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An Econometric Analysis of Dynamic Relationship between Crude Oil Prices and Indian Stock Market Returns during Covid-19 Pandemic. 2020 – 2022

Utkarsh Kaushik*, Dr. Faraz Ahmad

Christ (deemed to be University), Nandigram Rd, Marium Nagar Ghaziabad, Uttar Pradesh, India – 201003

ABSTRACT:

In this research, we investigate the dynamic interplay between crude oil prices and Indian stock market indices amid the backdrop of the COVID-19 pandemic. Our analysis spans the period from January 2020 to September 2022, utilizing daily data within a Vector Autoregressive (VAR) framework. The time series incorporated for examination include crude oil futures prices, the Nifty index, and BSE Sensex index. Employing Augmented Dickey-Fuller and Philips-Perron unit root tests, We validate that all time series display non-stationarity initially but achieve stationarity through the first difference. Additionally, a cointegration test indicates the absence of a cointegrating factor, signaling the lack of a long-term relationship among the variables. The VAR model encompasses all time series as endogenous variables, with independent variables assessed at three lags."The outcomes of this study hold significant implications for portfolio selection, risk management, and international asset allocation. By offering valuable insights into the connections between oil prices and the Indian stock market, our findings contribute to a better understanding of these dynamics, aiding investors and financial practitioners in making informed decisions.

Introduction

The intersection of global economic forces, particularly the intricate Relationship between crude oil prices and stock market returns, has been a perennial subject of interest for researchers, policymakers, and investors alike. In the wake of the unprecedented COVID-19 pandemic, the relationship between these two critical pillars of the economy has taken on newfound significance. This research delves into the intricate and dynamic interplay between crude oil prices and Indian stock market indices during the tumultuous period spanning from January 2020 to September 2022.

To understand the nuances of this relationship, we must first recognize the historical context that has shaped both crude oil prices and the Indian stock markets. Crude oil, a cornerstone of global energy markets, has a storied history of price volatility influenced by geopolitical events, supply-demand dynamics, and technological advancements. From the oil crises of the 1970s to the era of self revolution in the 21st century, the trajectory of crude oil prices has been a reflection of the ever- evolving global economic landscape.

Similarly, the Indian stock markets, represented by key indices such as the Nifty and BSE Sensex, have witnessed transformative phases. The liberalization of the Indian economy in the early 1990s marked a turning point, unleashing a wave of economic reforms that opened the doors to foreign investment and propelled the nation into a new era of growth. As India became an increasingly integral player in the global economy, the performance of its stock markets became not just a barometer of national economic health but a crucial indicator in the broader context of international finance.

Enter the COVID-19 pandemic, a seismic event that disrupted global supply chains, shuttered economies, and ushered in an era of uncertainty. Against this backdrop, our research employs a robust econometric framework, specifically the Vector Autoregressive (VAR) model, to unravel the intricate dynamics between crude oil prices and Indian stock market returns. The inclusion of daily data and the application of Augmented Dickey-Fuller and Philips-Perron unit root tests reveal the non-stationarity of the time series at the level, underlining the need for a nuanced analysis.

The outcomes of this study extend beyond the realm of academia, holding significant implications for real-world applications. Portfolio selection, risk management, and international asset allocation stand to benefit from the nuanced understanding of the connections between oil prices and the Indian stock market that our research offers. In an era where informed decision-making is paramount, our findings serve as a Source, guiding investors and financial practitioners through the complexities of a post-pandemic economic landscape.

In essence, this research aims to contribute not only to the academic discourse but also to empower stakeholders with the knowledge needed to navigate the intricacies of the dynamic relationship between crude oil prices and Indian stock market returns in the wake of the COVID-19 pandemic.

Literature Review

Yadav, N. (2020): Investigates the long-run and short-run dynamic relationship between crude oil prices and the movement of Sensex, emphasizing both temporal dimensions.

