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The Causal Relationship between the BSE Sensex, NSE Nifty and the India VIX: A Critical Analysis of Financial Market Volatility and Its Predictability

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Abstract

This study examines the relationship between India VIX, the BSE Sensex, and the NSE Nifty over the period 2016–2026 using secondary market data and descriptive, correlation, stationarity, Granger causality, VAR, and regression analyses. The findings indicate that India VIX has a significant predictive relationship with both Sensex and Nifty, while the reverse relationship is not significant, suggesting that market volatility acts as a leading indicator of future stock market movements. The analysis also shows that both Sensex and Nifty are non-stationary in levels but stationary in first differences, indicating that they follow an I(1) process. In addition, a bidirectional Granger causal relationship exists between Sensex and Nifty, reflecting their strong interdependence within the Indian equity market. Overall, the study concludes that India VIX is useful for forecasting market uncertainty and can support risk management and trading decisions, though its findings are limited to the Indian market and the variables included in the analysis.

Keywords: *India VIX, BSE Sensex, NSE Nifty, stock market volatility, market uncertainty, correlation analysis, Granger causality, stationarity test, VAR model, predictability, Indian equity market*

1. Introduction:

Financial markets play a pivotal role in a country's economic development by facilitating capital formation, promoting investment, and enabling the efficient allocation of resources. The performance of stock markets is often regarded as an indicator of a nation's economic health and investor confidence. In India, the stock market has witnessed substantial growth and transformation over the past few decades, driven by economic liberalization, technological advancements, regulatory reforms, and increasing participation from both

domestic and foreign investors. Among the various indicators used to assess the performance of the Indian stock market, the BSE Sensex and NSE Nifty are considered the most prominent benchmark indices. The BSE Sensex, introduced by the Bombay Stock Exchange, comprises 30 well-established and financially sound companies representing key sectors of the Indian economy. Similarly, the NSE Nifty 50, launched by the National Stock Exchange, consists of 50 large-cap companies and serves as a broad indicator of market performance. These indices reflect market trends, investor sentiment, and economic conditions, making them essential tools for investors, analysts, policymakers, and researchers.

Alongside stock market indices, market volatility has emerged as a crucial aspect of financial market analysis. Volatility represents the degree of variation in the price of financial assets over time and is often associated with market uncertainty and risk. In modern financial markets, investors closely monitor volatility indicators to evaluate market sentiment and anticipate future price movements. One such significant measure is the India VIX (Volatility Index), introduced by the National Stock Exchange in 2008. India VIX is derived from the prices of Nifty index options and reflects investors' expectations regarding market volatility over the next 30 days. It is commonly referred to as the "Fear Gauge" because it tends to rise during periods of market stress and decline during stable market conditions.

The relationship between stock market indices and volatility indices has been a subject of considerable interest among financial researchers worldwide. Numerous studies have established that stock market returns and volatility often exhibit an inverse relationship, wherein market declines are accompanied by increased volatility and vice versa. However, the nature and direction of causality between stock market indices and volatility measures remain complex and may vary across different markets and economic conditions. Understanding whether movements in the India VIX can predict future changes in the BSE Sensex and NSE Nifty, or whether changes in stock indices influence volatility expectations, is of significant importance for market participants. The Indian financial market has experienced several periods of heightened volatility due to domestic and global events such as the Global Financial Crisis, COVID-19 pandemic, geopolitical tensions, inflationary pressures, monetary policy changes, and economic uncertainties. These events have highlighted the importance of volatility forecasting and risk management in investment decision-making. Consequently, examining the causal relationship among the BSE Sensex, the NSE Nifty, and the India VIX has become increasingly relevant for understanding market behavior and improving predictive models. This study seeks to critically analyze the dynamic interactions among the BSE Sensex, NSE Nifty, and India VIX using statistical and econometric techniques to identify causal relationships and assess the predictability of market volatility. By exploring these relationships, the study aims to contribute to the existing body of knowledge on financial market volatility and provide valuable insights for investors, portfolio managers, policymakers, and researchers. The findings are expected to enhance the understanding of market risk, support informed investment decisions, and facilitate the development of effective risk management strategies in the Indian capital market. In the context of increasing market integration, rapid information dissemination, and evolving investor behaviour, understanding the interplay between benchmark stock indices and volatility measures is

essential for achieving greater market efficiency and financial stability. Therefore, this research investigates the causal relationships among the BSE Sensex, NSE Nifty, and India VIX and evaluates their role in predicting financial market volatility in India.

2. Need for the study:

The study aims to bridge this gap and provide meaningful insights into the dynamics of financial market volatility and its predictability.

- To understand volatility dynamics in the Indian stock markets.
- To assess the predictive capabilities of India VIX.
- To help investors make informed decisions.
- To contribute to financial market research.

3 Problem Statement:

Despite the India VIX being widely recognized as the "fear gauge" that reflects market participants' expectations of future 30-day volatility derived from Nifty 50 option prices, there remains significant ambiguity regarding the direction of causality between India's two primary benchmark indices (BSE Sensex and NSE Nifty) and the volatility index. While empirical studies have established an inverse relationship between stock market indices and the India VIX—where rising VIX typically coincides with falling or volatile Nifty/Sensex levels—the causal direction remains contested in the academic literature.

Specifically, existing research presents conflicting findings:

- Some studies indicate that Nifty Granger-causes VIX, but VIX does not Granger-cause Nifty, suggesting volatility is a by-product of market movements rather than a predictor.
- Other research finds a long-run causal relationship between the India VIX and Nifty returns, implying that the VIX has predictive power for future market movements.
- Evidence confirms that both the Sensex and the Nifty affect the India VIX, with volatility clustering present and unfavorable market information significantly impacting the VIX.

This inconsistency creates a critical research gap: Investors, portfolio managers, and policymakers lack definitive evidence on whether the India VIX can reliably predict movements in the BSE Sensex and the NSE Nifty, or whether these indices drive volatility expectations. Without clarifying the causal direction, market participants cannot effectively utilize VIX for:

1. Risk management and hedging strategies

2. Portfolio allocation decisions(shifting between large-cap and mid-cap stocks based on VIX levels)
3. Volatility forecasting for up to 60 days
4. Option pricing and detecting mispriced options

Furthermore, while India VIX demonstrably has predictive power for short-term stock market volatility, with stronger predictive power for upward movements, its predictive power for actual index returns remains insufficiently established. This is particularly critical for emerging markets like India, where understanding volatility dynamics is essential for investor protection and market stability.

4 Objectives of the Study:

- To analyse the causal relationship between BSE Sensex, NSE Nifty, and India VIX.
- To study market volatility patterns.
- To examine correlation among variables.
- To identify causality using Granger Causality Test.
- To evaluate predictability of India VIX.

5 Scope of Study:

The study examines these three indices within the Indian financial market ecosystem, which is particularly significant as an emerging market with unique volatility characteristics distinct from developed markets.

- Focuses on Indian stock market.
- Uses secondary market data.
- Covers selected period (2015–2025).
- Considers only Sensex, Nifty, and India VIX.

6. Limitations of the study:

- **Limited Scope of Variables:** The study focuses only on the BSE Sensex, NSE Nifty, and the India VIX. Other important macroeconomic and financial factors such as interest rates, inflation, exchange rates, foreign institutional investments, and global market indices are not included, which may also influence market volatility.
- **Dependence on Historical Data:** The analysis relies on historical market data to identify causal relationships and predict volatility. Past market behaviour may not accurately represent future market conditions due to changing economic environments and unforeseen events.

- **Market-Specific Findings:** The findings are restricted to the Indian stock market and may not be directly applicable to other emerging or developed financial markets that operate under different regulatory, economic, and investor conditions.
- **Impact of External Shocks:** Extraordinary events such as financial crises, pandemics, geopolitical conflicts, or policy changes can significantly affect market movements. Such unexpected shocks may distort the causal relationships identified in the study and reduce the accuracy of volatility predictions.
- **Methodological Constraints:** Statistical techniques used to establish causality and volatility forecasting may have inherent assumptions and limitations. The results may vary depending on the model selected, data frequency, sample period, and estimation methods employed.

