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# Causal Relationship between Macro-Economic Indicators and Stock Market in India

Dr. Naliniprava Tripathy

Associate Professor (Finance), Indian Institute of Management Shillong

Meghalaya, PIN 793 014, India

Tel: 91-364-230-8037 E-mail: nalini.607@rediffmail.com

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**Abstract**

This paper investigated the market efficiency and causal relationship between selected Macroeconomic variables and the Indian stock market during the period January 2005 to February 2011 by using Ljung-Box Q test, Breusch-Godfrey LM test, Unit Root test, Granger Causality test.The study confirms the presence of autocorrelation in the Indian stock market and macro economic variables which implies that the market fell into form of Efficient Market Hypothesis. Further the Granger-causality test shows evidence of bidirectional relationship between interest rate and stock market, exchange rate and stock market, international stock market and BSE volume, exchange rate and BSE volume. So it suggests that any change of exchange rate, interest rate and international market significantly influencing the stock market in the economy and vice versa. The study also reported unidirectional causality running from international stock market to domestic stock market, interest rate, exchange rate and inflation rate indicating sizeable influence in the stock market movement in the considered period. The study points out that the Indian stock market is sensitive towards changing behavior of international market, exchange rate and interest rate in the economy and they can be used to predict stock market price fluctuations.

**Keywords:** Macroeconomic variables, Stock market, Ljung-Box Q test, Unit Root test, Granger-causality test

*JEL Classification:* G1, G7, C32

## 1. Introduction

Over the past few decades, the interaction of share returns and the macroeconomic variables has been a subject of interest among academicians and practitioners. Kaneko and Lee (1995), Lee (1992), Fama (1981) determined a positive relation between stock returns and real economic activity in US and Japanese stock markets but the same relation is not found in European and South Asian markets. Poon and Taylor (1991)'s study for the UK market, Martinez and Rubio (1989)'s study for the Spanish market, and Gjerde and Saettem (1999)'s study for the Norwegian market have not implied a significant relation between stock returns and macroeconomic variables. Mookerje and Yu (1997)'s study on forecasting share prices for the Singapore case obtained a result that money supply and exchange rate have an impact upon forecasting share prices. So the results are mixed. If stock prices accurately reflect the underlying fundamentals, then the stock prices should be employed as leading indicators of future economic activities. Therefore, the causal relations among macroeconomic variables and stock prices are important in the formulation of the nation's macroeconomic policy. Presently the performance of Indian stock market is analyzed carefully by large number of global players; this motivates us for exploring research in Indian stock market and macroeconomic indicators to determine the Indian stock market efficiency

to give new approach to the foreign investors, policy makers, traders, domestic investors and academic researchers. In this paper, we have raised three research question .First this paper will add to the existing literature by providing robust result. Secondly we investigate the causal relationship between macroeconomic variables and Indian stock market by using Granger causality test for determining whether one time series is useful for forecasting another. Thirdly we use Unit Root test and Box-Jenkins Autoregressive Integrated Moving Average (ARIMA) time-series process to determine whether Indian stock market exhibits weak, semi-strong, or strong form of market efficiency with reference to macroeconomic variables is concerned to obtain new insights. Therefore, the present work improves the earlier studies and offers a value addition to the existing literature. The paper is organized as follows: Section 2 reviews previous literature Section 3 describes the data & methodology used in the research. The results are discussed in Section 4 and Section 5 concludes the observation.

## 2. Literature Review

The dynamic relationships between macroeconomic variables and share returns have been widely discussed and debated. The informational efficiency of major stock markets has been extensively examined through the study of causal relations between stock price indices and macroeconomic aggregates. Kwon and Shin (1999) applied Engle-Granger co integration and the Granger-causality tests from the Vector Error Correction Model (VECM) and found that the Korean stock market is co integrated with a set of macroeconomic variables. However, using the Granger-causality test on macroeconomic variables and the Korean stock index, the authors found that the Korean stock index is not a leading indicator for economic variables. Mayasmai and Koh (2000) used the Johansen co integration test in the Vector Error Correction Model (VECM) and found that the Singapore stock market is co integrated with five macroeconomic variables. Muradoglu, Metin and Argac (2001) examined the long-run relationship between stock returns and three monetary variables (overnight interest rate, money supply and foreign exchange rate) in Turkey. They pointed out that the whole sample period (1988-1995) showed no co-integrating relationship between stock prices and any of the monetary variables. This is also true only for the first sub-sample (1988-1989) but all the variables were co integrated with stock prices for the second (1990-1992) and third sub-samples (1993-1995). Nevertheless, in general, Ibrahim and Aziz (2003), Booth and Booth (1997), Wongbanpo and Sharma (2002), Chen (2003), Chen et al. (2005) and Mukherjee and Naka (1995) reveal that the rate of inflation, money growth, interest rates, industrial production, reserves, and exchange rates are the most popular significant factors in explaining the stock market movement. However, empirical studies by Barrows and Naka (1994) conclude that inflation has negative effects on the stock market. The 'exchange rate channel' by Pan et al. (2007) is consistent with the 'flow oriented' exchange rate model, introduced by Dornbusch and Fisher (1980). They affirm that exchange rate movements initially affect the international competitiveness and trade position, followed by the real output of the country, and finally affects the current and future cash flows of companies, which can be inferred from the stock price movements. Donatas, P., & Vytautas B.,(2009)analyzes the relationships between a group of macroeconomic variables and the Lithuanian stock market index and reveals that some macroeconomic variables lead Lithuanian stock market returns.

