Macro-Economic Indicators and Their Linkages with BSE Sensex Index: Causality Analysis and Vector Error Correction Model

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Abstract

This research study investigates the functioning of the Indian Stock market with the global and domestic macro-economic factors namely Foreign Exchange Rate, Price of Gold, Price of Crude Oil, Index of industrial production(IIP), Interest Rate and the wholesale price index(WPI) over the period January 2001 to December 2018 using monthly data. The research paper studies causality between the selected macroeconomic indicators with BSE Sensex. Econometric tools namely the Granger-Causality test, Cointegration test and Vector Error Correction Model(VECM) are employed in finding the relationship between them. The Granger-Causality test shows a unidirectional causality between BSE Sensex, Foreign Exchange rate, IIP, Crude oil prices and interest rate. For India, data are consistent with one cointegration equation between the BSE Sensex and the macroeconomic variables. The VECM indicates BSE Sensex has long-run causality between Exchange Rate, Wholesale Price index. The Wald test reveals BSE Sensex has a short-run causal relationship with the interest rate.

JEL Classification Codes: E44, F31,G10

I. INTRODUCTION

India aims to become the world's third-largest economy in the next decade & for global investors, it is considered as the most attractive emerging market as per the recent financial market attractiveness survey (2019) conducted by Emerging Market Private Equity Association (EMPEA). The nation focuses on $5 trillion GDP in the next decade and it has to overcome the liquidity, transparency and regulatory challenges. India's nominal GDP growth rate (ibef 2019) is projected at 12 percent for the year 2020. However, it is recuperating from the impact of rolling out the Goods and services tax(GST) and demonetization. Inflation remains close to 4% target, provides accommodation in monetary policy remains. The smoothing improvement in the Indian stock market proceeds to breath-taking. Across the globe, the stock market is a barometer of the economy. From the past literature, it is evident that macro-economic factors greatly influence the Stock market. However, there is a disagreement on the direction of causality between macro-economic indicators and stock market returns which remained a source of ambiguity. Most of the study confines only to developed nations like the US, UK, etc., whereas little attention was given to emerging countries. To understand in-depth stock market behaviour various studies have been conducted between various macroeconomic indicators. One of the reason for Volatility in the stock market is the impact of economic conditions. A host of literature (Fama and French (1989), Schwert (1990)) found there is a

significant relationship between returns of the stock prices and macroeconomic factors, such as an index of industrial production, inflation, interest rates, bond yield curve, and a risk premium. Though there is a rapid economic growth in emerging economies, fewer studies were focused on the Indian equity markets in the recent decade & this study can help the policymakers in monitoring the macro economic variables & caution the stock market index and help them in the future for decision making. The paper tries to find whether the stock market is uplifting the economy or growing economy is causing an upward trend in the stock market.

II.REVIEW OF LITERATURE

Cointegration analysis by Engle and Granger (1987) permitted a newer way to deal with the long-run relationship between the stock market and diverse monetary factors.(Hondroyiannis&Papapetrou, 2001)observed the dynamic interactions of macro-economic indicator with the Greece stock market and found the domestic macro-economic factors affect the domestic stock prices. The stock market responded negatively to interest rates.(Rani & Scholar, 2015) conducted a study on BSE Sensex and economic factors like money supply, IIP, Foreign exchange rates, inflation and Foreign institutional investors and existence of cointegration imply any one parameter can be focused as a policy variable which can bring changes in other variables. (Mustafa, Samsudin, Shahadan, & Yi, 2015) investigated how the stock market reacts to the changes made in the macroeconomic variable. (Megaravalli&Sampagnaro, 2018)cited India's Nifty Index and Chinese Shanghai Stock Index has co-integrated with the inflation and indicated there was a continuing association & Engle-Granger causality test revealed that there was a bidirectional relation between Nifty Index and Foreign Exchange rate & unidirectional causality found between Nikkei and Foreign Exchange rate. Mukherjee and Naka (1995) established a long-run relationship of the Japanese stock market with macroeconomic variables namely

