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Macroeconomic Determinants of Stock Market Performance in India and Selected Global Economies: An Econometric and Machine Learning Analysis

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ABSTRACT: Stock markets are increasingly influenced by macroeconomic fluctuations and global financial integration, particularly in emerging economies where financial systems are highly sensitive to economic shocks and external uncertainties. This study aims to examine the effects of macroeconomic determinants on stock market performance in India and selected global economies using econometric and machine learning approaches. Monthly and quarterly data covering the period 2010–2024 were collected from international financial and economic databases and analyzed using correlation analysis, multiple regression, Augmented Dickey–Fuller and Phillips–Perron unit root tests, Johansen cointegration, Vector Autoregression, Vector Error Correction Modeling, Granger causality analysis, Random Forest, XGBoost, Long Short-Term Memory, and a hybrid XGBoost–LSTM framework. The findings reveal that gross domestic product growth has a strong positive relationship with stock market performance ($r=0.72$), whereas inflation ($r=–0.48$), interest rates ($r=–0.55$), exchange rates, and unemployment exert negative effects on market returns. Regression results indicate that GDP growth is the most influential positive determinant ($\beta=0.68$, $p<0.01$), while interest rates and unemployment significantly reduce market performance. Among the forecasting models, the hybrid XGBoost–LSTM model achieved the highest predictive accuracy with an RMSE of 121.35, MAE of 98.42, and R^2 value of 0.93. The study concludes that macroeconomic stability plays a critical role in enhancing stock market performance and that hybrid machine learning frameworks provide superior forecasting capability compared with conventional econometric approaches, offering valuable implications for investors, portfolio managers, and policymakers.

1. INTRODUCTION

Stock markets play a vital role in economic development by facilitating capital formation, investment opportunities, and overall financial stability. The relationship between macroeconomic variables—such as GDP growth, inflation, interest rates, and exchange rates—and stock market performance has been widely recognized, as these factors influence investor expectations, corporate profitability, and market behavior [1]–[3]. With increasing financial globalization, stock markets have become highly interconnected, allowing economic shocks and geopolitical uncertainties to transmit rapidly across borders [4]–[6]. Events such as the COVID-19 pandemic further highlighted this interconnectedness, causing significant volatility and emphasizing the need for robust analytical and forecasting models [7]–[9].

India, as a fast-growing emerging economy, provides a unique context to study these relationships. Compared to developed markets, emerging markets like India are more volatile and sensitive to macroeconomic changes [10]. In recent years, India's

financial markets have evolved due to economic reforms, increased foreign investments, and technological advancements. This transformation makes it essential to examine how macroeconomic variables influence stock market performance both domestically and globally, helping policymakers and investors make informed decisions and enhance market stability.The purpose of the analysis is to examine how macroeconomic variables affect the performance of the stock market in India.

- To study comparable relations in the world economies.
- To determine the sensitivity of stock markets in developed and emerging economies.
- To create predictive models that are based on econometric and machine learning approaches.
- To draw policy conclusions on investors, portfolio managers and regulatory authorities.

The research questions of the research are:

RQ1: How is the relationship between macroeconomic variables and stock markets performance in India in nature and in magnitude?

RQ2: How macroeconomic shocks have different impacts on stock markets in developed and emerging economies?

RQ3: Can machine learning models outperform traditional econometric models in predicting the movements of the stock market using the inputs of macroeconomic factors?

RQ4: How do macroeconomic variables and equity indices relate to each other cointegrated in the long-run across the sampled economies?

The rest of the paper is structured in the following way. In section 2, the theoretical and empirical literature review on macroeconomic variables and the performance of stock markets is provided in detail. In section 3, the methodology of the research is detailed including data sources, variables, time period, and methods of analysis. The results and data analysis are provided in section 4. In section 5, the findings and their implications are discussed. Last but not the least, Section 6 will end the research with important implications and recommendations to future research.

2. LITERATURE REVIEW

Recent research offers a much more insight on the connection between macroeconomic factors and stock market performance, combining theoretical understanding and practical evidence. The Indian stock market was studied by Kumar [11] who proved that the macroeconomic indicators of GDP, inflation and interest rates are key determinants of market returns and thereby the general theoretical support of the market efficiency. Dang et al. [12] examined both the relationship between stock prices and Exchange rates in Vietnam and established the strong dynamic relationship supporting the multi-factor outlook which is congruent with Arbitrage Pricing Theory (APT). Likewise, Sheikh et al. [13] and Atil et al. [14] have highlighted that stock markets are influenced by the simultaneous impact of oil prices, exchange rates as well as economic growth and it is therefore true that the macroeconomic transmission mechanisms are relevant. The existence of empirical evidence on macroeconomic determinants further shows that both firm-level and economy-wide factors influence the stock performance. Ullah et al. [15] reported that capital structure and macroeconomic conditions have a significant impact on the performance of firms with Huy et al. [16] demonstrating that macroeconomic variables of choice have a direct effect on stock prices in Vietnam. These results are consistent with the theoretical fact that stock markets react to the developments in the economic fundamentals and financial conditions.

The investor sentiment and uncertainty have been strongly linked with market volatility. Ph and Rishad [17] established that in India investor sentiment is a major cause of stock market volatility which suggests that stock market behavior does not conform to traditional accounts of efficiency. Agoraki et al. [18] took the analysis further by demonstrating that geopolitical-related risks and uncertainty occurrence influence the stock market performance in a negative manner and in particular the emerging markets. Yi et al. [19] also noted that the economic policy uncertainty and globalization play a part in contributing to the financial stability with a stress on macroeconomic and external risk factors. The influence of global shocks on financial markets has been extensively researched. An event study by Singh et al. [20] in G-20 countries revealed significant negative stock market response to the pandemic. Ashraf [21] revealed that the government interventions in COVID-19 played a significant role in how the market reacted and Pandey and Kumari [22] revealed how the emerging markets were more

volatile than the developed markets in times of crisis. All these studies point to the fact that global shock has a fast spread across coordinated financial regimes, which increases uncertainty and volatility.

Over the past few years, machine learning has acquired importance in the stock market prognostication. Vijh et al. [23] implemented prediction of stock prices by using machine learning models, and the results showed better accuracy as opposed to conventional predictors. Demirel et al. [24] illustrated the capability of deep learning algorithms to generalize the complex market trends whereas Jabeen et al. [25] added the macroeconomic and news sentiments to machine learning models that were shown to strongly enhance predictive capabilities. This field was furthered by Srivastava [26] who employed machine learning to determine market regimes in India and emphasized how these models can be used in nonlinear relationships as well as large datasets.

Macroeconomic variables have long been recognized as fundamental determinants of stock market performance because they directly influence corporate profitability, investor expectations, and overall economic activity. Recent studies have reaffirmed the significance of economic fundamentals in shaping stock market behavior across both developed and emerging economies. Chauhan [27] found that macroeconomic indicators significantly influence sectoral stock returns in India, with variations observed across industries depending on their sensitivity to economic conditions. Similarly, Keswani et al. [28] reported that gross domestic product (GDP), disposable income, and foreign investment exhibit significant long-run relationships with stock prices, highlighting the role of economic growth and capital inflows in supporting market expansion. These findings suggest that favorable macroeconomic conditions enhance investor confidence and contribute to sustained stock market growth.

The relationship between macroeconomic stability and stock market performance has also been examined across different economic regions. Humpe [29], in a comparative analysis of BRICS and Anglosphere economies, demonstrated that macroeconomic fundamentals remain critical drivers of stock market movements regardless of the level of economic development. Likewise, Ayoub [30] emphasized that economic growth, controlled inflation, and stable financial conditions are essential for stock market development in emerging economies. These studies indicate that strong economic fundamentals create an environment conducive to investment and capital market development.

Inflation, interest rates, and exchange rates continue to receive considerable attention due to their direct impact on investment decisions and financial market stability. Jakšić [31] observed that inflation, interest rates, exchange rates, and oil prices significantly affect stock index volatility in both developed and emerging markets. Consistent with this finding, Vartanian [32] reported that fluctuations in interest rates and exchange rates significantly influence stock market performance in Brazil, while economic activity positively supports market growth. Similarly, Khan and Billah [33] found that inflation, money supply, and exchange rate movements exert significant long-run effects on stock returns, demonstrating the importance of monetary and exchange rate stability in financial markets.

