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# TESTS OF MARKET EFFICIENCY IN INDIAN STOCK FUTURES MARKET

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## Abstract

*With a view to analyzing the weak form of efficiency in futures market in India, considering index futures contracts on Nifty and also individual stock futures contracts in the present study, data on closing prices for the period of nine years (i.e., 1st April, 2003 to 31st March 2012) have been examined by applying auto correlation test, run test along with the stationarity test.*

***Key Words** : Auto correlation test, Random walk, Run test, Stationarity test, Weak-form of efficiency*

## I. Introduction

According to Fama (1970), there are three different forms of pricing efficiency of the market, namely, (a) weak-form of efficiency, (b) semi-strong-form of efficiency, and (c) strong-form of efficiency. In case of weak-form of efficiency all historical price and trading volume information are reflected in the current stock prices and the historical price changes cannot be used to predict future price movements in any meaningful way if successive stock price changes are independent of one another. Semi-strong-form of efficiency asserts that all publicly available information in respect of economy, companies, industries, etc., along with information about past market behaviour are fully impounded in prices. Strong-form of efficiency suggests that securities prices reflect all relevant information i.e., insider information along with the publicly available information and historical information.

There exists a vast literature in the field of weak-form of efficiency of stock markets in the western developed countries and the notable contributors are Kendall (1953), Cootner (1964), Samuelson (1965), Fama (1965, '70, '91,'98), Granger and Morgenstern (1963), Cooper

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(1982), DeBondt and Thaler (1985), Lo and Mackinlay (1988), Fama and French (1988), Poterba and Summers (1988), Panas (1990), Lehman (1990), Malkeil (1990), Frennberg and Hansson (1993), Blasco et al. (1997), Narayan and Smyth (2006), Chen and Shen's (2009), etc.

Empirical evidence on the weak form of efficiency of all these studies indicates mixed results. In the national context, probably the pioneer work on random walk hypothesis was of Rao and Mukherjee (1971). Other notable Indian scholars in this field are Sharma and Kennedy (1977), Kulkarni (1978), Barua (1981), Gupta (1985). Barua and Raghunathan (1986), Choudhary (1991), Ranganathan and Subramanian (1993), Belgaumi (1995), Poshakwale (1996), Bhaumik (1997), Kumar (1999), Samanta (2004), Nath and Dalvi (2005), Dhankar and Chakraborty (2005), Cooray and Wickramasinghe (2005), Ahmad et al.(2006), Padhan (2009), Hiremath and Kamiah (2010) etc. Most of these studies have observed that the Indian stock market is weakly efficient in pricing shares over different periods.

This weak form of efficiency is applicable to stock futures market also. The efficiency of the stock futures market can be examined on the basis of nature of movement of futures prices of index futures or stock futures. A handful of studies have also statistically tested the weak-form of efficiency in the futures markets. But these studies are mostly related to futures contracts on commodities [Stevenson and Bear (1977), Bird (1985), Elam et al. (1988), etc.], currencies [Harpaz et al. (1990), Lai et al. (1991), etc.], treasury bonds [Klemkosky and Lesser (1985)], metals [ Gross (1988), Chowdhury (1991), etc.] and so on and so forth. However, to the best of the authors' knowledge, there are only a few studies [Saunders et al. (1988), Goldenberg (1989), Chattopadhyay et al. (2003, '05), etc.] which have examined efficiency in futures segment of stock market and the aforesaid studies also produce mixed results.

In this background, we like to test the weak-form efficiency in the Indian stock futures market during a nine year period starting from 2003-04 to 2011-2012. Apart from this prologue the study has been structured as follows: Section II and Section III explain the database and methodology of the study, Section IV enumerates the analysis of the data and Section V sums up the findings of the study.

