

# Inter-Linkage between Macroeconomic Variables and Stock Indices: Using Granger Causality & Co-Integration Approach

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## ABSTRACT

As exchange rate and GDP are the important factors which influence the behavior of stock market. In this study we have examined the Co-integration between macroeconomic variables and Indian stock market and causality between exchange rate and GDP with stock return. We have applied 42years data on yearly basis for GDP, exchange rate and stock return and applied ADF test for checking Stationarity, Correlogram for serial correlation, Johansen Co-integration for association and Granger causality test for examine multiple causal relation by controlling the effects of other variables, then Impulse Response Function used for checking the responsiveness of a time series to unexpected shocks in other time series. The study found that exchange rate significantly granger causes the stock return Indian stock market and long run co-integration found to be significant in amongst the selected variables.

**KEYWORDS:** Stock Return, Stationarity, Granger Causality, and Variance Decomposition Analysis

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## ➤ INTRODUCTION

As stock market is working since over a decades in the country and it has participated prominent role in the growth of the economy directly or indirectly. From last few years, national as international investors and researchers have taken more emphasis on emerging financial market, especially in Asian countries markets. Stock market provides attractive investment opportunity to the investors. Since last one decade Indian stock markets are providing more attractive opportunities to the investors and this market is growing sharply during the period. So it has become very much profitable and attractive market for the investors. As we know, after globalisation Indian economy has been open for rest of the world. By this, international investors can invest in Indian stock market without extra restriction as it was earlier. By applying granger causality, variance decomposition and impulse response function, the author depicted stock market leads to economic activates except exchange rate. Exchange rate leads to stock price (Ahmed, 2008). A study confirmed that

exchange rate and stock prices are bi-directionally related to each other and positively related to each other (Srivastava A. &, 2011). Evidence depicted that growth rate and stock market are equally related to each (Agrawalla, 2007). The macroeconomic factors like IIPs, WPIs, affected more to the stock market than global factors in the long run (Srivastava, 2010).

As previous literatures also worked on the causality and co-integration among the macroeconomic variables and Indian stock market but previous literature consists data for maximum of 12 to 15 years only. Here we have used data for 42 years from 1980 to 2021 to examine the causality and co-integration amongst the variables as well responsiveness of time series to shocks. The first part of the article includes introduction and literature review. Second part consist objective, hypothesis and methodology. Third part of the article depicts models of causality and co-integration test, and then analysis and interpretation

have been shown related to unit root test, serial correlation, co-integration, VAR granger causality / Block Exogeneity Wald test. And finally we have presented discussion, managerial implication and conclusion of the study.

#### ➤ **Review of literature:**

Nakaet studied long run relationship between BSE stock price and select macroeconomic variables by using monthly data from 1960 to 1995. The study applied VECM to avoid potential misspecification biases. The study observed that five variables are co-integrated and exist long run equilibrium relation among these variables (Nakaet, 2001). (Irabian) analyse the dynamic interaction between stock price and select macro-economic variables. Under the stock monthly data from 1977 to 1996 have been used to examine the co-integration and granger causality between and among the variables. This study depicted that stock price is influenced by changes in official reserves and exchange rate in short run but there is no co-integration in long run (Irabian, 1999). **Bhattacharya and Mukharjee (2006)** empirically analysed the relationship between macroeconomic variables and Indian stock market. Under the study VAR model and non-granger causality technique applied, using data from April 1992 to Mar.2001. Result submitted that there is no causality between exchange rate, money supply, Index of Industrial Production, Gross National Product and Forex reserve and stock return. But inflation rate bi-directionally causes with stock return (**Bhattacharya and Mukharjee, 2006**). Another study examined the relationship between stock return and macroeconomic variables in India by using co-integration and error correction model for the period from April 1992 to Dec. 1997 on monthly basis. The study admitted that long run co-integration does not exist between the stock price and macro-economic variables also inferred weak form of causality running from IIPs to stock index (**karnik, 2000**). A study on the causal relationship between S&P 500 and exchange rate for short period of time has been conducted and by the study, authors depicted that there is bidirectional causality exists between both of these selected variables. On the other hand, co-integration analysis was failing to produce significant long run co-integration between S&P 500 and USD exchange rate (**Sohrabian, 1992**). The author studied the relationship between BSE stock index and three select macroeconomic variables i.e. IIPs, WPIs, Exchange Rate. By using monthly data he has applied unit root, correlation and granger causality to know relationship and granger cause between the variables. Study affirmed there is unit root in stock index, IIPs WPIs and Sensex. On the other hand, unidirectional

