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An empirical re-examination of the weak form efficient markets hypothesis of the Indian stock market using Q statistic

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Abstract
Lee (1992) employed variance ratio test to examine whether weekly stock returns of the United States and 10 industrialized countries: Australia, Belgium, Canada, France, Italy, Japan, Netherlands, Switzerland, United Kingdom and Germany follow a random walk process for the period 1967-1988. He found that the random walk model was still appropriate characterization of weekly return series for majority of these countries. Annuar *et al*. (1993) addressed similar issue but using indices data in place of individual stocks, covering sample period from January 1977 to May 1989, with weekly and monthly intervals. The results from unit root analysis, serial correlation test and Q statistics strongly suggested that the KLSE was weak form efficient, though, once again, pockets of inefficiency were reported for some indices.

Keywords: Modern period, random walk model, serial correlation test, variables, India

1. Introduction
Fama (1991) developed new classification for market efficiency: first, test for return predictability instead of weak form test; second, event studies instead of semi strong form test; third, test for private information instead of strong form test. For return predictability, he focuses on forecasting return with other variables like dividend yields and interest rate, test of assets pricing models and anomalies, and test for seasonal return and the volatility in security prices. On the other hand, event study is the clearest evidence of market efficiency because it gives a picture of the speed of price adjustment to new information. The test for market efficiency is conducted in event study with respect to the information about investment decisions, dividends changes, change in capital structure and corporate control transactions. Testing market efficiency with respect to private information can be performed by testing corporate insiders' activities, change in value line's rankings, analysts' survey and pension and mutual fund activities.

1.1 Definition of Efficient Market Hypothesis (EMH)
The primary hypothesis for EMH is that stock prices accurately and quickly reflect all the available information in such a way that no one can earn abnormal return. The time for the adjustment for any new information is considered a critical factor; if the market adjusts more rapidly and accurately, it is considered more efficient. Dyckman and Morse (1986) state "A security market is generally defined as efficient if (i) the price of the security traded in the market act as though they fully reflect all the available information and (ii) these prices react instantaneously, or nearly so, and in an unbiased fashion to new information".
The alternative hypothesis is that security market is inefficient and that result of stock price is not accurately reflecting the new information. Bansal Monica (2011) [16] This might result from the following: the investor is unable to interpret the new information correctly; the investors have no access to the new information; the transaction cost in trading security is an obstruction for free trading; the restriction on short selling and; finally, the investors might be misled by the change in accounting principles.

2. Review of Literature

Kok and Lee (1994) [1] analyzed the stock prices behaviour of 32 companies listed on the Second Board of KLSE over the period 2 January 1992 to 30 December 1994. The results from various statistical tests- runs test, serial correlation test, Ljung-Box-Pierce Q test and Von Neumann's ratio test, suggested that information based on historical prices was fully reflected in current price within a week but might not be fully impounded in current price within a day. Thus, the Second Board of KLSE was weak-form efficient with respect to weekly data. Though daily price series were serially correlated, the magnitude of their correlations was not large enough to devise any mechanical trading rules for profitable investment timing.

Belgaumi (1995) [2] studied on the weak form of market efficiency for a period of 1st April, 1990 to 31st March, 1992 with the help of 70 companies listed in the A category on the Bombay Stock Exchange and also listed and traded in the Calcutta, Madras and Ahmedabad Exchanges. The study analysed two sets of data i.e. the first set considered the Economic Times All India Index of Ordinary Shares which have the base year 1985. The second set was individual weekly share prices series of selected companies. The study used two tests, first was serial correlation coefficients computed from legs 1 to lags 10 and second was run test of consecutive price changes of the same sign were analysed. The study noted that first order coefficients were small in magnitude and statistically insignificant in almost all the cases. Out of the 70 serial correlation coefficients for lag 1, only one was statistically significant. The coefficients of other five companies were found to be greater than twice the standard error. In the higher order, serial coefficients also did not depict statistically significant relationship except for Standard Industries whose coefficients was greater than three times the standard error. In contrast, the stocks which showed temporal dependence as a result of serial correlation test, the runs test results did not show any non-random behaviour. On the basis of results of both the test used, it can be identified that the Indian Stock market were efficient in weak form.

Kok and Goh (1995) [3] studied the weak form efficiency and mean reversion in the Malaysian Stock Market and addressed the issue of weak form market efficiency in the Malaysian case by examining the random walk behaviour of stock prices over the short run in the KLSE using the closing levels of the seven KLSE stock indices: Composite Index, Emas Index and the five sectorial indices. The tests employed are run tests, serial correlation test, Ljung-Box-Pierce Q test and the von Neumann's ratio test, which are based on returns of short horizons.

