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Assessing the Impact of Crude oil price and Exchange rate Volatility on the Indian Stock market: A Covid-19 Perspective

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ABSTRACT
The transformative journey of Indian economy from Pre to Post Covid-19 pandemic has been identified and unveiled through the volatility of macroeconomic variables- crude oil prices, exchange rate and Indian stock market, in this study. The Covid-19 pandemic created matchless challenges in the macroeconomic variables across the globe. This study examines the volatility of crude oil price and exchange rate and its impact on the Indian stock market considering the daily data for 2020 January to 2023 March, using GARCH model. As a result of Johansen Co-integration variables, shows a long- run association and they move together as the line passes. In addition to the long run relationship, Granger Causality exhibits the direction of causal relationship and found that Exchange rate and BSE has unidirectional causality, Oil and the Exchange rate exhibits unidirectional causality and no particularly no cause and effect between Oil price and BSE. The volatility of crude oil prices and exchange rates has an impact on BSE. Finally, it's concluded that stock market swings are highly affected by their own previous shocks as well as other macroeconomic variables like oil price and exchange rate. Policymakers can employ these findings to mitigate the adverse volatilities in investment decisions.

Keywords: *Volatility, crude oil, BSE, exchange rate, GARCH.*

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I. Introduction

India and Macro-economic variables: An overview

India is a global economy that involves a multifaceted web of macroeconomic variables that could dynamically influence each other both in long run and short run. They act as fundamental pillars to reconstruct a stable economy and silhouette the trail of the country's performance. Complexities and interdependence of such variables creates promising ideas for policy makers, economists and other market participants to explore in deep the intricacies of an evolving economy. Proper analysis of the macro economy could foster sustainable economic development, mitigate risk and uncertainties, and thereby formulate effective policies. Through a scrupulous inspection of these variables, this study seeks to provide valuable insights into the complexities of the global economy in terms of crude oil, exchange rate and stock market, contributing to informed decision-making and policy formulation. As a country craving for being a protuberant player in global financial landscape, stock market plays a crucial role in boosting the same. There are multiple macroeconomic variables- crude oil, exchange rate, gold price, GDP growth rate, inflation etc. that have hidden patterns affect market volatilities.

Crude Oil, Exchange Rate and Stock market in India

In terms of Crude oil, or 'black gold', India is the third leading consumer in the world therefore is a pivotal commodity that shows a significant impact on the overall inflation of the country. Before the Covid-19 pandemic hit the Indian economy, the inflation was rounded to 2%, but it showed a drastic increase to 8%. The reason was to an extent the changes that happened in OPEC countries, will be discussed later in this study. Indian Rupee weakened a historic hike against US Dollar due to a large economic imbalance and suppressed investor appetite for emerging-market assets. Stock market prices are not merely dependent on the financial market and responsive to multiple other factors also, in which excess volatility that culminate in massive

financial crisis. A volatile stock market turns to be a serious problem for policymakers as the instability leads to uncertainty that may hinders the path way towards economic growth. According to Business standard (2019), India witnessed the first stock market crash in 1865 and therefore ups and downs became necessary in the stock market as a whole. Years of 1991, 1992, 2006, 2007, 2008, 2009, 2015, 2016, 2018 and recently, 2020 show a dynamic trend in the stock price. BSE Sensex fell more than 2% due to the outbreak of Coronavirus attack in China which is a global economy.

The marginal crude oil production in India paved the way for the import of oil from OPEC countries. US is one among the major exporter of crude oil to our country. In such a situation it becomes necessary to introduce the variable, exchange rate which is more meaningful. An increase in oil price leads to a rise in its cost of production. This causes a reduction in the earnings of the company whereas the selling price remains the same. In order to withstand inflationary pressure RBI increases interest rate that certainly affects the profitability of the firm. High- interest rate favours the high discounting rate for the lower fundamental value of shares of the company. The increase in the price of oil has a huge spectrum of overlapping repercussions on the economy, along with an increase in the cost of goods and services (inflation), a deterioration in the standard of living, and others (Sanusi & Kapingura, 2022).

