Testing Weak Form of Efficiency of Indian Stock Market

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Efficiency of financial market depends upon how quickly market assimilates new information. In weak form of efficient market, current price reflects all the information contained in past price. Hence, there are no linear as well as non-linear dependences with the lagged values and price process has no memory, thus follows a random walk model. This paper, attempts to verify weak form of efficient market hypothesis and random walk hypothesis using daily data for the index of Indian Stock Market specifically S&P CNX Nifty (Index of National Stock Exchange) for the period of 1 January 2000 to 31 Dec 2011. Statistical analysis is done with help of Augmented Dickey and Fuller (ADF) test, Auto-correlation test (Breusch-Godfrey Serial Correlation LM Test), Ljung-Box Q test, Auto-regression, ARIMA model, portmanteau BDS test and GARCH(1,1) model. Results exhibited that returns series are characterised by linear as well as nonlinear dependences and a high persistence of volatility clusters over the sample period. The hypothesis of random walk for the series has become redundant. Hence, it can be concluded that Indian Stock market do not show evidence of weak from of market efficiency.

Keywords: Autocorrelation, Weak form of market efficiency, National Stock Exchange, S&P CNX Nifty, Volatility Clustering.

Efficient Market Hypothesis has guiding light in the field of research on capital market theory. Market efficiency is a relationship between information and share price process. Information discharge makes the price process more informative in the short-run, it reduces its value in the long-run. (Brunnermeier 2005). Fama (1970) asserted that financial markets are "informational efficient". That is, one cannot consistently achieve returns in excess of average market returns on a risk-adjusted basis, given the information publicly available at the time the investment is made. Three levels of efficiency of market were identified by Fama: the strong form, the semi-strong form and the weak-form of efficiency. Market is said to have strong form of efficiency, when the current price reflects all information i.e. public, private as well as information contained in past prices and no investors will be able to recognize under-valued stocks. Market is considered to have semi-strong form of efficiency, when the current price reflects the information contained past prices as well as public information and there is no approach that can predict on using this information, which would be useful in finding under-valued stocks. Market is weak-form of efficient, when the current price reflects the information contained in all past prices only, suggesting that charts and technical analyses would no longer be useful in distinguishing under-valued stocks. Market efficiency influences the investment strategy decision of an investor. Lower the market efficiency; the greater will be the predictability of stock price changes. New information comes in a random fashion in an efficient market, so changes in prices should be random to this new information arrival.

In a weak-form efficient market, price movements occur randomly and successive price changes are discrete of one another. The random walk hypothesis of stock market prices states that price changes cannot be predicted. Hence, successive price changes in individual securities are independent over time and price movements did not follow any patterns or trends. Thus, past price movements cannot be used to forecast future price movements. Evidence supporting the random walk, correspond the weak form of the efficient market hypothesis, but not vice versa. But violation of the random walk model could not be evidence for weak form market inefficiency. (Ko and Lee (1991))

Random walk Hypothesis track a following model

$P_t = P_{t-1} + \mu_t$

Where, P_t is the price at time t, P_{t-1} is the price in time t-1 and μ_t is a random error term. Error term is also called white noise process which is also said to follow independent and identical distribution process.

Efficient market hypothesis and random walk model has close link with each other. Thus, according to both the hypothesis, prices of the stock market cannot be predicted. Hypothesis for this study are as follows.

1. India stock market follows random walk.

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2. That the Indian Stock Market is efficient in weak form.

Literature Review

Stock market efficiency is a key parameter to measure the efficiency of a financial system. Fluctuations in price changes attract the attention of investors, analysts and researchers. Various efficiency tests are conducted by the researchers by various ways so as produced contradictory results. Cooper (1982) examined the validity of the random walk hypothesis by employing correlation analysis, run tests and spectral analysis using monthly, weekly and daily data for 36 countries. In case of US and UK, the results supported the random walk hypothesis but for all other countries, the random walk hypothesis was rejected. Barnes (1986) confirmed high degree weak form market efficiency of the Kuala Lumpur Stock Exchange (KLSE) and further confirming his results Laurence (1986) suggest only slightly deviation from perfect weak-form efficiency for 16 individual stocks traded on the KLSE sample period of 1 June 1973 to 31 December 1978. But Saw and Tan (1989) found that the Malaysian stock market is weak form inefficient, using weekly data for 6 sector indices from 1975 to 1982, however market efficiency existed when monthly data was used. Panas (1990) established that the Athens stock market as efficient. Butler and Malaikah (1992) found Kuwaiti market efficient but the Saudi Arabian stock market, inefficient. Chan, Gup, and Pan (1992), found weak form efficient Asian Markets and U.S. markets, individually and jointly in the long run. Dickinson and Muragu (1994) provide substantiation of weak form of market efficiency in Nairobi Stock Exchange. Poshakwale(1996) demonstrate that Indian stock market is not weak form efficient.