Huang (1995) [4] examined the efficiency of nine Asian stock markets: Hong Kong, Indonesia, Japan, Korea, Malaysia, Philippines, Singapore, Thailand and Taiwan by using the variance ratio statistic with both assumptions homoscedastic and heteroskedastic. The data consisted of weekly stock returns of nine stock market indexes from the period 1988 to 1992. Excluding the market in Indonesia, Japan and Taiwan, the random walk hypothesis for the remaining markets is rejected. The result of variance ratio exceeded one in the markets of Korea, Malaysia, Hong Kong, Thailand and Philippines, indicating the presence of positive serial correlation. The hypothesis for markets of Korea and Malaysia was rejected for all holding periods, whereas the hypothesis for the Hong Kong, Singapore, and Thailand markets was also rejected by the use of heteroscedasticity-consistent variance ratio estimator.

3. Objective of the Study

The main objective of this research paper is to make a comparative study of the results under Runs Test, Serial Correlation and Q-Statistics of the Individual Stocks of Indian Stock Market.

4. Analysis and Interpretation

Comparison of the results under Runs Test, Serial Correlation and Q-Statistics

Empirical Results of the First Phase

During the first sub-period, the market has shown efficiency in weak form on the basis of majority of the stocks behaviour. In the first phase, out of 73 companies 3 companies have significant z-value at 5 per cent level and at 10 per cent level, there are 7 companies which have a significant z-value. There was no company which showed non-random pattern in weekly return series when examined at 99 per cent level of confidence. The results of autocorrelation for 73 companies are available for this phase. Out of 1168 autocorrelation matrices, there were 57 (4.88 per cent) coefficients which showed their value significant at 5 per cent and 5 (0.43 per cent) at 1 per cent level of significance. The results reported by the Q-statistics is that 13.70 (26.3 per cent) Q-statistics coefficients were significant at 5 per cent level, while the same has been reduced to 5.48 (32.0 per cent) at 10 per cent level of significance.

Results and Bear Market Phenomenon

During the bear market phenomenon, total cases were 156 in Runs test. Out of 89 sampled stocks, there is one company i.e. Hero Honda having significant z-value at 5 per cent, 2 companies at 10 per cent and 2 companies at 1 per cent level. These stocks showed non randomness by having z value significant at various levels. In the serial correlation coefficients, 76 (about 5.39 per cent) were significant at 5 per cent and 14 (about 0.99 per cent) were significant at 1 per cent level of significance. Also it has been found that 729 (about 51.77 per cent) were negative, 673 (about 47.80 per cent) were positive and 6 (0.43 per cent) were zero. The dominance of negative values shows depressed stock market conditions during the sub-period. However, the overall insignificance points to the efficiency of the markets in weak form. Although the results did not fully support the weak form efficiency but it gave strong evidence in favour of independence in the weekly return series of BSE Sensex index. The Q-statistics has reported that 10.21 (26.3 per cent) stocks showed significant value at 5 per cent level and 10.21 (32.0 per cent) at 10 per cent level.

Results and Bull Market Phenomenon

A total of 263 cases were reported in the Runs test. The results obtained during bull market have revealed that the mean returns were positive in case of 92 stocks out of 94 sampled stocks. Only two stocks showed negative mean returns. At 1 per cent level of significance, only one stock has reported significant z-value. Further when examined through z-value at 5 and 10 per cent level, there were 6 companies showing significant value at 5 per cent and 5 companies at 10 per cent level. In serial correlation, there were 1504 autocorrelation matrices. Out of 1504

autocorrelation matrices, there were 89 (5.92 per cent) coefficients which showed their value significantly different from zero for all 94 companies, in which 70 (about 4.65 per cent) were found significant at 5 per cent level of significance and 19 (1.26 per cent) at 1 per cent level of significance. The table also signifies that out of the total 1504 serial correlation coefficients,732 (about 48.67 per cent) were having negative values, 759 (about 50.46 per cent) had positive values while the remaining 13 (0.86 per cent) had experienced zero values. Therefore, the results strongly supported the successive independence of the stock return series of the sampled companies. Under Q-statistics, 8.51 (26.3 per cent) coefficients were significant at 5 per cent level while the same has reduced to 7.45 (32.0 per cent) at 10 per cent level of significance.