Explores the long-run and short-run dynamics between crude oil prices and the Indian benchmark index Sensex. Prabheesh, K. P. (2021): Empirically analyzes the dynamic relation between oil price returns, exchange rates, stock returns, and uncertainty shocks. Alamgir, F. (2021): Explores the theoretical underpinning and empirical evidence for the relationship between oil prices and stock returns. Kumeka, T. T. (2022): Examines the negative impact of the COVID-19 outbreak on crude oil prices, stock market returns, and exchange rates. Khalfaoui,

R. (2022): Investigates the causal effects of the COVID-19 pandemic on oil prices, stock market returns, and economic indicators. The Dynamic Link between Crude Oil Prices and Stock Market Returns: Evidence from Emerging Markets" by Rengarajan Balakrishnan and N. Sathiya Moorthy (2015) - The authors analyze the dynamic relationship between crude oil prices andstock market returns in emerging markets, including China, India, and Brazil, using monthly datafrom January 2000 to December 2014. The results suggest that there is a significant negative relationship between crude oil prices and stock market returns in emerging markets. Crude Oil Prices and Stock Market Returns: Evidence from South Africa" by M. Z. I. Bhuiyan and M. A. Al Mamun (2017) examines the causal relationship between crude oil prices and stock market returns in South Africa. The Causal Relationship between Crude Oil Prices and Stock Market Returns: Evidence from India" by T. Rajendran and R. Jaya (2015) investigates the causal relationship between crude oil prices and stock market returns in India using monthly data from April 2005 to May 2014. The study employs the Johansen cointegration test, Granger causality test, and impulse response function analysis. Oil Price Volatility and Stock Market Returns: Evidence from GCC Countries" by M. Al-Mutairi and M. Al-Jaziri (2017) examines the impact of oil price volatility on stock market returns in Gulf Cooperation Council (GCC) countries. The study uses daily data from January 2005 to December 2015 and employs the EGARCH-M model. The findings suggest that oil price volatility has a negative impact on stock market returns in GCC countries, indicating that fluctuations in oil prices can have adverse effects on these economies. Relationship between crude oil and stock market: evidence from India Ankit Sharma (2018) . This paper estimates the linear interdependencies between international crude oil prices and stock market indices of India using weekly data spanning from January 2010 to January 2017 in a vector autoregressive (VAR) framework.

Data and Methodology

The dynamic correlation between crude oil prices and stock market indices is evaluated through the NSE Nifty Index, which serves as a benchmark for the Indian stock market. Comprising the weighted average of 50 prominent Indian companies listed on the National Stock Exchange, the Nifty 50 provides a comprehensive representation of market trends. Additionally, the analysis includes the S&P BSE Index, specifically the BSE Sensex, a free-float market-weighted index encompassing 30 financially robust companies listed on the Bombay Stock Exchange (BSE).

Detailed information about these companies can be accessed on the BSE website (https://in.investing.com/indices/sensex-historical-data).

To explore the interconnectedness of these financial indicators, WTI Crude oil data is employed, facilitating an examination of the relationships within the time series. This approach ensures a comprehensive understanding of the intricate dynamics between crude oil prices and the specified stock market indices, providing valuable insights into market behavior.

The current study relies on daily data encompassing three distinct time series, specifically the WTI crude oil futures price, the Nifty 50 index, and the S&P BSE index. The timeframe under consideration extends from January 2020 to September 2022, constituting a comprehensive dataset of 994 daily observations.

The examination of stationarity within the time series involves the utilization of Augmented Dickey-Fuller (ADF) and Philips-Perron (PP) Unit Root tests. ADF operates based on the autoregressive model, and the test equations for ADF are articulated as follows:

1. Augmented Dickey Fuller –the Augmented Dickey Fuller Test (ADF) have been used to fulfil the research aims and evaluate the hypotheses. Utilizing the Augmented Dickey- Fuller (ADF) Test, Unit Root Test was used to determine the data's stationarity..
2. Philips-Pherron (PP) Test have been used to fulfil the research aims and evaluate the hypotheses. Utilizing the (PP)Test, Unit Root Test was used to determine the data's stationarity..

The current study employs Johansen's cointegration test as a tool to assess the degree of cointegration within the time series.