When there is an increase in crude oil price, the exchange rate also shows a significant change. The increase in the exchange rate means a fall in the value of the domestic currency. Devaluation leads to an increase in exports with a fall in imports. An export-oriented economy is spread with devaluation, and then it will positively affect the economy and stock market as well. The stock market is considered to be a highly volatile variable among financial time series. Volatility or volatile clustering is more in a falling market than in a rising market. It is necessary for the policy makers and participants in the financial market to understand the impact of multiple shocks that affects volatility of the variables over time.

Reasons for Macro-Economic Volatility Post Covid-19

When the pandemic hit the entire world economies, the situation was quite unusual and the above macro-economic essential factors shows random fluctuations throughout the period. After the Covid-19 pandemic, multiple changes happened in the Indian economy especially concerning the macro-economic variables on their volatility. *First* and foremost the Ukraine-Russian war. When the geopolitical condition got altered, the oil marketing companies were forced to increase oil price to reduce the losses that was expected to happen due to inflation. The intention that the circumstance leads to imbalances in imports and exports, which affected overall economic progress and development. This created indirect effect in the stock of the companies also. *Secondly*, OPEC countries minimised the oil output. As the crude oil had been imported from US to India, unintended effect will be captured in the Indian economy with whatever happening in the US global market. When US economy was expecting a recession during the same period, IT and oil companies in India started diminishing. But still RBI doesn't changed the Repo rate, kept constant at 6.5%, instead focused on tightening labour market, in order to reduce unemployment, condense spending and thereby dropping inflation. *Thirdly*, when the pandemic shook the economic activities, US Federal Reserve started increasing interest rate, as the inflation was at its peak, say 8%. Pre-Covid inflation was normal at 2%. The Fed's dual objectives are to maintain stable prices and to increase employment. The unemployment rate has dropped down to 3.9%, which is nearly pre-pandemic levels, while inflation has increased rapidly in recent months, rising to an annual rate of around 8%. This led to increased stock market volatility. *Fourth and lastly*, when Hindenburg research criticised the Adani Enterprise for its improper use of tax havens, led to significant fluctuations and instability in the stock market becoming unpredictable falling investors' confidence.

II. Literature Review

Multiple studies in India, evaluated the dynamic relationship between gold price, oil price, exchange rate and stock returns VAR co-integration techniques showing the largest portion of total variations in the exchange rate that are affected variables. Gold price volatilities are largely dependent on its own lags *(Sujit & Rajesh, 2011*). Also for specifically showing the long-run and short-run interaction of the variables and fit them within the VAR model, VECM is used and identified that positive coefficients shows positive impact on exchange rate and oil price and negative with gold price in case of stock exchange returns *(Mohanamani et.al, 2018).* But similar other models indicates that change in the exchange rate has no significant impact on either stock price or oil price *(Sahu et.al, 2014).* The limitations of other time series models to capture instant volatilities, GARCH and EGARCH models were incorporated in the study to explain positive and negative oil price shocks have a similar effect in terms of magnitude on exchange volatility and oil price shocks have a permanent effect on exchange rate volatility *(Ghosh, 2011).* The volatility spillover between oil price and exchange rate in India has been evaluated examined how oil price affect the exchange rate in Rupee against Dollar and analysis says that the increase in oil price returns will lead to depreciation of Indian currency with respect to foreign currency *(Mishra, 2017).* Forecasts have been done to check the presence of leverage effect

using GARCH where larger effect in the stock market than positive shocks gave a conclusion that EGARCH is a better forecasting model *(Vasudevan & Vetrival, 2016).* Certain studies also says that there exist two-way volatility spillovers between the exchange rate (USD) and returns on the Stock market of India (BSE), also unidirectional volatility spillover from BSE to the oil price. Equity returns of BSE are therefore influenced by oil price and exchange rate. Individual index volatility is measured using the GARCH model (*Hussain et.al (2019*).

After the Covid-19 pandemic multiple studies evolved concerning the dynamic relationship between the various macro-economic variables. Dynamic relationship between oil price, exchange rate and stock market performance in South Africa has been appraised using DCC-GARCH saying, static correlation between the variables are weak, but the dynamic correlation is positive . In a period of economic expansion, the exchange rate and market capitalization both have a substantial impact on oil prices (*Sanusi & Kapingura, 2022*). Indian studies on dynamics of oil prices, exchange rates and stock market under Covid-19 uncertainty identified that pandemic had a negative impact on global financial market and slowed down the oil and stock market, but not the exchange market *(Prabheesh & Kumar, 2021).*

While analyzing the relationship between macroeconomic variables disparities based on variable, time and other factors are a growing concern in the financial market. The absence of studies checking the volatility of the oil price, exchange rate and stock market made tis focus more on the same the study has the objectives, 1) To find the long-run dynamic relationship between the variables; 2) To determine the volatility in crude oil price and exchange rate and its impact on BSE 500 post covid-19 pandemic.