Ramasastri (1999) tested Indian stock markets during 1990s using the Dickey-Fuller unit root test and accepted that the stocks prices follow a random walk. Samanta (2004) used daily data on the BSE-100 for the period of January 1993 to December 2001 and establish interesting results that market efficiency differ in different time periods. Market was found inefficient during each sub-period till June 1996 and high level of efficiency during July 1996 to December 1999 and showed efficiency at a relatively lower level thereafter. Lim(2007) using rolling sample approach detected the periods of efficiency/inefficiency and exhibit significant nonlinear serial dependence. It further ranked the US market as the most efficient and Argentine stands at the last in ranking. Lim, Brooks and Hinich (2008) check and institute the weak-form efficiency in 10 Asian emerging stock markets using nonlinear dependence tests and found predictable nonlinearities even after eliminating linear serial correlation from the data. Dima and Milos (2009) affirm weak form of the efficiency in Romanian stock market but Moldovan(2010) contradict this results and found evidence of weak form of inefficiency in Romanian stock market. Siddiqui and Gupta (2010) rejected the presence of weak-form efficiency in Indian stock market using parametric (Auto-correlation test, Auto-regression, ARIMA model) and non parametric tests(Kolmogrov –Smirnov normality test and run test). Mishra(2011) also failed to provide evidence of weak form of efficiency in selected emerging and developed capital markets (India, China, Brazil, South Korea, Russia, Germany, US and UK) with help of unit root test and GARCH(1,1) model.

Methodological Framework

Empirical analysis is based on of daily data for market index S&P CNX Nifty (Index of National Stock Exchange) for period of 1st January 2000 to 31st December 2011 has been taken from its official website (http://www.nseindia.com/products/content/equities/indices/historical_index_data.htm). The daily stock index is computed as the first difference of the natural logarithm.

Return is calculated using logarithmic method as follows.

$$r_t = (\log p_t – \log p_{t-1})$$

where, r_t = Market return at the period t

P_t = Price index at day t

P_{t-1} = Price index at day t–1 and

log = Natural log

In order to test the stationarity of the series, Augmented Dickey and Fuller (ADF) test (a test for a unit root in a time series sample) has been used. The unit root test check whether a time series variable is non-stationary using an autoregressive model. Null hypothesis for this test is that the series is non-stationary (series has unit root).

Augmented Dickey and Fuller (ADF) Model:

$$\Delta Y(t) = \rho_0 + \rho Y(t-1) + \sum_{i=1}^{m} \Delta Y(t-i) + \varepsilon_t$$

Statistical properties such as skewness, kurtosis in historical data are used to test normal distribution of sample. The portmanteau BDS test is used to determine whether the residuals are iid (independent and identically distributed). BDS test is generally used to examine whether the given series or process is deterministic or stochastic and to explore non-linear dependences in the model. For delineation of high-order autocorrelations, correlogram was used. Results provided by the correlogram, are confirmed with Breush-Godfrey Serial Correlation LM test, Ljung-Box Q test and further by developing suitable ARIMA (Autoregressive Integrated Moving Average) model. The memory in stock market returns is due to its auto-correlation (ACF) and partial auto correlation (PACF) functions, which form a part of identification of a suitable ARIMA (Autoregressive Integrated Moving Average) model.