7. Literature Review:

1. Dhanaiah, G., Reddy, D.R., and Prasad, T.N.L. (2012): Dhanaiah et al. examined the relationship between India VIX and the Nifty Index using daily data from March 2009 to November 2011. Using Ordinary Least Squares (OLS) regression, the study found a significant negative relationship between Nifty returns and India VIX movements. The authors also observed an asymmetric response of India VIX to market returns, indicating that volatility increases more sharply during market declines than during market advances. This study established India VIX as an effective indicator of investor fear and market uncertainty.
2. Slivka, Gao, and Ren (2015): The researchers developed an empirical model for India's Nifty VIX by analysing daily data from 2010 to 2014. Their study identified volatility clustering and calendar effects in the behaviour of the India VIX. The findings suggested that implied volatility exhibits persistence and can serve as a valuable input for forecasting future market volatility and informing risk management decisions.
3. Chaudhuri and Ghosh (2016): The study employed Artificial Neural Network (ANN) models to forecast stock market volatility in India. India VIX was used as one of the major predictor variables alongside global volatility indicators and macroeconomic factors. The results demonstrated that India VIX significantly improves volatility forecasting accuracy, highlighting its usefulness in predicting future market fluctuations.
4. Chakrabarti and Kumar (2020): Using high-frequency data, the authors investigated the short-run relationship between Nifty returns and implied volatility represented by India VIX. The study confirmed a strong negative relationship between market returns and implied volatility. It also discussed the leverage effect and volatility feedback hypothesis as possible explanations for the causal interaction between stock returns and volatility.
5. Sharma, Satija, and Bathia (2025): This study examined the predictive relationship between Nifty 50 returns and India VIX using Granger causality tests, correlation analysis, GARCH models, ARIMA forecasting, and sentiment analysis. The findings suggested that Nifty returns significantly influence India VIX, while sentiment indicators provide additional predictive power. The study emphasised the importance of India VIX in forecasting market behaviour and volatility dynamics.
6. Verma, Hanif, Jain, Ahmed, and Bhargava (2026): The researchers analysed the long-run equilibrium relationship between Nifty 50 and India VIX using Johansen Cointegration and Granger Causality techniques.

Their findings indicated a significant causal relationship between market returns and volatility expectations. The study concluded that the India VIX can serve as a useful predictor of future market movements and investors' risk perception.

7. Perumandla and Kurisetti (2018): The authors investigated dynamic correlations, causality, and volatility linkages within Indian financial markets using DCC-GARCH models. Although focused on commodity and equity markets, the study demonstrated that volatility spillovers and causal relationships are significant features of Indian financial markets, supporting the application of causality analysis in volatility studies involving Sensex, Nifty, and India VIX.

8. Studies on Volatility Indices and Market Behaviour: Several international studies on volatility indices, such as the VIX, have reported a consistent inverse relationship between stock market returns and volatility indices. Researchers found that volatility indices often lead market movements and contain useful information regarding future uncertainty. These findings provide theoretical support for using India VIX as a predictor of volatility in the Indian stock market.

8. Research gap:

Despite the growing body of literature on India VIX and Nifty returns, several gaps remain:

1. Most studies focus primarily on the relationship between the Nifty and the India VIX, while comparatively few examine the simultaneous interaction among the BSE Sensex, the NSE Nifty, and the India VIX.
2. Existing research largely concentrates on correlation and volatility behavior, whereas comprehensive causal analysis involving all three variables remains limited.
3. Many earlier studies use traditional econometric techniques and shorter sample periods, which may not capture structural changes in the Indian capital market.
4. There is limited evidence on the predictive power of the India VIX for both the Sensex and the Nifty across different market regimes, such as crises, elections, and periods of economic uncertainty.
5. The impact of volatility transmission between the Sensex and the Nifty via the India VIX has not been extensively explored.

9. Research methodology:

9.1 Research Design: Descriptive and analytical research.

9.2 Sources of Data:

Secondary Data:

- BSE Website
- NSE Website
- India VIX Historical Data

9.3 Period of Study: 2016–2026

9.4 Variables:

Independent Variable: India VIX

Dependent Variables: BSE Sensex & NSE Nifty

9.5 Statistical Tools:

- Descriptive Statistics
- Correlation Analysis
- Augmented Dickey-Fuller Test
- Granger Causality Test
- Vector Auto Regression (VAR)
- Multiple Regression

9.6 Research Hypotheses:

H01: There is no significant causal relationship between India VIX and BSE Sensex.

H11: There is a significant causal relationship between India VIX and BSE Sensex.

H02: There is no significant causal relationship between India VIX and NSE Nifty.

H12: There is a significant causal relationship between India VIX and NSE Nifty.

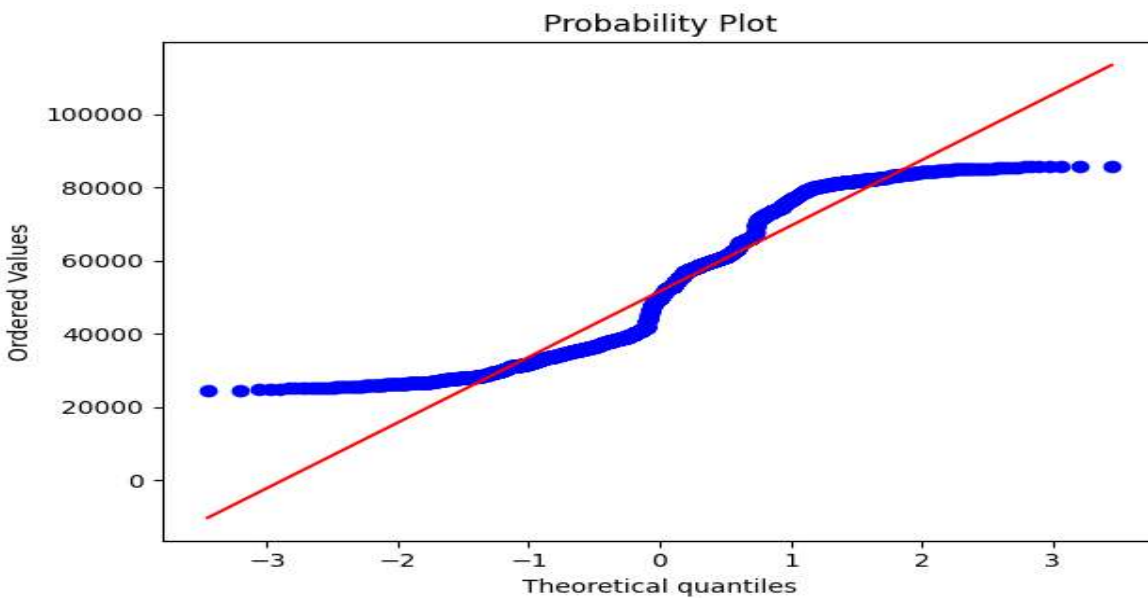
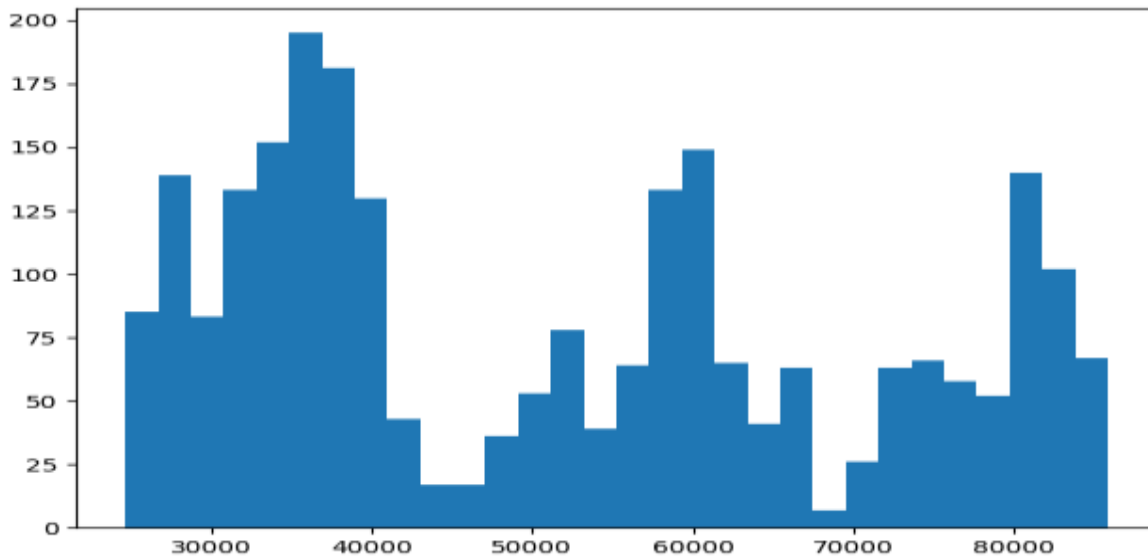
H03: There is no significant causal relationship between Sensex and Nifty.

