector. The primary objective of present research is to assess the forecast-ability of performance of various sectors in Indian stock market. As sectors' performance is represented by sensitivity index of respective sector, forecast-ability of relevant index is examined under present research. Stock market indices are used to evaluate presence or absence of random walk in the price generation process in a stock market.

There are many indices available that are used as the sign of the performance of Indian stock markets. These indices are constructed based on different methods and hence are expected to behave differently. Stock market Sensex is a popular choice for this study, as it is the most common market index and highly used by investors for benchmarking. Availability of data on Index for a longer period of time is an extra advantage for the research.
The following list depicts 4 types of Random Walk hypotheses.

Random Walk 1 (RW1): Independent and Identical Increment

Random Walk 2 (RW2): Independent Increment

Random Walk 3 (RW3): Uncorrelated Increment

Martingale: Fair Game

Testing of Random Walk 1 hypothesis is done using Cowles-Jones ratio (CJ)

Given a sample of n+1 returns $r_1, \ldots, r_{n+1}$, the number of sequences Ns and reversals Nr may be expressed as simple functions of the It's.

$$N_s \equiv \sum_{t=1}^{n} Y_t \ , Y_t \equiv I_t I_{t+1} + \ (1 - I_t)(1 - I_{t+1})$$

$$N_r \equiv n - N_s$$

$$\mathrm{CJ} \equiv \frac{\mathrm{N_s}}{\mathrm{N_r}} = \frac{\mathrm{N_s/n}}{\mathrm{N_r/n}} \ = \ \frac{\mathrm{p}}{1 - \mathrm{p}} \rightarrow 1$$

Testing of Random Walk 2 hypothesis is done using 1% Filter rules defined by Alexander (1961, 1964). As per Filter Rule an asset is purchased (long) when its price increases by *x*%, and sold (short) when its price drops by *x*%.

Testing of Random Walk 3 hypothesis is done using Ljung and Box (1978) statistic which is determined by following equation for a finite sample:

$$Q_m \equiv \mathrm{T(T+2)} \sum \rho^2 \,(\mathrm{k})/(\mathrm{T-k}) \qquad \text{where k=1, 2, …, } m$$

4. Results and discussion

Selection of sectors is important to get proper and comprehensive test results.

Following eight sectors are selected for this research to collect sector-wise daily index data from 01 April 2016 to 31 March 2021. Sectors with respective index:

1) Integrated Oil & Gas (S&P BSE OIL&GAS)
2) Banks (S&P BSE FINANCE)
3) IT Consulting & Software (S&P BSE INFORMATION TECHNOLOGY)
4) Iron & Steel (S&P BSE METAL)
5) Pharmaceuticals (S&P BSE HEALTHCARE)
6) Construction & Engineering (S&P BSE INFRASTRUCTURE)
7) Cigarettes &Tobacco products (S&P BSE FAST MOVING CONSUMER GOODS)
8) Telecom Services (S&P BSE TELECOM).

The above sectors cover a major share of market capitalization.

Following results are observed after testing Random Walk 1 by Cowles-Jones Statistic.

Table 2.Random Walk 1 Test Result (Time Period: 01 April 2016 to 31 March 2021)

Statistic/Attribute	**BSE SENSEX**	**BSE FINANCE**	**BSE INFORMATION TECHNOLOGY**	**BSE HEALTH CARE**	**BSE TELECOM**	**BSE OIL&GAS**	**BSE METAL**	**BSE INFRASTRUCTURE**	**BSE FAST MOVING CONSUMER GOODS**
Sequence Count (Ns)	653	652	615	688	615	639	642	668	623
Reversal Count (Nr)	583	584	621	548	621	597	594	568	613
Cowles-Jones Statistic (Ns/Nr)	1.12	1.12	0.99	1.26	0.99	1.07	1.08	1.18	1.02
Random Walk Test :Does index follow Random Walk 1 ? (YES if 0.95<CJ<1.05)	NO	NO	YES	NO	YES	NO	NO	NO	YES

From the test result shown in Table No. 2, it is observed that following three sectors follow Random Walk 1.