the inflation, foreign exchange rate, money supply, long-term government bond yield, index of industrial production, and call money rate. Granger & VAR model (Sharma, Singh, & Singh, 2012)indicated CPI,WPI and the exchange rate of India and Srilanka do not influence each other but variance decomposition model shows shock in the stock market are visible due to macroeconomic variables. (Misra, 2018) explored a short-term causal relation between dependent and independent parameters by Wald test and recommended long-run causality using the Vector error correction model (VECM). Chatrath et al. (1997) investigated a negative trend between inflation and stock market returns was documented for developed economies in North America and Europe. (Garg&Kalra, 2018) delve the association between CNX Nifty and inflation, GDP, Investment, Exports, and Imports. (Patel, 2012) assessed the causality run from foreign exchange rate to Nifty & BSE Sensex to IIP and Crude oil price. (K & BS, 2016) demonstrated changes in macro-economic variables significantly influence BSE Sensex. Foreign Exchange rate and FII do not granger cause with BSE 500. (Bhuiyan&Chowdhury, 2019) supported long tenure interest rates had a negative relationship with the US stock index. (Parab& Reddy, 2019) the study showed a significant positive relationship on the interest rate, crude oil prices, REERs, FDI, imports of goods and services, GDP and tax revenue and there is bidirectional causality between interest rates and stock market exchanges. (Humpe& Macmillan, 2009) examined the macroeconomic influence on S&P 500 &Nikkie 225 stock indices. The long-term relationship was established using the Johannsencointegration analysis. Industrial production is positively related & the consumer price index is negatively related to the US stock market. Japanese stock market has a negative relationship with the consumer price index. Granger & VAR model (Sharma et al., 2012)indicated CPI, WPI, and the exchange rate of India and Srilanka do not have any influence on each other but variance decomposition model shows shock in the stock

market are visible due to macroeconomic variables. Akbar et al(2012) employed Co-integration and Vector error correction model and argued a long-run equilibrium exists between Karachi stock exchanges and chosen macroeconomic variables and the result revealed exchanges had a negative relation with foreign exchange reserve and inflation. Data are analysed using different econometric tools by researchers in their studies to know the linkages of macroeconomic variables with the stock market in case of India, US, UK, Germany, Japan, China, Canada, Turkey, Netherlands, Australia, Brazil, Pakistan, Indonesia with each other or with the country. Prominent methods employed are Granger causality, Co-integration, VECM.

III.RESEARCHMETHODOLOGY

3.1 Need for the study:

Domestic and global investors view emerging markets as a haven for investment portfolios. It will be of greater importance to know how macroeconomic shocks affect the developing markets. Fiscal and monetary policy is seen as a tool of a country that can steer the wheel of the stock market.

3.2 Description of Data:

Sources of data

The period of the study is from January 2001 to December 2018 and monthly data are taken. The total number of observations is 216. Data on BSE Sensex have been obtained from the BSE website. Repo rates have been obtained from rbi dot gov dot in., Index of industrial production from data dot gov dot in, Wholesale price index from eaindustry dot nic dot com and Gold price and Oil price from Indexmundi dot com. Exchanges rates from Fred dot stlouisfed dot org. The data are analyzed using Eviews. Log values of the stock market and macroeconomic factors are taken.

3.3 Explanatory variables:

BSE Sensex: BSE Sensex is Asia's first stock exchange & world's 10th largest stock exchange. It is a free-float market, with 30 largest, financially sound companies and highly liquid across different sectors. It is considered a bellwether index and the barometer of India's Economy. It is traded internationally on the leading exchanges of China, Brazil, Russia, and South Africa. Our study is confined to BSE Sensex 30 which is the foremost index. If BSE Sensex plunges, stocks of most of the companies go up and if it surges stocks of most of the companies go down.

Crude Oil Price: A prime source of energy globally. India meets 80% of Crude oil demand only through imports, any rise in crude prices have a greater impact on the government finances. Companies like logistics, airlines, paint, tyre, refinery, auto ancillary firms rely hugely on crude oil prices. A fall in price affects the input cost of production and it has a positive impact on these company Stocks. An increase in Crude oil prices rises the demand for dollars and thus affecting the rupee-dollar exchange rate.

Inflation: Inflation is usually equated as a negative trigger to the stock market. Higher the inflation rate means a higher cost of living and lower purchasing power which discourages the investors to invest Less in the stock market. Listed Companies postpone their investment and production due to uncertainty in the market which results in negative economic growth and harm the stock prices.

Foreign Exchange rate: Foreign Exchange rate fluctuations affect exports, imports, International Investments, Foreign currency reserves. The relationship between the equity market and the exchange rate is important as it affects decisions about fiscal and monetary policy. Volatility on the exchange rate implies the financial sector. The exchange rate of a country relies on the import and export process. Exported goods become cheaper globally when a country's currency is weakened.