causality of WPIs exists with Sensex as well as strong correlation in between (**Singh, 2010**). Recent study analysed the relationship between Indian stock market index (BSE Sensex) and select variables namely IIPs, WPIs, Money Supply, and exchange rate. Under the study monthly data have been used from 1999 to 2017 and for the analysis causality, co-integration and VECM has been applied to know the causality and relationship. The results significantly depict that BSE Sensex causes changes in the exchange rate and money supply, FII, gold prices and IIP (**Misra, 2018**). Naik and Padhi analysed the long run relationship between stock index and macroeconomic variables for the period from April 1994 to Jun 2011 by using Johansen co-integration and VECM techniques. The result showed co-integration among the variables while stock price influenced by exchange rate and interest rate insignificantly. IIPs and Money supply are positively related to stock prices (**Pramod Kumar NAIK, Puja PADHI, 2012**). A study examine the causal relationship between macro-economic variables and Indian stock index by using different test i.e. unit root test, Ljung –Box Q test and granger causality. The study affirmed there is autocorrelation existing between stock index and macro-economic variables. The study depicted bilateral relationship between stock market and macroeconomic variables (**Tripathy, 2011**).

Here we have deeply studied the previous literatures concerned with our study and found that some literatures are confined existence of long run relationship between stock price and select macroeconomic variables. On the other, some studies are saying about non-existence of co integration among the exogenous and endogenous value in long run. With this, we have arrived at a point that there is conflict between the previous result and need to conduct further research using long period data for confirming the relationship between the variables. So we have used very long data for 41 years of select macroeconomic variables for the purpose of study.

➤ **Objective of the study:** The main objective of the study –

1. To know the Stationarity in time series variables
2. To find the Causality among GDP Exchange rate and stock return.
3. To examine the Co-integration among the macroeconomic variables.
4. To examine the responsiveness of time series variables to their own lagged shocks and shocks of lagged movement of remaining variables.

➤ **Research Hypothesis:**

H<sub>01</sub>: There is Stationarity problem in time series.

H<sub>02</sub>: GDP and Exchange rate do not significantly cause to BSE return.

H<sub>03</sub>: There is no significant Co-integration among the Variables.

➤ **Research Methodology:**

- 1. Nature of the study:** The study is of analytical and Descriptive nature
- 2. Variables selection:** The yearly data of Exchange Rate, Annual GDP and BSE Sensex return have been used for the period of 42 years.
- 3. Statistical and econometric tools:** we have used open access software for the purpose of finding the relation among the variables and applied ADF

➤ **Analysis and interpretation of the study:**

Unit root test, Correlogram, Johansen Co-integration and Granger Causality and Variance Decomposition Analysis.

**4. Presentation of Data:** Tabulation, Line & Bar Graph have been used.

**5. Data Description:** Here, we have used average yearly continuously compounded log return of BSE Sensex as a benchmark of Indian Stock market. Under the study, relative change in GDP and exchange rate data used to confirm Stationarity in data set without making any transformation in data set for proper application of econometric tools in the study.

**Table 1- Descriptive statistics-**

Variable	Mean	Std. Dev.	Skewness	Kurtosis	Jarque-Bera	P Value
GDP	-0.000661	0.036990	0.058300	6.296378	18.58615	0.000092
Exchange Rate	5.597132	8.306994	1.338220	6.332432	31.96975	0.000000
BSE Return	0.205896	0.316407	0.289344	2.918577	19.17887	0.000068

**Source:** Authors own analysis

The above table presents the higher volatility in the time series of the variables and series is leptokurtic because kurtosis value is more than and approximately 3 i.e. the distribution show high probability of return inclining to zero with a high positive and negative return. The statistics of Jarque-Bera show significant that is greater than zero (because of leptokurtic data). So Jarque-Bera depicts all the series are normally distributed.