III. Research Methodology

The empirical study is carried out using the daily data from January 2020 to March 2023. Indian Stock market data (S&P BSE Sensex as proxy), crude oil price and Exchange rate data is collected from the Bombay Stock Exchange, Government of India's Ministry of Petroleum and Natural Gas (also Bloomberg database) and RBI and Handbook of Statistics, respectively. Crude oil data is measured in price per barrel in Dollar using WTI (West Texas Intermediate) price and exchange rate in Rupee against Dollar. The Econometric methodology employed is GARCH. In order to test stationarity, graphical analysis and Unit root Augmented Dicky Fuller (ADF) test is used for this finding.

Augmented Dicky Fuller Test: The standard Dickey Fuller test is carried out by estimating the equation:

$$y_t = \rho\, y_{t-1} + e_t \quad (1)$$

where -1 <= ρ <= 1 and e_t is the white noise error term. Subtract y_{t-1} to obtain,

$$y_t - y_{t-1} = \rho\, y_{t-1} - y_{t-1} + e_t \quad (2)$$

$$\Delta y_t = \delta\, y_{t-1} + e_t \quad (3)$$

where $\delta = (\rho - 1)$ If $\delta = 0$ then $\rho = 1$ showing a non stationary time-series data .

DF test assumes when error term e_t are uncorrelated. When e_t is correlated, then ADF test is used, by adding the lagged values of dependent variable Δy_t.

$$\Delta y_t = \beta_1 + \beta_2 t + \delta\, y_{t-1} + \sum_{i=1}^{m} \alpha_i \Delta\ \ y_{t-1} + e_t \quad (4)$$

e_t is a white noise error term where $y_{t-1} = (y_{t-1} - y_{t-2})$, $y_{t-2} = (y_{t-2} - y_{t-3})$. The number of lagged difference terms to include that the error term is serially uncorrelated. In ADF we still test whether $\delta = 0$ using the critical values.

Johansen Co-integration test is applied to test the co-integration among the variables. That is the long run relationships of the variables are tested here.

Johansen Co-integration is based on the methodology developed in Johansen (1991, 1995) performed using estimated VAR object

Consider a VAR of order p:

$$y_t = A_1\, y_{t-1} + \cdots + A_p\, y_{t-p} + Bx_t + u_t \quad (5)$$

Where y_t is a vector of non-stationary I (1) variables, x_t is a vector of disturbance variables and u_t is a vector of innovations.

$$\Delta y_t = \pi y_{t-1} + \sum_{i=1}^{p-2} \tau \Delta y_{t-i} + Bx_t + u_t \quad (6)$$

where $\pi = \sum_{i=1}^{p} A_i - I$ and $\tau = -\sum_{j-i+1}^{p} A_j$ (7)

Granger representation theorem asserts that if the coefficient matrix π has reduced rank r < k, there exist k * r matrices $\propto and\ \beta$ each with rank r such that $\pi = \propto \beta'$ and $\beta' y_t$ is I (0). R is the number of co-integrating relations (co-integrating rank) and each column of β is the co-integrating vector. This method is to estimate the π matrix from an unrestricted VAR and to test whether we can reject the restrictions implied by the reduced rank of π.

Granger Causality test is done for testing the causality or causal relationship between the variables (cause an effect relation). When we say there are two variables X and Y, change in X causes a change in Y then we can say X is granger-cause Y.

The simplest test of Granger Causality requires estimating following pairs of regression.

$$Y_t = \beta_1 + \sum_{i=1}^{p} \beta_{1i} X_{t-i} + \sum_{j=1}^{p} \beta_{1p+j} Y_{t-j} + u_{1t} \quad (8)$$

$$X_t = \beta_2 + \sum_{i=1}^{p} \beta_{2i} X_{t-i} + \sum_{j=1}^{p} \beta_{2p+j} Y_{t-j} + u_{2t} \quad (9)$$

Where, p is the number of lags that adequately models of the dynamic structure so that the coefficients of further lags of variables are not statistically significant ad the error terms are white noise. The error terms may be correlated over the equations. If p parameter β_{1p+j} are jointly significant then null that X does not Granger cause Y can be rejected.