## II. Database

With a view to analyzing the weak form of efficiency in futures market in India, index futures contracts on Nifty and also individual stock futures contracts have been considered in the present study. Initially, futures contracts data were available on thirty stocks in NSE. From these thirty futures contracts ten stock futures contracts (namely, BPCL, CIPLA, Guj.Ambuja Cement, Hero Honda, Infosys tech., ONGC, Polaris, Ranbaxy, SBI, and Wipro) have been selected randomly for the purpose of our study. For all these selected ten stocks and nifty index, we have collected the data on closing prices in their three types (i.e., one month, two month and three month) of the selected twenty two stock futures as well as the data on closing Nifty index from the website, http://nseindia.com during the period of nine years (i.e., 1st April, 2003 to 31st March 2012).

## *III. Methodology*

In our study, we have examined the weak form of pricing efficiency in the Indian stock futures market by applying auto correlation test, run test along with the stationarity test. All these tests are explained below:

### *Autocorrelation Test*

Autocorrelation coefficient provides a measure of relationship between the value of random variable in time (t) and its value in k period earlier or later (for any lagged or lead value of K). To determine whether an autocorrelation coefficient of order K is significantly different from zero, t test is applied. On the basis of the estimated coefficients of auto correlation, uniform and consistent result may not be derived. To overcome this problem, Hull's Q statistic (2002, Pp. 381-382) has been applied which approximately follows $?^2$ distribution with p degree of freedom.

### *Run Test*

Beside this auto-correlation test, the randomness of the occurrence of sample members in a series is tested by Run Test. To examine the randomness of a given series on futures prices, total number of runs (r), number of positive price changes of futures prices ($n_1$) and number of negatives price changes of futures prices ($n_2$) have been counted. After getting this information, the mean value of runs ($\mu_r$) and the standard error ($\sigma_r$) of runs ($\sigma_r$) are calculated. The

appropriate test statistic for runs under $H_o$ (which implies randomness in the series) is $R_0 = (r - \mu_r) / \sigma_r$ which approximately follows Z distribution.

***Stationarity Test***

In order to examine the weak form of pricing efficiency in the Indian stock futures market, augmented Dickey and Fuller test of the form $? y_t = \mu + ? y_{t-1} + \sum_{j=1}^{p} a_j ? y_{t-j} + ? t + e_t$ has been applied as it constructs a parametric correction for higher order correlation by assuming that the y series follows an AR (p) process and adding p lagged difference terms of the dependent variable y to the right hand side of the test regression [Eviews 4 User's Guide (2002), P. 334]

## IV. Data Analysis and Results

***Results of Autocorrelation Test and Test of Q Statistic***

The autocorrelation test has been applied on the series of daily return [(i.e., $R_t = l_n( P_t / P_{t-1})$] of nifty index as well as selected stock futures contracts to examine the weak form of market efficiency in Indian stock futures market. The autocorrelation coefficients have been computed on the basis of the original series of daily returns of all the selected futures contracts (in their all types) along with their each of 15 lagged series like an earlier study [Chattopadhyay et. al (2003)]. The estimated values of the autocorrelation coefficients are presented in Table1.

From Table 1 we see that the values of autocorrelation coefficient of daily return of Nifty futures are statistically significant at three period lag and ten period lag for one-month contract; at eight period lag and thirteen period lag for two month contract; and at nine period lag and thirteen period lag for three month contract. All other values of auto-correlation coefficient of daily return of Nifty futures are statistically insignificant. The values of the auto-correlation coefficient for all the selected stock futures contracts are statistically significant at maximum three different lag periods out of 15 lag periods in all their near-month, middle-month and far-month types. On an average, the estimated coefficients of serial correlation are statistically insignificant at twelve to fourteen different lag periods out of fifteen lag periods for all the selected stock futures contracts. So from these results, it cannot be concluded with confidence whether the Indian stock futures market is efficient or not in its weak form.