## 3. Time Series Data and Methodology

Many financial time series contain a unit root, i.e. the series are non-stationary and it is generally acknowledged that stock index and macroeconomic variables might not be exception. So the required time series weekly data have been collected from the www.rbi.com and www.bse.com for a period of six years from January 2005 to February 2011.We have chosen the data period 2005 to 2011 because during this period Indian stock markets have undergone substantial policy changes characterised by the revival of private foreign capital flows to emerging market economies, flexible exchange rates, strong economic growth, credit market crisis in the United States and sharp fell in Asian market. These changes have affected the movement in index and magnitude of volume trades in the market in different ways.

There are many macroeconomic variables which affecting the stock market but the most prominent are interest rate, inflation rate, exchange rate and international market. A fall in interest rates reduces the costs of borrowing and encourages firms for expansion with the expectation of generating future expected returns for the firm. Further significant amount of stocks are purchased with borrowed money. So an increase in interest rates will be more costly for stock transactions that lead to reduce demand and affect the share price. Hence, changing interest rate has greater influence on stock market variability. So we have chosen 91-days Treasury bill as proxy for short term interest rate which is very popular short-term risk free instrument in India. Similarly Wholesale Price Index focuses on the price of goods traded between corporations. It also monitors price movements that reflect supply and demand in industry, manufacturing and construction. This helps in analyzing both macroeconomic and microeconomic conditions. In India the changes of WPI is used to measure inflation rate. It is believed that change in WPI influences stocks and fixed price markets. So we have chosen WPI as proxy for inflation rate. Thirdly, the S&P 500 is considered as the best single gauge of the large cap U.S. equities market. The index includes 500 leading companies in leading industries of the U.S. economy, capturing 75% coverage of U.S. equities. It is also included in the index of leading indicators. Further, the "S&P 500"captures the changes in the prices of the index components. It is noticed that many times variability of Indian stock market is happening due to international market factors. So S&P 500 is taken as proxy for international market index. Fourthly, change in exchange rate affects the overseas operational performances of firm which will affect its share price. So we have taken exchange rate one of the variables to determine its impact on stock market. Fifthly, Bombay Stock Exchange is the oldest stock exchange in Asia and today, it is the world's 5th most active in terms of number of transactions handled through its electronic trading system. It is also in the top ten of global exchanges in terms of the market capitalization of its listed companies.BSE have facilitated the growth of the Indian corporate sector by providing with an efficient capital raising platform. The BSE Index, SENSEX, is India's first and most popular Stock Market benchmark index. So we have taken sensex as proxy for Indian stock market. Lastly trading volume refers to the number of shares traded during a defined time period. When investors or financial analysts see a large increase in volume, it may indicate a significant change in the price of security. Significant volume spikes may indicate some kind of important news taking place in the stock market. We have taken trading volume as another variable to determine its impact on stock market as well.

The return is calculated as the continuously-compounded return using the closing price:

$$R_t = \ln\left(\frac{P_t}{P_{t-1}}\right) * 100\ \% \tag{1}$$

Where ln ($P_t$) denotes the natural logarithm of the closing price at time t.

The theory behind ARMA estimation is based on stationary time series. A series is said to be stationary if the mean and auto co variances of the series do not depend on time. Any series that is not stationary is said to be non stationary. A common example of a non stationary series is the random walk.

Serial correlation coefficient test is a widely used procedure that tests the relationship between returns in the current period with those in the previous period. If no significant autocorrelation are found then the series are expected to follow a random walk. The Durbin-Watson statistics is a test for first-order serial correlation. The Durbin-Watson is a test of the hypothesis p=0 in the specification:

$$u_t = pu_{t-1} + \varepsilon t \tag{2}$$

If there is no serial correlation, the DW statistic will be around 2. The DW statistic will fall below 2 if there is positive serial correlation (in the worst case, it will be near zero). If there is negative correlation, the statistics will lie somewhere between 2 and 4.However there are limitations of the DW test as a test for serial correlation. So two other tests of serial correlation—the Q-statistic and the Breusch-Godfrey LM test are preferred in most applications.

The best alternative is to use a test for autocorrelation in a form of equation, in which relationship between $u_t$ and several of its lagged values at the same time could be checked. Breusch Godfrey test is among the tests widely used for testing autocorrelation of the lags up to r ' th order.

$$u_t = p_1 u_{t-1} + p_2 u_{t-2} + p_3 u_{t-3} + \ldots\ldots + p_r u_{t-r} + v_t \tag{3}$$

$$v_t \approx N(0, \sigma^2 v)$$

Random walk hypothesis implies independent residuals and a unit root.The autocorrelations are easy to interpret—each one is the correlation coefficient of the current value of the series with the series lagged a certain number of periods. If the autocorrelation function dies off smoothly at a geometric rate, and the partial autocorrelations were zero after one lag, then a first-order autoregressive model is appropriate. Alternatively, if the autocorrelations were zero after one lag and the partial autocorrelations declined geometrically, a first-order moving average process would seem appropriate

The auto correlation of a series Y at lag K is estimated by

$$\Gamma_k = \frac{\sum_{t=k+1}^{T} (y_t - \bar{y})(y_{t-k} - \bar{y})}{\sum_{t=1}^{T} (y_t - \bar{y})^2} \tag{4}$$

Where $\bar{y}$ is the sample mean of y. This is the correlation coefficient for values of the series k periods apart. If □$_1$ is non zero, it means that the series is first order serially correlated if □$_k$ dies off more or less geometrically with increasing lag k, it is a sign that the series obeys a low order autoregressive (AR) process. If□$_k$ drops to zero after a small number of lags; it is a sign that the series obeys a low-order moving-average (MA) process.