GARCH model is estimated in order to estimate individual index volatility and also to see to what extend the risk of one market affect the other market.

ARCH and GARCH models are capable of capturing many of the stylized facts of the volatility behavior usually observed in financial time series including time varying volatility or volatility clustering and is modelled as a simple AR (autoregressive) process.

Let y_t denote a stationary time series such as financial returns, then y_t can be expressed as its mean plus a white noise if there is no significant autocorrelation in y_t itself:

$$y_t = c + e_t \quad (10)$$

where c is the mean of y_t and e_t is IID with mean zero. To allow for volatility clustering or conditional heteroskedasticity, assume that $Var_{t-1}(e_t^2) = \sigma^2$ with $Var_{t-1}(.)$ denoting the variance conditional on information at time t-1, and

$$e_t^2 = \alpha_0 + \alpha_1 e_{t-1}^2 + \ldots\ldots + \alpha_p e_{t-p}^2 + u_t \quad (11)$$

where $u_t = e_t^2 - e_{t-1}(e_t^2)$ which is a zero mean white noise process. The above equation represents an AR (p) process for e_t^2 and the model in (1) and (2) is known as the autoregressive conditional heteroskedasticity (ARCH) model introduced by Engle (1982), which is usually referred to as the ARCH (p) model. Before estimating a full ARCH model for a financial time series, it is necessary to test for the presence of ARCH effects in the residuals. Under the null hypothesis that there is no ARCH effects: $H0 = \alpha_1 = \alpha_2 = \ldots\ldots\ldots = \alpha_{p=0}$. If p-value is smaller than the conventional 5% level, the null hypothesis that there are no ARCH effects will rejected.

A more parsimonious model proposed by Bollerslev (1986) replaces the AR model with;

$$\sigma_t^2 = \sum_{i=1}^{p} \propto_i e_{t-i}^2 + \sum_{j=1}^{q} b_j \sigma_{t-j}^2 \quad (12)$$

where the coefficients α_i(*0.....*, *p*) and b_j (j =*1.....q*)are all assumed to be positive to ensure that the conditional variance σ^2 is always positive. The model in (equation 4) together with (equation 1) is known as the generalized ARCH or GARCH (*p, q)* model. When q = 0, the GARCH model reduces to the ARCH model. Under the GARCH (*p, q*) model, the conditional variance of e_t, σ_t^2 depends on the squared residuals in the previous *p* periods, and the conditional variance in the previous *q* periods. Usually a GARCH (1, 1) model with only three parameters in the conditional variance equation is adequate to obtain a good model fit for financial time series data.

IV. Results and Discussion

Descriptive statistics

It is evident that after the pandemic the volatility of stock market and its riskiness increased considerably. As the J-B test shows a high value in the initial condition at a significant level the normality null is being rejected. The volatility of exchange rate has shown a rise whereas the standard deviation of oil price has diminished than before. It has been inferred that the volatility of BSE and exchange is noticeably affected by Covid-19, whereas the instability was not prevalent in case of fluctuations in oil price.

Table 1.1
Descriptive statistics

	BSE	EXCHANGE	OIL
Mean	50458.88	67.94764	75.91632
Median	52846.70	70.46000	74.81100
Maximum	63284.19	123.7000	83.01300
Minimum	25981.24	-37.63000	70.71000
Std. Dev.	9549.922	24.17152	3.169800
Jarque-Bera	79.23207	3.796694	107.7084
Probability	0.000000	0.00000	0.000000