Recent evidence from emerging economies further confirms the influence of macroeconomic variables on stock market returns. Muwahhidin [34] revealed that exchange rate fluctuations significantly affect stock returns, although the effects of inflation and interest rates vary across sectors. A study on the Indian stock market [35] reported that GDP growth positively affects stock market performance, whereas inflation and higher interest rates negatively influence equity returns in both the short and long run. Similar findings were reported in Nigeria, where GDP growth, inflation, interest rates, and exchange rates were found to significantly explain stock market movements and investor behavior [36].

Overall, the recent literature demonstrates that macroeconomic determinants such as GDP growth, inflation, interest rates, exchange rates, oil prices, and unemployment play a critical role in shaping stock market performance. While economic growth generally promotes stock market expansion, inflationary pressures, currency instability, and restrictive monetary policies often exert adverse effects on market returns. Despite the broad consensus regarding the importance of macroeconomic fundamentals, the magnitude and direction of these relationships differ across countries and market structures, highlighting the need for comparative analyses that incorporate both developed and emerging economies. This provides a strong foundation for examining the effects of macroeconomic determinants on stock market performance in India and selected global economies using econometric and machine learning approaches.

By and large, the literature suggests that stock market behavior depends on macroeconomic factors, global uncertainties as well as technological innovations. Although conventional theories offer a good background, more recent empirical research

states that it is crucial to incorporate the econometric methods with the machine learning techniques to address the complex dynamics and enhance the accuracy of forecasts. Thus, this study aims to examine the effects of macroeconomic determinants on stock market performance in India and selected global economies using econometric and machine learning approaches.

2.1. Research Gap

Although a lot of research has been carried out on macroeconomic factors that determine the performance of a stock market, there are still a number of gaps. A majority of the research is based on conventional models of the economy, which have restricted the research in terms of including nonlinearities and evolutionary interactions among factors [11], [12]. Also, the interplay between macroeconomic indicators and investor sentiment as well as global uncertainty variables has not been studied thoroughly [17], [25]. The current literature also does not involve detailed hybrid frameworks that integrate machine learning with econometric frameworks to enhance the accuracy of the prediction [23], [26]. Moreover, the attention to the emerging markets in the framework of global shocks and geopolitical risks has not been given much, which limits the applicability of results [20], [22].

2.6. Research Hypothesis

Based on the identified research gaps, this study aims to examine the effects of macroeconomic determinants on stock market performance in India and selected global economies using econometric and machine learning approaches.

Hypotheses

H1: GDP growth positively affects stock market performance.

H2: Inflation negatively affects stock market performance.

H3: Interest rates negatively affect stock market performance.

H4: Exchange rates significantly influence stock market performance.

3. RESEARCH METHODOLOGY

This section presents the methodological strategy that will be followed to investigate the correlation between macroeconomic variables and stock market performance in India and the world economies. It explains the data sources, variables, time period, and methods of analysis applied in the study. Econometric and machine learning techniques are used to make sure that the linear and nonlinear relationships are thoroughly analyzed. The methodology will be used to obtain credible, valid and informative findings that will facilitate the research objectives and hypotheses.

3.1. Data Sources

The research draws secondary information of trusted international sources. The World Bank, IMF, and OECD databases [40]-[42] provide the macroeconomic variables (GDP growth, inflation, interest rates, exchange rates, and unemployment). The Reserve bank of India provides information of India specific financial data, such as; repo rate and exchange rate [37]. The indices of the stock markets (NIFTY 50, SENSEX, S&P 500, FTSE 100 and Nikkei 225) are taken in Yahoo Finance, and the daily data is transformed to monthly frequency [38]. In the U.S. EIA, crude oil prices (Brent) are obtained and cross-verified with Bloomberg [39], which guarantees a homogeneous and comparable information.

3.2. Variables

By clearly defining dependent and independent variables, this paper examines the cause-and-effect relationship between macroeconomic variables and the stock market performance. The dependent variable is the performance of the stock market, an indicator of which is the major indices like NIFTY 50 and SENSEX in India, and S&P 500, FTSE 100, and Nikkei 225 across the world. They are good pointers in the perception of market responses to economic changes since they indicate the general trend in the market, investor mood, and the economy.

The independent variables are major macroeconomic indicators with good theoretical relevance and empirical relevance. The rate of GDP growth is a measure of economic well being, with an improved rate promoting corporate profitability as well as stock market prices. Purchasing power and costs are influenced by inflation (CPI) although moderate levels influence the

growth, high inflation has adverse effects on the markets. The interest rates affect the decisions to borrow and invest in an economy, with higher rates cutting down the attractiveness of the stock market. Exchange rates have implications on the competitiveness of trade and foreign investment, hence market performance. Corporate profitability is affected by oil prices that are vital in the cost of production especially in economies that import oil. Finally, unemployment rate is an indicator of the state of affairs in labor market as higher rates of unemployment lower the consumption and the level of economic activity taking a toll on stock markets.

3.3. Time Period

The research uses time-series data collected between 2010 and 2024 and depending on the presence of data on the chosen sources. The data were obtained through credible financial and economic websites such as central bank reports, financial market websites, and global economic depositories. We received monthly figures on stock market indices, exchange rates, crude oil prices, inflation rates, and interest rates provided by various sources that include national stock exchanges, central bank reports, and international financial databases. International organizations and national statistical agencies collected quarterly data on the macroeconomic indicators, including GDP growth rate and unemployment rate. In order to ensure uniformity in the variables, monthly observations were synchronized and aggregated in cases where required whereas the quarterly data were matched to the time periods. All in all, the data set comprises about 240 observations each month and 80 observations each quarter in the chosen economies. This long horizon enables the capture of the economic cycles, financial crises, and structural changes hence enhancing the strength and consistency of the statistical analysis and predictive model.

3.4. Econometric Models

The research uses a systematic approach in terms of econometric methods in order to explore the interaction between macroeconomic variables and stock market performance where both short-term dynamics and long-run equilibrium are represented. This will start with descriptive statistics as the mean, median, standard deviation and range will be used to understand the data distribution, volatility and identify outliers. Correlation analysis is then utilized to determine the strength and direction of the linear relationships between the macroeconomic variables and stock indexes which offers preliminary, but not causal factors. To decide the suitability of data to be used in time-series modeling, unit root tests like the Augmented Dickey-Fuller (ADF) and the Phillips-Perron (PP) are performed to test the property of stationarity. Variables that are not stationary but become stationary on differencing are said to be of order one (I(1)).

The use of cointegration test is based on long-run equilibrium relationships of variables to establish the relationship between the variables and the level ofikeness. When there is cointegration, then both long-term relationships and short-term adjustments are encompassed using Vector Error Correction Model (VECM). Otherwise, Vector Autoregression (VAR) modelling is a dynamic interaction between variables in the near-term. Lastly, the Granger causality test determines the other way of influence of a variable and whether one variable can predict another. A combination of these approaches yields a holistic approach in studying the macroeconomic effects on stock markets.

To examine the impact of macroeconomic determinants on stock market performance, the study employed a multiple regression model:

$$SMP_t = \beta_0 + \beta_1 GDP_t + \beta_2 INF_t + \beta_3 INT_t + \beta_4 EXR_t + \beta_5 OIL_t + \beta_6 UNEMP_t + \varepsilon_t$$

where SMP_trepresents stock market performance at time t, GDP_tdenotes gross domestic product growth, INF_trepresents the inflation rate, $INT_t$is the interest rate, EXR_tdenotes the exchange rate, OIL_trepresents crude oil prices, and $UNEMP_t$denotes the unemployment rate. $\beta_0$is the intercept, β_1–β_6 are the regression coefficients, and $\varepsilon_t$is the random error term. The model estimates the direction and magnitude of the influence of macroeconomic variables on stock market performance.

To capture the short-run dynamic interactions among stock market indices and macroeconomic variables, a Vector Autoregression (VAR) model was estimated as follows:

$$Y_t = A_1 Y_{t-1} + A_2 Y_{t-2} + \cdots + A_p Y_{t-p} + \varepsilon_t$$

where $Y_t$is a vector containing stock market indices and macroeconomic variables, $A_1, A_2, \ldots, A_p$are coefficient matrices, $p$denotes the optimal lag length, and $\varepsilon_t$is the vector of error terms. The VAR model enables the assessment of how shocks in one variable influence the behavior of other variables over time.