Empirical Results of the Fourth Phase

The fourth and last phase of the present study has documented evidences in favour of weak form efficiency when tested the Indian capital market through various tests. During the fourth sub-period, 99 companies out of 109 have shown positive mean returns in the Runs test. Only 10 companies have shown negative mean returns. The total cases during this sub-period were 153. There were 9 companies showing significant value at 5 per cent and 6 companies at 10 per cent. At 1 per cent level of significance, there is strong evidence in favour of stocks following random walk as there is not a single stock having significant value.

194 (about 11.12 per cent) coefficients were noted significant out of total 1744 coefficients in the serial correlation. Out of the total 1744 serial correlation coefficients, 775 (44.43 per cent) were having negative values, 962 (55.16 per cent) had positive values while the remaining 7 (0.40 per cent) had experienced zero values. The examination of the significance of correlation coefficients in relation to its levels reveals that a handful of 168 coefficients (9.63 per cent) were noted significant at 5 per cent and 26 (1.49 per cent) were found significant at 1 per cent level. On the whole, it is observed that the Indian stock market is efficient in its weak form during this sub-period. 14 companies out of 108 have shown significant value at 5 per cent which is 12.96 per cent when examined through Q-statistics. Further, when examined at 10 per cent level, there were 24 companies showing significant value i.e. 22.22 per cent.

Table 1: Box-Ljung Q-Statistic based on Autocorrelation Matrices (2003-2008)

Code	Name of Company Stock	Q-Statistics	Code	Name of Company Stock	Q-Statistics
1	A B B Ltd.	17.906	29	Exide Industries Ltd.	13.342
2	Aban Offshore Ltd.	23.888	30	Federal Bank Ltd.	11.196
3	A C C Ltd.	23.625	31	G A I L (India) Ltd.	28.444**
4	Adani Enterprises Ltd.	11.931	32	Glaxosmithkline Consumer Healthcare Ltd.	18.598
5	Aditya Birla Nuvo Ltd.	13.272	33	Glaxosmithkline Pharmaceuticals Ltd.	11.194
6	Ambuja Cements Ltd.	19.155	34	Godrej Industries Ltd.	14.813
7	Apollo Hospitals Enterprise Ltd.	12.516	35	Grasim Industries Ltd.	15.795
8	Apollo Tyres Ltd.	30.847**	36	Great Eastern Shipping Co. Ltd.	6.211
9	Ashok Leyland Ltd.	13.610	37	H D F C Bank Ltd.	182.853*
10	Asian Paints Ltd.	29.777**	38	H M T Ltd.	13.263
11	Aurobindo Pharma Ltd.	25.328	39	Havells India Ltd.	6.887
12	Bajaj Holdings & Invst. Ltd.	33.455*	40	Hero Honda Motors Ltd.	13.931
13	Bank Of Baroda	21.588	41	Hindalco Industries Ltd.	10.802
14	Bharat Electronics Ltd.	22.825	42	Hindustan Petroleum Corpn. Ltd.	27.838*
15	Bharat Forge Ltd.	20.893	43	Hindustan Unilever Ltd.	12.596
16	Bharat Heavy Electricals Ltd.	17.061	44	Hindustan Zinc Ltd.	158.144*
17	Bharat Petroleum Corpn. Ltd.	31.087**	45	Housing Development Finance Corpn. Ltd.	41.592*
18	Bhushan Steel Ltd.	26.024	46	I D B I Bank Ltd.	9.795
19	Bosch Ltd.	15.181	47	I F C I Ltd.	17.595
20	Castrol India Ltd.	140.297*	48	I T C Ltd.	13.999
21	Century Textiles & Inds. Ltd.	18.856	49	Indian Hotels Co. Ltd.	13.306
22	Chambal Fertilisers & Chemicals Ltd.	19.921	50	Indian Oil Corpn. Ltd.	27.136**
23	Cipla Ltd.	15.693	51	Infosys Ltd.	18.846
24	Container Corpn. Of India Ltd.	11.794	52	J S W Ispat Ltd.	19.080
25	Crompton Greaves Ltd.	12.796	53	J S W Steel Ltd.	14.149
26	Cummins India Ltd.	19.128	54	Jain Irrigation Systems Ltd.	15.928
27	Dabur India Ltd.	10.401	55	Jindal Saw Ltd.	7.101
28	Dr. Reddy'S Laboratories Ltd.	8.010	56	Kotak Mahindra Bank Ltd.	10.732
57	L I C Housing Finance Ltd.	15.823	76	Shree Cement Ltd.	10.108
58	Lupin Ltd.	35.187*	77	Shriram Transport Finance Co. Ltd.	23.479
59	Mahindra & Mahindra Ltd.	16.676	78	Siemens Ltd.	10.058
60	Marico Ltd.	17.696	79	Sintex Industries Ltd.	2.169
61	N C C Ltd.	16.504	80	State Bank Of India	8.872
62	National Aluminium Co. Ltd.	14.072	81	Steel Authority Of India Ltd.	0.354
63	Neyveli Lignite Corpn. Ltd.	21.720	82	Sterlite Industries (India) Ltd.	27.836**
64	Oil & Natural Gas Corpn. Ltd.	22.691	83	Sun Pharmaceutical Inds. Ltd.	38.672*
65	Oriental Bank Of Commerce	10.580	84	Tata Communications Ltd.	7.006
66	Pantaloon Retail (India) Ltd.	24.287	85	Tata Global Beverages Ltd.	15.958
67	Piramal Healthcare Ltd.	16.164	86	Tata Motors Ltd.	17.457
68	Rajesh Exports Ltd.	21.553	87	Tata Power Co. Ltd.	16.135
69	Ranbaxy Laboratories Ltd.	26.114	88	Tata Steel Ltd.	27.487**