**Table – 2 Correlogram: Auto Correlation and Partial Auto correlation**

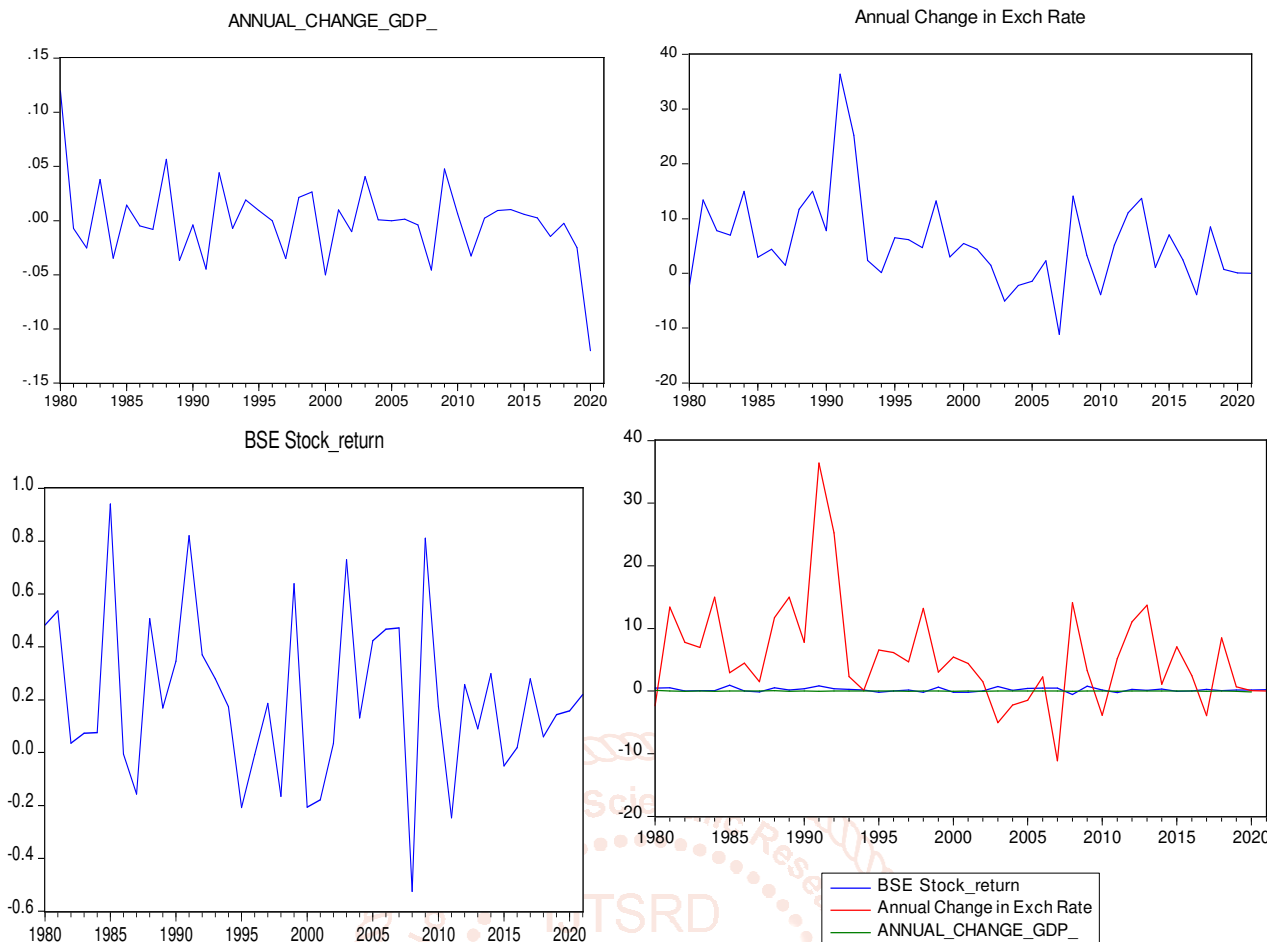
Lag	AC	PAC	Q-Stat.	Prob.
1	-0.175	-0.175	1.3734	0.241
2	-0.122	-0.157	2.0568	0.358
3	-0.131	0.084	2.8701	0.412
4	0.010	0.034	2.8747	0.579
5	-0.152	-0.123	4.0282	0.545
6	0.064	0.007	4.2355	0.645
7	-0.011	-0.037	4.2421	0.752
8	0.000	0.030	4.2421	0.835
9	-0.246	-0.269	7.6309	0.572
10	0.005	-0.113	7.6322	0.665
11	0.033	-0.046	7.6956	0.740
12	0.002	0.033	7.6956	0.808
13	0.026	0.051	7.7384	0.860

**Source:** Authors own calculation

The result of Correlogram is showing that almost every lag has significant value which could be seen by Q-statistics that's indicate significant serial correlation and this is rejection of weak form of market efficiency. It affirms existence of autocorrelation of macroeconomic variables and Indian stock market which implies operation of market follows the information rationally.

➤ **Figure 1- Graphical Presentation of Data:**

To analyse the trend of the time series data we have plot the graph of data set during the study period. With the graph, we can say that there is high volatility in the series which indicates for checking Stationarity in data set so that we could further apply the econometric tools for authentic research.