**Table 1: Computed Autocorrelation Coefficients between Different Sets of Original Series and Different Lagged Series of Daily Returns of the Nifty Futures and Selected Stock Futures Contracts**

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| | | .046 | -.012 | .021 | .014 | -.038 | .012 | .005 | -.017 | -.094* | .048 | -.036 | -.06* | .050 | .070** | .016 |
| | | -.051 | -.07* | -.048** | -.048 | .000 | -.07* | .042 | .060* | .010 | -.08* | -.036 | -.029 | .004 | .047 | .006 |
| | | -.045 | -.008 | .004 | -.031 | -.06* | -.050 | .026 | -.036 | .022 | -.038 | .035 | .008 | -.014 | -.068* | -.034 |
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| | | -.018 | -.009 | -.002 | .004 | -.006 | .011 | .009 | -.117* | -.004 | -.001 | .008 | .001 | .019** | .010 | -.005 |
| | | -.027 | -.014 | -.001 | .003* | -.004 | .013 | .010 | -.118* | -.005 | -.003 | .013 | -.001 | .012 | .011 | -.003 |
| | | -.012 | -.007 | -.007 | .003* | -.002 | .011 | -.002 | -.001 | .008 | .001* | .002** | .004 | .000 | .001 | .000 |
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| | | -.018 | -.006 | -.033 | .019 | .004 | -.025 | -.001 | -.029 | -.009 | -.027 | .014 | .015 | -.011 | -.009 | -.008 |
| | | -.020 | -.012 | -.028 | .020* | .003 | -.026 | .005** | -.033 | -.008 | -.028 | .012 | .018 | -.012 | -.005 | -.010 |
| | | -.015 | -.017 | -.011 | -.012 | .016* | -.016 | .001 | -.035 | -.033 | .014 | .013 | .007 | -.033 | -.003 | -.009 |
| | | .042 | -.017 | -.021 | .000 | -.054 | -.010 | .005** | .010 | -.024 | .006 | .022 | -.009 | .021** | .001 | .027 |
| | | .039 | -.025 | -.013 | .005* | -.050 | -.013 | .013 | .017 | -.005 | -.010 | .015** | -.031 | .036 | .008 | .030 |
| | | -.021 | -.033 | -.029 | -.06* | -.034 | -.019 | .005 | -.012 | .034 | .005 | -.010 | .034 | .017 | -.017 | -.011 |
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| | | .011 | .001 | .061* | -.033 | .015 | .007 | .009 | .029 | .033 | -.011 | -.042 | -.032 | -.013 | -.011 | .004 |
| | | -.013 | -.003 | .053 | -.031 | .010 | .010* | .016 | .028 | .013 | .002* | -.034 | -.025 | -.020 | .001 | .010 |
| | | -.019 | -.025 | -.023 | .028 | .007* | -.019 | .024 | .019 | .001 | .008 | -.029 | -.07* | .017 | -.003 | .005 |
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**Table 2: Estimated Values of Hull's Q Statistic$^{+}$ Based on Computed Autocorrelation Coefficients of Nifty Futures and Selected Stock Futures Contracts**

| Futures Contract on | Type of Contract | Hull's Q Statistic($Q_H$)$^{+}$ | Results$^{\#}$ |
|---|---|---|---|
| NIFTY | One month | 23.32573*** | Inefficient |
| | Two month | 25.47863** | Inefficient |
| | Three month | 21.68666 | Efficient |
| BPCL | One month | 36.0668* | Inefficient |
| | Two month | 42.00958* | Inefficient |
| | Three month | 25.70876** | Inefficient |
| CIPLA | One month | 11.3767 | Efficient |
| | Two month | 45.6138* | Inefficient |
| | Three month | 2.996421 | Efficient |
| GUJAMBCEM | One month | 18.859 | Efficient |
| | Two month | 19.74206 | Efficient |
| | Three month | 0.588603 | Efficient |
| HEROHONDA | One month | 24.80005*** | Inefficient |
| | Two month | 57.80719* | Inefficient |
| | Three month | 11.17097 | Efficient |
| INFOSYSTCH | One month | 26.048626** | Inefficient |
| | Two month | 16.456101 | Efficient |
| | Three month | 24.574296*** | Inefficient |
| ONGC | One month | 24.07527*** | Inefficient |
| | Two month | 11.41906 | Efficient |
| | Three month | 13.62039 | Efficient |
| POLARIS | One month | 38.90636* | Inefficient |
| | Two month | 41.14244* | Inefficient |
| | Three month | 11.83222 | Efficient |
| RANBAXY | One month | 23.17418*** | Inefficient |
| | Two month | 9.649997 | Efficient |
| | Three month | 12.36665 | Efficient |
| SBIN | One month | 19.24518 | Efficient |
| | Two month | 14.9703 | Efficient |
| | Three month | 17.95179 | Efficient |
| WIPRO | One month | 48.30529* | Inefficient |
| | Two month | 13.55834 | Efficient |
| | Three month | 23.744241*** | Inefficient |