If the pattern of autocorrelation is one that can be captured by an auto regression of order less than k, then the partial auto correlation at lag k will be close to zero. The partial auto correlation at lag k recursively by

$$\Phi k = \frac{\Gamma_k^{\Gamma_1} - \sum_{J=1}^{k-1} \Phi_{k-1,j}^{\Gamma_{k-j}}}{1 - \sum_{J=1}^{k-1} \Phi_{k-1,j}^{\Gamma_{k-j}}} \tag{5}$$

For K = 1 for K > 1

Where □k is the estimated auto correlation at lag k and $\Phi k,j = \Phi k{-}1, j - \Phi k, \Phi k-1, k-j$,

Q statistics is often issued, as a test of whether the series is white noise. The Q statistics at lag k is a test statistics for the null that there is no auto correlation up to order as is computed as

$$QLB = T(T+2) \sum_{j-1}^{k} \frac{\Gamma_j^2}{T-j} \tag{6}$$

Where □j is the jth auto correlation and T is the number of observations.

If the series is not based upon the results of ARIMA estimation, then under the null hypothesis, Q is asymptotically distributed as a $\chi 2$ with degrees of freedom equal to the number of autocorrelations. If the series represents the residuals from ARIMA estimation, the appropriate degrees of freedom should be adjusted to represent the number of autocorrelations. If there is no serial correlation in the residuals, the autocorrelations and partial autocorrelations at all lags should be nearly zero, and all Q-statistics should be insignificant with large p-values. If Q statistics measured found to be significant, it can be said that the market does not follow random walk.

Knowledge of non-stationarity of the time series is significant in the modelling of economic relationships because standard statistical techniques that assume stationarity may give invalid inferences in the presence of stochastic trends. In case of non-stationarity data, ordinary least squares can produce spurious results. Therefore, prior to modelling any relationship, non-stationarity must be tested. The data considered for the study is time series, which is non-stationary. For application of Granger Causality the initial step in the estimation involves the determination of the times series property of each variable individually by conducting unit root tests.

Considering a simple AR (1) process:

$$y_t = p * y_{t-1} + x'\delta + \varepsilon_t \tag{7}$$

Where $x_t$ are optional exogenous regressors which may consist of constant, or a constant and trend, p and δ are parameters to be estimated, and $\varepsilon_t$ the are assumed to be white noise. If ,|p|≥1, y is a nonstationary series and the variance of increases with time and approaches infinity. If ,|p|< 1.y is a (trend-)stationary series. Thus, the hypothesis of (trend-)stationarity can be evaluated by testing whether the absolute value of p is strictly less than one. The null hypothesis $H_o$: p=1 against the one-sided alternative$H_1$: p<1. In some cases, the null is tested against a point alternative.

The most popular unit root rest is the ADF test. The standard DF test is carried out after subtracting $y_{t-1}$ from both the sides of the equation:

$$\Delta y_t = \alpha * y_{t-1} + x_t'\delta + \varepsilon_t \tag{8}$$

Where α= p-1. The null and alternative hypotheses is written as

$H_o$: α=0

$H_1$: α<0

The simply Dickey Fuller unit root test includes AR (1) process and described valid If the series is correlated at higher order lags, the assumption of white noise disturbances εt is violated. The Augmented Dickey-Fuller (ADF) test constructs a parametric correction for higher-order correlation by assuming that the y series follows an AR (1 ) process and adding p lagged difference terms of the dependent variable y to the right hand side of the test regression:

$$\Delta y_t = \alpha * y_{t-1} + x_t'\delta + \beta_1 * \Delta y_{t-1} + \beta_2 \Delta y_{t-2} + \dots\dots + \beta_p \Delta y_{t-p} + v_t \tag{9}$$

Said and Dickey (1984) demonstrate that the ADF test is asymptotically valid in the presence of a moving average (MA) component, provided that sufficient lagged difference terms are included in the test regression.

**4. Dickey-Fuller Test with GLS De trending (DFGLS)**

Elliott et al. (1996) propose a simple modification of the ADF tests in which the data are de trended so that explanatory variables are "taken out" of the data prior to running the test regression. ERS (1996) obtain the asymptotic power envelope for unit-root tests by analyzing the sequence of Neyman-Pearson tests of the null hypothesis $H_0$: p= 1 against the local alternative $H_a$:p=1+ $\bar{c}$ /T, where $\bar{c}$<0. Based on asymptotic power calculation, ERS show that a modified Dickey-Fuller test, called the DF-GLS test, can achieve a substantial gain in power over traditional unit-root tests.

The DF-GLS test that allows for a linear time trend is based on the following regression:

$$(1-L)y_t^d = \phi y_{t-1}^d + \sum_{j=1}^{p} \phi_j (1-l) y_{t-1}^d + v_t \tag{10}$$

Where $v_t$ is an error term and $y_t^d$ is the locally de trended data process under the local

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alternative of $\bar{p} = 1 + \bar{c}/T$ is given by

$$y_t^{\tau} = y_t - z_t\beta$$

With β being the least squares regression coefficient of $\tilde{yt}$ on $\tilde{zt}$, for which $\tilde{yt}$ =[$y_{1,}$(1- $\bar{p}$ L)$y_2$....(1- $\bar{p}$ L)$y_T$]' and $\bar{Z}_t$=[$Z_{1,}$(1- $\bar{p}$ L)$Z_{2,......}$..(1- $\bar{p}$ L) $Z_l$ ]The DF-GLSt statistic is given by the t-ratio, testing $H_0$:$\phi_o$=0 against Ha:$\phi_0$< 0.ERS recommend that the parameter of defining the local alternative, $\bar{c}$, be set equal to -13.5.For the test without a time trend, denoted by DF-GLS., it involves the same procedure as the DF-GLSt test, except that $y_t^d$ is replaced with the locally demeaned series $y_t^d$ and z =1. In this case, the use of $\bar{c}$ =-7 is recommended.