➤ **Augmented Dickey–Fuller unit root test:** (at level / without Difference)

**H<sub>0</sub>:** Variables have unit root Problem or data is not stationary.

Previous literatures confirmed that most of the financial time series is to be Non-stationary or random walk when the series are in their original form. So we have examined unit root problem in the time series before applying any type of econometric technique in the study. The presence of Non-stationary or random walk in the series may lead to fallacious inferences in the study. Thus, by applying augmented dickey-fuller (ADF) test, we have scrutinize the presence of unit root in the data set/ series. ADF test is to be expressed as:

**Table-03 Augmented Dickey–Fuller (ADF) test**

Variable	ADF test	Prob.	Null hypothesis	Result
GDP	-7.739291	0.0000	Rejected H <sub>0</sub>	Variable is stationary
Exchange Rate	-4.737280	0.0004	Rejected H <sub>0</sub>	Variable is stationary
BSE Return	-7.524013	0.0000	Rejected H <sub>0</sub>	Variable is stationary

**Source:** Authors.

Note: A null hypothesis is to be rejected when test statistics > Critical Value

Asymptotic Critical Values\*

At Level	1%	5%	10%
<b>Critical Value(C.V)</b>	-3.605593	-2.936942	-2.606857

Result of the ADF test showing that the three variables of time series i.e. log Sensex return, relative GDP and Exchange rate are free from unit root problem or series are stationary because the prob. Value is less than 0.05 which confirms rejection of null hypothesis and now we can further use the data set for further study.

➤ **Table-04: Johansen Co-integration Test:** at Lag Length = 0

**H<sub>0</sub>** = There is no co-integration among the variables

In the process of examine the Co-integration among the variables the trace statistics test considered by following equation (2):-



**Result:**

Variable	H <sub>0</sub>	Eigen value	Critical Value	Trace statistic	Critical Value	Prob.**
<b>BSE Stock Return to GDP &amp; Exchange Rate</b>	r = 0	47.62384*	21.13162	93.33649*	29.79707	0.0000
	r = 1	31.03955*	14.26460	45.71264*	15.49471	0.0000
	r = 2	14.67310*	3.841466	14.67310*	3.841466	0.0001

Source: The author's

\*denotes rejection of the Hypothesis at the 0.05 level

\*\*Mackinnon-Haug-Michelis (1999) p-value

The result of Johansen Co-integration test based on the principle which has been discussed in the literature concerned with Johansen Co-integration (**Johansen 1995**). In accordance with the principle when the value of test statistics is less than the critical value at significance level of 5 %. The null hypothesis of no co-integration among the variable rejected and we can confirm that there is long run association exist among GDP, Exchange Rate and Sensex return as well as Eigen value & trace rank test also supports the co-integration among the variables.

➤ **Table – 05 Granger Causality Test-** At Lag – 2, Observation– 41

As it is all known, this test is one of most important test in the field of time series research,. We can complete one research only with the help of this test significantly. So by this, we can understand how much important this test.

**Result:**

Null Hypothesis	F-Statistic	Prob.
Annual Change in Exchange Rate does not Granger Cause Annual Change in GDP	1.12214	0.3373
Annual Change in GDP does not Granger Cause Annual Change in Exchange Rate	0.77320	0.4695
BSE Stock Return does not Granger Cause Annual Change GDP	0.23628	0.7908
Annual Change in GDP does not Granger Cause BSE Stock Return	0.83051	0.4440
BSE Stock Return does not Granger Cause Annual Change in Exchange Rate	0.33158	0.7200
Annual Change in Exchange Rate does not Granger Cause BSE Stock Return	4.01708	0.0269

Source: The author's

The table - 05 presented pair wise causality between the variables with log 2 which is appropriate lag order based on Akaike Information Criteria (AIC) for the sample period. Here annual change in GDP, Exchange rate and stock returns are macroeconomic variables that have been selected for the study. Results are depicting that the null hypothesis of annual change in exchange rate and annual change in GDP does not granger cause to each other has been accepted because F-statistics and P value is greater than 0.05 significance level which confirm there is no causal relation between both of these variables. Further, Hypothesis of BSE stock return and GDP does not granger cause to one another is also accept because of high prob. Value (0.7908 & 0.4440) than 0.05 critical value that is indicating absence of causal relation between BSE stock return and annual change in GDP. And if we will see the causality between exchange rate and BSE return, we can say there is significant causal relation exist between annual change in exchange rate and stock return because p value (0.0269) is less than 0.05 which is significantly rejecting the null hypothesis of annual change in exch. Rate does not granger cause to BSE return. But on the other hand, BSE Sensex return does not granger cause to exchange rate, as we can see in the table where p value (0.7200) is greater than 5% significance level.