When residuals of the developed ARIMA model for stock returns does not exhibit constant variance and the period of high volatility followed by the period of high volatility and the period of low volatility followed by the period of low volatility, that is having volatility clustering. This suggests that the residuals or error terms is conditionally hetroscedastic and can be demonstrated by ARCH and GARCH model. Thus econometric estimation of the GARCH (1, 1) model is used to observe the volatility clustering and as a result, the weak form market inefficiency. As per the GARCH (1, 1) model, the presence of persistence in volatility clustering implies inefficiency of a capital market. Generalised ARCH models were developed independently by Bollerslev (1986) specified as follows

Mean Equation: $r_t = c + u_t$

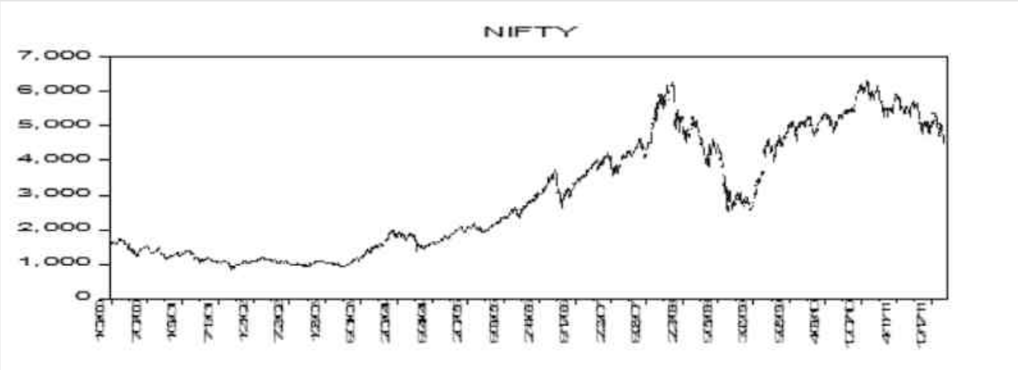
Variance Equation: $\sigma_t^2 = \alpha_o + \alpha_1 u_{t-1}^2 + \beta\, \sigma_{t-1}^2$

This is a GARCH(1,1) model where σ2t is known as conditional variance (one-period ahead forecast variance based on past information) which is dependent on α0 (constant), information about volatility from the previous period, measured as the lag of the squared residual from the mean equation (α1 u2t -1) and forecasted variance the model during the previous period (β σt-12). In the variance equation, (α1+ β) shows high persistence in volatility clustering if the value is very close to one; it implies inefficiency of a stock market.

Results and Discussion

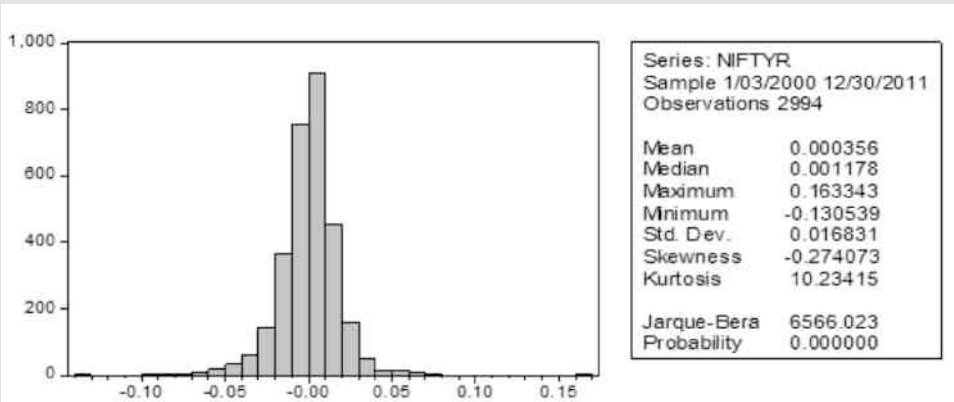
Empirical analysis on S&P CNX Nifty (index of National stock exchange) is based on daily observations (from 1st January 2000 to 31st December 2011). Figure 1 shows the trend graph of S&P CNX Nifty.

Figure 1: Trend of S&P CNX Nifty for 11 years



Statistical properties (Skewness, Kurtosis) reveal the fact that this historical data is non-normally distributed and the stationarity tests (Augmented Dickey- Füller) reveal the fact that the series are not stationary in levels. To make index series stationary, daily returns has been identified as the difference in the natural logarithm of the closing index value for the two consecutive trading days. The series on which the tests were applied is represented by the calculated log returns of the daily closing values of the S&P CNX Nifty, during 2000-2011, and having 2994 observations. The histogram and descriptive statistics for the log returns of index for 11 years was computed. The mean, standard deviation, minimum, maximum, range, skewness, kurtosis and statistics are reported.