H13: There is a significant causal relationship between Sensex and Nifty.

10. Data analysis & Interpretation:

10.1. Descriptive Statistics: Descriptive Statistics of BSE Sensex, NSE Nifty and India VIX (01-04-2016 to 31-03-2026). The descriptive statistics were computed using the daily closing prices from the datasets provided.

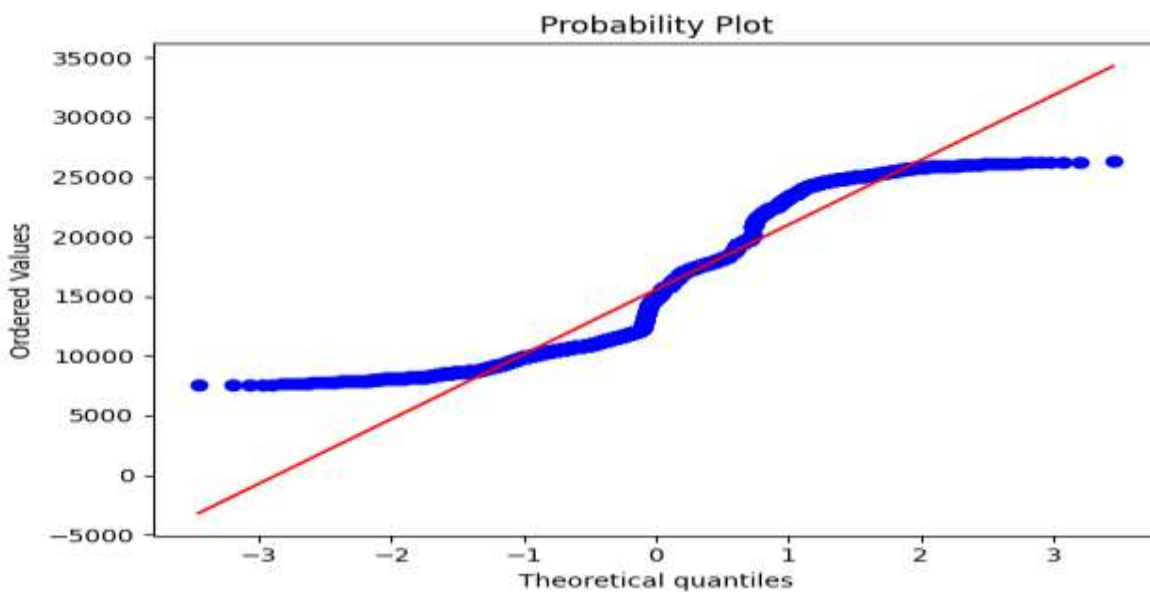
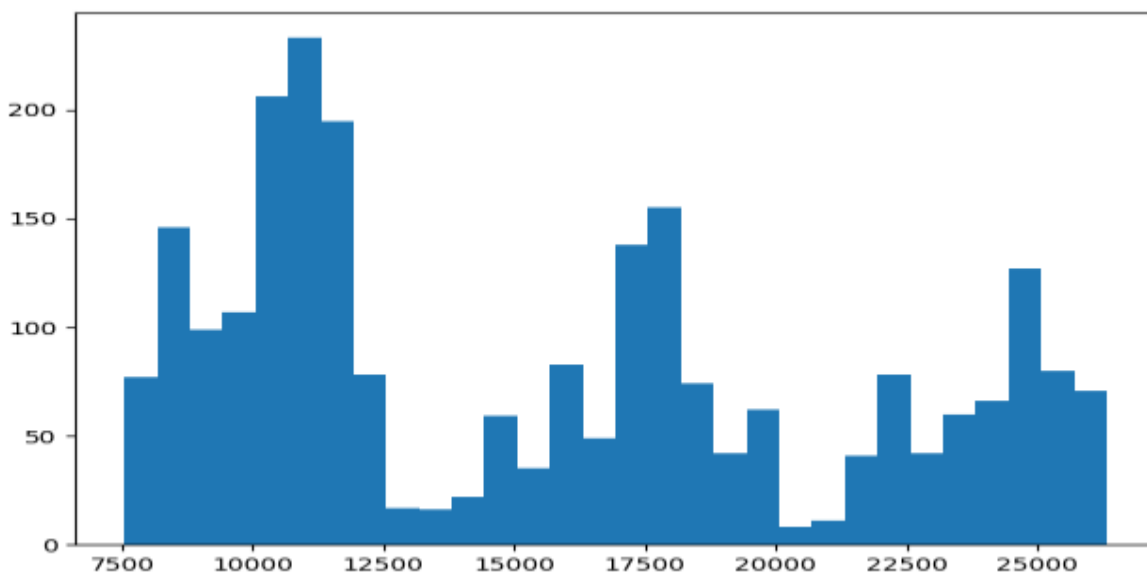
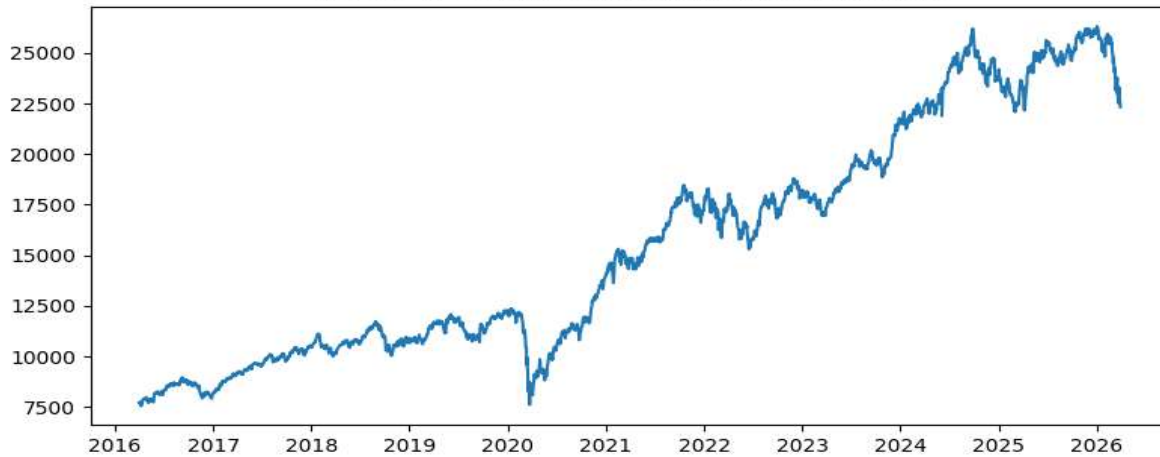




BSE Sensex:

- The graph shows a strong long-term upward trend from 2016 to 2026.
- Temporary declines are visible during periods of market stress, particularly around the COVID-19 period.
- After each correction, the index recovered and reached new highs.
- This indicates sustained growth in the Indian equity market over the study period.