Observations	779	779	779

Unit Root Test

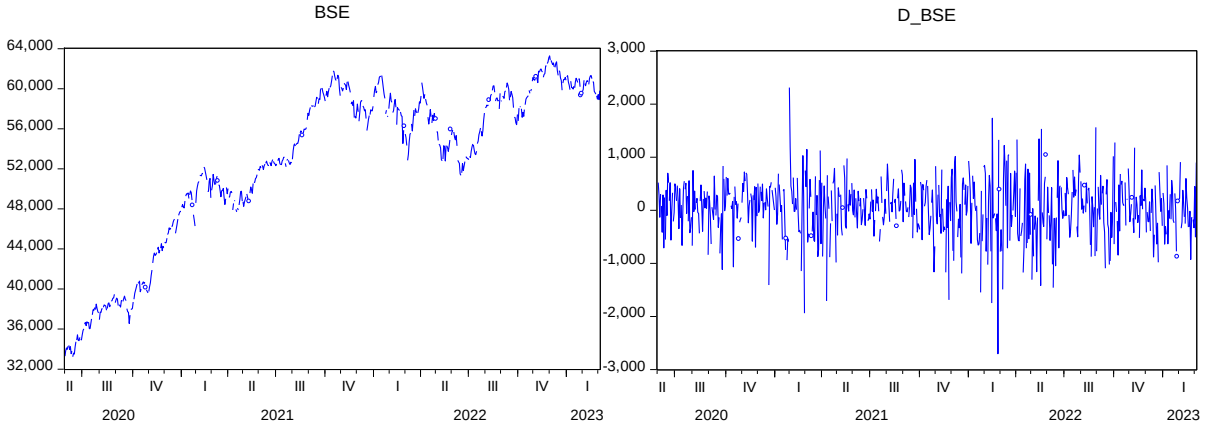
The result obtained based on Augmented Dicky Fuller test on the unit root of the variables respectively. This leads to the creation of a return variable using which we use to make the data stationary and therefore the measurement of causality and volatility. The results states that that there is a presence of unit root and no stationarity in the data at levels for all variables, exceeding p-value 0.05 critical level. The variables seems to be stationary at first difference.