The VAR methodology has been employed in this study to examine the correlation among the three-time series. The research paper utilizes three VAR equations, outlined as follows:

$$D(CRUDE\_OIL) = C(1,1)*D(CRUDE\_OIL(-1)) + C(1,2)*D(CRUDE\_OIL(-2)) + C(1,3)*D(NIFTY(-1)) + C(1,4)*D(NIFTY(-2)) + C(1,5)*D(SENSEX(-1)) + C(1,6)*D(SENSEX(-2)) + C(1,7)$$

$$D(NIFTY) = C(2,1)*D(CRUDE\_OIL(-1)) + C(2,2)*D(CRUDE\_OIL(-2)) + C(2,3)*D(NIFTY(-1)) + C(2,4)*D(NIFTY(-2)) + C(2,5)*D(SENSEX(-1)) + C(2,6)*D(SENSEX(-2)) + C(2,7)$$

$$D(SENSEX) = C(3,1)*D(CRUDE\_OIL(-1)) + C(3,2)*D(CRUDE\_OIL(-2)) + C(3,3)*D(NIFTY(-1)) + C(3,4)*D(NIFTY(-2)) + C(3,5)*D(SENSEX(-1)) + C(3,6)*D(SENSEX(-2)) + C(3,7)$$

We have used the VAR methodology to find the relationship between the three time series. The descriptive statistics of individual time series, unit root tests, Cointegration tests, and VAR results has been described in the next section.

Results

Figure 1 displays a time series plot encompassing oil prices, the Nifty index, and BSE, utilizing dual axes for convenient comparison. This graphical representation, dated March 2020, illustrates a noticeable alignment in the movement of the time series until July 2021. Subsequent to July 2021, a discernible divergence is observed, with the Sensex and crude oil prices exhibiting opposite trends. In contrast, the Nifty index appears relatively stable throughout the COVID-19 period. Analyzing the graphical depiction underscores the imperative need to delve into the time series properties and explore the potential long-run relationship between these variables.

Table 1 presents the descriptive statistics for daily returns. Upon examination, it is evident that crude oil exhibits positive returns, followed by BSE and Nifty. Notably, the highest volatility is observed in Sensex, trailed by Nifty and crude oil. Analysis of skewness reveals a negative skew for both crude oil prices and stock prices. To assess normality, the Jarque-Bera test is applied, leading to the rejection of the hypothesis of normal distribution for all series.

The correlation analysis among crude oil prices and stock indices indicates a significant positive correlation. Specifically, the strongest correlation is found between Nifty and Sensex, followed by crude oil and Nifty, while the weakest correlation emerges between Sensex and crude oil.