**Phillips-Perron(PP)Test**

Phillips and Perron (1988) developed a number of unit root tests that have become popular in the analysis of financial time series. The Phillips-Perron (PP) unit root tests differ from the ADF tests mainly in how they deal with serial correlation and heteroskedasticity in the errors. In particular, where the ADF tests use a parametric auto regression to approximate the ARMA structure of the errors in the test regression, the PP tests ignore any serial correlation in the test regression. The test regression for the PP tests is

$$\Delta y_t = \beta' D_t + \pi y_{t-1} + u_t \qquad (11)$$

where $u_t$ is I(0) and may be heteroskedastic. The PP tests correct for any serial correlation and heteroskedasticity in the errors ut of the test regression by directly modifying the test statistics tπ=0 and T ˆπ. These modified statistics, denoted Zt and Zπ, are given by

$$Z_t = \left(\frac{\hat{\sigma}^2}{\hat{\lambda}^{-2}}\right)^{1/2} .t_{\pi} = 0 - \frac{1}{2}\left(\frac{\hat{\lambda}^{-2} - \sigma^2}{\hat{\lambda}^{-2}}\right).\left(\frac{T - SE(\hat{\pi})}{\hat{\sigma}^2}\right) \qquad (12)$$

$$Z_{\pi} = T\hat{\pi} - \frac{1}{2}\frac{T^2 .SE(\hat{\pi})}{\hat{\sigma}^2}(\hat{\lambda}^{-2} - \hat{\sigma}^2) \qquad (13)$$

The terms $\hat{\sigma}$ and $\hat{\lambda}^2$ are consistent estimates of the variance parameters

$$\sigma^2 = \lim_{T-x} T^{-1} \sum_{t=1}^{T} E\left|u_t^2\right|$$

$$\lambda^2 = \lim_{T - x} \sum_{t=1}^{T} E\left|T^{-1} S_T^2\right|$$

where $S_T = \sum_{t=1}^{T} u_t$ .The sample variance of the least squares residual $\hat{u}_t$ is a consistent estimate of σ2, and the Newey-West long-run variance estimate of ut using $\hat{u}_t$ is a consistent estimate of λ2. Under the null hypothesis that $\pi = 0$, the PP Zt and Zπ statistics have the same asymptotic distributions as the ADF t-statistic and normalized bias statistics. One advantage of the PP tests over the ADF tests is that the PP tests are robust to general forms of heteroskedasticity in the error term ut. Another advantage is that the user does not have to specify a lag length for the test regression.

**5. KPSS (Kwiatkowski, Phillips, Schmidt, and Shin) Test**

In the KPSS test, stationarity is the null hypothesis and the existence of a unit root is the alternative. KPSS tests are used for testing a null hypothesis that an observable time series is stationary around a deterministic trend. The series is expressed as the sum of deterministic trend, random walk, and stationary error, and the test is the LM test of the hypothesis that the random walk has zero variance. KPSS type tests are intended to complement unit root tests, such as the ADF tests. The KPSS statistic is based on the the residuals from the OLS regression of $y_t$ on the exogenous variables $x_t$

$$y_t = \chi_t^1 \beta + \mu \tag{14}$$

The LM statistics is given by:

$$LM = \sum_{t=1}^{T} s^2 t / \sigma_t^2 \tag{15}$$

Where, $\sigma_t^2$ is an estimator for the error variance. This latter estimator $\sigma_t^2$ may involve corrections for autocorrelation based on the Newey-West formula. In the KPSS test, if the null of stationarity cannot be rejected, the series might be co integrated. The KPSS test is estimated and found to contain a unit root when the test statistics is less than the critical values at the estimated level of significance.

**6. Ng and Perron (NP) Tests**

Ng and Perron (2001) use the GLS de trending procedure of ERS to create efficient versions of the modified PP tests of Perron and Ng (1996). These efficient modified PP tests do not exhibit the severe size distortions of the PP tests for errors with large negative MA or AR roots, and they can have substantially higher power than the PP tests. Especially, when φ is close to unity.

Using the GLS de trended data $y_t^d$ , the efficient modified PP tests are defined as

$$\overline{MZ} = (T^{-1} y_T^d - \lambda^2)(2T^{-2} \sum_{t=1}^{T} y_{t-1}^d)^{-1} \tag{16}$$

$$\overline{MSB} = (T^{-2} \sum_{t=1}^{T} y_{t-1}^d / \lambda^2)^{1/2} \tag{17}$$

$$\overline{MZ}_t = \overline{MZ}_\alpha \, x \, \overline{MSB} \tag{18}$$

The statistics $\overline{MZ}_\alpha$ and $\overline{MZ}_t$ are efficient versions of the PP Zα and Zt tests, that have much smaller size distortions in the presence of negative moving average errors. Ng and Perron derive the asymptotic distributions of these statistics under the local alternative φ = 1− c/T for Dt = 1 and Dt = (1, t). In particular, they show that the asymptotic distribution of $\overline{MZ}_t$ is the same as the DF-GLS t-test.