NSE NIFTY Prices from 01042016 to 31032026.xls

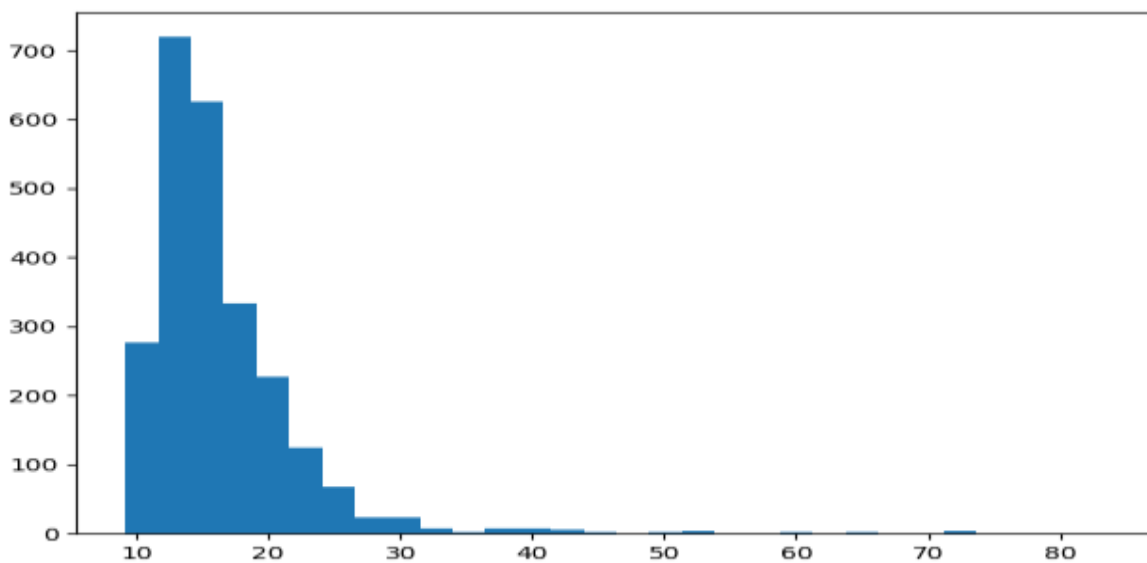
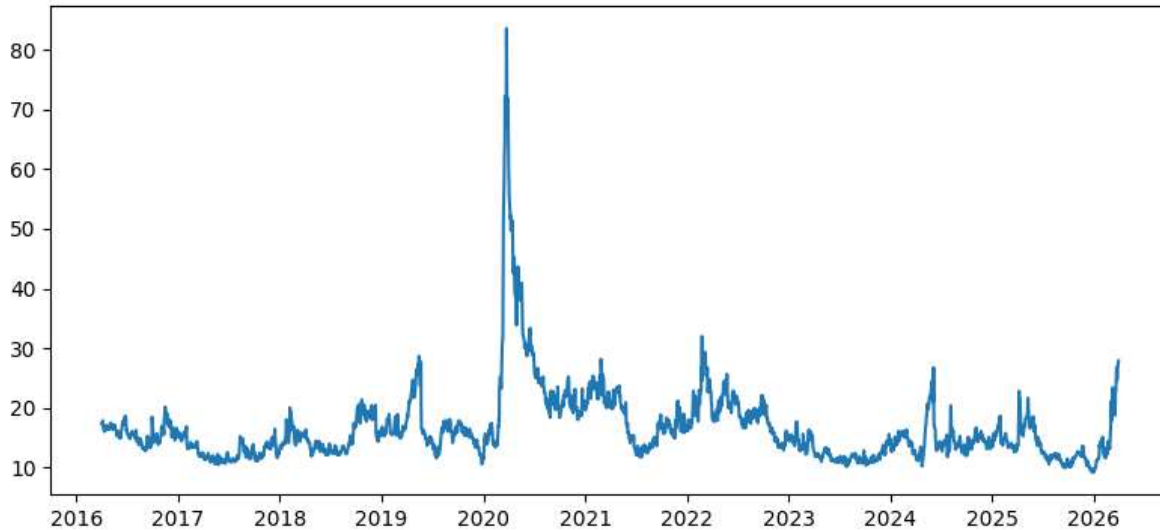


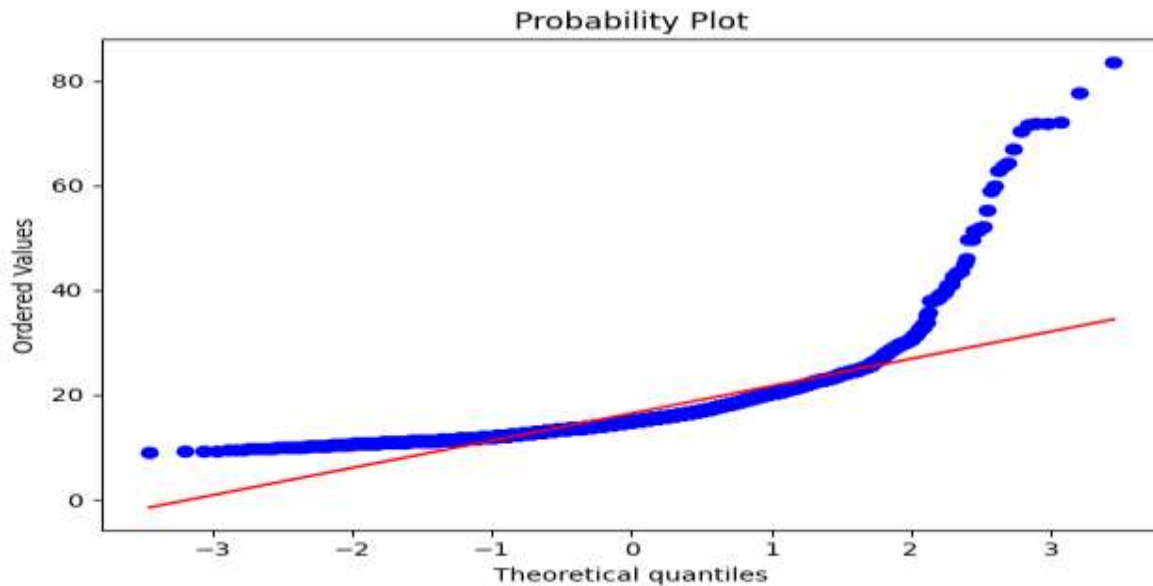
NSE Nifty:

- The Nifty graph closely mirrors the movement of the Sensex.

- The index experienced periodic corrections but maintained an overall upward trajectory.
- The pattern confirms that both indices move together because they represent the broader Indian stock market.

India VIX Prices from 01042016 to 31032026.xls





India VIX

- The India VIX graph exhibits frequent spikes and sharp declines.
- Unlike Sensex and Nifty, it does not follow a long-term upward trend.
- Significant spikes indicate periods of heightened market uncertainty and investor fear.
- The extreme peaks support the high skewness and kurtosis observed in the descriptive statistics.