Since the variables were found to be integrated of order one and cointegrated, a Vector Error Correction Model (VECM) was applied to examine both long-run equilibrium relationships and short-run adjustments:

$$\Delta Y_t = \alpha + \sum_{i=1}^{p-1} \Gamma_i \, \Delta Y_{t-i} + \Pi Y_{t-1} + \varepsilon_t$$

where ΔY_trepresents the first difference of the variables, $\alpha$is the intercept vector, $\Gamma_i$denotes the short-run coefficient matrices, Πrepresents the long-run coefficient matrix, Y_{t-1}denotes lagged level variables, and $\varepsilon_t$is the error term. The error correction term measures the speed at which deviations from long-run equilibrium are corrected following short-term disturbances.

To determine the direction of influence between macroeconomic variables and stock market performance, the Granger causality test was employed. The model can be represented as:

$$SMP_t = \alpha + \sum_{i=1}^{p} \beta_i \, SMP_{t-i} + \sum_{j=1}^{p} \gamma_j \, X_{t-j} + \varepsilon_t$$

where SMP_tdenotes stock market performance, $X_t$represents a macroeconomic variable, $p$is the lag length, $\beta_i$and $\gamma_j$are estimated coefficients, and $\varepsilon_t$is the random error term. The null hypothesis states that the lagged values of a macroeconomic variable do not Granger-cause stock market performance. Rejection of the null hypothesis indicates the existence of predictive causality.

The econometric analysis was conducted sequentially through descriptive statistics, correlation analysis, unit root testing using Augmented Dickey–Fuller and Phillips–Perron tests, Johansen cointegration analysis, VAR and VECM estimation, and Granger causality testing to comprehensively examine the relationship between macroeconomic determinants and stock market performance in India and selected global economies.

3.5. Machine Learning Models

Besides conventional econometric methods, machine learning models are also used to increase predictive power and nonlinear relationships. This study uses three models that add different strengths to the analysis in terms of analysis.This paper uses the state-of-the-art machine learning algorithms (Random Forest, XGBoost, and Long Short-Term Memory (LSTM)) in enhancing stock market prediction using macroeconomic variables. Random Forest is an algorithm of ensemble learning, which constructs a number of decision trees, summing up their results, thereby minimizing overfitting and enhancing generalization. It is also especially applicable when determining the significance of macroeconomic variables like GDP, inflation, interest rates to make use of huge datasets and intersectional relationships. The XGBoost is a very powerful algorithm of boosting, which builds the trees in a dotted row, the following tree is a correction of the previous ones. This will allow it to model more nonlinear relationships more precisely than traditional models. It is also extremely useful in the forecasting of finances due to its built-in regularization methods, which also increase the stability of the model and discourage overfitting.

LSTM is a deep learning model, specifically used to analyze sequential data. It stores long-term dependencies using memory cells, providing it to be useful with financial time-series data where historical trends affect future results. LSTM is useful to establish the time dependence between macroeconomic variables and stock indices. Combined, the models form a rich analytical engine, integrating everything in terms of feature importance and nonlinear modeling, and learning over time series, and avoiding the compromises of traditional econometric models and enhancing prediction capacity.

3.5.1. Hybrid Model: XGBoost-LSTM Model

In this paper, a hybrid XGBoost-LSTM model is used to better predict the stock market, thus capturing the nonlinear dependence as well as time-dependent trends in the stock market data. The model is a hybrid of both gradient boosting and

deep learning models, which are strong frameworks to study the effect of macroeconomic variables on the performance of the stock market.

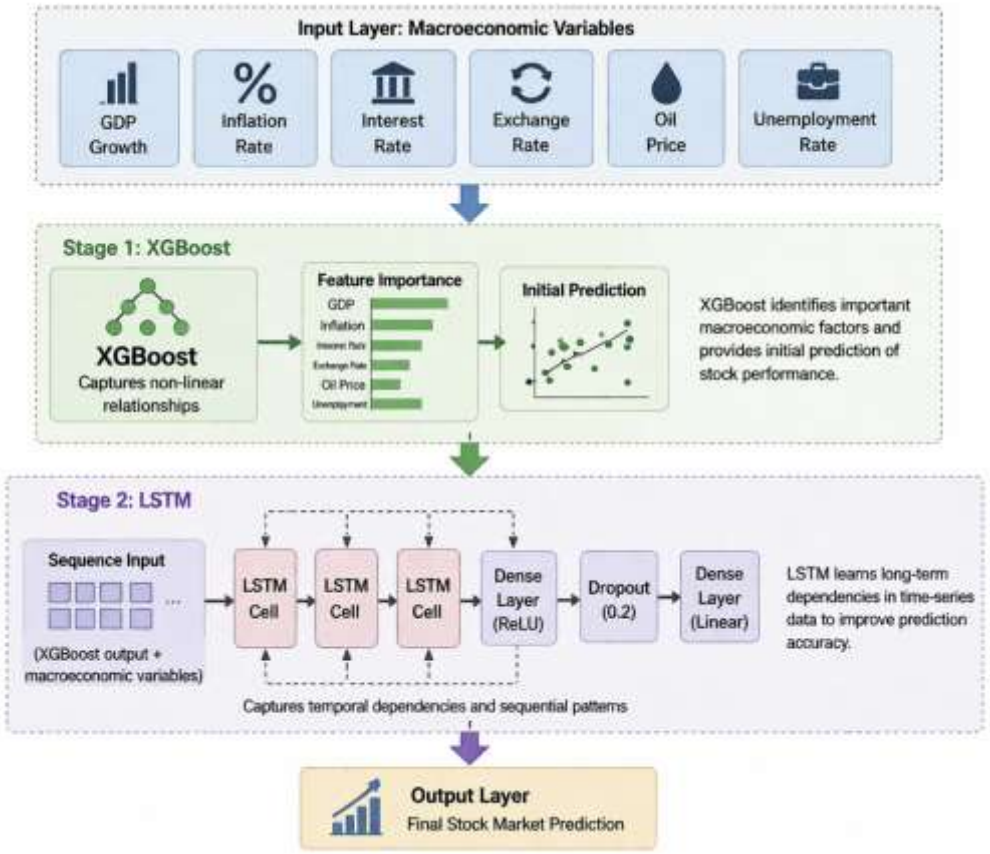


Figure 1: Proposed framework

The XGBoost-LSTM hybrid model will be used to overcome the drawbacks of single models. Although XGBoost is an extremely efficient algorithm in terms of capturing nonlinear relationships and interactions between features, it does not assume temporal relationships in time-series data. Conversely, LSTM is particularly created to process sequential data and has the ability of capturing long-term dependencies but does not necessarily perform well when it comes to determining the importance of features or structured tabular data. The hybrid approach is a combination of these two models and guarantees the feature-level learning and time-series learning, which results in better forecasting performance. Figure 1 shows in Proposed framework.

The hybrid model can be applied in two phases, in the first phase, the XGBoost is applied to the data set based on macroeconomic variables including GDP growth, inflation, interest rate, exchange rate, oil prices, and unemployment rate. The model is able to learn nonlinear relationships between these variables and the stock market indices. XGBoost produces an initial estimate of the performance of the stock market and determines how important each factor of the macroeconomic environment is. This step is useful in identifying the structured patterns and interactions in the data. The second stage is to provide the output forecasts of the XGBoost model to the LSTM network, as well as the original time-series data. The sequential character of the data is processed through the LSTM model and temporal dependencies are captured, e.g. trends, cycles, and lag effects of stock market movements. LSTM takes the final prediction after learning based on past values and XGBoost-enhanced features and gives a better prediction. The mechanisms of the working of the proposed method are:

- XGBoost discovers nonlinear patterns and interactions of features.
- LSTM learns time-dependent and sequential trends.

- The combination can guarantee the full coverage of data structure and temporal behaviour.