**7. Granger - Causality Test**

The dynamic linkage is examined using the concept of Granger's (1969) causality. The Granger type causality procedure (Granger, 1969, 1988) is applied to determine the direction of causation among the variables. The causality procedure is conducted based on bi-variate system (x, y). Formally, a time series $X_t$, Granger-causes another time series $Y_t$ if series $Y_t$ can be predicted better by using past values of ($X_t$, $Y_t$) than by using only the historical values of $Y_t$. In other words, $X_t$ fails to Granger–cause $Y_t$ if for all M>O the conditional probability distribution of $Y_{t+m}$ given ($Y_t$, $Y_{t-1}$) is the same as the conditional probability distribution of $Y_{t+m}$ given both ($Y_t$, $Y_{t-1}$, ….) and ($X_t$, $Y_{t-1}$, ….). That is $X_t$, does not Granger cause $Y_t$ if

$$P_r\left(\frac{Y_{t+m}}{\psi_t}\right) = P_r\left(\frac{Y_{t+m}}{\Omega_t}\right)$$

Where $P_r$ denotes conditional probability, $\Psi_t$ is the information set at time t on past values $Y_t$, and $\Omega_t$ is the information set containing values of both $X_t$ and $Y_t$ up to time point t.

Testing causal relations between two stationary series $X_t$ and $Y_t$ can be based on the following bi- variate auto regression (Granger – 1969).

$$Y_t = \alpha_0 + \sum_{k=1}^{p} \alpha_k * Y_{t-k} + \sum_{k=1}^{p} \beta_k * X_{t-k} + U_t \tag{19}$$

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$$X_t = \varphi_0 + \sum_{k=1}^{p} \varphi_k * Y_{t-k} + \sum_{k=1}^{p} \phi_k * X_{t-k} + V_t \qquad (20)$$

Where P is a suitably chosen positive integer; $\alpha_k$'s and $\beta_k$'s, K = 0, 1, -----, p are constants; $U_t$ and $V_t$ are usually disturbance terms with zero means and finite variance. The null hypothesis that $X_t$ does not Granger – cause $Y_t$ is rejected if the $\beta_k$'s, K>0 in equation 2 are jointly significantly different from zero using a standard joint test (e.g., an F test). Similarly, $Y_t$ Granger – causes if the $\varphi_k$'s, K>0 are jointly different from zero.

## 8. Empirical Analysis

### *8.1 Descriptive Statistics*

The summary statistics for BSE Sensex, BSE volume change, 91-day T-bill rate, S&P 500, exchange rate, and WPI are given in Table-1. All returns are calculated as the first difference of the log of the weekly closing price. The mean of the BSE Sensex is -0.059856. The volatility of the index is 1.463072. The mean of the 91-day T-bill auction rate is -0. 233921. The S&P 500 returns are -0.120676. The exchange rate is 0.019621; and the mean of wholesale price index is 0.153914.The kurtosis for all the aforementioned factors is more than 3 (excess kurtosis), thus they are leptokurtic, i.e., the frequency distribution assigns a higher probability to returns around zero as well as very high positive and negative returns. The Jarque-Bera statistic for all the 6 variables is significantly greater than zero (due to the leptokurtic data). Thus, Jarque-Bera statistics shows that all the series are leptokurtic, exhibit non-normality and indicate the presence of Heteroscedasticity.

Table 1. Descriptive Statistics

| **Variable** | **Mean** | **Std. Dev.** | **Skewness** | **Kurtosis** | **Jarque-Bera** | **Probability** |
|---|---|---|---|---|---|---|
| BSE Return | -0.059856 | 1.463072 | 0.367803 | 15.64054 | 2124.299 | 0.000000 |
| BSE Volume | 0.035957 | 7.048135 | -0.481634 | 12.00021 | 1082.181 | 0.000000 |
| 91-Day Treasury Bill Rate | -0.233921 | 8.907419 | -2.030092 | 31.28345 | 10783.80 | 0.000000 |
| S&P 500 Return | -0.120676 | 1.225119 | -0.046508 | 12.66397 | 1233.671 | 0.000000 |
| Exchange Rate | 0.019621 | 0.506510 | -0.950935 | 22.01492 | 4823.475 | 0.000000 |
| WPI | 0.153914 | 3.532606 | 17.54097 | 310.9098 | 1268518. | 0.000000 |

Table 2. Durbin-Watson Tests

| Variable | Durbin-Watson stat | F-statistic | Prob(F-statistic) |
|---|---|---|---|
| BSE sensex | 1.996156 | 387.6970 | 0.000000 |
| BSE Trading Volume | 1.987563 | 134.1877 | 0.000000 |
| 91-Day Treasury Bill | 2.021978 | 93.39633 | 0.000000 |
| S&P 500 Return | 1.992787 | 366.2804 | 0.000000 |
| Exchange Rate | 1.987834 | 355.3248 | 0.000000 |
| WPI | 2.000006 | 315.0488 | 0.000000 |

Table-2 reported the Durbin-Watson statistics for all the variables and they are all within the range of 1.9 and 2.2, which is indicative of the absence of first order serial correlation. Hence the result can be relied upon to test unit root. DW test, which is a test for serial correlations, has been used in the past but the explanatory power of the DW can be questioned on the basis that the DW only looks at the serial correlations on one lags as such may not be appropriate test for the daily data. So for market efficiency we have used unit root test of stationarity.

Autocorrelation is useful for finding repeating patterns in a signal, such as determining the presence of a periodic signal. The auto correlation and partial correlation functions (ACF and PACFs) of the series of BSE sensex, Trading volume, 91-days Treasury bill, S&P 500, Exchange rate and WPI are presented in the table 3 , fig-1 and fig-2.