Figure 2: Histogram and descriptive statistics



Mean of Nifty log returns are 0.0356%. The standard deviation of returns is 0.016831 for Nifty. The maximum return of 16.3343% and minimum return is -13.0539%. A distribution that is asymmetric as the return series is negatively skewed with value of -0.274073 and kurtosis is more than 3 that is 10.23415 which means distribution is peaked i.e. leptokurtic having fat tails. Jarque-Bera (JB) statistics reject the null hypothesis of normal distribution at the 1% level of significance for both indices. Table 1 signify Augmented Dickey Fuller statistics for transformed series (Difference of natural logarithm of the closing value for S&P CNX Nifty). Test statistics revealed that series is stationary at 1% significance level.

Table 1: Augmented Dickey-Fuller test

Null Hypothesis: NIFTYR has a unit root			
Exogenous: Constant			
Lag Length: 0 (Automatic based on SIC, MAXLAG=28)			
		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-50.74930	0.0001
Test critical values:	1% level	-3.432345	
	5% level	-2.862307	
	10% level	-2.567223	
*MacKinnon (1996) one-sided p-values.			

If a market is weak-form efficient, then there is no correlation between successive prices i.e. through the study of historical prices of a particular security cannot consistently be used to achieve excess returns. In other words technical analyses cannot be used to recognize undervalued or overvalued stocks. Autocorrelations are reliable measures for testing of linear dependence or independence of random variables in a series. If no autocorrelations are found in a series then the series is considered random. Transformed series (first difference of natural logarithm of the closing index value for the two consecutive trading days) is used for testing autocorrelations. The autocorrelation coefficients have been computed for the transformed index with the purpose to ascertain whether information obtained even with transformation is of the higher order. Breusch-Godfrey Serial Correlation LM Test, Ljung-Box Q test and Autoregressive model at first lag order was used test the autocorrelation. The Serial Correlation Coefficient measures the relationship between the values of a random variable with its lagged value. Significant values of coefficient divulge presence of critical linear dependences at first lag order (at 1% significant value) and second lag order (at 5% significant value). By applying the Ljung-Box Q test revealed the presence of linear dependences, the p values being smaller that the critical value of 0.05. In such a condition, the possibility is that correlations arise due to a weak trading. Furthermore, to confirm this, AR(1) model was tested with log-returns. AR(1) is significant at 1% level, indicating the presence of high first order lag relationship with in the return series of index.

Table 2: Breusch-Godfrey Serial Correlation LM Test for Autocorrelation

Breusch-Godfrey Serial Correlation LM Test:				
F-statistic	12.12648	Prob. F(2,2991)		0.0000
Obs*R-squared	24.08201	Prob. Chi-Square(2)		0.0000
Sample: 1/04/2000 12/30/2011				
Included observations: 2994				
Presample missing value lagged residuals set to zero				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	1.65E-07	0.000306	0.000537	0.9996
RESID(-1)	0.078795	0.018263	4.314466	0.0000
RESID(-2)	-0.049161	0.018265	-2.691563	0.0072

Table 3: Auto-regressive Model at first order lag (AR(1))

Dependent Variable: NIFTYR				
Method: Least Squares				
Date: 03/14/12 Time: 12:15				
Sample (adjusted): 1/05/2000 12/30/2011				
Included observations: 2993 after adjustments				
Convergence achieved after 3 iterations				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.000346	0.000332	1.042408	0.2973
AR(1)	0.075106	0.018225	4.121124	0.0000
R-squared	0.005646	Mean dependent var		0.000347
Adjusted R-squared	0.005314	S.D. dependent var		0.016826
S.E. of regression	0.016781	Akaike info criterion		-5.336484
Sum squared resid	0.842260	Schwarz criterion		-5.332472
Log likelihood	7988.049	Hannan-Quinn criter.		-5.335041
F-statistic	16.98366	Durbin-Watson stat		1.989632
Prob(F-statistic)	0.000039			