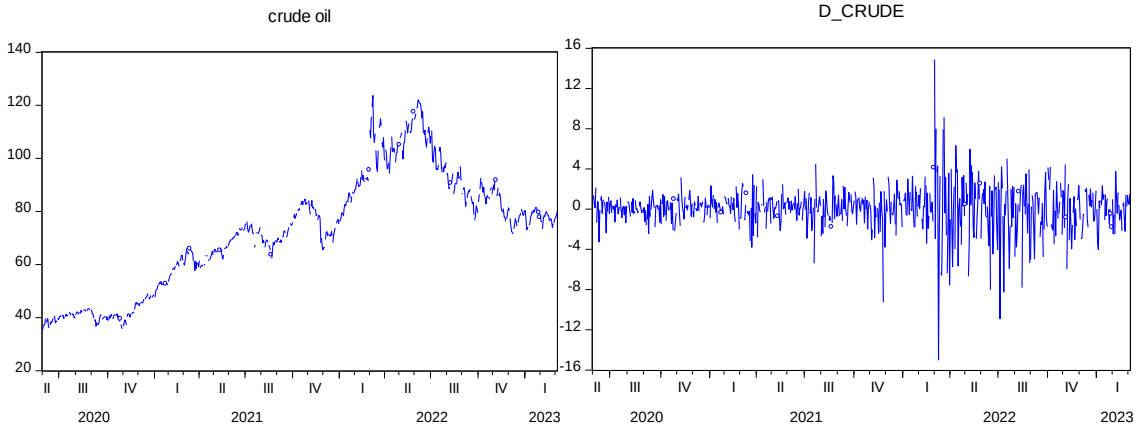
Table 1.2
Unit root test

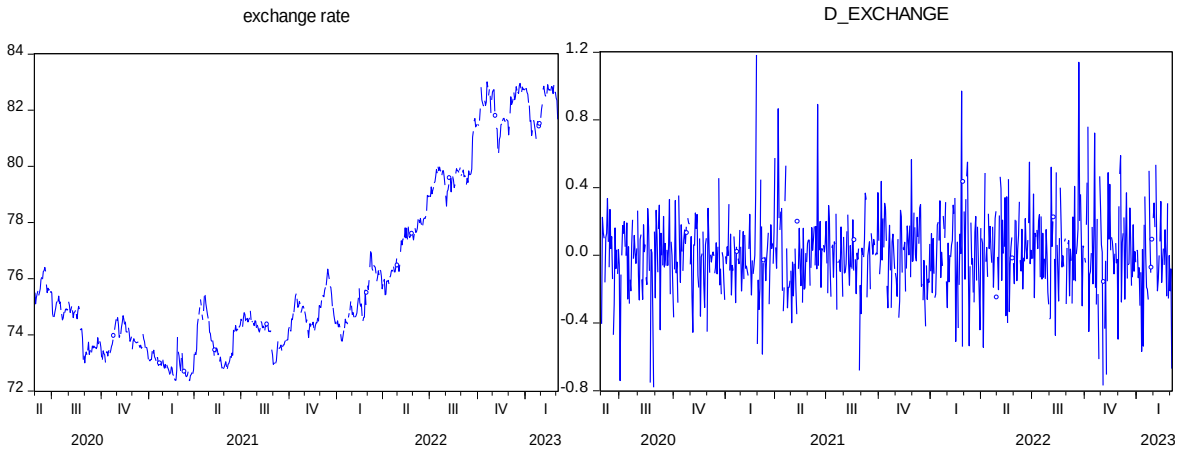
	At levels p-value	Stationarity	At first difference p-value	Stationarity
BSE	0.788	No	0.0000	Yes
EXCHANGE RATE	0.825	No	0.0000	Yes
OIL PRICE	0.674	No	0.0000	Yes

Graph 1.1
Graphical Representation of the data showing trend of variables

At Levels **At first difference**







Johansen Co-integration Test

The Trace and Maximum Eigen values are calculated as per Johansen (1995). The computed trace value is greater than the critical value and is statistically significant indicating the presence of co-integration among BSE, exchange rate and crude oil price and therefore shows a has long run relationship between them. Maximum Eigen statistic value 195.66 is greater than 21.13162 critical value reveals that there exists a strong co-integration between the chosen variables such as BSE Sensex, crude oil and exchange rate. That means there is co-integration among the 3 variables. The variables like BSE, exchange rate and oil price has long run association and they move together as the time passes.

Table 1.3
Johansen Co-integration test

Hypothesized No. of CE(s)	Eigenvalue	Trace statistics	Critical value @0.05	p-value	Max-Eigen statistics	Critical value @0.05	p-value
None *	0.223631	446.7273	29.79707	0.0001	195.6673	21.13162	0.0001
At most 1 *	0.173034	251.0600	15.49471	0.0001	146.8631	14.26460	0.0001
At most 2 *	0.126105	104.1969	3.841466	0.0000	104.1969	3.841466	0.0000

Granger Causality Test

While evaluating the long run causal relationship between the selected variables, there exist a uni-directional causality between exchange rate and BSE 500. The causality between crude oil price and exchange rate also has a uni-directional causality. The rest of the cases, the variables doesn't have a directional relationship with each other.

Table 1.4
Granger Causality Test

Null hypothesis	P value	Cause
Exchange rate does not Granger Cause BSE	0.5724	No
BSE does not Granger Cause Exchange rate	0.0063	Yes
Oil price does not Granger Cause BSE	0.8319	No
BSE does not Granger Cause Oil price	0.2496	No
Oil price does not Granger Cause exchange rate	0.0109	Yes
Exchange rate does not Granger Cause OIL	0.0768	No

ARCH effect

The optimum lag length is obtained at 6 for the given time period. A regression equation is being estimated to satisfy the conditions of heteroscedasticity and autocorrelation. To identify the ARCH effect of residuals, a least square regression is estimated at:

BSE Returns= 42.32 + 13.96 Crude oil returns – 481.83 Exchange returns (13)

Conditions of heteroscedasticity and autocorrelation are identified after testing for residual diagnostics. Here Correlogram Q statistics and squared residuals for identified for the presence of autocorrelation in the data. As

the p-values of both the tests are statistically significant we can prove the presence of autocorrelation in the residuals. Similarly for testing heteroscedasticity ARCH test, the p-value is again significant showing the condition of heteroscedasticity being satisfied. ARCH effect is present in the model.