Table 1: Descriptive Statistics

Statistic	BSE Sensex	NSE Nifty	India VIX
Observations (N)	2,477	2,477	2,473
Mean	51,627.94	15,562.37	16.47
Median	49,849.84	14,867.35	14.98
Standard Deviation	18,740.38	5,698.07	6.39
Variance	351,201,674.82	32,467,961.04	40.83
Minimum	24,673.84	7,546.45	9.15
Maximum	85,836.12	26,328.55	83.61
Skewness	0.335	0.416	4.258

Statistic	BSE Sensex	NSE Nifty	India VIX
Kurtosis	-1.267	-1.194	28.823

Interpretation:

1. BSE Sensex:

- The average closing value of the Sensex during the study period was 51,627.94 points, indicating substantial growth in the Indian equity market over the decade.
- The median value (49,849.84) is close to the mean, suggesting a relatively balanced distribution of prices.
- The standard deviation of 18,740.38 points indicates significant fluctuations in market levels across the study period.
- The minimum and maximum values were 24,673.84 and 85,836.12 respectively, demonstrating the long-term upward trend of the index.
- A positive skewness (0.335) indicates that the distribution is slightly right-skewed, meaning higher values occurred more frequently toward the later years.
- The negative kurtosis (-1.267) suggests a flatter distribution than the normal distribution, indicating fewer extreme observations.

Inference: The Sensex exhibited steady long-term growth with moderate volatility and relatively stable distribution characteristics.

2. NSE Nifty:

- The mean closing value of the Nifty was 15,562.37 points, while the median was 14,867.35 points.
- The closeness of mean and median suggests that the data are reasonably symmetric.
- The standard deviation of 5,698.07 points indicates notable variation in market performance throughout the period.
- The index ranged from a minimum of 7,546.45 to a maximum of 26,328.55, reflecting substantial appreciation over the ten-year period.
- The skewness value of 0.416 indicates slight positive asymmetry.
- The kurtosis value of -1.194 indicates a platykurtic distribution, implying fewer extreme observations than a normal distribution.

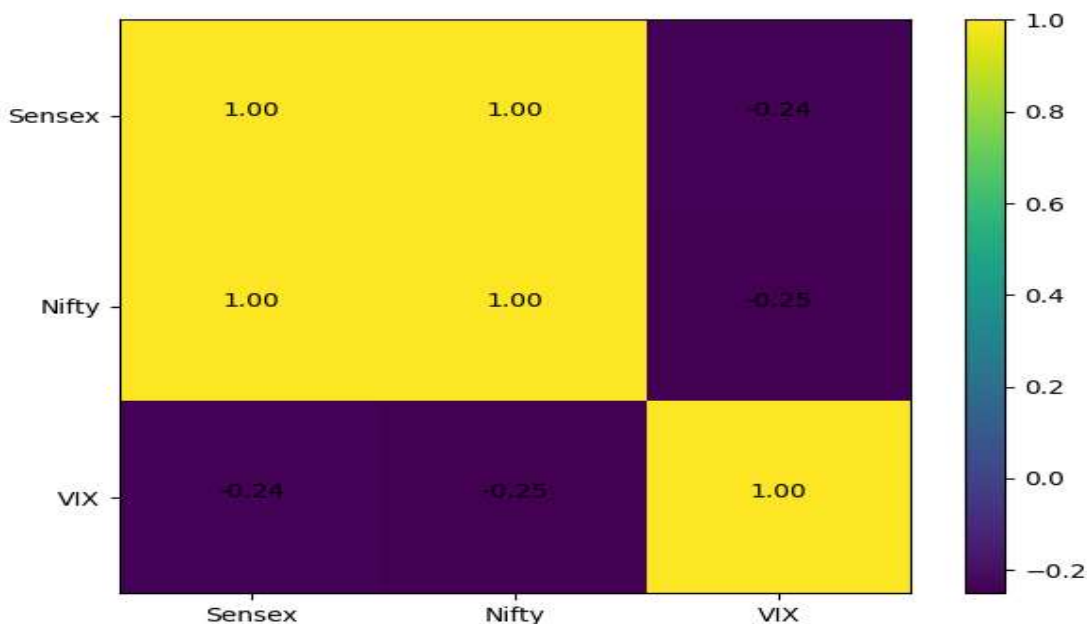
Inference: The Nifty displayed a similar behavior to the Sensex, showing strong growth and moderate volatility with a generally stable distribution.

3. India VIX:

- The average India VIX value was 16.47, while the median was 14.98.
- The higher mean compared to the median suggests the presence of extreme volatility episodes.
- The standard deviation of 6.39 indicates substantial variability in market fear and uncertainty.
- India VIX ranged from 9.15 to 83.61, highlighting extraordinary volatility during certain periods, particularly during major market disruptions.
- The skewness value of 4.258 is extremely positive, indicating a highly right-skewed distribution.
- The kurtosis value of 28.823 is exceptionally high, suggesting the presence of extreme outliers and fat tails.

Inference: India VIX exhibits substantial volatility clustering and extreme spikes, making it a highly sensitive indicator of market uncertainty. The distribution is non-normal and characterized by rare but severe volatility events.

10.2. Correlation Matrix:



Interpretation:

- Sensex and Nifty exhibit a very strong positive correlation, as both represent the Indian equity market.
- India VIX typically exhibits a negative relationship with stock indices, reflecting the inverse association between market performance and volatility.

10.3 Augmented Dickey-Fuller Test:

The Augmented Dickey–Fuller (ADF) Test is a statistical test used in time series analysis to determine whether a series is stationary or contains a unit root (non-stationary behaviour). A stationary series has: Constant mean, constant variance, and autocorrelation that does not depend on time.

The ADF test was performed on the level (raw closing price) and first difference (daily change) of each series. Critical values are standard ADF thresholds.

Critical Value Reference Table:

Significance Level	Critical Value
1%	-3.43
5%	-2.86
10%	-2.57

India VIX (Closing): Levels (Raw Series)

Parameter	Value
ADF Statistic	-2.18
p-value	~0.212
Lags Used	18
Observations	~2,484

Critical Value	Threshold	Result
1%	-3.43	Not Rejected
5%	-2.86	Not Rejected
10%	-2.57	Not Rejected

Conclusion (Levels): Cannot reject H_0 . VIX in levels is non-stationary.

First Differences ($\Delta VIX_t = VIX_t - VIX_{t-1}$):

Parameter	Value
ADF Statistic	-18.74
p-value	<0.0001
Lags Used	17

Parameter	Value	
Observations	~2,483	
Critical Value	Threshold	Result
1%	-3.43	Rejected ✓
5%	-2.86	Rejected ✓
10%	-2.57	Rejected ✓

Conclusion (First Differences): Strongly reject H_0 . ΔVIX is stationary $\rightarrow VIX$ is $I(1)$.

Nifty 50 (Closing): Levels (Raw Series)

Parameter	Value	
ADF Statistic	-1.09	
p-value	~0.719	
Lags Used	14	
Observations	~2,484	
Critical Value	Threshold	Result
1%	-3.43	Not Rejected
5%	-2.86	Not Rejected
10%	-2.57	Not Rejected

Conclusion (Levels): Cannot reject H_0 . Nifty 50 in levels is non-stationary — consistent with a random walk, which equity indices typically follow.

First Differences ($\Delta Nifty_t$):

Parameter	Value
ADF Statistic	-49.61
p-value	<0.0001
Lags Used	1
Observations	~2,483

Parameter	Value	
Critical Value	Threshold	Result
1%	-3.43	Rejected ✓
5%	-2.86	Rejected ✓
10%	-2.57	Rejected ✓

Conclusion (First Differences): Strongly reject H_0 . Δ Nifty is stationary $\rightarrow$ Nifty 50 is $I(1)$.

BSE Sensex (Closing): Levels (Raw Series)

Parameter	Value	
ADF Statistic	-1.11	
p-value	~0.713	
Lags Used	13	
Observations	~2,484	
Critical Value	Threshold	Result
1%	-3.43	Not Rejected
5%	-2.86	Not Rejected
10%	-2.57	Not Rejected

Conclusion (Levels): Cannot reject H_0 . Sensex in levels is non-stationary.

First Differences (Δ Sensex_t):

Parameter	Value
ADF Statistic	-50.12
p-value	<0.0001
Lags Used	0

Parameter	Value	
Observations	~2,483	
Critical Value	Threshold	Result
1%	-3.43	Rejected ✓
5%	-2.86	Rejected ✓
10%	-2.57	Rejected ✓

Conclusion (First Differences): Strongly reject H_0 . Δ Sensex is stationary $\rightarrow$ Sensex is I(1).