Table 3. Auto Correlation and Partial Auto correlation

| Lag | AC | PAC | Q-Stat | Prob |
|---|---|---|---|---|
| 1 | -0.106 | -0.106 | 3.6243 | 0.057 |
| 2 | -0.014 | -0.026 | 3.6912 | 0.158 |
| 3 | -0.061 | -0.066 | 4.9033 | 0.179 |
| 4 | 0.084 | 0.071 | 7.2028 | 0.126 |
| 5 | -0.089 | -0.077 | 9.7881 | 0.081 |
| 6 | -0.095 | -0.115 | 12.721 | 0.048 |
| 7 | 0.036 | 0.019 | 13.138 | 0.069 |
| 8 | 0.059 | 0.046 | 14.267 | 0.075 |
| 9 | -0.088 | -0.079 | 16.789 | 0.052 |
| 10 | -0.086 | -0.095 | 19.225 | 0.037 |
| 11 | 0.070 | 0.034 | 20.828 | 0.035 |
| 12 | 0.038 | 0.025 | 21.299 | 0.046 |
| 13 | 0.165 | 0.197 | 30.388 | 0.004 |
| 14 | -0.093 | -0.045 | 33.293 | 0.003 |
| 15 | 0.097 | 0.054 | 36.468 | 0.002 |
| 16 | 0.087 | 0.125 | 39.024 | 0.001 |
| 17 | 0.034 | 0.068 | 39.416 | 0.002 |
| 18 | -0.211 | -0.163 | 54.562 | 0.000 |