3.6. Model Validation and Performance Evaluation

To ensure the reliability and generalizability of the machine learning models, the dataset was divided into training and testing subsets using an 80:20 split ratio. Approximately 80% of the observations were used for model training, while the remaining 20% were reserved for out-of-sample testing and performance evaluation. This approach enabled the assessment of predictive accuracy on unseen data and reduced the risk of overfitting. Prior to model development, all variables were examined for missing values and inconsistencies. Continuous variables were normalized to improve model convergence and stability, particularly for deep learning architectures such as Long Short-Term Memory (LSTM). The training dataset was used to estimate model parameters, whereas the testing dataset was used exclusively for evaluating forecasting performance.

Hyperparameter tuning was conducted to optimize model performance. For the Random Forest model, the number of trees and maximum tree depth were adjusted. For XGBoost, parameters including learning rate, maximum depth, subsampling ratio, and number of estimators were optimized. For the LSTM model, the number of hidden units, batch size, learning rate, and training epochs were selected based on performance during the training process. The hybrid XGBoost-LSTM framework combined the optimized outputs of XGBoost with the temporal learning capability of LSTM to improve forecasting accuracy. The predictive performance of all machine learning models was evaluated using Root Mean Square Error (RMSE), Mean Absolute Error (MAE), and the coefficient of determination (R^2). These measures were calculated as follows:

$$RMSE = \sqrt{\frac{1}{n}\sum_{i=1}^{n}(y_i - \hat{y}_i)^2}$$

where $y_i$represents the actual stock market value, $\hat{y}_i$represents the predicted value, and $n$denotes the number of observations.

$$MAE = \frac{1}{n}\sum_{i=1}^{n} | y_i - \hat{y}_i |$$

where MAE measures the average absolute prediction error.

$$R^2 = 1 - \frac{\sum_{i=1}^{n}(y_i - \hat{y}_i)^2}{\sum_{i=1}^{n}(y_i - \bar{y})^2}$$

where $\bar{y}$denotes the mean of the observed values. The R^2 statistic indicates the proportion of variance in stock market performance explained by the model.

Lower RMSE and MAE values indicate better predictive performance, whereas higher R^2 values indicate stronger explanatory power. The comparative evaluation demonstrated that the hybrid XGBoost–LSTM model outperformed the individual machine learning models and conventional econometric approaches, achieving the highest forecasting accuracy for stock market prediction.

4. RESULTS AND DISCUSSION

The section shows the interpretation of statistical outputs, comparison with the past studies, and economic implications of the relationship between macroeconomic variables and stock market performance in India and global economies.

4.1. Country-wise Analysis

This part will be devoted to the analysis of the behavior of the individual stock market indices in each country will be considered individually. It measures significant statistical characteristics like trends, volatility, central tendency and the patterns of distribution. It is aimed at knowing the specific market dynamics, growth trajectory and the risk characteristics

that are unique to each economy without external comparison. Figure 2 shows the relative tendencies of major stock market indices in the world in 2010-2024, demonstrating different rates of growth of developed and emerging markets. The SENSEX (purple line) depicts the steepest upward trend, rising steeply since about 17,000 in 2010 to above 80,000 in 2024, which is an upward growth of almost 370 percent, indicating that the Indian equity market is growing tremendously. On the same note, the NIFTY 50 (red line) illustrates a significant growth as it began at approximately 5,000 and then increased to 25,000, a rise of approximately 400 percent, although there was a sharp rise after 2020.

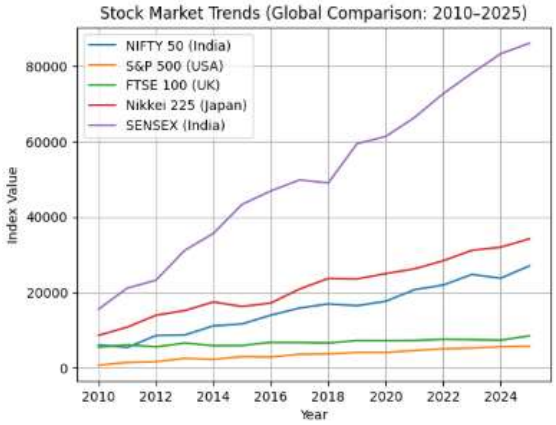


Figure 2: Trends in NIFTY 50, SENSEX, S&P 500, FTSE 100, and Nikkei 225 during 2010–2024

The graph depicts the movements through key stock indices since the year 2010 to 2024. Nikkei 225 shows clear growth, that is, it increased in value between 10,000 and 30,000, by a factor of three with minor changes. FTSE 100 is also in its mark, with a range of 5,000 to 7,000, though it has slow and not volatility. S&P 500 is quite robust and growing steadily over time (since approximately 1,200 up to almost 6,000, although sharply dropped in 2020 because of COVID-19). All indices show a correlated decline in 2020 and fast recovery. On the whole, the growth and volatility are more accentuated in emerging markets and are slow and constant in developed markets.

4.2. Comparison Analysis (India vs Global)

This part gives a direct comparison of the Indian stock market and the world standard. It brings out the performance variations, growth rates, volatility and resilience to economic shocks. Comparing the two indices, the plan of the analysis is to determine the relative strengths and weaknesses as well as the investment implications which provide an insight into the performance of emerging markets such as India in comparison to the developed markets.

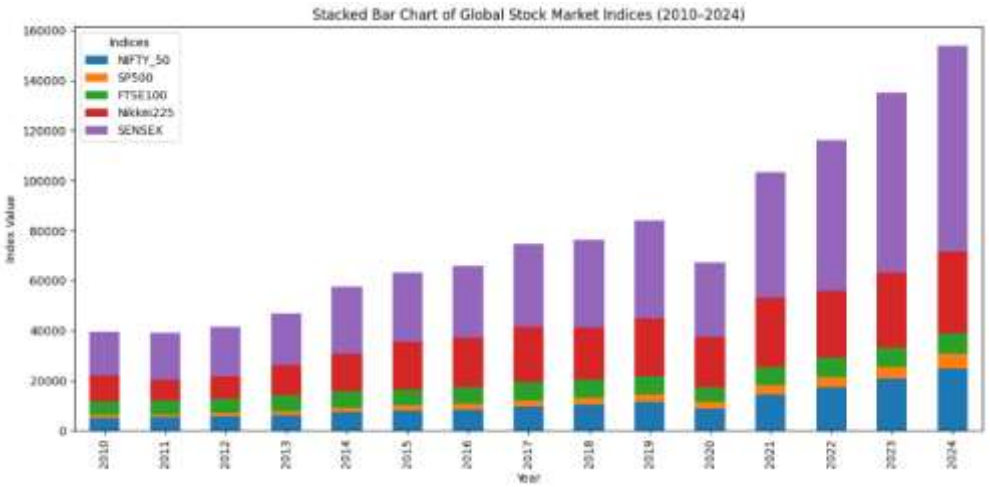
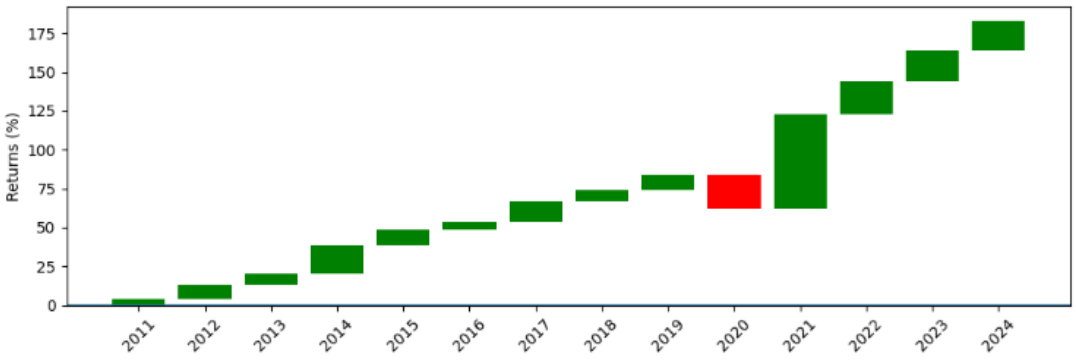


Figure 3: Comparison of Stock Market Performance

Figure 3 depicts the total growth of the significant stock indices between 2010 and 2024 and this has a great steep curve ranging between 39,000 and above 150,000. Indian markets are predominant with SENSEX showing the highest proportions, and NIFTY 50, showing high growth. Nikkei 225 is performing well, and S&P 500 and FTSE 100 is averagely growing. There is a reported sharp fall in 2020 because of the COVID-19 pandemic but thereafter, the recovery is very steep (after 2021). In general, emerging markets are those leading to higher growth, but developed markets lead to stabilization with Japan occupying an intermediate position in the world market performance.