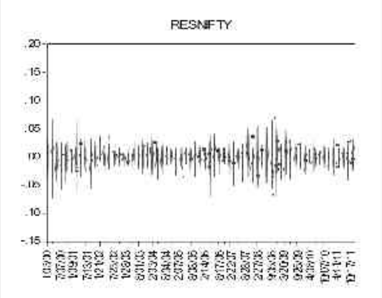
The use of random walk test reflects the fact that S&P CNX Nifty follows a random-walk process. According to random walk model, error term should be a white noise i.e. having independent and identical distribution. The portmanteau BDS test is used to determine whether the residuals are iid (independent and identically distributed) and to explore non-linear independence/ dependence within residuals. This test applied to residuals from the initial unadjusted returns. As p values are below 0.05, the presence of nonlinear dependencies has been confirmed, the residuals being not normally (abnormally) distributed.

Table 4: BDS Test for Residuals

BDS Test for RESID
Date: 03/14/12 Time: 12:15
Sample: 1/03/2000 12/30/2011
Included observations: 2995

Dimension	BDS Statistic	Std. Error	z-Statistic	Prob.
2	0.024412	0.001631	14.96641	0.0000
3	0.048033	0.002592	18.53375	0.0000
4	0.066146	0.003086	21.43640	0.0000
5	0.078244	0.003216	24.33110	0.0000
6	0.083998	0.003101	27.08807	0.0000

Figure 3: Residuals of Nifty Returns



From figure 3, it has been observed that the period of high volatility followed by the period of high volatility and the period of low volatility followed by the period of low volatility, this suggests that the residuals or error terms is conditionally heteroscedastic and can be represented by ARCH and GARCH model.

GARCH(1,1) model is fitted to the first difference of log daily S&P CNX Nifty using backcast values for the initial variances and Bollerslev-Wooldridge standard errors.

Table 5: GARCH(1,1)-Nifty

Dependent Variable: RESNIFTY
Method: ML - ARCH (Marquardt) - Normal distribution
Sample (adjusted): 1/04/2000 12/30/2011
Included observations: 2994 after adjustments
Convergence achieved after 13 iterations
Presample variance: backcast (parameter = 0.7)
GARCH = C(2) + C(3)*RESID(-1)^2 + C(4)*GARCH(-1)

Variable	Coefficient	Std. Error	z-Statistic	Prob.
C	0.000725	0.000226	3.216487	0.0013
	Variance Equation			
C	7.29E-06	8.54E-07	8.543099	0.0000
RESID(-1)^2	0.142043	0.009842	14.43240	0.0000
GARCH(-1)	0.836332	0.009927	84.24545	0.0000

Sum of ARCH and GARCH coefficient measures the persistence of volatility. The reported results show that the sum of the coefficients of the ARCH and GARCH in equation very close to one (0.9783), and both of them are positive and statistically significant. Thus, suggesting thereby a high persistence of volatility clusters over the sample period in the market. As GARCH coefficient is greater than ARCH coefficient, it represents that conditional variance is more dependent on last period's forecast variance.

These statistical tests applied on the daily closing returns of the S&P CNX Nifty, confirmed the incidence of linear as well as non-linear correlations and high persistence of volatility during the sample period. Hence, the price of the stocks is influenced by arrival of the new information in the market, thus the random walk hypothesis being rejected. Furthermore, statistical results cannot sustain the existence of a weak form of information efficiency, thus usefulness of simple technical analysis and arbitrage phenomenon has not being rejected.

Conclusion

Testing of the financial market efficiency is a key concern for investors, researchers, analysts and regulators dealing with emerging equity market such as India. Testing weak-form of efficiency is important sign of predictability, making arbitrages possible. To test weak form of efficiency, various test were employed to check linear dependences and non-linear dependences. Ljung-Box Q statistics, serial correlation LM test and autoregressive model confirmed the presence of linear dependences. To test non-linearity; BDS test is applied on the residuals series generated by ARMA model and revealed the presence of nonlinear dependences. Furthermore, GARCH(1,1) model represents high persistence in volatility clustering for the sample period of 11 years. Results provide evidence for the absence of the weak-form of efficiency and random walk hypothesis, thus making the usefulness of predictable characteristics of market. Consequently, determining the success of technical analysis and arbitrage phenomenon.

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