1. Information Technology
2. Telecom
3. Fast Moving Consumer Goods

It is also observed that following five sectors do not follow Random Walk 1.

1. Finance
2. Healthcare
3. Oil & Gas
4. Metal
5. Infrastructure

The sectors which follow Random Walk 1, do not follow any past movement pattern and hence their future movement cannot be predicted by their historic data. On the other hand, forecasting is possible for the sectors not following Random Walk 1, as they follow some pattern of movement, which can be modeled by Time Series Analysis (like ARIMA) and Regression Analysis (linear or non-linear).

Long term data is required to test RW2 as it tries to identify the Trend in time series data. We need at least 30 years' index data to test RW2, which is not possible at this moment. However, we have still applied 1% Filter Rule on five years' data (Time Period: 01 April 2016 to 31 March 2021) and have obtained test results shown in Table 3.

Table 3.Random Walk 2 Test Result (Time Period: 01 April 2016 to 31 March 2021)

1% Filter Rule	BSE SENSEX	BSE FINANCE	BSE INFORMATION TECHNOLOGY	BSE HEALTH CARE	BSE TELECOM	BSE OIL&GAS	BSE METAL	BSE INFRASTRUCTURE	BSE FAST MOVING CONSUMER GOODS
Number of days having >=1% Increase (X)	141	218	221	197	270	249	347	235	162
Number of days having >=1% Decrease	126	181	172	180	297	217	293	205	130

(Y)								
1% Change Ratio R=(X/Y)	1.12	1.20	1.28	1.09	0.91	1.15	1.18	1.15	1.25
Does the sector follow Random Walk 2? YES if 0.95<R<1.05	NO	NO	NO	NO	NO	NO	NO	NO	NO

The results are shown in Table No. 4 after testing Random Walk 3 using Box-Ljung Statistic.

Null Hypothesis: H_0: Sector Index follows Random Walk 3 (uncorrelated increments)
Alternative Hypothesis: Ha: Index does not follow Random Walk 3 (uncorrelated increments)
at significance level of 5%.

Table 4. Random Walk 3 test result (Time Period: 01 April 2016 to 31 March 2021)