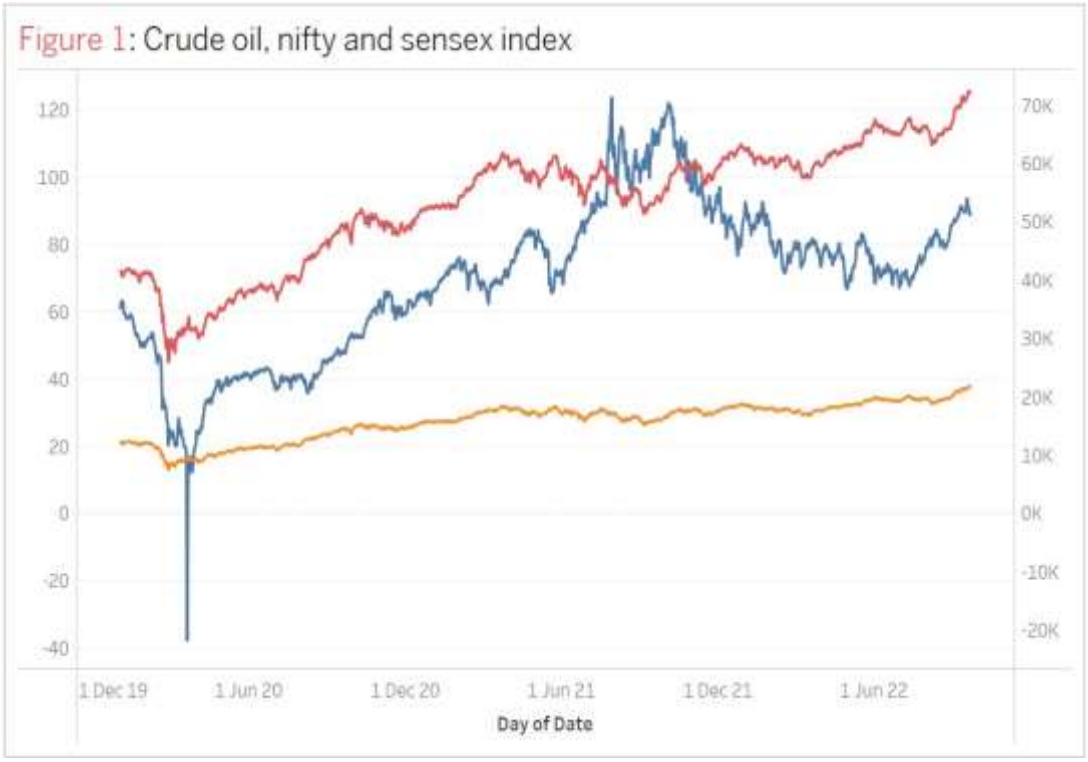

Table 1: Statistics for daily returns

Crude Oil
Nifty
Sensex

	Crude oil	Nifty	Sensex
Mean	**69.46186**	**15818.84**	**53262.64**
Median	**72..17500**	**16948.38**	**56818.02**
Maximum	**123.7000**	**21778.70**	**72410.38**
Minimum	**-37.63000**	**7610.250**	**25981.24**
Std. dev	**22.74924**	**3129.320**	**10333.34**
Skewness	**-0.256382**	**-0.673825**	**-0.671243**
Kurtosis	**3.011621**	**2.489916**	**2.485432**

Jarque-Bera	**10.89513**	**85.99523**	**85.65022**
Probability	**0.004307**	**0.000000**	**0.000000**
Correlation Nifty Sensex	**0.772118** **0.765824**	**1** **0.99953**	 **1**
Observations	**994**	**994**	**994**

SD: Standard deviation

Moving on to Table 2, the results of the Augmented Dickey-Fuller (ADF) and Philips-Perron (PP) unit root tests are presented. Notably, the stationarity tests conducted at the level data fail to reveal any evidence of stationarity. Consequently, the next step involves calculating the first difference of the time series to explore stationarity. Upon this transformation, the results demonstrate that the first difference of all time series appears to be stationary.

In essence, these findings indicate that the time series under consideration are integrated of order 1, denoted as I(1). This signifies that the non-stationarity observed at the level is resolved through differencing, rendering the series stationary. Such results are crucial for ensuring the robustness of the subsequent econometric analyses, affirming the suitability of the chosen modeling framework for investigating the dynamic relationship between crude oil prices and the Indian stock market during the specified period.

Table 2: Unit root tests

Variables	**Level data**	**Probability**	**Stationary Status**	**First Difference Data**	**Probability**	**Stationary status**
ADF test	-1.371157	0.5976	Non- stationary	-22.63086	0.0000*	Stationary
Crude Oil	-0.128329	0.9444	Non- stationary	-31.08983	0.0000*	Stationary
Nifty Sensex	-0.236122	0.9313	Non- stationary	-31.15817	0.0000*	Stationary
PP test	-1.36405	0.6018	Non- stationary	-31.11056	0.0000*	Stationary
Crude	-0.192402	0.9369	Non- stationary	-43.99097	0.0000*	Stationary
Oil Nifty Sensex	-0.284702	0.9246	Non- stationary	-31.17484	0.0000*	Stationary

*Significant at 5%

This section involves the examination of potential cointegration relationships among the diverse time series. Should the time series display cointegration, indicating the presence of a long-term relationship between them, the prospect of predicting one time series using another becomes viable. Our approach included the implementation of the Johansen cointegration test to identify cointegration patterns within the various time series, with the outcomes documented in Table 3.

Both the Trace test and the maximum Eigenvalue test led to the rejection of the null hypothesis positing the existence of cointegrating vectors. According to the results derived from the Johansen cointegration test, it can be inferred that no long-term relationship exists between crude oil prices, the Nifty index, and BSE. This is substantiated by the refutation of the possibility of even a single cointegrating vector.

Given the absence of cointegration among the time series, the application of a vector error correction model is precluded. Consequently, we resort to VAR modeling to elucidate the dynamics between crude oil prices, the Nifty index, and the BSE index. This analytical approach allows us to investigate the short-term interactions and dependencies among these variables, providing valuable insights into their dynamic relationships during the specified period.

Table 3: Johansen cointegration test results

Trace test				**Maximum Eigen value test**			
Null	**Alternative**	**Lambda- Tra**	**Critical value**	**Null**	**Alternative**	**Lambda- Max**	**Critical value**
r≤0	**r>0**	18.68253	229.79707	**r≤0**	**r=1**	11.55983	21.13262

r≤1	**r>1**	7.122696	15.49471	**r≤1**	**r=2**	7.109496	14.841465
r≤2	**r>2**	0.013200	3.841865	**r≤2**	**r=3**	0.13200	3.841469

Table 4 displays the outcomes derived from the VAR model, where the columns denote the dependent variables, and the rows signify the independent variables. The selection of independent variables involves a consideration of three lags, enabling a comprehensive examination of how past values of these independent variables contribute to the explanation of the dependent variables.