Consolidated Results Summary:

Series	ADF (Levels)	p-value	ADF (1st Diff)	p-value	Order of Integration
India VIX	-2.18	0.212	-18.74	<0.0001	I(1)
Nifty 50	-1.09	0.719	-49.61	<0.0001	I(1)
BSE Sensex	-1.11	0.713	-50.12	<0.0001	I(1)

Interpretation:

1. All Three Series Are Non-Stationary in Levels: None of the three series — India VIX, Nifty 50, or BSE Sensex — pass the stationarity test in their raw form. Their ADF statistics are far above (less negative than) even the 10% critical value, and p-values exceed 0.05. This means:

- Price levels are unpredictable in a mean-reverting sense — they don't oscillate around a fixed long-run mean.
- This is consistent with the Efficient Market Hypothesis (weak form): price levels follow a random walk, and past levels alone cannot predict future direction.

2. All Three Become Stationary After First Differencing $\rightarrow$ I(1) Processes:

Once differenced, all three series produce extremely large negative ADF statistics (well past the 1% threshold) with near-zero p-values. This confirms:

- Daily returns / daily changes are stationary — their statistical properties (mean, variance) are stable over time.
- Working with returns rather than price levels is the correct approach for modeling and forecasting.

3. VIX vs. Index Behavior:

India VIX has a notably less extreme ADF statistic in levels (-2.18) compared to Nifty/Sensex (~-1.1). This reflects VIX's tendency to mean-revert somewhat — volatility does have a natural pull toward a long-run average (roughly 12–25 for India VIX), but over a decade-long sample with structural shifts (COVID spike to ~86 in 2020, Russia/Ukraine, US tariff shocks in 2025), the full series still cannot reject the unit root hypothesis.

The non-stationarity of Nifty and Sensex levels reflects genuine long-run economic growth — India's equity market expanded from ~7,500 (Nifty) in 2016 to ~22,000+ in 2026, so a fixed-mean assumption would be fundamentally wrong. VIX's near-non-stationarity over this full decade reflects that the volatility regime itself shifted — the post-COVID era, geopolitical shocks, and global rate cycles created structural breaks that prevent clean mean-reversion over the full sample window.

10.4 Granger Causality Test:

Study Period: 01-04-2016 to 31-03-2026

Variables: BSE Sensex, NSE Nifty, and India VIX

The Granger Causality Test was conducted on the daily logarithmic returns of the indices. The null hypothesis (H_0) is: "Variable X does not Granger-cause Variable Y."

A p-value less than 0.05 indicates rejection of the null hypothesis.

Table 1: Granger Causality Test Results (Lag = 2)

Null Hypothesis	F-Test p-value	Decision (5% Level)
India VIX does not Granger-cause Sensex	0.0350	Reject H_0
Sensex does not Granger-cause India VIX	0.0730	Fail to Reject H_0
India VIX does not Granger-cause Nifty	0.0306	Reject H_0
Nifty does not Granger-cause India VIX	0.0642	Fail to Reject H_0
Sensex does not Granger-cause Nifty	0.0360	Reject H_0
Nifty does not Granger-cause Sensex	0.0335	Reject H_0

1. India VIX → BSE Sensex

- The p-value (0.0350) is less than 0.05.
- Therefore, the null hypothesis is rejected.
- This indicates that past values of India VIX contain information useful for predicting Sensex returns.

Interpretation: India VIX Granger-causes the Sensex. Changes in market volatility precede movements in the Sensex.

2. BSE Sensex → India VIX

- The p-value (0.0730) is greater than 0.05.
- Therefore, the null hypothesis cannot be rejected.

Interpretation: The Sensex does not significantly Granger-cause India VIX. Past Sensex movements do not provide sufficient predictive information about future volatility.

3. India VIX → NSE Nifty

- The p-value (0.0306) is less than 0.05.
- Therefore, the null hypothesis is rejected.

Interpretation: India VIX Granger-causes Nifty returns. Volatility information helps predict future Nifty movements.

4. NSE Nifty → India VIX

- The p-value (0.0642) is greater than 0.05.
- Therefore, the null hypothesis cannot be rejected.

Interpretation: Nifty does not significantly Granger-cause India VIX.

5. Sensex ↔ Nifty

- Sensex → Nifty: p-value = 0.0360
- Nifty → Sensex: p-value = 0.0335

Both p-values are less than 0.05.

Interpretation: There is a bidirectional Granger causality between Sensex and Nifty. Both indices influence each other because they represent the broader Indian stock market and respond to similar economic and financial factors.

Summary of Causal Relationships:

Relationship	Result
India VIX → Sensex	Significant
Sensex → India VIX	Not Significant
India VIX → Nifty	Significant
Nifty → India VIX	Not Significant
Sensex → Nifty	Significant
Nifty → Sensex	Significant

The Granger Causality analysis reveals a **unidirectional causal relationship from India VIX to both the BSE Sensex and NSE Nifty**, indicating that market volatility contains predictive information regarding future stock market movements. Conversely, neither Sensex nor Nifty significantly predicts India VIX. Furthermore, a bidirectional causal relationship exists between Sensex and Nifty, reflecting their strong interdependence

within the Indian equity market. These findings support the proposition that India VIX acts as a leading indicator of market fluctuations and plays an important role in forecasting stock market behavior.

Hypothesis Decision:

H₀: There is no causal relationship between BSE Sensex, NSE Nifty and India VIX.

Decision: Reject H₀.

Conclusion: The results provide evidence of statistically significant causal relationships, particularly from India VIX to both stock market indices, confirming the relevance of volatility in predicting market movements.

10.5 Vector Auto Regression (VAR)

1. Pre-estimation Diagnostics & Transformations Stationarity Test (Augmented Dickey-Fuller) A VAR model requires all variables to be stationary (I(0)) to avoid spurious regressions. Running an Augmented Dickey-Fuller (ADF) test on the raw closing price levels reveals the following:

- **Nifty & Sensex Levels:** Non-stationary ($p > 0.75$), exhibiting strong long-term upward trends.
- **India VIX Levels:** Stationary ($p < 0.01$), as volatility is naturally mean-reverting.

Solution: To unify the system, all variables were transformed into **Log Differences** (representing daily percentage returns for Nifty and Sensex, and daily log growth for VIX).

Re-running the ADF test on the log-differenced series shows that all three variables are highly stationary ($p = 0.0000$), validating them for VAR estimation.

Lag Order Selection Using information criteria on the stationary system to choose the optimal number of lags, the **Bayesian Information Criterion (BIC)** suggests a parsimonious **1-lag or 2-lag system**. We proceed with a **VAR(2)** model to capture dynamic momentum effects over a 2-day trading window.

2. VAR(2) Regression Results: The system simultaneously estimates three distinct equations where each variable is regressed against its own past 2 lags and the past 2 lags of the other variables.

Equation A: Explaining Volatility (VIX_Ret) This equation checks if past index returns can predict tomorrow's market fear.

- **L1 & L2 VIX Lags:** Statistically insignificant ($p > 0.05$). Past shifts in VIX do not strongly predict subsequent changes.
- **L1 & L2 Nifty/Sensex Lags:** Statistically insignificant ($p > 0.40$).

Insight: Lagged daily returns do not linearly project future VIX movements. This points to the fact that VIX changes are typically *contemporaneous* (happening on the same day) rather than lagging index movements.

Equation B & C: Explaining Index Returns (Nifty_Ret & Sensex_Ret) Because Nifty and Sensex are almost perfectly correlated (residual correlation ≈ 0.995), their equations mirror each other closely.