*Notes:* $^{+}$ $Q_H = n\ S\ w_j r_j^2$ *where* $w_j = (n-2)/(n-j)$, $r_j$ *denotes jth order autocorrelation coefficient, j=1*

*n is the number of observations, p is the total length of lag, $Q_H$ follows $?^2$ distribution with 15 degrees of freedom; *implies significant at 1 % Level, **implies significant at 5 % Level, ***implies significant at 10 % Level, # Significant (insignificant) value of $Q_H$ implies that the estimated autocorrelation coefficients of different orders are jointly significant (insignificant) and hence price inefficiency (efficiency) in the futures market is established.*

In order to get conclusive results we have employed Hull's Q Statistic as a measure of weak form of market efficiency. The values of Hull's Q Statistic have been estimated on the basis of the earlier estimated values of the autocorrelation coefficients. The estimated values of Hull's Q Statistic are presented in Table 2. From Table 2 we see that Hull's Q test rejects the joint null hypothesis of zero autocorrelation for Nifty-one month and two-month futures contracts. But we cannot reject this null hypothesis for Nifty three-month futures contract. It is also observed that the computed values of Q statistic are statistically significant (i.e., the rejection of efficient market hypothesis) for 6 one-month stock futures contracts (namely, stock futures on Hero Honda, Infosys Tech, ONGC, Polaris, Ranbaxy, and Wipro) out of selected 10 stock futures contracts during the study period. For two-month stock futures contracts the calculated values of Q statistic are statistically significant for 4 companies (viz., BPCL, Cipla, Hero Honda, Polaris,) out of selected 10 companies. But so far as the three-month stock futures are concerned, the computed values of Q Statistic are statistically significant only for three companies (e.g., BPCL, Infosys Tech., and Wipro). However, the estimated values of Hull's Q statistic are statistically insignificant (that establishes efficient market hypothesis) only for two stock futures contracts (namely, Gujrat Ambuja and SBIN) in all their three types. So except these two stock futures contracts, the estimated values of Hull's Q statistic are statistically significant for the other eight selected stock futures contracts at least in one of their three types. Based on the above results, we cannot definitely conclude that Indian stock futures market in all its segments is inefficient in its weak form.

### *Results of Run Test*

The runs have been computed on the basis of negative and positive values of the first differences of the futures prices (i.e., $? F_t = F_t - F_{t-1}$). The computed values of run-test are presented in Table 3.

From Table 3 we observe that the estimated values of runs for Nifty futures contracts are statistically significant at 1% level for all their three types (i.e., one month, two month and three month contracts). The observed values of runs for one month stock futures contracts are statistically significant for two companies (namely, Infosys Tech, and Wipro) and these are statistically insignificant for all other eight stock futures contracts. So far as the two months futures contracts are concerned, the estimated values of runs are statistically significant for one company (viz., Infosys Tech) out of ten companies. The values of run test for all the selected stock futures contracts in case of far month are statistically significant at 1% level. So the results of run test on the Indian stock futures market efficiency remain inconclusive.