		BSE SENSEX		BSE FINANCE		BSE INFO TECH		BSE HEALTHCARE		BSE TELECOM		BSE OIL&GAS		BSE METAL		BSE INFRASTRUCTURE		BSE FAST MOVING CONSUMER GOODS	
Lag	Sig	Autocorrelation	Box-Ljung Value	Autocorrelation	Box-Ljung Value	Autocorrelation	Box-Ljung Statistic Value	Autocorrelation	Box-Ljung Statistic Value	Autocorrelation	Box-Ljung Value	Autocorrelation	Box-Ljung Value	Autocorrelation	Box-Ljung Value	Autocorrelation	Box-Ljung Statistic Value	Autocorrelation	Box-Ljung Statistic Value
1	0	0.994	1226.3	0.993	1224.74	0.995	1228.289	0.994	1226.86	0.993	1223.1	0.991	1219.7	0.995	1228.6	0.996	1231.945	0.993	1224.468
2	0	0.988	2438.8	0.986	2433.01	0.99	2444.831	0.988	2440.089	0.986	2430	0.982	2418.6	0.99	2446.1	0.992	2455.19	0.987	2434.219
3	0	0.982	3637.7	0.979	3624.93	0.985	3651.067	0.983	3640.295	0.979	3622	0.973	3595.9	0.985	3652.4	0.988	3668.968	0.981	3629.469
4	0	0.976	4823.7	0.972	4801.29	0.981	4847.087	0.977	4827.732	0.973	4799.7	0.964	4751.9	0.981	4848.5	0.984	4873.377	0.974	4810.28
5	0	0.97	5995.7	0.965	5961.08	0.976	6032.161	0.971	6001.605	0.967	5963.6	0.955	5887	0.976	6033.7	0.979	6067.665	0.967	5975.093
6	0	0.963	7151.9	0.957	7102.02	0.97	7205.313	0.965	7161.427	0.96	7112.2	0.945	6999.9	0.97	7207.2	0.974	7250.825	0.96	7122.434
7	0	0.957	8294	0.949	8226.11	0.965	8367.184	0.959	8307.833	0.953	8245.2	0.936	8093.1	0.965	8369.3	0.97	8423.864	0.953	8254.36
8	0	0.95	9421.6	0.941	9332.31	0.96	9518.014	0.953	9440.639	0.946	9361.9	0.927	9166.1	0.96	9519.3	0.965	9586.334	0.945	9369.706
9	0	0.944	10535	0.933	10420.6	0.955	10657.931	0.947	10560.586	0.939	10463	0.918	10219	0.955	10658	0.96	10737.788	0.939	10470.611
10	0	0.938	11635	0.925	11490.3	0.95	11786.058	0.941	11666.945	0.932	11548	0.909	11253	0.95	11785	0.955	11877.71	0.933	11557.706
11	0	0.931	12719	0.916	12540.2	0.945	12902.225	0.934	12759.326	0.924	12615	0.9	12265	0.944	12900	0.949	13005.249	0.926	12630.253
12	0	0.924	13789	0.907	13571.1	0.939	14007.169	0.928	13838.172	0.916	13665	0.89	13256	0.938	14002	0.944	14120.339	0.92	13689.464
13	0	0.917	14843	0.898	14582	0.934	15100.642	0.922	14902.821	0.907	14697	0.88	14226	0.932	15092	0.938	15221.982	0.913	14734.642
14	0	0.91	15882	0.889	15572.7	0.929	16182.442	0.915	15953.059	0.899	15710	0.87	15176	0.926	16169	0.932	16310.294	0.907	15766.914
15	0	0.903	16906	0.88	16544.6	0.924	17253.365	0.909	16990.666	0.891	16706	0.861	16106	0.921	17233	0.926	17386.576	0.901	16786.685
16	0	0.896	17915	0.871	17498.1	0.919	18313.654	0.903	18015.782	0.883	17686	0.851	17016	0.915	18286	0.92	18450.737	0.895	17794.053

Test Hypotheses are given below:

H_0: Sector wise Index follows uncorrelated increments (RW3)
Ha: Sector wise Index does not follow uncorrelated increments (RW3)
at 5% significance level

As obtained Significance values for all sectors are less than 0.05, hence we can say that H_0 is rejected

Hence, Sector wise Index does not follow uncorrelated increments (RW3) for selected eight sectors.

From the above test result, it is observed that following eight sectors do not follow Random Walk 3.

1. Information Technology
2. Telecom
3. Fast moving consumer goods
4. Finance
5. Healthcare
6. Oil & Gas
7. Metal
8. Infrastructure.

Hence, the selected eight sectors do not follow the uncorrelated increments which imply that the sector wise indices have no linear autocorrelation.

5. Conclusion

Random Walk of stock market indices is closely related to sustainability of economy. Now-a-days capital maker plays a major role for any economic growth. Hence, compliance to Random Walk characteristics helps to improve the overall performance of stock market and economy.

As per test results of present research, none of selected eight sectors follow Random Walk 3, but only three sectors follow Random Walk 1. Information Technology, Telecom and Fast Moving Consumer Goods follow RW1. The market is highly efficient in these three sectors. However, the market is not that much efficient for other five sectors which do not follow RW1, which means the relevant information is not properly disseminated among all stake holders of market within the sector. No sector follows Random Walk 2 and Random Walk 3 as per our test result which implies that sector wise indices do not follow purely independent increments and uncorrelated increments. There is a Trend present in

the index data. However, this inference can be further confirmed by testing with a data set of longer period (at least 30 years'). Finally, higher market efficiency or compliance to Random Walk leads to higher sustainability of economy as a whole and Stock Market needs to increase the market efficiency. The stock market should reduce information barriers and improve information dissemination among stake holders to achieve higher market efficiency. Efficient market supports perfect competition among market players and sustainable economic growth.

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