Index of Industrial production: Theoretical studies show that during economic expansion industrial production increases and decreases during a recession which signals a change in the economy. It influences the stock market with cash flows and the trend goes along with the stock prices. As monthly data are unavailable for GDP, General index numbers of Industrial production is used as a proxy for GDP.

Gold Prices: Gold is considered a good indicator to show how healthy the economy is. It is considered as a haven among all other investments. Stock markets and gold are generally indirectly proportional. The fall in price generally indicates the market is strong and vice versa. It is strongly believed that despite high inflation, the value of gold does not depreciate.

Interest rates: Stock price and Interest rates maintain an inverse relationship. The stock market surge leads to a higher rate of stock prices and is highly liquidated which makes the central bank to indirectly control the situation. The bank reduces the money supply to other banks by increasing the reserve rates. The financial institutions raise the interest rates to it, consumers. Consumers do not borrow a higher rate of interest.

Table 1 :Description of the explanatory variable

Name of the variable	Represented as	Proxy Used
Inflation	WPI	Wholesale Price Index (WPI)
Exchange Rate	FX	Monthly average rupees per unit of US dollar
Gold Price	Gold	Mumbai average price rupees per 10 gms
Oil price	Oil	Crude Oil

		(petroleum) Monthly Price - Indian Rupee per Barrel
Index of Industrial production	IIP	General index numbers of industrial production
Interest rates	IR	Repo rate
Stock Market Index	BSE30	The closing price of BSE Sensex

3.4 Techniques Used:

Augmented Dickey-Fuller test used to find the stationarity of the data. The causal relationship between the dependent and independent variables is tested using the Granger causality test. Cointegration and Vector Error Correction Model is employed to confirm the long-run relationship between the variables. Wald test examines the short-run relationship between the variables.

3.5 RESEARCH OBJECTIVE OF THE STUDY

1.   To examine the cause and effect relationship between BSE Sensex and selected macro-economic variables such as foreign exchange rate, gold price, index of industrial production, interest rate, oil price, and wholesale price index.

2.   To determine the strength between the BSE Sensex and macro-economic variables using the Granger Causality test and Vector Error Correction Model.

 The model is described as:

BSE30 $=C+\beta 1$ FX$+$ $\beta 2$Oil$+$ $\beta 3$IIP $+$ $\beta 4$WPI$+$ $\beta 5$Gold$+$ $\beta 6$ IR$+$ et

Where $\beta 1, \beta 2, \beta 3, \beta 4, \beta 5, \beta 6$ are the coefficients and et is the error term.

IV. EMPIRICAL RESULTS AND DISCUSSION   4.1 Descriptive Statistics

Table 2: Descriptive Statistics of BSE Sensex and Macro-Economic Indicators of India

Descriptive Statistics	BSE Sensex Index	Foreign Exchange Rate	Price of Gold	Index of Industrial Production	Price of Oil	Interest Rate	Whole Sale Price Index
Descriptive Statistics	BSE Sensex Index	Foreign Exchange Rate	Price of Gold	Index of Industrial Production	Price of Oil	Interest Rate	Whole Sale Price Index
Mean	16579.42	52.21	17663.22	80.12	3389.53	7.02	133.70
Median	17160.20	48.26	16653.44	85.01	3264.68	7.00	122.65
Maximum	38645.07	73.56	31672.83	119.24	6926.83	9.00	190.20
Minimum	2811.60	39.27	4267.17	43.23	887.42	4.75	104.70
Standard Deviation	9680.51	9.14	10224.96	22.11	1589.20	1.06	24.94
Skewness	0.27	0.63	0.03	-0.24	0.33	-0.25	0.64
Kurtosis	2.12	1.95	1.29	1.78	2.15	2.32	2.00
Jarque-Bera	9.49	24.29	26.21	15.31	10.55	6.42	23.75
Probability*	0.01	5.32E-06	2.03E-06	0.00	0.01	0.04	7E-06
Sum	3581155.78	11277.30	3815255.68	17305.90	732139.11	1516.31	28878.50
Sum of Squared Dev.	20148132884.00	17947.60	22478191713.00	105143.96	542993295.00	241.51	133722.00

4.2 Test of Stationarity:

Time series data are mostly nonstationary which means there is a possibility of trend (either upward or downward) in mean and variance. To enhance the accuracy of the model the variable has to be made stationery which means it must have constant mean and constant variance. The simplest test to check for stationarity is to plot the time series and find the trend of the variable. If the variable found to have an upward or downward trend, then the series can be regarded as non-Stationary. To make the selected variables stationery Augmented Dickey-Fuller (ADF), differencing has to be done until it becomes significant.