Finally we can say that change in exch. Rate leads to BSE Sensex return significantly in long run but annual change in GDP does not do so. Thus we admit that exchange rate is a leading factor for stock return. So at the time of taking decision regarding investment in stocks people should critically examine the changes take placed in exchange rate in long time.

**Table – 06 Variance Decomposition:**

<b>Variance Decomposition of ANNUAL_CHANGE_IN_EXCH_RATE:</b>				
Period	S.E.	ANNUAL_CHANGE _IN_EXCH_RATE	ANNUAL_CHANGE _GDP_	BSE_STOCK_RETURN
1	8.454357	100.0000	0.000000	0.000000
2	8.914901	97.58479	0.796539	1.618672
3	9.076320	95.16961	3.260537	1.569850
4	9.096783	94.80722	3.628401	1.564380
5	9.098799	94.79722	3.638828	1.563950
6	9.098951	94.79550	3.640518	1.563981
7	9.098993	94.79473	3.641211	1.564060
8	9.098996	94.79469	3.641254	1.564060
9	9.098997	94.79468	3.641254	1.564061
10	9.098997	94.79468	3.641256	1.564061
<b>Variance Decomposition of ANNUAL_CHANGE_GDP_:</b>				
Period	S.E.	ANNUAL_CHANGE _IN_EXCH_RATE	ANNUAL_CHANGE _GDP_	BSE_STOCK_RETURN
1	0.033759	1.168292	98.83171	0.000000
2	0.036309	11.42695	85.66895	2.904109
3	0.036406	11.54330	85.21488	3.241827
4	0.036426	11.56184	85.17796	3.260203
5	0.036428	11.56069	85.17426	3.265047
6	0.036429	11.56277	85.17211	3.265121
7	0.036429	11.56315	85.17155	3.265306
8	0.036429	11.56321	85.17148	3.265310
9	0.036429	11.56322	85.17147	3.265314
10	0.036429	11.56322	85.17147	3.265315
<b>Variance Decomposition of BSE_STOCK_RETURN:</b>				
Period	S.E.	ANNUAL_CHANGE _IN_EXCH_RATE	ANNUAL_CHANGE _GDP_	BSE_STOCK_RETURN
1	0.297267	2.858329	3.508028	93.63364
2	0.339792	21.30653	4.688019	74.00545
3	0.343038	21.09047	5.672621	73.23691
4	0.344415	21.52293	5.645658	72.83141
5	0.344458	21.51926	5.664976	72.81577
6	0.344490	21.52384	5.664878	72.81128
7	0.344491	21.52420	5.664852	72.81095
8	0.344492	21.52416	5.664840	72.81100
9	0.344492	21.52419	5.664838	72.81097
10	0.344492	21.52419	5.664840	72.81097
<b>Cholesky Ordering:</b> ANNUAL_CHANGE_IN_EXCH_RATE ANNUAL_CHANGE_GDP_ BSE_STOCK_RETURN				

Source: The author's

**Figure: 02 Graph of Variance Decomposition**  
 Variance Decomposition using Cholesky (d.f. adjusted) Factors



Source: The author's

The variance decomposition function provides something different method of analyzing the dynamics of vector auto regression system. Variance decomposition depicts the proportion of change in endogenous variables, due to shocks of their 'own' lag versus lagged shocks of other remaining variables in the system.

By analyzing the above figure 1, we can understand that exchange rate is affected by its own lagged shock rather than other endogenous variables lagged shock and figure 2 shows annual change in GDP is slightly affected by shock of remaining endogenous variables. But Sensex return is highly affected by the change in exchange rate and slightly affected by shock of lag value of GDP. It means exchange rate change have high impact on Sensex return than change in GDP. This indicated that any change in exchange rate in future would influence the decision of investors and BSE return is so sensitive with respect to exchange rate.

➤ **Conclusion:**

The time series data set comprises of 42 observations of relative alter in GDP, Exchange rate and BSE return. Correlogram affirmed the nearness of serial auto correlation of macroeconomic factors with Indian stock market. The study includes Johansen co-integration test to examine long run association among the variables and study affirmed that all selected variables are interrelated to each other. On the other hand, granger causality test exhibits significant causal relationship and it was confirmed that any change in exchange rate affect the stock prices in long run. The analysis of Variance Decomposition depicts that unexpected own lagged shock as well as lagged shock of other variables affects the price of dependent variables. Here exchange rate has high composition to BSE return

than GDP. So investors should try to take in consideration at the time of taking investment decision. It also implicates that the rational investors can obtain abnormal return in Indian stock market by using historical data of macroeconomic variables and they would be able to predict the fluctuations in stock prices.

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