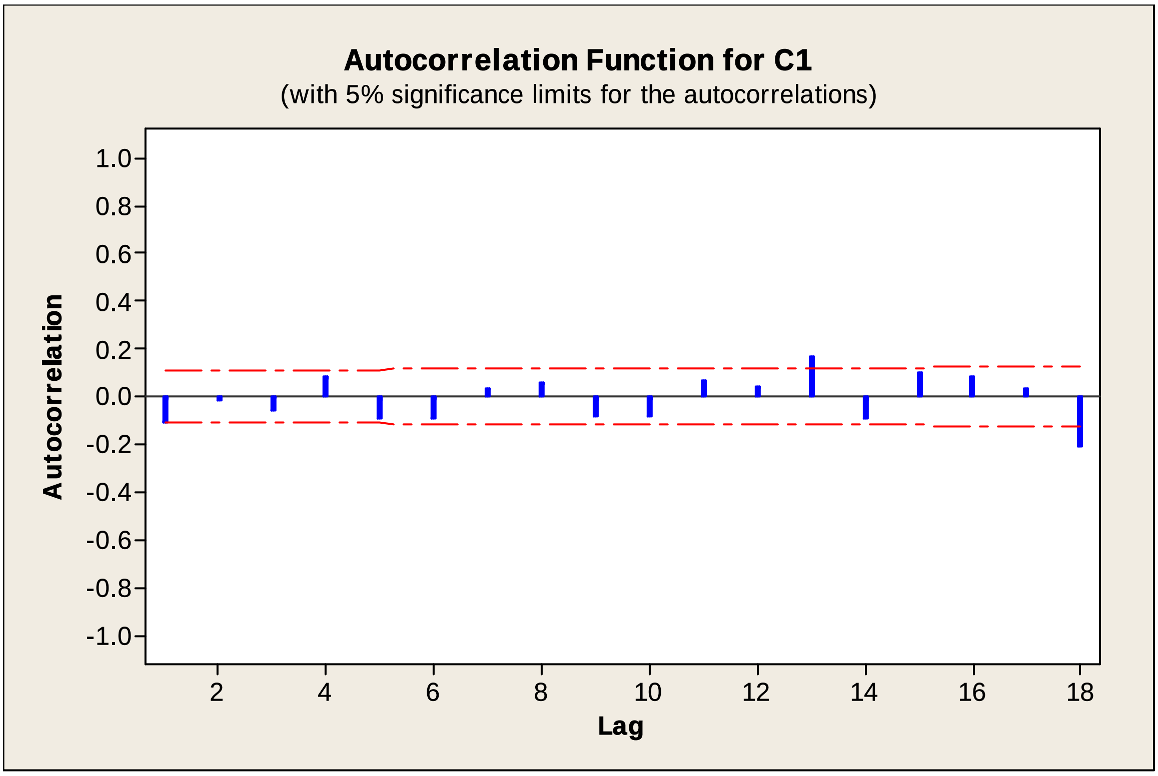


Figure 1

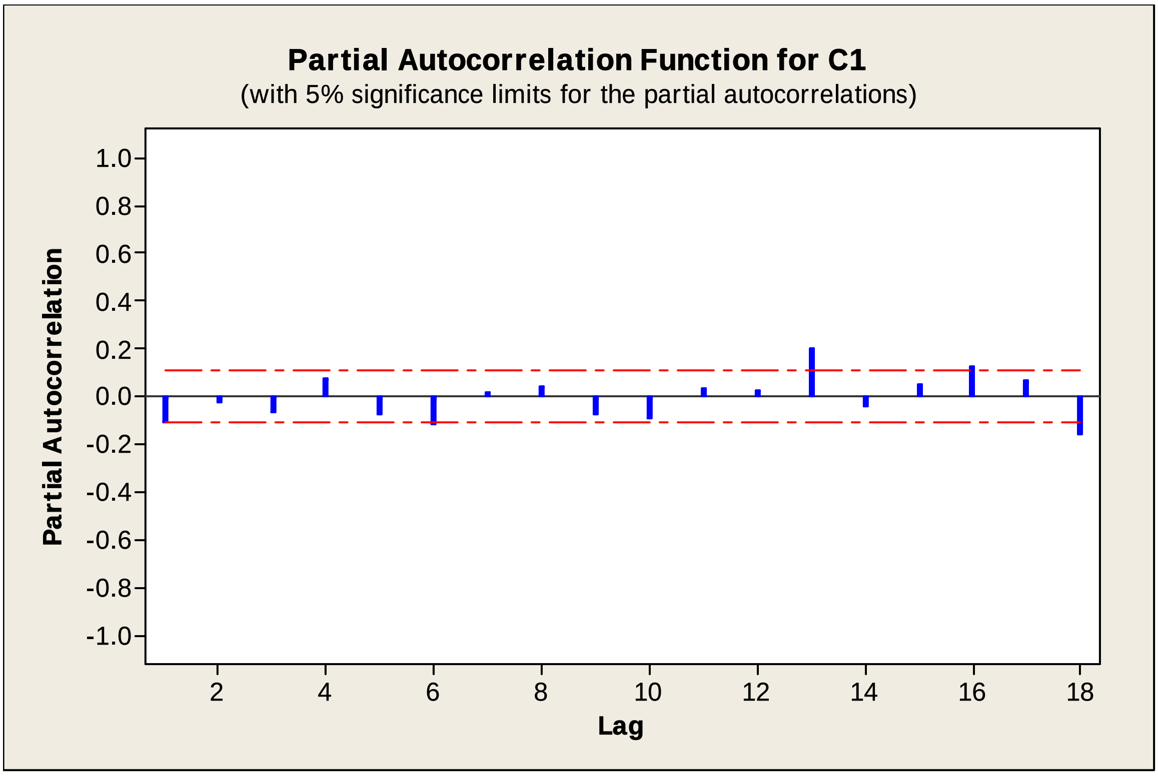


Figure 2

The results of the test presented in table-3 that Q-statistics are significant at almost all lags, indicating significant serial correlation in the residuals and the null hypothesis of weak-form market efficiency is rejected. It confirms the presence of autocorrelation in the Indian stock market and macro economic variables, which implies that the market does not follow random walk and fell into a form of Efficient Market Hypothesis.

However, the theory of stock market behaviour and anomalies presents evidence against the EMH. The study here suggests that market rationally process information so that market efficiency holds but significant autocorrelation may arises from market friction. It indicates that market frictions may be due to dependence on weekly returns of macroeconomic variables.

Table 4. Breusch-Godfrey Serial Correlation LM Test

| | | | |
|---|---|---|---|
| F-statistic | 9.271466 | Probability | 0.000000 |
| Obs*R-squared | 34.16653 | Probability | 0.000001 |

Breusch-Godfrey Serial Correlation LM Test is presented in table 4 and the test rejects the hypothesis of no serial correlation. The Q-statistic and the LM test both indicate that the residuals are serially correlated and presence of efficient at the weak-form.

Table 5. Unit Root Test

| Variable | ADF test | DF-GLS test | PP test | KPSS test | Ng-Perron test |
|---|---|---|---|---|---|
| BSE sensex | -19.69002* | -19.68534* | -19.97884* | 0.157864* | 0.05629* |
| BSE Trading Volume | -13.14690* | -13.12342* | -22.94935* | 0.048900* | 0.03122* |
| 91-Day Treasury Bill | -10.86672* | -16.99582* | -37.41525* | 0.322414* | 0.05055* |
| S&P 500 Return | -19.13845* | -19.12985* | -19.13375* | 0.570382* | 0.05604* |
| Exchange Rate | -18.85006* | -18.87945* | -18.82371* | 0.082894* | 0.05635* |
| WPI | -17.74962* | -17.75305* | -17.74960* | 0.184215* | 0.05625* |

Asymptotic Critical values*

| | | | | | |
|---|---|---|---|---|---|
| 1% level | -3.458973 | -2.572277 | -3.458470 | 0.739000 | 0.17400 |
| 5% level | -2.874029 | -1.941827 | -2.873809 | 0.463000 | 0.23300 |
| 10% level | -2.573502 | -1.616030 | -2.573384 | 0.347000 | 0.27500 |

The study here employs the unit root test to examine the time series properties of concerned variables. Unit root test describes whether a series is stationary or non-stationary. For the test of unit root the present study employees the Augmented Dickey Fuller test, DF-GLS test, PP test, KPSS test and Ng-Perron test. These tests are used to measure the stationarity of time series data which in turn tells whether regression can be done on the data or not. It is apparent from table-5 that the results are statistically significant and less than critical values. So the results of all tests are consistent suggesting that these markets are not weak form efficient. It recommends that the return series of all variable does not follow random walk model and the stock returns display predictable behaviour.

On observing the outputs it is seen that the test statistic for all 6 variables are less than the critical values at 1%, 5% and 10% confidence level. So, the null hypothesis is rejected and the data is found to be stationary. Therefore, we can apply Granger causality test which requires the data to be stationary in order to avoid getting spurious results.