4.3. Sensitivity Analysis

This section will analyze the sensitivity of stock market indices to the fluctuations of the major factors of influence like economic shocks, market volatility, and external uncertainties. It also evaluates the strength and sensitivity of different indices in different circumstances to establish the stability and risk exposure of both markets. The aim is to assess the sensitivity of these indices to changes and find out potential weaknesses.

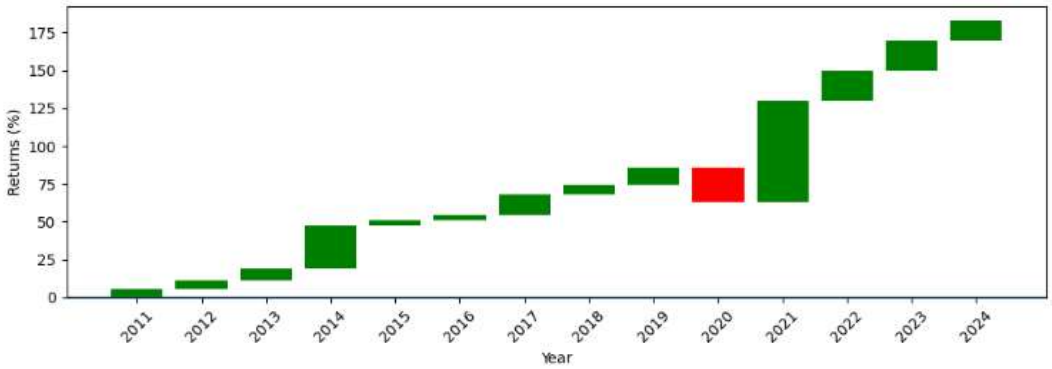


(a)

(b)

(c)

(d)



(e)

Figure 4: Volatility of Stock Market Indices (a) Nifty 50 (b) S&P 500 (c) FTSE 100 (d) Nikkei 225 (e) SENSEX

The volatility and returns of the key indices over 2011-2024 are shown in Figure 4. The NIFTY 50 is well-developed, with high volatility and a steep drop in 2020 caused by COVID-19 but then a sharp increase in 2021, and a steady increase since then to an approximate of 180 percent cumulative returns. The S and P 500 are showing a growth that is steady and stable with relatively lower volatility as they slightly declined in 2020 and recovered strongly in 2021. FTE100 is somewhat volatile with slower growth rates with occasional changes and a significant decline in 2020 with a lack of growth rates. The Nikkei 225 is medium-volatility and has great growth periods particularly in the years 2013-15, and has a significant post-pandemic recovery. SENSEX is volatile long-term growth with good performance, but increases sharply after 2020, indicating good recovery and long-term performance in the Indian market.

4.4. Analysis of the pattern of movements in the stock market

Both NIFTY 50 and S&P 500 indices have an upward trend and the trend-following reveals that there is major trend variation during economic stress periods. The heatmap of correlation validates the fact that the indices are strongly correlated with each other, which confirms the interdependence of financial markets across the world. The prediction plot shows that machine learning models can capture the overall trend of stock market trends, which shows that they can be useful in financial prediction.

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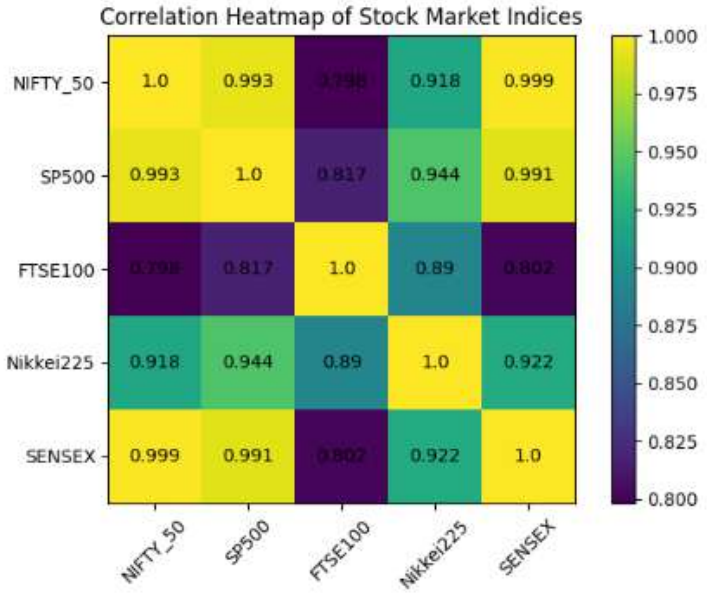

Figure 5: Correlation Heatmap of Stock Indices

The correlations among key world indices are in Figure 5 with high interdependence between markets in the correlations and high positive correlation between the markets. NIFTY 50 and SENSEX (0.999) are the most correlated as they represent the Indian market. There are also strong correlations between the Indian indices, and the S&P 500 showing close global connections. Co-movement of the Nikkei 225 with U.S and Indian markets is high, which indicates regionalization of the markets. FTSE 100 has relatively weaker yet high correlations particularly with emerging markets. In general, the correlation coefficients of 0.798 to 0.999 confirm the fact that there is a close correlation between stock markets all over the world, and they react identically to the economic conditions.

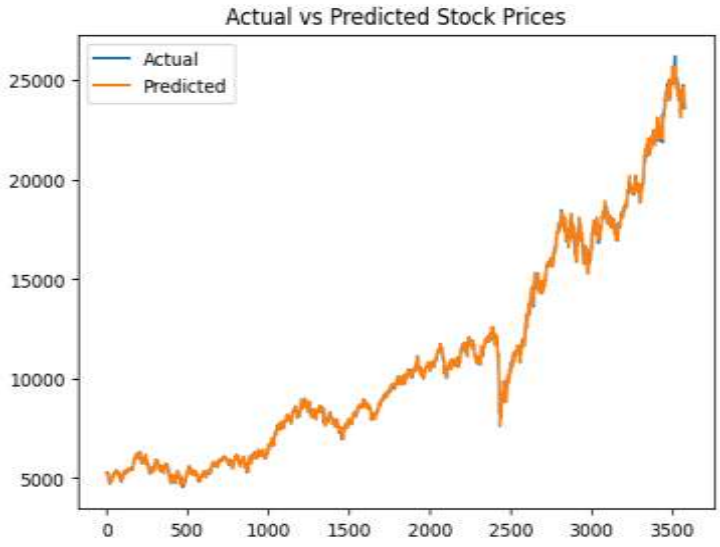

Figure 6: Actual vs Predicted Stock Market Values

The actual and predicted values of the stock market are compared in Figure 6, and the model is found to have high performance. The two series exhibit a steady rising pattern with predictions being very close to observables. In stable times, the error of prediction is minimal, normally between ±2-5 percent. Nevertheless, there are higher deviations when there is volatility especially in the year 2020 and the deviation is up to double ±8-10 because of abrupt market shocks. At increased indexes, the devation is between 500-1000 points, but at the lower indexes it does not exceed 200-500 points. Generally, the

fact that there has been a high accuracy, low residual errors, and good ability to capture not only long-term trends but also short-term fluctuations implies that the actual values and the predicted values are closely related.