Table 1.5
Heteroscedasticity LM test

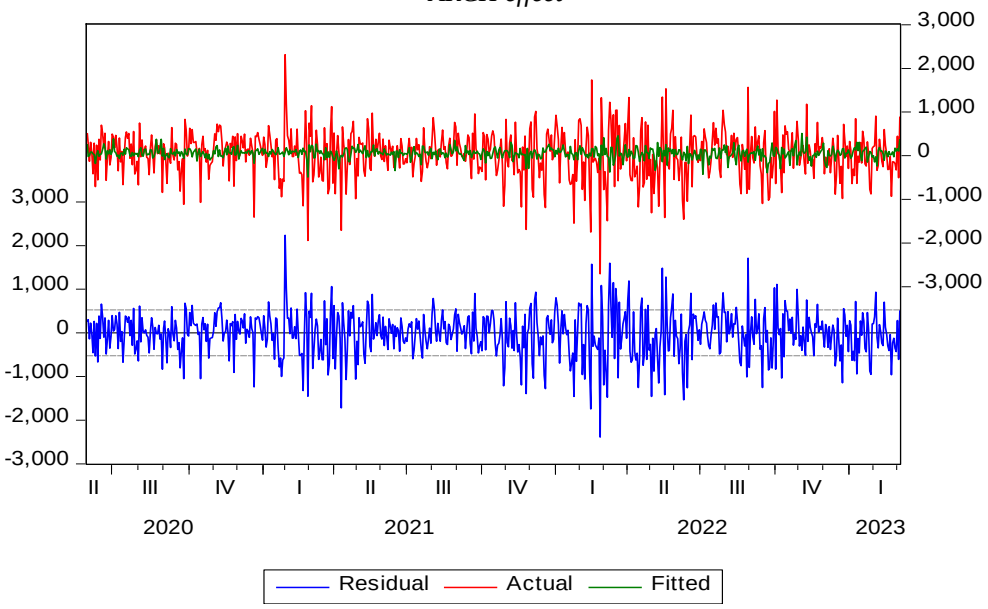
Variable	Coefficient	t-statistic	Prob
C	1001964.	2.435137	0.0151
RESID^2(-1)	1.025508	26.77053	0.0000
RESID^2(-2)	-0.069959	-1.833425	0.0672
F-statistic			4128.890
p-value			0.0000
Durbin-Watson			1.9777
R-square			0.92

Table 1.6
Presence of Autocorrelation Test

	Correlogram Q-statistics				Correlogram Squared Residuals			
Lags	AC	PAC	Q-STAT	PROB	AC	PAC	Q-STAT	PROB
1	0.985	0.985	666.21	0.000	0.957	0.957	628.32	0.000
2	0.971	-0.016	1313.5	0.000	0.911	-0.059	1198.4	0.000
3	0.957	0.028	1943.6	0.000	0.878	0.133	1728.7	0.000
4	0.943	-0.025	2555.8	0.000	0.842	-0.071	2216.7	0.000
5	0.928	-0.011	3150.4	0.000	0.803	-0.014	2662.1	0.000
6	0.914	0.015	3728.3	0.000	0.775	0.080	3076.7	0.000
7	0.901	0.007	4290.3	0.000	0.748	-0.006	3463.5	0.000
8	0.889	0.026	4837.8	0.000	0.727	0.093	3829.6	0.000
9	0.877	0.015	5371.7	0.000	0.706	-0.032	4175.3	0.000
10	0.865	-0.003	5892.2	0.000	0.685	0.025	4501.9	0.000
11	0.854	0.016	6400.2	0.000	0.666	-0.011	4810.3	0.000
12	0.841	-0.077	6893.5	0.000	0.637	-0.115	5093.0	0.000
13	0.827	-0.024	7371.5	0.000	0.605	-0.026	5348.4	0.000
14	0.814	-0.004	7834.7	0.000	0.579	0.029	5582.8	0.000
15	0.801	0.008	8283.7	0.000	0.555	0.011	5798.6	0.000

The residual graph of volatility clustering is shown in Figure 1.2 to help comprehend the presence of the ARCH effect. The residuals vary, indicating heteroscedasticity, implying that volatility in one variable induces volatility in others. During the pandemic, the volatility is so high and the movement of the dependent variable based on the residual and the response of the independent variable, especially exchange rate was high when compared to the fluctuations in oil price. There exist a volatility spill over from one market to the other market.

Graph 1.2
ARCH effect



GARCH model

The GARCH (1,1) estimated mean equation finds the p-values are statistically significant at 5% level for each variable i.e.: 0.0016, 0.000 and 0.005 respectively). A unit change in exchange returns and oil returns can have a significant impact over the Sensex returns. The crude oil price has a positive effect (0.0204) on BE Sensex. That is Sensex will be having an existence of direct relationship with that of crude oil price. Increase in crude oil price will lead to an increase in stock price and its volatility spill over. The same way exchange rate has a negative coefficient which shows that there will be an inverse relationship of exchange rate with Sensex.