Null Hypothesis Ho: Selected Explanatory variable is not stationary

Alternative Hypothesis Ha: Selected Explanatory variable is stationary

Table 3 :Augmented Dickey-Fuller (ADF) Unit Root Test for BSE Sensex and Macro-Economic Indicators of India

Variables	At Level		First Difference	
	Test Statistics	Probability	Test Statistics	Probability
BSE Sensex	-0.777	0.965	-13.301	0.000

Foreign Exchange Rate	-0.301	0.917	-10.221	0.000
Price of Gold	-1.311	0.625	-14.972	0.000
Index of Industrial Production	-1.689	0.436	-21.732	0.000
Price of Oil	-1.985	0.293	-10.599	0.000
Interest Rate	-2.794	0.061	-6.720	0.000
Whole Sale Price Index	-2.063	0.260	-14.459	0.000

From the above table, it is evident that all the macroeconomic indicators and BSE Sensex are non-stationary at the level I (0) with an intercept at 5 % level of significance and when converted to the first difference I(1), all variables become stationary at 5 % level of significance. As an outcome, the null hypothesis is rejected at the first difference I(1). The following graphs represent a log of BSE Sensex index return and macro-economic indicators of India.
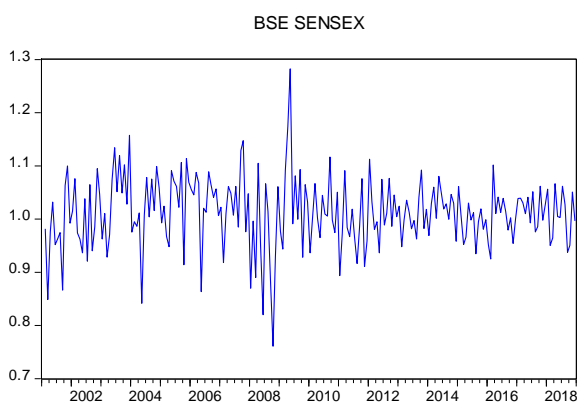

Chart 1 : Representing Log of BSE Sensex after 1st difference
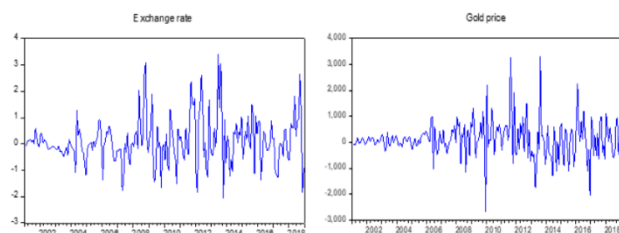

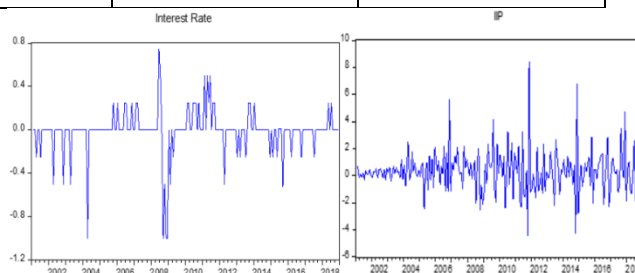Chart 2: Representing the log of exchange rate & the gold price after 1st difference

Chart 3:Representing log of Interest rate and IIP after 1st difference
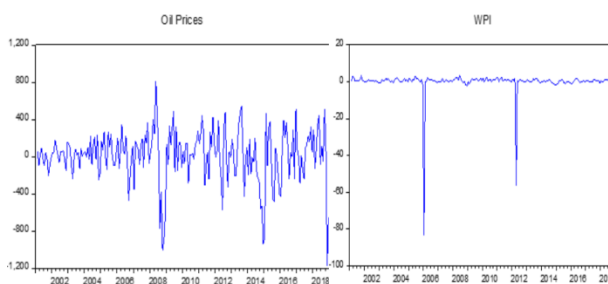
Chart 4:Representing log of oil prices & WPI after 1st difference

4.3 Granger Causality Test

The events in the past could cause an event to happen in the future and not vice versa(Koop,2000). Granger causality helps to ascertain whether the variable is meaningful enough to predict another variable in the short run. With the help of F & p-value, the null hypothesis can be rejected or accepted. If the p-value is < 0.05, reject the null hypothesis which implies X Granger cause Y and if p-value >0.05 accepts the null hypothesis.