70	Rashtriya Chemicals & Fertilizers Ltd.	18.661	89	Thermax Ltd.	22.329
71	Reliance Capital Ltd.	23.574	90	Titan Industries Ltd.	10.585
72	Reliance Industries Ltd.	12.465	91	United Phosphorus Ltd.	5.761
73	Reliance Infrastructure Ltd.	22.675	92	Voltas Ltd.	17.329
74	Sesa Goa Ltd.	16.742	93	Wipro Ltd.	12.455
75	Shipping Corpn. Of India Ltd.	5.246	94	Zee Entertainment Enterprises Ltd.	23.625

Source: Data Compiled from CMIE – Prowess database.

** Significant at 5 per cent level of significance. * Significant at 10 per cent level of significance.

Table 2: Box-Ljung Q-Statistic based on Autocorrelation Matrices (2008-2011)

Code	Name of Company Stock	Q-Statistics	Code	Name of Company Stock	Q-Statistics
1	A B B Ltd.	11.565	28	Coromandel International Ltd.	38.512*
2	Aban Offshore Ltd.	38.467*	29	Crompton Greaves Ltd.	19.531
3	A C C Ltd.	22.925	30	Cummins India Ltd.	10.854
4	Adani Enterprises Ltd.	17.876	31	Dabur India Ltd.	18.150
5	Aditya Birla Nuvo Ltd.	30.863**	32	Dr. Reddy'S Laboratories Ltd.	13.353
6	Ambuja Cements Ltd.	14.667	33	Essar Oil Ltd.	23.757
7	Apollo Hospitals Enterprise Ltd.	29.211**	34	Exide Industries Ltd.	22.371
8	Apollo Tyres Ltd.	22.231	35	Federal Bank Ltd.	30.680**
9	Areva T & D India Ltd.	32.016*	36	Financial Technologies (India) Ltd.	24.939
10	Ashok Leyland Ltd.	47.545*	37	G A I L (India) Ltd.	17.999
11	Asian Paints Ltd.	16.355	38	Glaxosmithkline Consumer Healthcare Ltd.	12.544
12	Aurobindo Pharma Ltd.	44.133*	39	Glaxosmithkline Pharmaceuticals Ltd.	20.453
13	Bajaj Holdings & Invst. Ltd.	41.868*	40	Godrej Industries Ltd.	28.868**
14	Bank Of Baroda	13.216	41	Grasim Industries Ltd.	23.458
15	Bharat Electronics Ltd.	13.198	42	Great Eastern Shipping Co. Ltd.	32.738*
16	Bharat Forge Ltd.	22.347	43	H D F C Bank Ltd.	26.779**
17	Bharat Heavy Electricals Ltd.	12.630	44	H M T Ltd.	31.824**
18	Bharat Petroleum Corpn. Ltd.	10.234	45	Havells India Ltd.	22.035
19	Bhushan Steel Ltd.	19.359	46	Hero Honda Motors Ltd.	14.454
20	Bosch Ltd.	12.150	47	Hindalco Industries Ltd.	14.581
21	Castrol India Ltd.	17.102	48	Hindustan Petroleum Corpn. Ltd.	11.240
22	Century Textiles & Inds. Ltd.	27.773**	49	Hindustan Unilever Ltd.	22.627
23	Chambal Fertilisers & Chemicals Ltd.	28.605**	50	Hindustan Zinc Ltd.	8.433
24	Cipla Ltd.	17.084	51	Housing Development Finance Corpn. Ltd.	40.097*
25	Colgate-Palmolive (India) Ltd.	17.764	52	I D B I Bank Ltd.	30.519**
26	Container Corpn. Of India Ltd.	16.327	53	I F C I Ltd.	30.532**
27	Core Projects	22.178	54	I T C Ltd.	25.049
55	Indian Hotels Co. Ltd.	22.226	83	Reliance Capital Ltd.	45.795*
56	Indian Oil Corpn. Ltd.	19.095	84	Reliance Industries Ltd.	26.123
57	Infosys Ltd.	24.354	85	Reliance Infrastructure Ltd.	40.284*
58	J S W Ispat Ltd.	36.355*	86	Sesa Goa Ltd.	19.487
59	J S W Steel Ltd.	25.911	87	Shipping Corpn. Of India Ltd.	33.880*
60	Jain Irrigation Systems Ltd.	34.453*	88	Shree Cement Ltd.	31.506**
61	Jindal Saw Ltd.	20.564	89	Shriram Transport Finance Co. Ltd.	15.852
62	Kotak Mahindra Bank Ltd.	14.379	90	Siemens Ltd.	12.850
63	L I C Housing Finance Ltd.	4.749	91	Sintex Industries Ltd.	79.259*