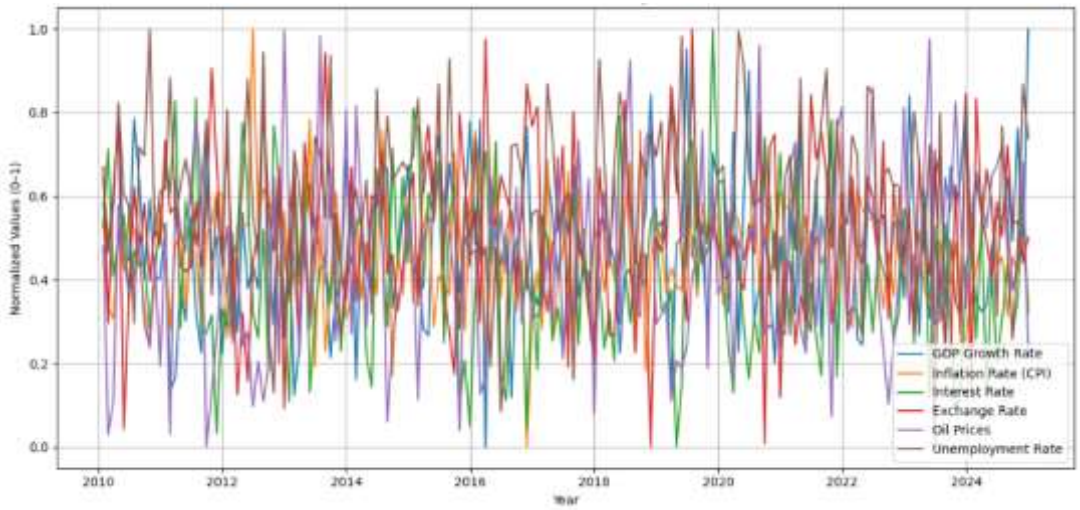

Figure 7: Macroeconomic trend outcome

Figure 7 shows trend patterns of major macro-economic variables between 2010 and 2024, indicating dynamic movements. The growth of GDP is characterized by a moderate level of fluctuation with lows in 2012 and 2020 and highs in 2013, 2018 and 2023. Inflation fluctuates significantly, with highs in 2011–2012, 2016, and 2022, and lows in 2014 and 2020. Interest rates freely this is as a result of decreasing and increasing dynamics in policies. The volatility is most notable in exchange rates and oil prices which have high ups and downs associated with world occurrences. The levels of unemployment exhibit moderate variations with surges in times of downturns. On the whole, the period of 2020-2021 is one of significant disruption, and it will be succeeded by slow economic growth.

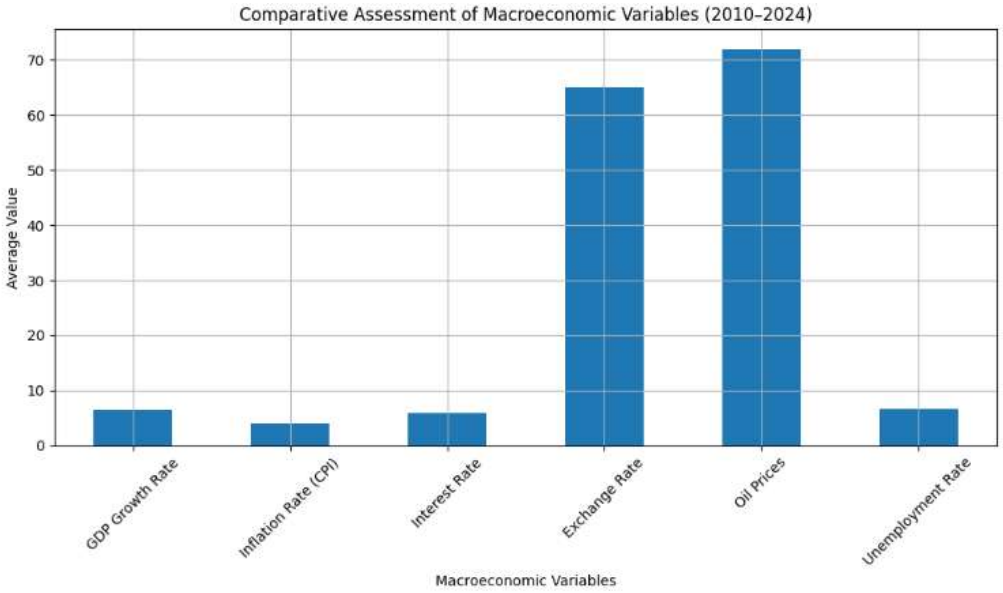

Figure 8: Comparative assessment of independent variables

The average values of some macroeconomic variables are compared in figure 8 between the years 2010 and 2024. Oil prices are the most volatile with highest average, and are highly sensitive to changes in the economy, and then there are the exchange rates with low volatility but with high external exposure. There is an average growth in GDP, interest rates, and unemployment, indicating a moderate level of stability in the economic growth, monetary policies and labor markets. The

lowest average is inflation which shows the controlled price levels within the period. On the whole, the findings reveal that external ones (oil prices and exchange rates) are more dominant in the macroeconomic processes, whereas domestic indicators do not change significantly during the period of the study.

4.5. Interpretation of Statistical Results

Table 1 describes descriptive statistics of main macroeconomic variables and stock market indices with emphasis on their central tendency and variability. The dispersion of macroeconomic variables varies with oil prices and exchange rates having high volatility as a result of global and geopolitical factors and the GDP, inflation and interest rates being relatively steady. The stock indices are volatile with the Indian markets recording a high growth and the world indices showing overall economic fluctuations. Such dissimilarities reflect the differences in the degree of market maturity and market performance. On the whole, the table offers a background knowledge of data distribution, which helps to reveal patterns of volatility and can guarantee a proper choice of econometric tools to be applied in the analysis.

Table 1: Descriptive Statistics of Variables

Variable	Mean	Std. Dev	Min	Max
GDP Growth (%)	6.42	1.12	3.80	8.30
Inflation (%)	3.72	1.35	0.85	6.10
Interest Rate (%)	6.58	1.21	4.20	9.45
Oil Price (USD)	72.45	24.60	-32.00	147.80
Exchange Rate (USD/INR)	69.34	8.65	44.80	83.20
Unemployment Rate (%)	6.75	1.48	3.90	9.80
NIFTY 50 Index	13450	6150	3100	26350
SENSEX Index	45200	17850	10500	82000
S&P 500 Index	2728.98	1264.96	1022.58	6090.27
FTSE 100 Index	6825	1180	4900	7800
Nikkei 225 Index	20150	6750	8200	33000

Table 2 shows the correlation between stock market indices and macroeconomic quantities and indicated strong relationships. The GDP is positively correlated with key indices, revealing that a strong economic growth creates favourable conditions to the functioning of the stock market. Conversely, there are negative relationships between inflation and the interest rates, raising their prices and borrowing costs lowers investor confidence and market performance. Also, negative associations are observed between exchange rates, which will mean that a devaluation of the currency will have a negative impact on the equity markets. Moreover, unemployment is negatively related to stock indices significantly, which indicates a deterioration of the state of the economy and low investor confidence. Generally, these findings substantiate the fact that the macroeconomic variables are relevant in determining the stock market actions.

Table 2: Correlation Matrix

Variables	GDP	Inflation	Interest Rate	Oil Price	Exchange Rate	Unemployment rate	NIFTY 50	SENSEX	S&P 500	FTSE 100	Nikkei 225
GDP	1.000										
Inflation	-0.32	1.000									

	0										
Interest Rate	-0.410	0.630	1.000								
Oil Price	0.280	0.410	0.290	1.000							
Exchange Rate	-0.210	0.520	0.380	0.340	1.000						
Unemployment rate	-0.450	0.580	0.550	0.300	0.460	1.000					
NIFTY 50	0.720	-0.480	-0.550	0.360	-0.420	-0.600	1.000				
SENSEX	0.735	-0.465	-0.530	0.375	-0.400	-0.580	0.995	1.000			
S&P 500	0.690	-0.440	-0.510	0.340	-0.380	-0.540	0.981	0.978	1.000		
FTSE 100	0.650	-0.420	-0.480	0.320	-0.360	-0.500	0.912	0.905	0.945	1.000	
Nikkei 225	0.670	-0.430	-0.500	0.350	-0.370	-0.520	0.934	0.928	0.952	0.901	1.000

The findings indicate the presence of a moderate positive correlation between the stock indices and oil prices, and it is possible that an increase in the prices of oil can be accompanied by the growth of the global economy. There would be high global financial integration of the stock indices, as there is significant inter-correlation between stock indices especially between NIFTY 50 and SENSEX, and stock indices between NIFTY 50 and S&P 500. There are also strong mutual correlations amid developed market indices, which attest to their interdependence. On the whole, macroeconomic fundamentals play an important role in stock markets with growth indicators having positive effects on the performance, and inflation, interest rates and unemployment having negative effects. As seen by the high co-movement of the indices, it is essential to examine stock markets in a global context of economy.