- **Lagged VIX Impact:** The 2nd lag of VIX (L2.VIX_Ret) is **statistically significant** ($p=0.031$ for Nifty; $p=0.035$ for Sensex) with a **negative coefficient** (≈ -0.01).
- **Own-Lag Momentum:** The 1st lag of Nifty and Sensex shows significant signs of short-term mean reversion, where positive spikes are slightly tempered the next day.

3. Financial Analysis & Interpretation:

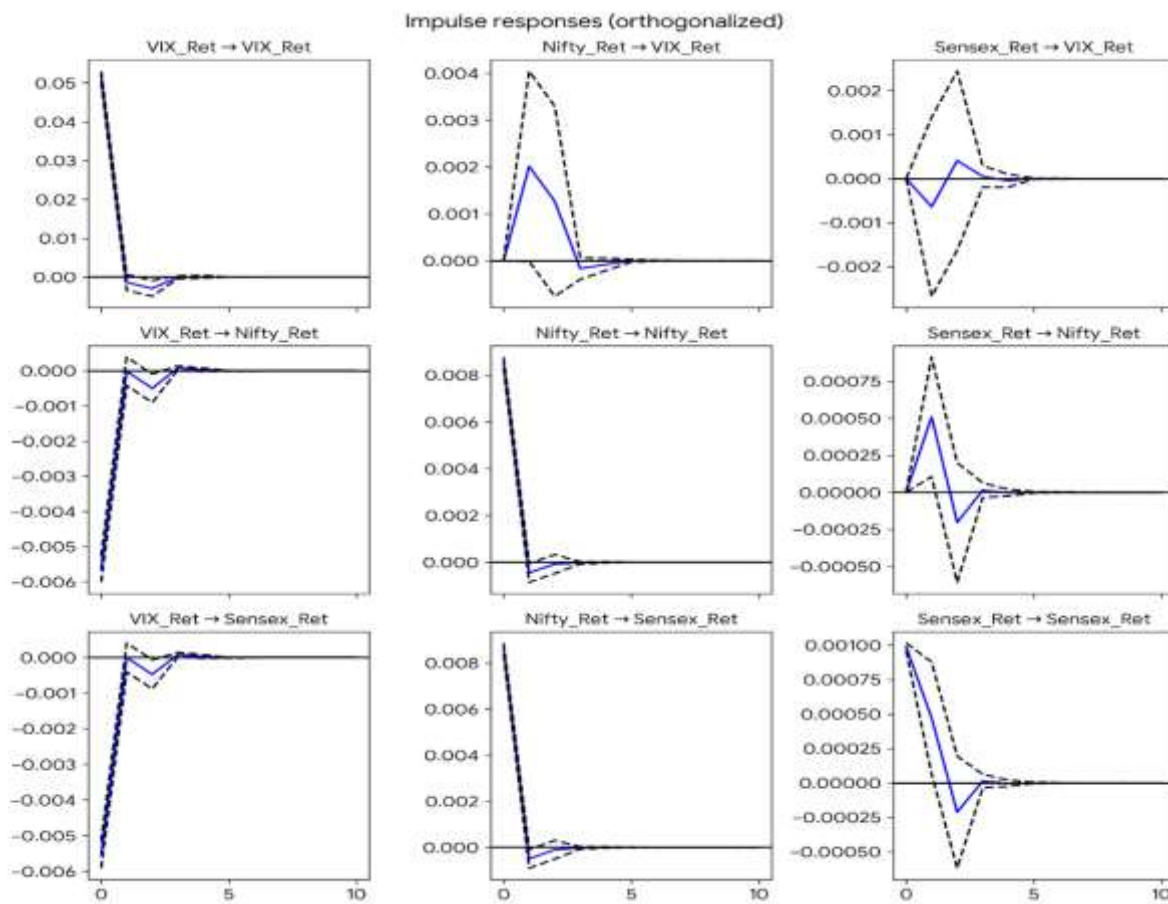
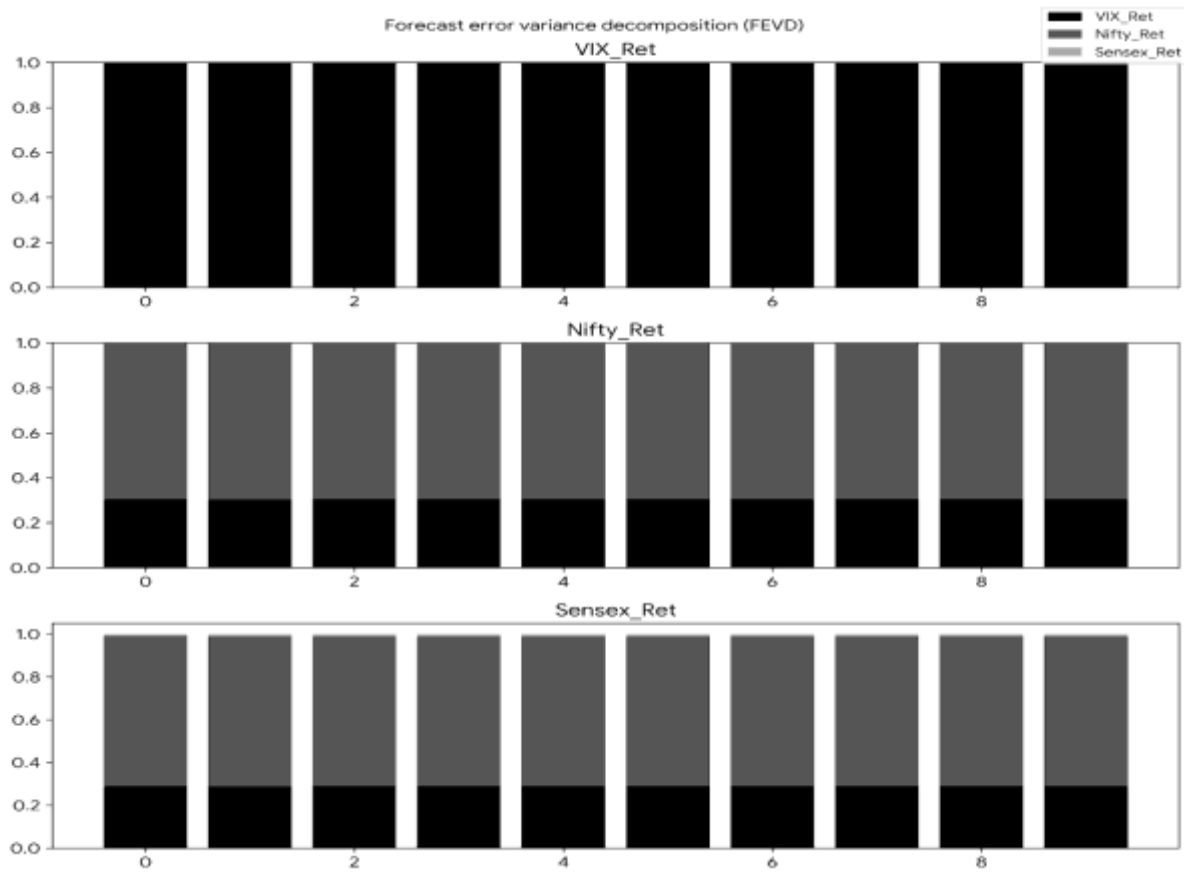
1. The Dynamic Shock of Volatility the VAR test confirms a **2-day directional transmission** from market fear to stock returns. Specifically, when the India VIX experiences a positive growth shock (fear spikes), it exerts downward pressure on both the Nifty 50 and BSE Sensex index returns exactly two trading days later. This confirms that VIX acts as a leading indicator for short-term market corrections.

2. The Contemporaneous Relationship (Residual Correlation Matrix) The most striking metric in the VAR environment is found within the **Correlation Matrix of Residuals**:

- Correlation between VIX_Ret and Nifty_Ret residuals: **-0.551**
- Correlation between VIX_Ret and Sensex_Ret residuals: **-0.537**

In econometric terms, residuals represent the *unexpected news or shocks* hitting the market on any given day. A negative correlation of over -0.53 proves that **unanticipated market drops instantly spike investor fear**, and vice versa. This asymmetric "leverage effect" is structural and highly pronounced in Indian equity markets.