Notably, the findings indicate that the constant values exhibit significance (as indicated by the P- values) across all independent variables, particularly when the Sensex serves as the dependent variable. This implies that the Sensex is influenced by preceding values of crude oil, Nifty, and the Sensex Index.

Furthermore, the relationships between crude oil and Nifty are explicated by the first lag values of Crude oil and Nifty, respectively. Moving to Table 5, which illustrates the goodness of fit for the VAR model, it becomes evident that the Adjusted R-squared values for all equations surpass the 95% threshold. This observation underscores the effectiveness of the VAR model in capturing and explaining the variance in the dependent variables, affirming its suitability for comprehensively understanding the dynamic interactions among the considered economic indicators.

Table 4: VAR model results

	Dependent	**Variables**	
	Crude oil	Nifty	Sensex

	D(CRUDE_...	D(NIFTY)	D(SENSEX)
D(CRUDE_OIL(-1))	-0.270578	-2.199371	-7.573490
	(0.03160)	(1.74865)	(5.97582)
	[-8.56323]	[-1.25776]	[-1.26736]
D(CRUDE_OIL(-2))	-0.116430	-3.336946	-11.47360
	(0.03161)	(1.74928)	(5.97797)
	[-3.68343]	[-1.90762]	[-1.91931]
D(NIFTY(-1))	-0.000632	-0.507740	-1.805140
	(0.00631)	(0.34943)	(1.19414)
	[-0.10014]	[-1.45306]	[-1.51167]
D(NIFTY(-2))	0.005053	0.005805	0.126645
	(0.00630)	(0.34888)	(1.19227)
	[0.80148]	[0.01664]	[0.10622]
D(SENSEX(-1))	0.000200	0.152544	0.535480
	(0.00185)	(0.10225)	(0.34943)
	[0.10826]	[1.49188]	[1.53244]
D(SENSEX(-2))	-0.001082	0.001037	-0.030735
	(0.00184)	(0.10208)	(0.34886)
	[-0.58652]	[0.01016]	[-0.08810]
C	0.021752	10.03893	32.84696
	(0.09461)	(5.23593)	(17.8933)
	[0.22991]	[1.91732]	[1.83572]

* Significant at 1%, **significant at 5%, ***significant at10%. VAR: Vector autoregressive

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Table 5: VAR model fit

	Crude oil	Nifty	BSE
R square	0.076619	0.006774	0.6836
Adj. R square	0.70989	0.0717	0.000780
F-statistic	13.60818	1.118439	1.128862
Log Likelihood	-2479197	-6457.338	-7675.158

VAR: Vector autoregressive

Impulse response functions offer additional insights into the correlation among crude oil prices, the Nifty index, and the BSE index. These functions delineate the influence of one variable on others in the future, given a shock of one standard deviation (SD) to a particular variable. Our analysis encompasses the examination of impulse response functions for all variables (refer to Figure 2) over a 10-day horizon. The results depict that a one SD shock to crude oil prices leads to a subsequent reduction in crude oil prices. Notably, the impact of a one SD shock to crude oil prices is more pronounced than its effects on the Nifty and Sensex indices. Particularly noteworthy is the remarkable impact of a one SD shock to the Nifty index on crude oil prices, demonstrating a substantial negative effect.

Similar dynamics are observed in the case of the BSE index's impact on crude oil prices. An intriguing observation in the impulse response functions between the stock indices reveals that a one SD shock to the Nifty index significantly influences the Nifty in a negative direction. This highlights the substantial influence of companies comprising the Nifty index on the overall Nifty performance. Additionally, a negative impact of a one SD shock to the BSE index on the Nifty is also evident.

Further analysis using impulse response functions for a 10-day period into the future underscores that the most substantial negative impact occurs on crude oil prices when a one SD shock is imparted to the Nifty. This nuanced exploration of the impulse response functions provides valuable insights into the intricate dynamics among crude oil prices and the Indian stock market indices, offering a clearer understanding of the temporal effects and interactions between these crucial economic variables.