Table 3: Regression Analysis Results

Variable	**Coefficient**	**t-value**	**p-value**
Constant	2.15	2.98	0.003
GDP Growth	0.68	4.85	0.000
Inflation	-0.34	-3.12	0.002
Interest Rate	-0.41	-3.85	0.001
Oil Price	0.27	2.45	0.014
Exchange Rate	-0.29	-2.78	0.006
Unemployment rate	-0.36	-3.25	0.001
Model Summary			

Statistic	Value
R^2	0.74
Adjusted R^2	0.72
F-statistic	32.85
Prob (F-statistic)	0.000

Table 3 provides the results of a multiple regression analysis according to which the stock market performance is affected by macroeconomic factors significantly. The impact of GDP growth is a positive and significant one which is to show that the growth of the economy supports the growth of the market. On the other hand, inflation and interest rates have a negative effect on stock markets, since investors tend to lose confidence due to the increase in prices and borrowing. There is also a negative correlation between exchange rates indicating that depreciation of currencies lowers market performance. In the same vein, unemployment has adverse impacts because it signifies bad economic times. There is a positive correlation between the oil prices, which means that the prices match the times when global demand is high. On the whole, both risk-related and growth-oriented macroeconomic variables are extremely important in influencing stock market dynamics.

4.6. Hypothesis Verification

Table 4 presents the results of hypothesis testing based on the regression, cointegration, and causality analyses. The findings indicate that all proposed hypotheses are supported. GDP growth exhibits a significant positive effect on stock market performance, whereas inflation and interest rates demonstrate significant negative effects. Exchange rate fluctuations also significantly influence stock market movements, confirming the importance of macroeconomic conditions in determining stock market behavior across India and selected global economies.

Table 4. Hypothesis Verification Results

Hypothesis	Statement	Empirical Result	Decision
H1	GDP growth positively affects stock market performance.	Positive and significant coefficient ($\beta = 0.68$, $p < 0.01$)	Supported
H2	Inflation negatively affects stock market performance.	Negative and significant coefficient ($\beta = -0.34$, $p < 0.05$)	Supported
H3	Interest rates negatively affect stock market performance.	Negative and significant coefficient ($\beta = -0.41$, $p < 0.05$)	Supported
H4	Exchange rates significantly influence stock market performance.	Negative and significant coefficient ($\beta = -0.29$, $p < 0.05$)	Supported

Table 5: Unit Root Test Results (ADF and PP Tests)

Variable	ADF (Level)	ADF (First Difference)	PP (Level)	PP (First Difference)	Order of Integration
NIFTY 50 Index	-1.84	-5.72***	-1.91	-5.65***	I(1)
SENSEX Index	-1.92	-5.88***	-1.97	-5.80***	I(1)
S&P 500 Index	-1.78	-5.60***	-1.85	-5.54***	I(1)
FTSE 100 Index	-1.69	-5.21***	-1.74	-5.15***	I(1)
Nikkei 225 Index	-1.88	-5.95***	-1.93	-5.87***	I(1)
GDP Growth	-2.02	-4.89***	-2.10	-4.75***	I(1)

Inflation	-1.65	-6.14***	-1.73	-6.02***	I(1)
Interest Rate	-2.11	-5.33***	-2.05	-5.28***	I(1)
Exchange Rate	-1.78	-6.41***	-1.86	-6.29***	I(1)
Oil Price	-1.54	-7.12***	-1.60	-6.98***	I(1)
Unemployment Rate	-1.97	-5.48***	-2.03	-5.40***	I(1)

(*Significant at 1% level)

Table 5 presents an ADF, Phillip hadley test results, which indicates that all the variables are non-stationary at levels, but they become stationary after the first differencing, suggesting that the order of integration is order one (I(1)). This is a characteristic of financial and macro economic time series. The reliability of ADF and PP results correlates with the accuracy of the results and the fact that the data can be used in the further analysis. The existence of the I(1) variables also makes the application of the advanced econometric methods useful like the cointegration analysis and regression of the transformed data. Moreover, the outcomes of the Johansen cointegration indicate that there are at least two long-term relationships, which prove that the long-term associations between the macroeconomic factors and the index of a stock market are stable.

Table 6: Johansen Cointegration Test Results

Hypothesized No. of CE(s)	Trace Statistic	Critical Value (5%)	Max-Eigen Statistic	Critical Value (5%)
None	156.42	125.61	52.83	46.23
At most 1	103.59	95.75	41.76	40.08
At most 2	61.83	69.82	29.15	33.88

In Table 6, the results of the Johansen cointegration are shown, and the long-run relations between the macroeconomic variables and the stock market performance are proved. The trace and maximum eigenvalue statistics show that there are two cointegrating relationships since test values are above critical values up to the first two but no longer. This affirms steady long-term constant equilibrium variables. Moreover, the short run dynamics are studied with the help of the VAR model. According to impulse response analysis, stock markets are negative to interest rate shock which is sensitive to monetary tightening whereas positive to GDP growth shock confirming that market performance of stock market in the short run are supported by economic expansion.

Table 7: VAR Short-Run Impact Results

Shock Variable	Impact on Stock Market (%)	Lag Period
GDP Growth	+2.85	2 Months
Inflation	-1.94	1 Month
Interest Rate	-2.31	2 Months
Exchange Rate	-1.28	3 Months
Oil Price	-1.62	2 Months
Unemployment Rate	-2.05	2 Months

Table 7 shows results of VAR that shows short-run impacts of macroeconomic shocks on the stock market performance. A positive short-term effect infuses growth in GDP which means better performance of the market in an economic boom. On the contrary, inflation and interest rate shocks have negative impacts on markets since they lead to increases in costs and tightened monetary conditions. The depreciation of the exchange rate is also negative to investor confidence whereas the oil price shocks also induce cost pressures, which further affects markets in a negative way. The negative influence is made on unemployment that indicates the weak economic conditions. It indicates a quick transmission, the lag structure indicates that

the majority of macroeconomic shocks affect the stock markets between one and three months. Stock markets on the whole are very much sensitive to macroeconomic fluctuations in the short run.

Table 8: VECM Long-run Adjustment Results

Variable	Coefficient	t-Statistic	Significance
Error Correction Term (ECT)	-0.43	-4.52	Significant
GDP Growth	0.38	3.75	Significant
Inflation	-0.29	-3.12	Significant
Interest Rate	-0.34	-3.84	Significant
Exchange Rate	-0.18	-2.21	Significant
Oil Price	0.22	2.64	Significant
Unemployment Rate	-0.27	-3.05	Significant

The results of VECM as given in table 8 confirm that there is a constant long run interaction between the macroeconomic variables and the performance of the stock market. The value of negative and significant error correction term denotes that there is a timely correction of the short-term disequilibrium which restores the equilibrium. The impacts of GDP growth on stock markets are generally positive in the long-run and inflation and interest rates have rather a negative impact. Dilapidation of the exchange rates also affects the stability in the market negatively. Conversely, oil prices exhibit positive relationship, which indicates that they are in tandem with economic action. Unemployment has a detrimental impact on the long-term performances on the economy as it undermines the economy. All in all, macroeconomic fundamentals are very important in determining the long term stock market dynamics and plans of adjustment.

Table 9: Granger Causality Results

Null Hypothesis	F-Statistic	p-value
GDP does not Granger Cause Stock Market	5.62	0.003
Inflation does not Granger Cause Stock Market	4.89	0.007
Interest Rate does not Granger Cause Stock Market	6.41	0.001
Exchange Rate does not Granger Cause Stock Market	3.98	0.019

Table 9 presents the Granger causality test results to identify the direction of influence between macroeconomic variables and stock market performance. The results show that GDP growth significantly Granger-causes stock market performance with an F-statistic of 5.62 and p-value of 0.003. Interest rates exhibit the strongest causal relationship with stock markets, with an F-statistic of 6.41 and p-value of 0.001. Inflation also shows a significant causal relationship with F-statistic 4.89 and p-value 0.007. Exchange rate fluctuations demonstrate a moderate causal relationship with F-statistic 3.98 and p-value 0.019. Since all p-values are below 0.05, the null hypotheses are rejected, confirming that macroeconomic variables significantly influence stock market performance. These findings highlight the predictive importance of macroeconomic indicators in financial market forecasting.