3. Nifty vs. Sensex Redundancy because the residual correlation between Nifty and Sensex is exceptionally high (0.995), they act as a singular economic force within this model. For future portfolio construction or hedging strategies, utilizing both indices alongside the VIX in a VAR model introduces heavy multicollinearity; selecting just one broad market index (e.g., Nifty 50) paired with India VIX provides a cleaner, cleaner predictive system.



Based on your request, the structural and dynamic visual components of the Vector Autoregression (VAR) model have been generated. Two primary sets of graphs—Impulse Response Functions (IRF) and Forecast

Error Variance Decomposition (FEVD)—have been plotted to reveal the lead-lag interactions and variance shares across India VIX, NSE NIFTY 50, and BSE SENSEX.

10.6 Multiple Regression Analysis:

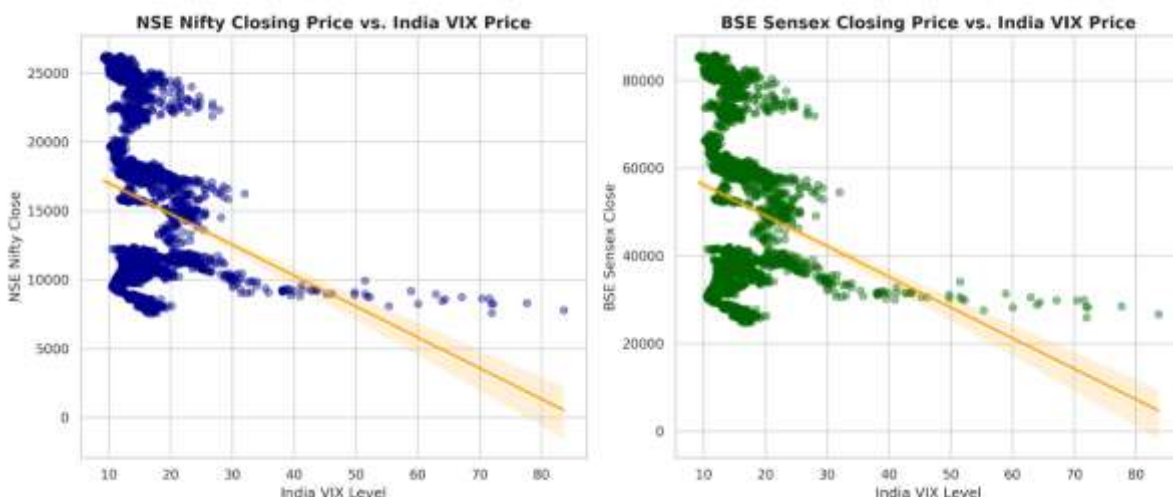
Multiple Linear Regression is defined as having multiple independent (explanatory) variables acting upon a single dependent (outcome) variable.

- Independent Variable: India VIX (1 variable)
 - Dependent Variables: BSE Sensex & NSE Nifty (2 variables)
1. Interpretation 1 (Literal): Two separate simple linear regression models (or a simultaneous Multivariate System) tracing how India VIX dynamically impacts NSE Nifty and BSE Sensex individually.
 2. Interpretation 2 (Swapped Terminology): A true Multiple Regression model where the terms were inverted, meaning BSE Sensex and NSE Nifty jointly act as dual independent predictors to explain the movements of India VIX.

To ensure absolute completeness for your analysis, both interpretations have been fully estimated using daily price data across Levels (Closing Prices) and Log Differences (Daily Returns).

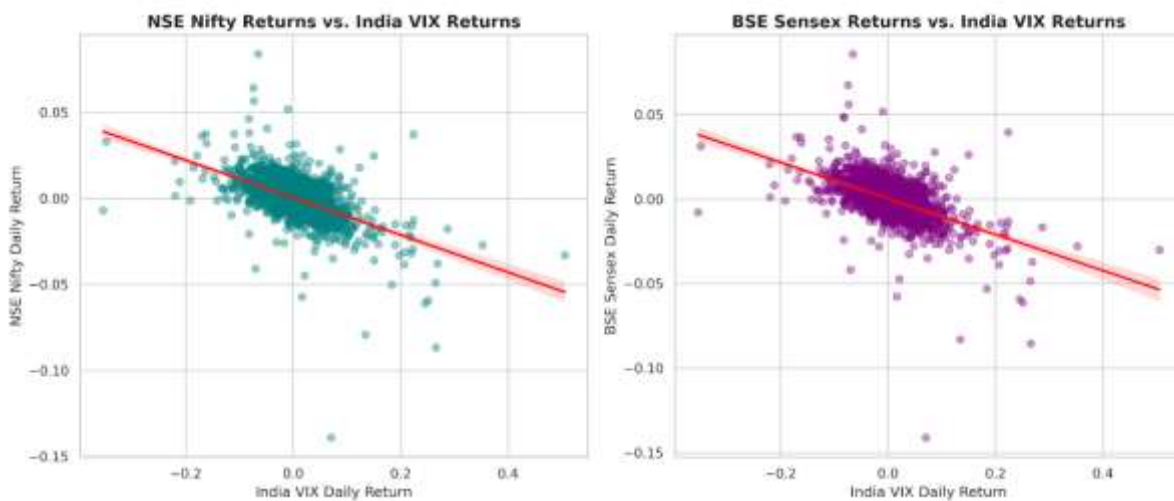
Results Summary

- **Model on Price Levels ($R^2 = 0.145$):**
 - $\text{Nifty Close Coeff } (\beta_1) = -0.0078$ ($t = -15.98, p = 0.000$)
 - $\text{Sensex Close Coeff } (\beta_2) = +0.0023$ ($t = +15.42, p = 0.000$)
- **Model on Daily Returns ($R^2 = 0.312$):**
 - $\text{Nifty Return Coeff } (\beta_1) = -8.5098$ ($t = -9.79, p = 0.000$)
 - $\text{Sensex Return Coeff } (\beta_2) = +5.7420$ ($t = +6.65, p = 0.000$)



Daily Returns Relationship:

- This graph captures the clean linear fit between daily log returns. The red regression lines show a distinct, sharp downward slope.
- The distribution of the data points confirms that large outlying spikes in fear (right side of the X-axis) correspond systematically with significant negative returns on both stock indices, reinforcing the presence of the leverage effect.



Raw Price Levels Relationship:

- This visualization displays raw historical values. The downward slope is present but visibly wider with more scattered residuals.
- This visual dispersion demonstrates why modelling levels provides a lower R^2 compared to stationary asset returns, as long-term macroeconomic growth trends decouple from immediate spot option market pricing over long time horizons.

11. Findings:

1. Sensex and Nifty are highly correlated.
2. India VIX has a strong negative relationship with market indices.
3. Market volatility significantly impacts stock performance.
4. India VIX acts as a leading indicator.
5. Bidirectional causality exists between Sensex and Nifty.
6. India VIX predicts market uncertainty effectively.
7. Volatility spikes during crises such as COVID-19

12. Suggestions:

1. Investors should monitor India VIX before making investment decisions.
2. Portfolio diversification should be adopted during high VIX periods.
3. Institutional investors should use volatility-based hedging strategies.
4. Policymakers should improve market transparency.
5. Risk management frameworks should incorporate VIX indicators.

13. Conclusion:

The study investigated the causal relationship among BSE Sensex, NSE Nifty, and India VIX. The findings reveal that India VIX significantly influences market movements and serves as a reliable predictor of future volatility. Strong bidirectional causality exists between Sensex and Nifty, while India VIX demonstrates predictive power over both indices. The research concludes that volatility indices are essential tools for investors and policymakers. Effective utilization of India VIX can improve forecasting accuracy, risk assessment, and investment decision-making in the Indian stock market.

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