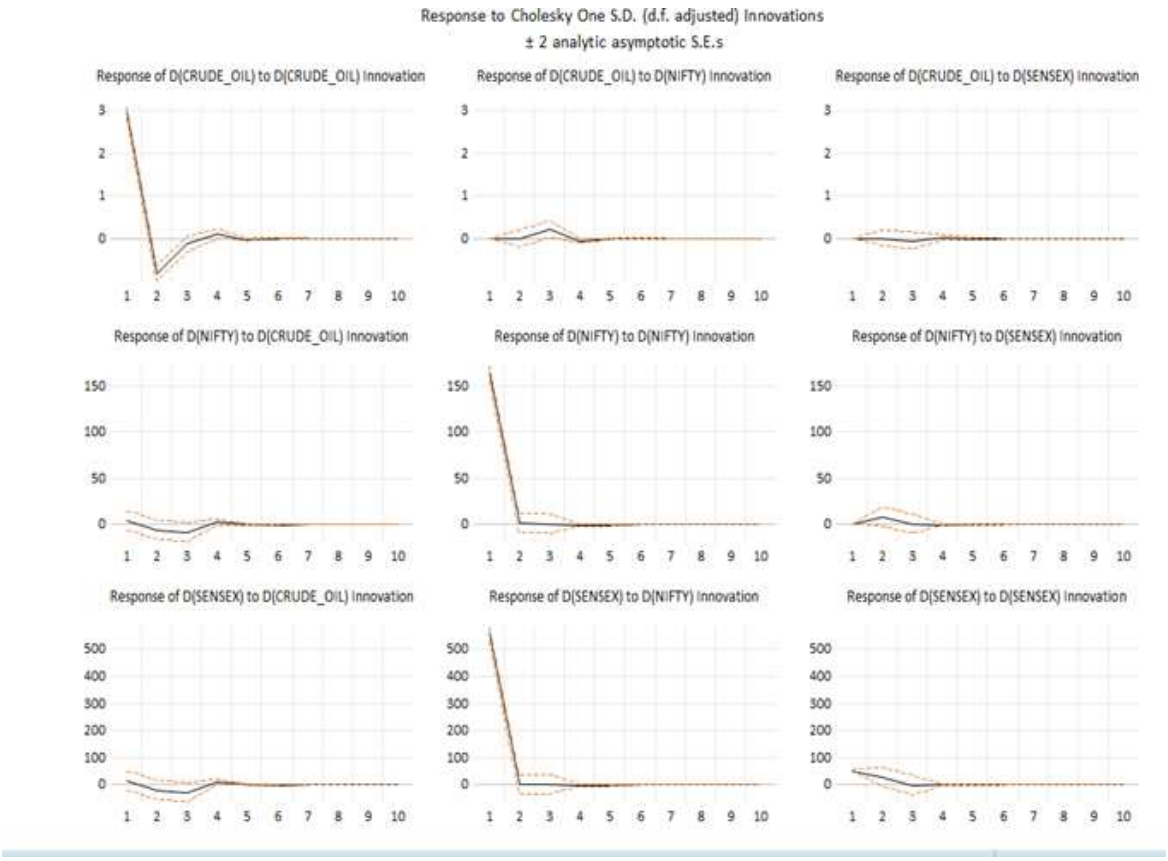

Figure 2: Impulse response functions

CONCLUSIONS

The current investigation examined the correlation among crude oil future prices, the Nifty, and the BSE Index. Upon conducting a unit root analysis, it was discerned that these variables are stationary at the first difference, indicating that all time series are integrated of order one. Subsequent cointegration tests indicated the absence of a long-term relationship among crude oil future prices, the Nifty, and the BSE Index during covid-19 pandemic.

In the VAR model, it was observed that the BSE Index is influenced by all the independent variables, a noteworthy finding considering the lack of cointegration among the time series. This implies that even in the absence of a long-term association, the BSE Index is influenced by lag values of independent variables, as revealed by the VAR model.

An intriguing insight emerged from the VAR model's impulse response function over a 10-day horizon. It showed that crude oil prices exhibit a negative response to one standard deviation shocks in stock indices. The impact of shocks on the Nifty increases over time, while the effect of the BSE Index on crude oil prices remains constant. Notably, in comparison to the BSE Index, the Nifty is more significantly affected by crude oil shocks, during covid-19 and this impact appears to intensify with the passage of time.

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