Ho (Null Hypothesis): Study macroeconomic variable does not granger cause BSE Sensex

BSE Sensex does not granger cause study macroeconomic variable

Ha (Alternative Hypothesis): Study macroeconomic variable granger cause BSE Sensex

 BSE Sensex granger cause study macroeconomic variable

To examine the causal relationship between BSE Senses Index and macro-economic indicators, the Granger causality test is applied and results are given in Table 3.

Table 4: Pairwise Granger Casualty Test for BSE Sensex Index and Macro-Economic Indicators of India

Null Hypothesis	F-Statistic	Probability	Results
LFX does not Granger Cause LBSE30	0.85456	0.4270	Accepted
LBSE30 does not Granger Cause LFX	4.52862	0.0119	Rejected
LGOLDdoes not Granger Cause LBSE30	1.12187	0.3500	Accepted
LBSE30 does not Granger Cause LGOLD	0.32171	0.8995	Accepted
LIIPdoes not Granger Cause LBSE30	0.36558	0.6942	Accepted
LBSE30 does not Granger Cause LIIP	8.25963	0.0004	Rejected
LOIL does not Granger Cause LBSE30	0.82273	0.4407	Accepted
LBSE30 does not Granger Cause LOIL	6.63807	0.0016	Rejected
LIR does not Granger Cause LBSE30	8.07024	0.0004	Rejected
LBSE30 does not Granger Cause LIR	2.30446	0.1024	Accepted
LWPI does not Granger Cause LBSE30	0.19360	0.8241	Accepted
LBSE30 does not Granger Cause LWPI	0.75647	0.4706	Accepted

At 2 lag BSE Sensex index has a unidirectional relationship with the exchange rate as the p-value 0.0119 is lesser than 0.05(Significance level) and has a higher F-statistic value (4.52862). At lag 2,4 and 5, BSE Sensex index has no relationship with gold price as the p-value 0.8995 is greater than 0.05(Significance level) and has a lower F -statistic value (0.32171). At lag 2, BSE Sensex index has a unidirectional relationship with IIP as the p-value 0.0004 is lesser than 0.05(Significance level) and has a higher F-statistic value (8.25963). At lag 2, BSE Sensex index has a unidirectional relationship with Oil prices as the p-value 0.0016 is lesser than 0.05(Significance level) and has a higher F-statistic value (6.63807). At lag 2, the BSE Sensex index has no relationship with an interest rate as the p-value (0.1024) is greater than 0.05(Significance level)

whereas the interest rate has a unidirectional relationship with BSE Sensex index as the p-value 0.0004 is lesser than 0.05 (Significance level). At lag 2, the BSE Sensex index has no relationship with WPI as the p-value 0.4706 is greater than 0.05(Significance level).

4.4 Johansen Co-integration Test

If all the selected variables become stationary at first-order differencing I(1), the Cointegretaion test can be employed to test the long-run relationship. The Johansen Co-integration test is employed for this study and results are given in the below table

Ho= No cointegrating vector

Ha= Co integrating vector

Table:5a Unrestricted Cointegration Rank Test(Trace)

Hypothesized No. of CE(s)	Eigen Value	Trace Statistic	5% Critical Value	P-Value
None	0.2965	163.935*	125.615	0.0000
At most 1	0.1896	89.375	95.733	0.1268
At most 2	0.0755	44.815	69.819	0.8367
At most 3	0.0611	28.168	47.856	0.8064
At most 4	0.0363	14.800	29.797	0.7929
At most 5	0.0273	6.954	15.495	0.5830
At most 6	0.0051	1.076	4.841	0.2996

Table-5b. Unrestricted Cointegration Rank Test(Maximum Eigen Value)

Hypothesized No. of CE(s)	Eigen Value	Maximum Eigen Statistic	5% Critical Value	P-Value
None	0.2965	74.560*	46.231	0.000
At most 1	0.1896	44.560	40.078	0.9748
At most 2	0.0755	16.646	33.877	0.9346
At most 3	0.0611	13.368	27.584	0.8636
At most 4	0.0363	7.846	21.132	0.9129
At most 5	0.0273	5.878	14.265	0.6290
At most 6	0.0051	1.076	3.841	0.2996

At 5% significance, the value of trace statistic and maximum Eigenvalue statistic shows one cointegrating vector as the p-value is 0.000 which evidenced a long term relationship between the macroeconomic factors and BSE Sensex. The lag lengths are subjective to the factors chosen. Lesser number of lags have autocorrelation effect and a large number of lags lead to losing the observation. 3 lags are selected using Akaike Information criteria (AIC) for this study.