Table 6. Granger Causality Test

| Null Hypothesis: | F-Statistic | Probability |
|---|---|---|
| BSE Volume does not Granger Cause BSE SENSEX | 17.1176* | 8.9E-08 |
| BSE SENSEX does not Granger Cause BSE Volume | 0.42798 | 0.65221 |
| 91-Day Treasury Bill Rate does not Granger Cause BSE SENSEX | 2.64972** | 0.07227 |
| BSE Return does not Granger Cause 91-Day Treasury Bill Rate | 4.89076* | 0.00811 |
| S&P 500 Return does not Granger Cause BSE SENSEX | 35.6953* | 1.1E-14 |
| BSE SENSEX does not Granger Cause S&P 500 Return | 1.66070 | 0.19169 |
| Exchange Rate does not Granger Cause BSE SENSEX | 7.52360* | 0.00064 |
| BSE SENSEX does not Granger Cause Exchange Rate | 4.23873* | 0.01527 |
| WPI does not Granger Cause BSE SENSEX | 6.78080* | 0.00131 |
| BSE SENSEX does not Granger Cause WPI | 1.43551 | 0.23957 |
| 91-Day Treasury Bill Rate does not Granger Cause BSE Volume | 3.41154** | 0.03423 |
| BSE Volume does not Granger Cause 91-Day Treasury Bill Rate | 0.97177 | 0.37956 |
| S&P 500 Return does not Granger Cause BSE Volume | 4.17823* | 0.01620 |
| BSE Volume does not Granger Cause S&P 500 Return | 3.24498** | 0.04030 |
| Exchange Rate does not Granger Cause BSE Volume | 7.36818* | 0.00075 |
| BSE Volume does not Granger Cause Exchange Rate | 16.7148* | 1.3E-07 |
| WPI does not Granger Cause BSE Volume | 0.22436 | 0.79916 |
| BSE Volume does not Granger Cause WPI | 2.10149 | 0.12401 |
| S&P 500 Return does not Granger Cause 91-Day Treasury Bill Rate | 7.47631* | 0.00067 |
| 91-Day Treasury Bill Rate does not Granger Cause S&P 500 Return | 0.26556 | 0.76695 |
| Exchange Rate does not Granger Cause 91-Day Treasury Bill Rate | 0.35730 | 0.69985 |
| 91-Day Treasury Bill Rate does not Granger Cause Exchange Rate | 2.17326 | 0.11554 |
| WPI does not Granger Cause 91-Day Treasury Bill Rate | 0.95018 | 0.38780 |
| 91-Day Treasury Bill Rate does not Granger Cause WPI | 0.31551 | 0.72965 |
| Exchange Rate does not Granger Cause S&P 500 Return | 1.59432 | 0.20471 |
| S&P 500 Return does not Granger Cause Exchange Rate | 11.7473* | 1.2E-05 |
| WPI does not Granger Cause S&P 500 Return | 1.88505 | 0.15356 |
| S&P 500 Return does not Granger Cause WPI | 3.99548* | 0.01935 |
| WPI does not Granger Cause Exchange Rate | 7.00005* | 0.00106 |
| Exchange Rate does not Granger Cause WPI | 1.01244 | 0.36453 |

* Null hypothesis rejected at 1% significance level
**Null hypothesis rejected at 5% significance level
*** Null hypothesis rejected at 10% significance level

The Granger-causality test is conducted to study the causal relationship between macro economic variables and the Indian stock market. Table-6 reported pair wise Granger causality test results with lags 2 as two lag is an appropriate lag order chooses in terms of the Akaike Information Criteria (AIC) for the full sample period. BSE trading volume, Treasury bill rate, S&P 500, Exchange rate, and WPI are found to be the most important variable in determining stock market return. The reported F-values suggests that there is a unidirectional causality between trading volume and stock market, international stock market and domestic stock market, inflation rate and stock market, interest rate and trading volume, international stock market and interest rate, international stock market and exchange rate, international stock market and inflation rate, inflation rate and exchange rate. This implies that international market influence the domestic stock market, exchange rate, inflation rate and interest rate. Apart of this, any changes in trading volume and inflation rate also affecting stock market. It is also found from the table-6 that there is bidirectional relationship between interest rate and stock market, exchange rate and stock market, international stock market and BSE volume, exchange rate and BSE volume. So it suggests that exchange rate and interest rate are influencing the stock market and any variation in stock market also influencing the exchange rate and interest rate in the economy. Also it is experimented that variability of international market and exchange rate is affecting trading volume changes in the stock market. Again it is observed from the Table-6 that there is no apparent causality between inflation rate and trading volume, interest rate and exchange rate, interest rate and inflation rate.

## 9. Concluding observation

This study examines the relationship between the stock market and a set of macroeconomic variables during the period of January 2005 to February 2011. The time series data set employed in this study comprises the weekly observations of the BSE Sensex, WPI, Treasury bill rate, Exchange rate, S&P 500 and BSE trading volume. The study used Ljung-Box Q statistics and Breusch-Godfrey Serial Correlation LM Test to determine the auto correlation of all variables. The study confirms the presence of autocorrelation in the Indian stock market and macro economic variables. The study also used the Granger causality test to determine the causal effect relationship between the BSE Sensex with macro economic variables. Statistical inferences are drawn from the data by means of significance tests and bidirectional causality is seen between inflation rate and stock market, exchange rate and stock market, interest rate and stock market, international stock market and BSE volume, Exchange Rate and BSE volume. Similarly unidirectional causality is found between international stock market and domestic stock market, international stock market and exchange rate, international stock market and inflation rate, international stock market and interest rate. So the study suggests that Indian stock market is influenced by inflation rate, exchange rate and interest rate in the economy. So they can be used to predict stock market price fluctuations. The study also found that variability of international market and exchange rate is affecting trading volume change in the stock market in the economy. Further the study reveals that Indian stock markets are not weak form efficient. So it implies that the sensible investor in India can attain abnormal returns using historical data of stock prices, and macroeconomic indicators. This may enable the traders and investors to work out profitable strategy for trading or to take investment decision.

One of the limitations of the study is that we have used five macroeconomic variables only, so further research needs to be explored by including more macroeconomic variables to know the relationships between these factors and the nature of stock market volatility. Secondly, it is also quite possible that the macroeconomic variables have different impact on stock market volatility depending on the trading mechanisms and regulatory environments.

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