**Table 3: Computed Runs Daily Futures Price of Nifty Futures and Selected Stock Futures Contracts**

| Futures Contract on | Type of Contract | Runs | Value of Test Statistic | Results# |
|---|---|---|---|---|
| NIFTY | One month | 406 | -2.68243108* | Inefficient |
| | Two month | 498 | -2.911565649* | Inefficient |
| | Three month | 498 | -2.929323378* | Inefficient |
| BPCL | One month | 552 | -1.037802075 | Efficient |
| | Two month | 552 | -0.712273993 | Efficient |
| | Three month | 117 | -3.140174602* | Inefficient |
| CIPLA | One month | 583 | -2.31759314 | Inefficient |
| | Two month | 581 | -1.770362348 | Efficient |
| | Three month | 567 | -6.116832136* | Inefficient |
| GUJAMBCEM | One month | 551 | 1.204767736 | Efficient |
| | Two month | 534 | 0.525398075 | Efficient |
| | Three month | 135 | -3.136626194* | Inefficient |
| HEROHONDA | One month | 668 | 0.960532237 | Efficient |
| | Two month | 633 | -0.313348918 | Efficient |
| | Three month | 115 | -4.178998195* | Inefficient |
| INFOSYSTCH | One month | 569 | -2.556826377** | Inefficient |
| | Two month | 573 | -2.292681351** | Inefficient |
| | Three month | 593 | -5.997099488* | Inefficient |
| ONGC | One month | 623 | -0.229322745 | Efficient |
| | Two month | 606 | -1.159353383 | Efficient |
| | Three month | 271 | -5.11724554* | Inefficient |
| POLARIS | One month | 600 | -1.454805267 | Efficient |
| | Two month | 634 | 0.375309313 | Efficient |
| | Three month | 169 | -3.395505733* | Inefficient |
| RANBAXY | One month | 626 | -0.114258237 | Efficient |
| | Two month | 604 | -1.310879734 | Efficient |
| | Three month | 255 | -5.426006237* | Inefficient |
| SBIN | One month | 638 | 0.728384176 | Efficient |
| | Two month | 628 | 0.197474539 | Efficient |
| | Three month | 263 | -4.17041035* | Inefficient |
| WIPRO | One month | 875 | -9.104541086* | Inefficient |
| | Two month | 643 | 0.813923226 | Efficient |
| | Three month | 233 | -4.676827993* | Inefficient |

Notes: *implies significant at 1 % Level, **implies significant at 5 % Level (on the basis of both-tailed test), # Significant (insignificant) value of test statistic implies that the estimated runs are significant (insignificant) and hence price inefficiency (efficiency) in the futures market is established.

***Results of Stationarity Test***

In our study, we have applied all the three ADF equations to examine the stationarity of the return series of stated futures contracts. However, it is found that the results are invariant to the model specification except minor differences in ADF Values. In all the cases the calculated values of adjusted R square are high in case of equation (3). Therefore, only the results of ADF test based on equation (3) are presented in Table 4.

From Table 4 it is seen that all the adjusted R square are statistically significant at 1% level. So the selected equation for the ADF test gives us overall good fit. We also observe that all the estimated coefficients (? ) for ADF test are statistically significant at 1% level. It implies that the null hypothesis of the existence of unit root is rejected in all the cases. From these observed results it can be concluded that the daily return series of the selected stock futures and index futures contracts are stationary. Therefore, based on ADF tests on return series we can infer that the futures market in India is efficient in its weak form.