64	Larsen & Toubro Ltd.	0.141	92	State Bank Of India	28.060**
65	Lupin Ltd.	1.847	93	Steel Authority Of India Ltd.	25.341
66	Mahindra & Mahindra Ltd.	20.744	94	Sterlite Industries (India) Ltd.	21.084
67	Mangalore Refinery & Petrochemicals Ltd.	9.842	95	Sun Pharmaceutical Inds. Ltd.	16.923
68	Marico Ltd.	24.013	96	Tata Chemicals Ltd.	16.217
69	Motherson Sumi Systems Ltd.	12.158	97	Tata Communications Ltd.	29.041**
70	Mphasis Ltd.	0.645	98	Tata Global Beverages Ltd.	17.576
71	N C C Ltd.	29.793**	99	Tata Motors Ltd.	60.120*
72	National Aluminium Co. Ltd.	18.155	100	Tata Power Co. Ltd.	23.561
73	National Fertilizers Ltd.	44.032*	101	Tata Steel Ltd.	53.365*
74	Nestle India Ltd.	13.040	102	Thermax Ltd.	38.650*
75	Neyveli Lignite Corpn. Ltd.	34.771*	103	Titan Industries Ltd.	15.290
76	Oil & Natural Gas Corpn. Ltd.	14.887	104	Unitech Ltd.	22.612
77	Oriental Bank Of Commerce	14.470	105	United Phosphorus Ltd.	36.815*
78	Pantaloon Retail (India) Ltd.	22.242	106	Videocon Industries Ltd.	41.703*
79	Piramal Healthcare Ltd.	19.398	107	Voltas Ltd.	43.650*
80	Rajesh Exports Ltd.	14.210	108	Wipro Ltd.	22.216
81	Ranbaxy Laboratories Ltd.	12.819	109	Zee Entertainment Enterprises Ltd.	38.408*
82	Rashtriya Chemicals & Fertilizers Ltd.	41.529*			

Source: Data Compiled from CMIE – Prowess database.

** Significant at 5 per cent level of significance. * Significant at 10 per cent level of significance.

5. Empirical Results of the Overall Study Period

During the overall study period the runs test has reported 782 cases. When statistical significance of z-values was tested at 5 per cent and 10 per cent levels of significance, the evidences reported higher order of efficiency in its weak form. At 10 per cent level of significance, 6 stocks out of 62 stocks reported significant z-value and 8 stocks showed significant z-value at 5 per cent level. No stock reported significant value at 1 per cent which is quite satisfactory to interpret Indian stock market as an efficient stock market. The results of autocorrelation for 68 companies have shown for the overall study period. Out of 1088 autocorrelation matrices, there were 94 (8.63 per cent) coefficients which showed their value significant at 5 per cent level of significance and the number of these significant autocorrelation coefficients have fallen to 60 (5.51 per cent) when the level of significance has come down to 1 per cent. The table also represents that 475 (about 43.66 per cent) were negative and 605 (about 55.61 per cent) were positive, while the remaining 8 (0.73 per cent) were zero. Therefore, the results highly supported the successive independence of the stock return series of the sampled companies. The results reported for Q-statistics reveal that 11.76 (26.3 per cent) Q-statistics coefficients were significant at 5 per cent while the same has increased is 44.12 (32.0 per cent) at 10 per cent level of confidence. Majority of the stocks showed non-random behaviour during this phase.

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