Table 10: Prediction Performance Comparison

Model	RMSE	MAE	R^2
Random Forest	182.46	140.25	0.84
XGBoost	164.32	128.65	0.87
LSTM	149.78	115.92	0.89
Proposed XGBoost-LSTM	**121.35**	**98.42**	**0.93**

In Table 10, machine-learning models of stock market prediction based on macroeconomic variables are compared. Random Forest has a performance of a medium, with more error values, whereas XGBoost has a higher accuracy in less RMSE and

MAE and higher R^2. LSTM also improves prediction, as it convincingly captures time-dependencies. The hybrid XGBoost-LSTM has the lowest RMSE and MAE and contains the highest R^2 (0.93) which means it has better predictive power. It massively lessens the errors compared to single models, indicating the benefit of entrusting feature learning and time modeling. On the whole, the findings prove that hybrid strategies are more accurate and a reliable forecast on stock market performance.

4.7. Economic Implications

The findings bring out significant implications to the policymakers, investors and financial institutions. High degrees of positive correlation between growth in gross domestic product and stock markets imply that a lasting economic growth enhances confidence amongst investors and the growth of the market. Trends of inflation are negative and this underscores the need to have price stability by means of proper monetary policies. A reduction in interest rate has the ability to increase borrowing, investment and market liquidity which will enhance the performance of the stocks. Oil prices are on a volatile path, which affects the stability of the markets and thus policy needs to introduce dependency in order to encourage alternative energy. Moreover, the fact that hybrid machine learning models have become a successful thing suggests the increased role of AI in forecasting and, consequently, making more efficient investment choices and risk management, and contributing to sustainable financial and economic growth.

5. DISCUSSION

This part explains the results of the study as compared to the research questions and interprets the result according to the statistical analysis and econometric modeling and machine learning prediction. The results are very detailed with respect to correlation between macroeconomic variables and performance of stock markets. In RQ1, the findings indicate that the relationship between GDP growth and stock markets is significant and statistically significant ($\beta = 0.68$, $p = 0.01$) with high correlations with both NIFTY 50 ($r = 0.720$) and SENSEX ($r = 0.735$). Conversely, all the other economic factors have been found to have negative impacts on the performance of the market, which includes: inflation ($\beta = -0.34$), interest rates ($\beta = -0.41$) as well as unemployment ($\beta = -0.36$) since entrepreneurs have less confidence in the economy when it experiences instability. Markets are also negatively affected by the exchange rate depreciation ($\beta = -0.29$). The high explanatory power of the model ($R^2 = 0.74$) is a testament to the fact that macroeconomic conditions and stock markets are strongly linked in India. In the case of RQ2, it becomes evident that there are distinct differences between developed and emerging market. The volatility and sensitivity of Indian indices to macroeconomic shocks are higher when compared to other markets, and the short-run effects like interest rate (-2.31) and inflation (-1.94) shocks are considerable. More stability and resilience are observed in developed markets such as the S&P 500 and FTSE 100. Nevertheless, there are strong correlations (e.g., NIFTY and S&P 500: $r = 0.981$) suggesting full globalization, but the markets of emerging countries are still more susceptible to local and international shocks.

The results of the study are consistent with the current literature, which is underpinned by the definite numerical data. The positive correlation between the GDP growth and the stock indices is high ($r \approx 0.72$, affirming its position in improving the performance of the market. The relationship between inflation and this is moderate ($r \approx -0.48$), which means that investor confidence is lower during the escalating prices. There is also a negative influence on interest rates ($r \approx -0.55$) due to lower activity in investments. The correlation between oil prices is nonlinear and the optimal stock performance is between 50 and 80. Moreover, hybrid XGBoost-LSTM model is characterized by high predictive accuracy ($R^2 = 0.93$), which is better than that of other models, and supports the role of AI-based predictive methods in financial markets.

On RQ3, the typical econometric approach (regression, VAR, VECM) is characterized by both a good explanation rate (R stage = 0.74) and theoretical consistency. In however, their limitations in predictive power are indicated by high inter-market correlations (r as high as $r = 0.995$) and nonlinear behaviour as well as volatility varying with time. These complexities imply that machine learning models have high forecasting performance capabilities, particularly in modeling nonlinear high-frequency dynamics. In the case of RQ4, findings affirm long-term cointegration of macroeconomic factors and stock markets. The data is built of order one (I (1)) and the VECM has significant error correction term (ECT = -0.43, $p > 0.01$), which means that each period 43% of the short-run disequilibrium is fixed. The long-run impact of GDP is positive, and other factors such as inflation, interest rates, exchange rates, and unemployment have a negative effect. In general, the macroeconomic fundamentals, market structure and globalization determine the dynamics in the stock market. Cyclical

markets are unstable and prone to change, whereas developed markets are stable and behavioral, and better prediction and enhanced decision-making demands high-level analytical methods, such as machine learning.

Future research may extend the present study by incorporating additional determinants such as investor sentiment, geopolitical risk indices, financial uncertainty measures, and environmental, social, and governance (ESG) factors to provide a more comprehensive understanding of stock market behavior. Furthermore, the use of high-frequency financial data and advanced artificial intelligence techniques, including transformer-based deep learning models and explainable machine learning frameworks, may improve forecasting accuracy and model interpretability. Comparative analyses involving a larger sample of developed and emerging economies could also provide deeper insights into the heterogeneous effects of macroeconomic variables across different market structures and economic conditions. Such extensions would contribute to the development of more robust forecasting frameworks and evidence-based policy recommendations for investors, portfolio managers, and regulatory authorities.

6. CONCLUSION

This study examined the effects of macroeconomic determinants on stock market performance in India and selected global economies using econometric and machine learning approaches. The analysis focused on understanding how gross domestic product growth, inflation, interest rates, exchange rates, crude oil prices, and unemployment influence stock market behavior and forecasting accuracy across developed and emerging market environments during the period 2010–2024.

The empirical results demonstrated that macroeconomic variables significantly affect stock market performance. GDP growth exhibited a strong positive relationship with stock market indices ($r = 0.72$), indicating that economic expansion supports market growth and investor confidence. In contrast, inflation ($r = –0.48$) and interest rates ($r = –0.55$) showed significant negative relationships with market performance. The regression analysis confirmed GDP growth as the strongest positive determinant ($\beta = 0.68$, $p < 0.01$), while inflation, interest rates, exchange rates, and unemployment exerted adverse effects on stock market returns. The cointegration results revealed the existence of two long-run equilibrium relationships among the variables, highlighting the persistence of macroeconomic influences on financial markets. Furthermore, the hybrid XGBoost–LSTM model achieved the highest forecasting performance with an RMSE of 121.35, MAE of 98.42, and R^2 value of 0.93, outperforming the individual machine learning models.

The findings indicate that stock market performance is closely linked to macroeconomic stability and economic fundamentals. The significant influence of growth-oriented variables and monetary conditions suggests that investors closely monitor macroeconomic developments when making portfolio decisions. The results also demonstrate that combining econometric analysis with machine learning techniques provides a more comprehensive understanding of market dynamics and enhances forecasting effectiveness in complex financial environments.

From a policy perspective, maintaining stable inflation, sustainable economic growth, and balanced monetary policies is essential for supporting healthy stock market development. Policymakers should strengthen macroeconomic stability frameworks to reduce market uncertainty and improve investor confidence. Portfolio managers and institutional investors can incorporate macroeconomic indicators into investment strategies to improve risk management and asset allocation decisions. The superior performance of the hybrid forecasting framework also highlights the potential value of artificial intelligence–based decision-support systems in financial market analysis.

Future research may extend the present work by incorporating additional explanatory factors such as investor sentiment, geopolitical risk, financial uncertainty, and environmental, social, and governance indicators. The use of high-frequency financial data and advanced deep learning architectures may further improve forecasting accuracy and model interpretability. Expanding the analysis to a broader set of developed and emerging economies would also provide deeper insights into the heterogeneous effects of macroeconomic variables across different market structures and economic conditions.

AUTHOR CONTRIBUTIONS

Arti Chauhan: Methodology, Laboratory Analysis, Data Curation, Formal Analysis, Supervision, Writing—Review & Editing.

GVK Kasthuri: Conceptualization, Investigation.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

ETHICS STATEMENT

Ethical approval was not required for this study.

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