In accordance with the variance equation, when Covid was at its peak, the previous day's volatility negatively affected the variance of the residual at -0.121 square of the units of mean value. Also the previous period's squared residual affected the H_t at 0.0204. When the previous days' volatility and pervious periods squared residuals are 0, then the GARCH (1, 1) term is 2.24E-06.

Mean Equation for GARCH (1,1) model is :

$$BSE = 59.91 - 411.02\ EXCHANGE + 30.91\ OIL \quad (14)$$

Variance Equation is:

$$H_t = 2.24E\text{-}06 - 0.120562\ H_{t-1} + 0.020443\ e^2_{t-1} \quad (15)$$

GARCH (1,1) Model

	GARCH (1,1) model		Variance Equation		
Variable	Coefficient	Prob.	Variable	Coefficient	Prob.
C	*59.91*	0.0016	C	*2.24E-06*	0.0000
Exchange rate	*-411.02*	0.0000	Residual $(-1)^2$	*0.121*	0.0000
Crude oil	*30.91*	0.0005	GARCH(-1)	*0.0204*	0.0000
R-square D-W statistic			0.043 1.939		

By adjusting the GARCH effect, the autocorrelation and heteroscedasticity problems are removed involving the presence of spill-over effect. The p-values are statistically insignificant being greater than 0.05 showing the presence of risk involved in the relationship between the variables.

Table 1.8
Presence of Autocorrelation Test- Post GARCH estimation

	Correlogram Squared Residuals				Correlogram Q-statistics			
Lags	AC	PAC	Q-STAT	PROB	AC	PAC	Q-STAT	PROB
1	0.041	0.041	1.1321	0.287	0.023	0.023	0.3614	0.548
2	-0.022	-0.024	1.4719	0.479	-0.030	-0.031	0.9915	0.609
3	-0.051	-0.049	3.2700	0.352	0.006	0.007	1.0161	0.797
4	0.002	0.006	3.2729	0.513	-0.018	-0.019	1.2432	0.871
5	0.042	0.039	4.4736	0.483	-0.034	-0.033	2.0460	0.843
6	-0.016	-0.022	4.6498	0.589	-0.011	-0.010	2.1225	0.908
7	-0.011	-0.007	4.7299	0.693	-0.019	-0.020	2.3673	0.937
8	-0.030	-0.026	5.3569	0.719	0.027	0.027	2.8630	0.943
9	-0.050	-0.050	7.0601	0.631	-0.006	-0.010	2.8888	0.969
10	-0.006	-0.005	7.0820	0.718	-0.024	-0.023	3.2743	0.974
11	0.018	0.015	7.2974	0.775	-0.019	-0.020	3.5251	0.982
12	-0.010	-0.016	7.3661	0.833	0.010	0.010	3.6017	0.990
13	-0.046	-0.044	8.8692	0.783	-0.035	-0.036	4.4790	0.985
14	0.003	0.011	8.8774	0.839	0.038	0.040	5.5005	0.978
15	0.049	0.044	10.550	0.784	0.054	0.049	7.5554	0.940

V. Conclusion

The dynamic interplay between crude oil price and exchange rate volatility is demonstrated its far-reaching influences on India's stock market, underscoring the pressing need for proactive and multifaceted policy interventions to fortify resilience and boost investor confidence in the growing economy. Volatility in BSE Sensex is highly overdone when today's fluctuation is influenced by yesterday's fluctuations. These internal shocks are more reliable in measuring the trend of stock market returns. Encouraging investment in energy projects could reduce import of crude oil to India and can mitigate price volatilities, can further reduce uncertain changes in stock market. Exchange rate management system should be stabilized to boost investor confidence and adopt significant policies. Efficient regulation to detect and prevent excessive speculation on stock investments that would worsen the volatile impact. Investors are given proper information and education on the high volatile nature of the existing variables. The vulnerable nature of crude oil and exchange rate can be lessened by encouraging Indian companies to adopt vigorous risk management practices. Researches should be carried out in this area for better effectiveness that was declined by the pandemic.

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