4.5 Vector Error Correction Model

Based on the results of the Augmented Dickey-Fuller (ADF) and Johansen Cointegration test indicates that a long-run relationship between BSE Sensex and macro-economic indicators of India.

Hence, it is necessary to build a Vector error correction model.

$D(LBSE30) = C(1)*(LBSE30(-1) - 0.127283499621*LFX(-1) - 0.0498305076279*LOIL(-1) + 0.112539756864*LIIP(-1) - 0.0117091257782*LWPI(-1) - 0.00258411543169*LGOLD(-1) + 0.0484654932242*LRATE(-1) + 0.388990659736) + C(2)*D(LBSE30(-1)) + C(3)*D(LBSE30(-2)) + C(4)*D(LFX(-1)) + C(5)*D(LFX(-2)) + C(6)*D(LOIL(-1)) + C(7)*D(LOIL(-2)) + C(8)*D(LIIP(-1)) + C(9)*D(LIIP(-2)) + C(10)*D(LWPI(-1)) + C(11)*D(LWPI(-2)) + C(12)*D(LGOLD(-1)) +$

C(13)*D(LGOLD(-2)) + C(14)*D(LRATE(-1)) + C(15)*D(LRATE(-2)) + C(16)

Table 6: VECM

	Co-efficients	Probability
C(1)	-0.91309	0.0000
C(2)	-0.05031	0.6475
C(3)	-0.10466	31597
C(4)	-0.83133	0.0091
C(5)	0.28771	0.3735
C(6)	-0.01071	0.8574
C(7)	-0.05153	0.3911
C(8)	0.11828	0.662
C(9)	0.37592	0.1645
C(10)	0.08121	0.3531
C(11)	-0.15024	0.0882
C(12)	0.20845	0.0781
C(13)	0.13642	0.2558
C(14)	0.39405	0.0149
C(15)	-0.13464	0.399
C(16)	-0.00355	0.4868

VECM model is strong as R square value is 51.81 % and it is significant. The value of Durbin Watson statistics is 2.04. The model has no serial correlation and autocorrelation. For estimating long-run relationship C(1) coefficient to be negative and probability value should be always lesser than 5%. The results show that the VECM developed is strong and exists a long-run relationship between the independent (macroeconomic indicators) and the dependent variable(BSE Sensex)

Long term equation of BSE Sensex for the period 2001 to 2018.

LBSE30=-0.913090(LBSE30)-0.007072(LFX-1)+0.493977(LIIP-1)-0.053779(LWPI-1)+0.036896(LRATE-1)

Long-Run Causality

C (1) and C (4) is the error correction term. C(n) to be negative and less than 5% significance level for long-run causality (1) (FX rate) has -0.913090 with p-value of 0.0000 and C(4) (WPI) has -0.831337

with p-value of 0.0091 have. Fx rate and WPI have a significant and positive relationship. IIP has a significantly negative relationship. Oil, gold and interest rates have a negative and insignificant relationship.

4.6 Short Run Causality

Wald test examines causality in the short-run between the independent and dependent variables. For short-run causality, the Chi-Square value has to be less than 5% in the Wald test.

Table 7: Results of Wald test

Variables	F-Statistics /Probability	Chi-Square /Probability
FX rate	0.6619	0.6619
	0.4168	0.4159
Oil Price	0.6558	0.6558
	0.4190	0.4180
IIP	1.1104	1.1104
	0.2932	0.2920
WPI	0.9707	0.9707
	0.3256	0.3245
Gold Price	0.1354	0.1354
	0.7132	0.7128
Interest Rate	8.1335	8.1335
	0.0048	0.0043

The test result shows that a short-run causality exists between BSE Sensex and interest rate whereas there is no short-run causality between BSE Sensex index and FX rate, Oil Price, IIP, WPI, and Gold rate.

V. CONCLUSION

BSE Sensex mirrors the economy of India. Numerous studies are carried out in finding the influence of macroeconomic indicators on the stock market of developed and developing economies. This study is backed by the economic theory which justifies there is a linkage between macro-economic

and stock prices. The study reveals all the variables are stationary at the first-order difference and had one cointegrating equation. A significant result shows long-run causality run between Exchange Rate, Whole Sale Price Index with BSE Sensex. A Short-run relationship is established by interest rate with BSE Sensex. Investors need to consider the macroeconomic variables before investing in the stock market. In the case of turmoil, government should frame the economic policy to boost the investor's confidence in the stock market.

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