**Table 4: Results of Stationarity Test on Return Series of Futures Price for the Period 2003-04 to 2011-12**

| Futures Contract on | Type of Contract | ?$^{+}$ | ADF Test Statistic$^{\#}$ | Adj $R^2$ | F Statistic | DW Statistic |
|---|---|---|---|---|---|---|
| NIFTY | One month | -1.05839* | -16.34990 | 0.495372* | 205.6758 | 1.996288 |
| | Two month | -1.04057* | -16.17612 | 0.491949* | 202.8920 | 1.995753 |
| | Three month | -1.036568 | -16.12903 | 0.491873* | 202.8305 | 1.996037 |
| BPCL | One month | -0.97498* | -15.21657 | 0.474324* | 171.0857 | 1.992425 |
| | Two month | -1.31924* | -17.68935 | 0.526302* | 210.4332 | 1.975021 |
| | Three month | -1.16365* | -16.60118 | 0.522854* | 207.5572 | 2.008075 |
| CIPLA | One month | -0.93930* | -15.64574 | 0.484882* | 196.1633 | 1.999952 |
| | Two month | -1.36051* | -18.24343 | 0.541760* | 246.1228 | 1.997283 |
| | Three month | -1.05311* | -16.23839 | 0.505700* | 213.1151 | 2.000254 |
| GUJAMB-CEM | One month | -1.03222* | -14.76028 | 0.506517* | 184.2145 | 1.999889 |
| | Two month | -1.04607* | -14.80686 | 0.510759* | 187.3510 | 1.999867 |
| | Three month | -1.02630* | -14.73574 | 0.503260* | 181.8432 | 1.999955 |
| HERO-HONDA | One month | -1.20047* | -18.08039 | 0.496421* | 213.6007 | 2.003712 |
| | Two month | -1.59928* | -20.09979 | 0.59045* | 311.9271 | 1.999910 |
| | Three month | -1.19056* | -17.53556 | 0.534118* | 248.2546 | 1.999918 |
| INFOSYS-TCH | One month | -1.03469* | -15.67352 | 0.50716* | 210.2464 | 1.999176 |
| | Two month | -1.03823* | -15.67974 | 0.508030* | 210.9709 | 1.999280 |
| | Three month | -1.04117* | -15.73917 | 0.505435* | 208.8025 | 1.999335 |

| | | | | | | |
|---|---|---|---|---|---|---|
| ONGC | One month | -1.05402* | -16.83279 | 0.477460* | 191.3605 | 1.995495 |
| | Two month | -1.04963* | -16.69907 | 0.478988* | 192.5292 | 1.995059 |
| | Three month | -1.21206* | -17.90725 | 0.51248* | 220.0023 | 2.002294 |
| POLARIS | One month | -1.07381* | -17.05495 | 0.469487* | 185.3682 | 1.998670 |
| | Two month | -1.07979* | -14.79200 | 0.470214* | 132.0622 | 2.027037 |
| | Three month | -1.02662* | -15.53283 | 0.517329* | 224.2926 | 2.000789 |
| RANBAXY | One month | -0.94611* | -15.35148 | 0.495102* | 205.4549 | 2.000108 |
| | Two month | -0.98314* | -15.57594 | 0.505990* | 214.5564 | 2.000145 |
| | Three month | -1.03507* | -15.77652 | 0.508330* | 216.5653 | 1.999808 |
| SBIN | One month | -1.04436* | -16.36939 | 0.476967* | 190.9845 | 1.995892 |
| | Two month | -1.07088* | -16.61298 | 0.489916* | 201.0958 | 1.997236 |
| | Three month | -1.18320* | -17.11597 | 0.517014* | 224.0113 | 2.000100 |
| WIPRO | One month | -1.06188* | -16.08805 | 0.524137* | 230.4674 | 1.998876 |
| | Two month | -1.13284* | -16.45564 | 0.539461* | 245.0356 | 1.999845 |
| | Three month | -1.07113* | -16.27689 | 0.505536* | 213.9981 | 1.999831 |

*Notes:* +? is estimated by fitting the equation in the form: $? y_t = \mu + ? y_{t-1} + Sa_j ? y_{t-j} + ?t + u_t$

$j=1$

MacKinnon Critical value for rejection of hypothesis of ADF Test is -3.9705, *implies significant at 1 % Level.

## V. Conclusion

Thus, we get conclusive result of futures market efficiency based on stationarity test while the results based on run test or autocorrelation test remains inconclusive. So we can conclude that the Indian stock futures market is efficient in its weak form.

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